



Overview of Arc Hydro Terrain Preprocessing Workflows

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This document (original development: 6/1/2012, current version 2/6/2013) describes key steps in Arc Hydro deranged, combined, and dendritic terrain preprocessing using Arc Hydro tools version 2.1.0.125 and higher. The processing is organized into workflows based on the key geomorphologic characteristic of the terrain being processed. Approach taken in this document is to describe multiple use cases and which tools to use to generate “proper” results.

Geomorphologic (use case) terminology:

- Completely deranged terrain. Contains only sinks. Streams are not represented in Arc Hydro.
- Completely dendritic terrain. There are no sinks in the system, only streams.
- Combined dendritic/deranged terrain. There are streams and sinks in the system. Streams can be independent from the sinks and/or flow into them.

There can be additional steps in terrain preprocessing that are not discussed in this document such as sink prescreening or walling. These techniques/tools do not impact the order and tool capabilities presented in this document. These operations can be inserted into presented workflows with minimal impact. The placement though needs to be correct to obtain proper effect (e.g. first fence and then burn if you want the fenced area to flow out, or first burn and then fence if you do not want the area to flow out).

	Deranged only	Combined	Dendritic only
DEM only (no stream or sink information)	Use case 1 Use case 2	Use case 4	Use case 7
DEM and known sinks	Use case 3		
DEM and known streams and sinks		Use case 5 Use case 6	
DEM and known streams			Use case 8 Use case 9

Table 1. Overview of terrain processing use cases/workflows.

Use cases

Use case 1: Completely deranged terrain with unknown sink location and no filling of sinks

- 1) Sink Evaluation.
- 2) Create Sink Structures.
- 3) Flow Direction.
- 4) Adjust Flow Direction in Sