Global Delineation with EDNA Data

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Table of Contents

1.0 Tool operation 1
2.0 Data requirements and proposed structure 2
2.1 Database structure 2
2.2 CU data 3
2.3 Global network 3

1.0 Tool operation

The Global Point Delineation tool operates in the following way:

1) The user clicks on the tool in the Arc Hydro Tools toolbar, and clicks on the map at the location where the global delineation is to be performed.

2) The function identifies which cataloging unit (CU) the point is in by retrieving the "Name" attribute in a reference theme (e.g. HUC 8 layer).

3) The function selects on the fly preprocessed (through Arc Hydro preprocessing) feature classes for the CU identified in step 2. The database design and the directory structure are fixed, so once the CU is identified the application knows where to get required data. These parameters are set in the XML file associated to the Arc Hydro Tools.

4) Using standard Arc Hydro watershed delineation functionality (with data from step 3), the function determines the watershed within the CU of interest.

5) The function checks whether the point of interest is on the global network (to be discussed later). If it is, it means that there is an upstream area that needs to be added to the area identified in step 4 (proceed to step 5), otherwise the function performs a local delineation and the work is done.

6) If the point is located on the global network, the function performs an upstream trace on the global network.

7) Based on the elements resulting from the upstream trace performed in step 6 and on a prededefined relationship class between the network elements and the CUs, the function identifies the upstream CUs.

8) The function merges the geometries of upstream CUs identified in step 7 with the geometry of the local watershed determined in step 4.

9) The function stores the results in the global point and watershed file.

Alternative approach

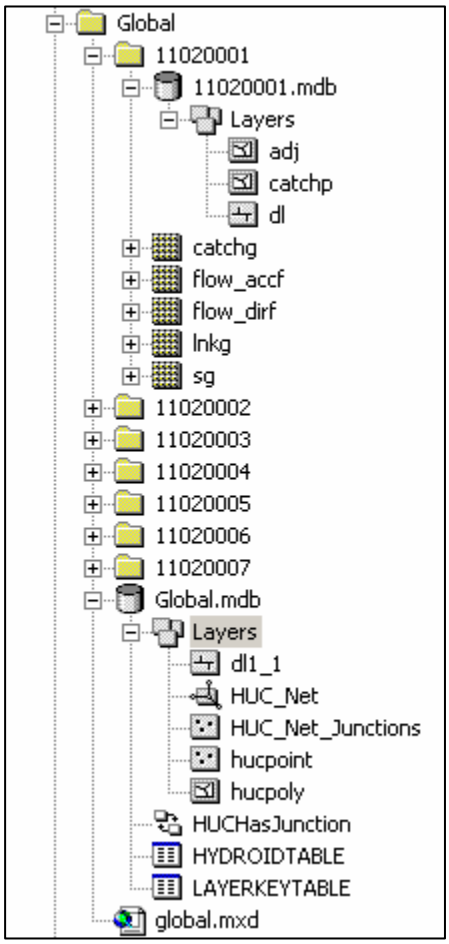
If the performance of the original implementation is not satisfactory, upstream contributing areas can be preprocessed at the CU level. Every CU will have an adjoint polygon pre-computed that will include all the upstream areas draining into that CU.

2.0 Data requirements and proposed structure

The keys for the implementation of the Global Delineation are a consistent data structure and the existence of a global network that correctly connects the CUs.

2.1 Database structure

Figure 2.1 presents the proposed data structure. Other naming conventions can be adopted for the CU and feature class names, but once defined they should not be changed, and they must be implemented consistently for each CU. The tool is written in such way that the naming is flexible (parameters are set in the XML), but consistency of naming across the CUs is required.



Consider the data structure in Figure 2.1. The top directory "Global" contains many directories, each representing a single CU (e.g. 11020001, 11020002, etc.). Each CU directory (e.g. 11020001) contains all the raster feature classes (e.g. catchg, flow_accf, etc.) and a geodatabase (e.g. 11020001.mdb) containing all the vector feature classes (eg. Adj, catchp, and dl) needed for processing. These data cover the extent of that CU only.

Naming of raster and vector feature classes within and across CUs is consistent, for example, the name for a flow direction grid in CU 11020001, 11020002, etc., is the same (e.g. flow_accf).

The "Global" directory also contains a geodatabase (e.g. Global.mdb) that contains a polygon feature class with CUs (e.g. hucpoly), a global network establishing the connectivity of CUs (e.g. HUC_Net), and all other necessary feature classes (e.g. dl1_1, HUC_Net_Junctions, and hucpoint).

Figure 2.1 - Data structure for global analyses

2.2 CU data

Each CU is processed using the Arc Hydro tools. It is not necessary to have unique HydroIDs across the CU, that is, each CU can be processed completely independently from each other. The key requirement is that all the feature classes of the same type have the same name for each CU (this can be easily fixed in ArcCatalog if necessary). All the steps (except Drainage Point Processing) from the "Terrain Preprocessing" Arc Hydro tools menu must be performed. Using the EDNA data (delivered as a package for an 8-digit HUC), the processing can start with the "Stream definition" step, as flow direction and flow accumulation grids are already computed and available. For an average EDNA CU, preprocessing takes about 15 minutes using the default values (1% threshold for stream origination) on a good PC.

2.3 Global network

The role of the global network is to establish the correct connectivity of the CUs. Figure 2.2 shows the 2156 8-digit HUCs for the conterminous USA. The global network would show how these HUCs are connected to each other through a geometric network.

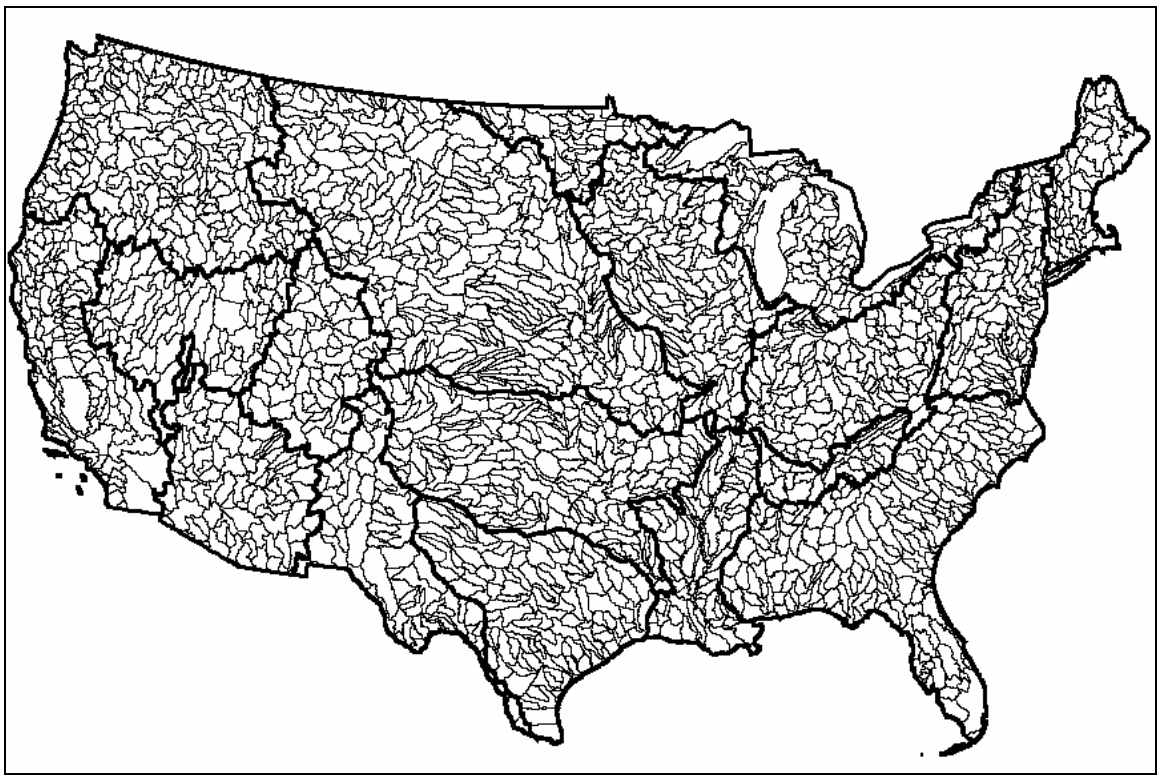


Figure 2.2 - 8-digit HUCs for the conterminous USA.

The bold lines identify the extents of 2-digit HUCs (regions).

To create a consistent global network based on EDNA data, the following process is recommended:

1) Process all CUs of interest.

2) For each CU, delineate a watershed at the outlet of that CU. This will generate an "outlet" watershed (polygon) that encompasses the whole CU and a point at its outlet. Use the CUs ID (e.g. 11020001) as the point/watershed name. This polygon will be used to identify the CU's extent, as some of the other data sources might not have the same resolution/quality/consistency (see Figure 2.3).

3) Create a new polygon feature class and merge into it all the "outlet" watersheds from all CUs. This is the global CU feature class (catchment).

4) Create a new point feature class and merge into it all the "outlet" points from all CUs. This is the global drainage point feature class.

5) Create a new polyline feature class and merge into it all the drainage lines from all CUs. This will be the basis for the global drainage line and network.

6) Clean the global drainage line.
    a. Ensure connectivity:
        i. Split the existing drainage line in one CU where another CU's drainage line is coming into (create a new node). This will be necessary where one CU drains into middle of another one.
            1. Extend the incoming drainage line and snap it onto the newly created node.
    b. Simplify drainage line (not necessary, but will improve performance for processing, tracing, and display):
        i. Delete all the drainage lines that are not on the main stem of the river going through a CU that drains another CU (reduces the geometry).
        ii. Merge all the remaining drainage line features that are not connecting other CUs (reduces the number of features and junctions).

7) If necessary, assign HydroIDs to feature classes developed in (3), (4), and (6).

8) Build the geometric network from the global drainage line. It will automatically generate the Hydro Junctions where necessary (all junctions of linear features).

9) Assign HydroID to the Hydro Junctions.

10) Use the "Store Area Outlets" function to identify which CU polygon drains to which Hydro Junction.

11) Establish a relationship class (e.g. CUHasJunction) that establishes the relationship between the JunctionID field in the CU polygon feature class with the HydroID of the Hydro Junction feature class.

The global network not only allows global watershed delineation but can also be used as a national-level hydro network for any Arc Hydro or general ArcMap operations.

If the alternative global delineation is implemented, the network is required for correct HUC and parameter aggregation.

Although in the presented example HUCs were used as CUs, this approach can be used for processing of data at any level. Such an approach will have to be implemented at smaller cataloging units if the resolution of the underlying DEM increases (e.g. 5m DEM derived from LIDAR survey).

Following are several figures showing details that might help understanding the process.

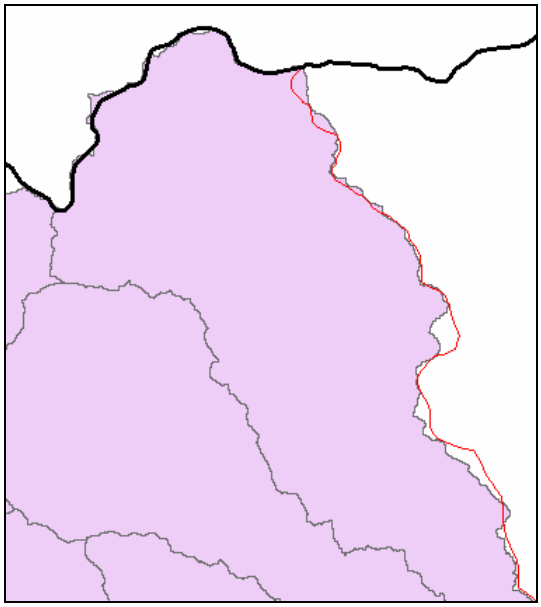


Figure 2.3 - EDNA and general HUC boundaries

Figure 2.3 shows that the EDNA HUC boundaries (purple polygon) do not match the general HUC boundaries (thick black and red lines). The portion presented is the eastern boundary of CU 11020001. The widest discrepancy is in the order of magnitude of one mile.

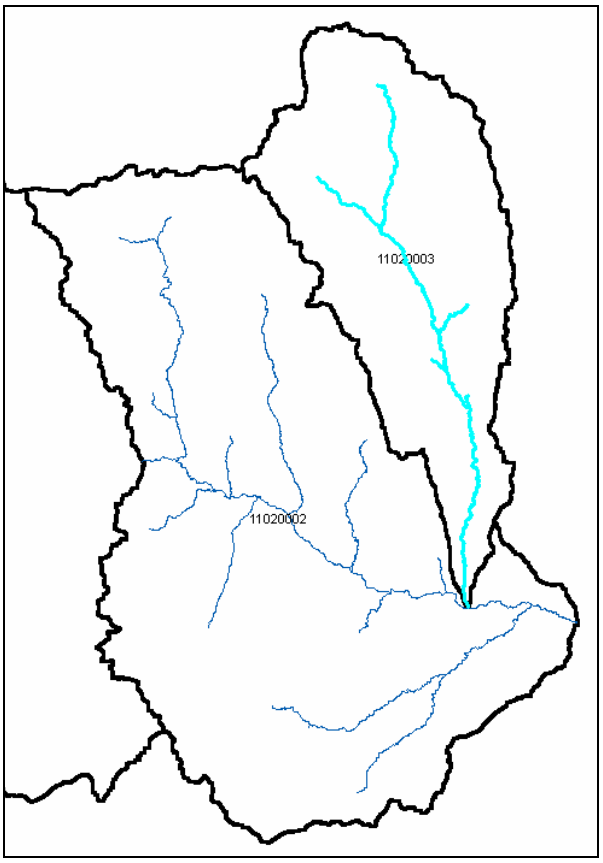


Figure 2.4 - Merged drainage lines from CU 11020003 (light blue) and 11020002.

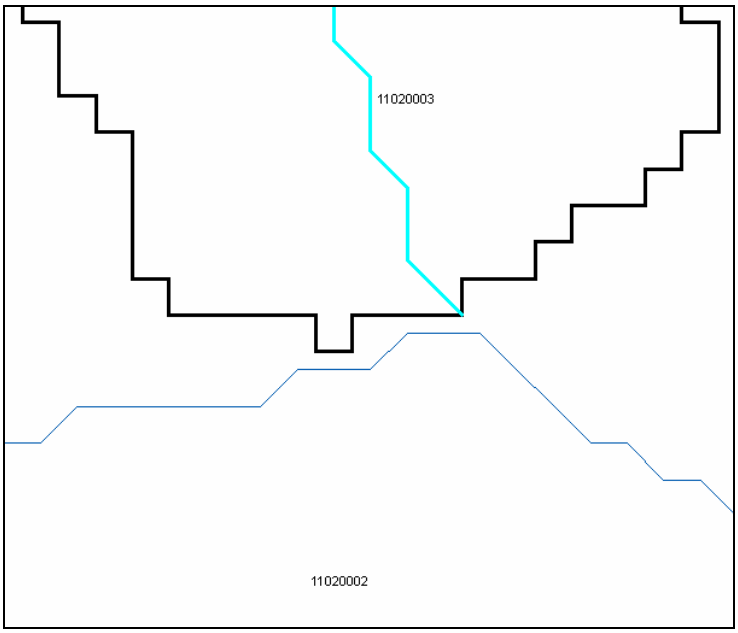


Figure 2.5 - Detail of merged lines from CU 11020003 (light blue) and 11020002.

Notice how the lines do not connect in Figure 2.5.

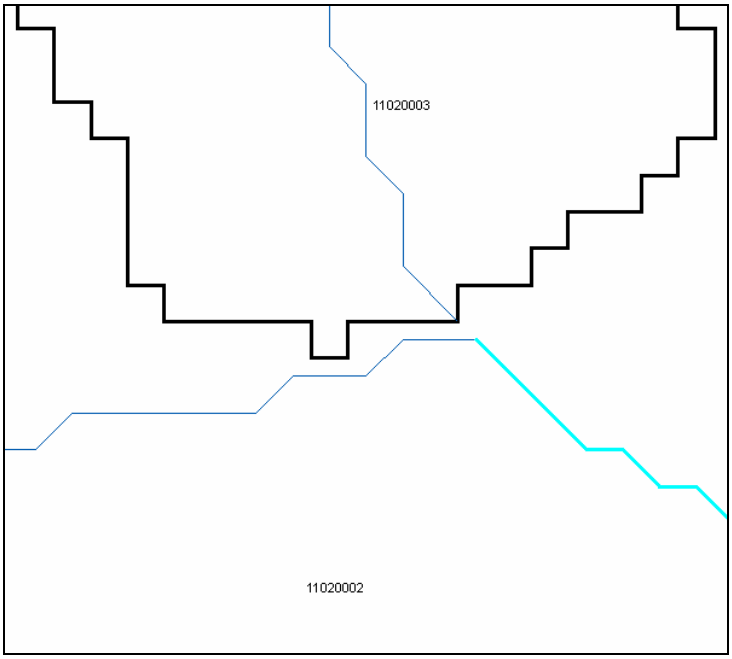


Figure 2.6 - Detail showing that drainage line for CU 11020002 was split (light blue) so that it can accommodate future extension of drainage line from CU 11020003.

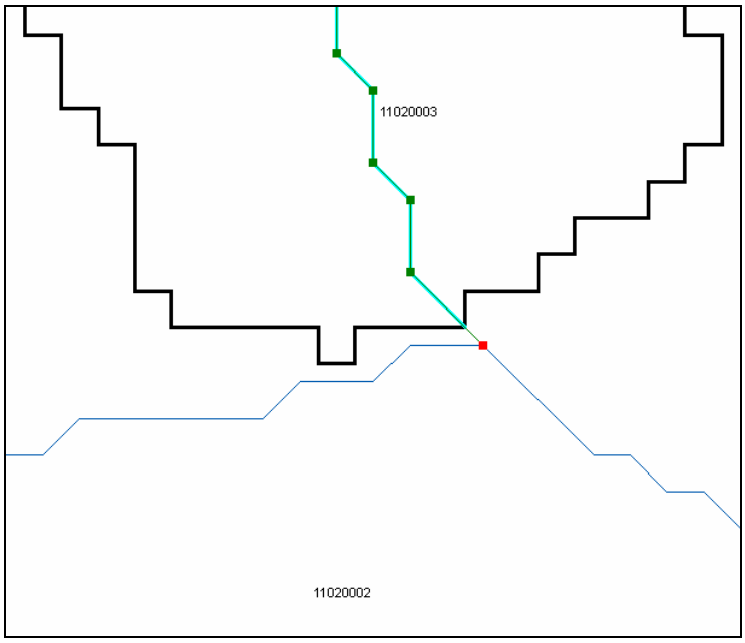


Figure 2.7 - Detail showing that drainage line for CU 11020003 was extended (light blue) so that it can connect to drainage line from CU 11020002 (at the red node).

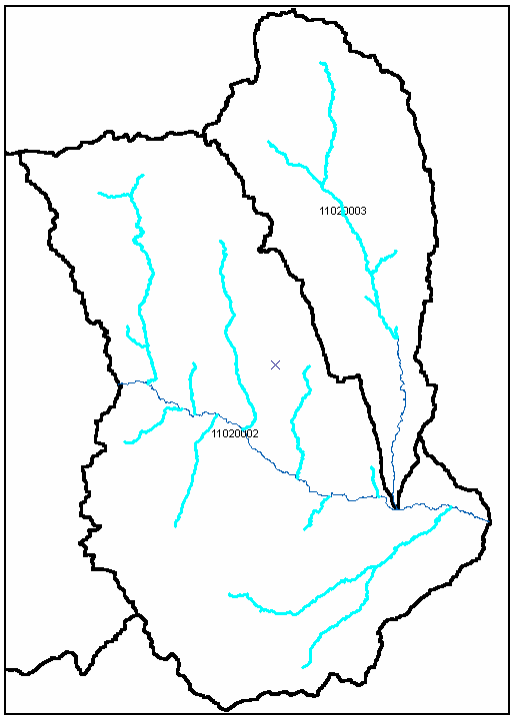


Figure 2.8 - Detail showing drainage lines in CU 11020002 and 11020003

The drainage lines shown in Figure 2.8 are not needed in the global network since they are not "carrying" drainage from upstream CU, and should be deleted.

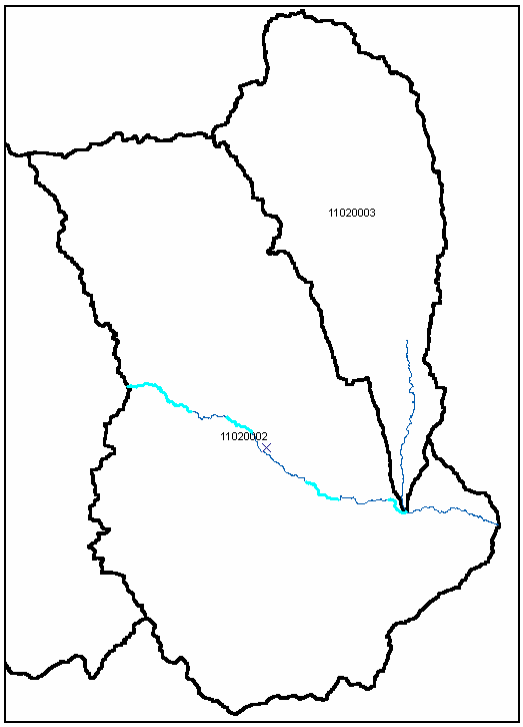


Figure 2.9 - Detail showing existence of segments in upper portion of drainage line in CU 11020002 that can be merged (from the beginning of that line on the western border to the junction with drainage line from CU 11020003).

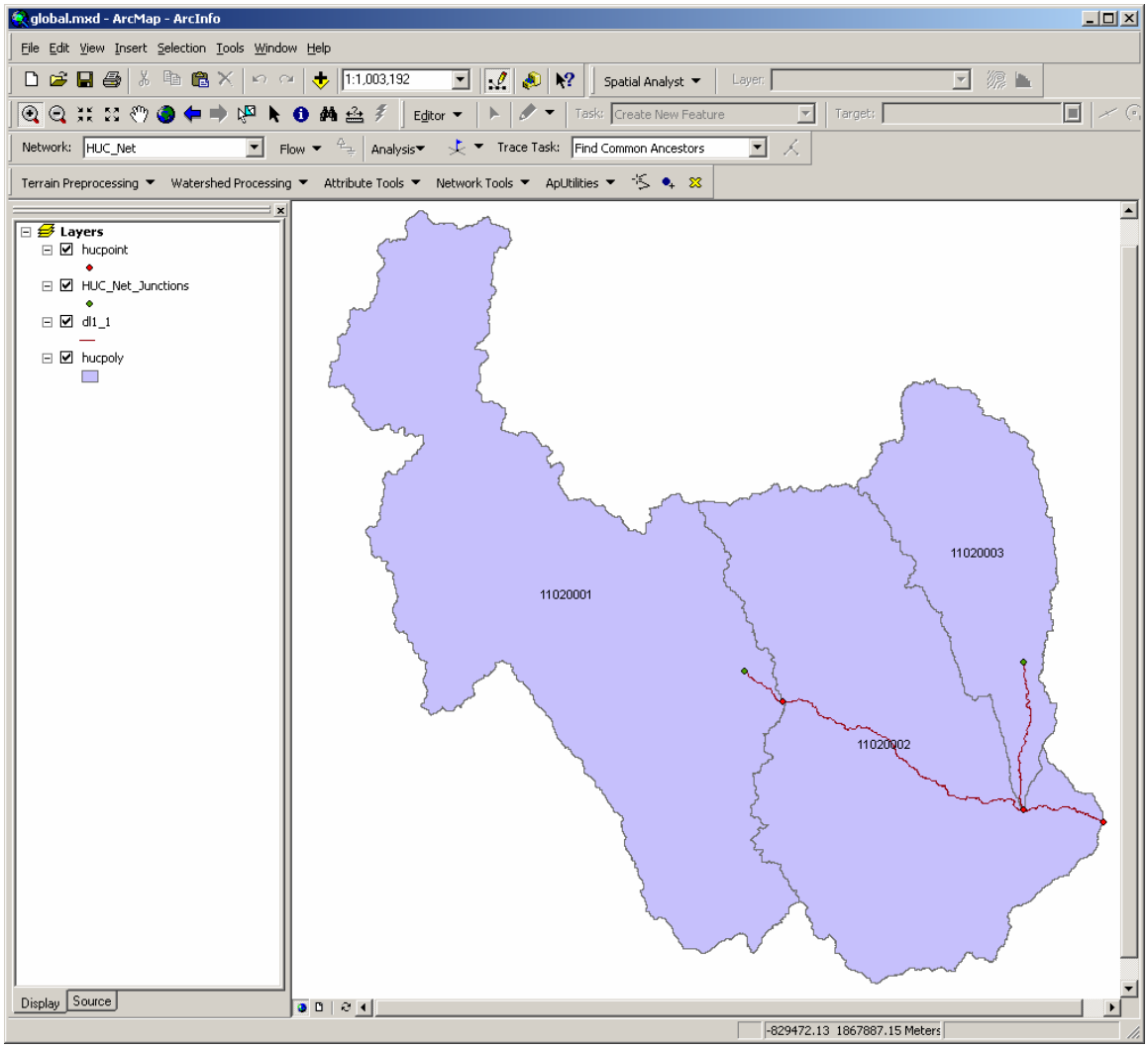


Figure 2.10 - "Global" dataset for CUs 11020001, 11020002, and 11020003.

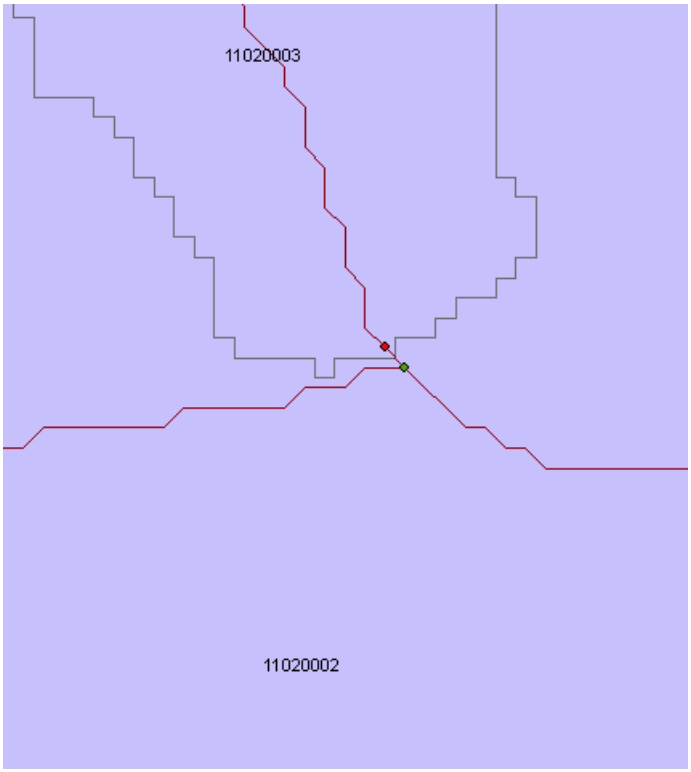


Figure 2.11 - Detail showing junction of drainage line from CU 11020003 with 11020002 (green point), and location of the drainage point for CU 11020003 (red point).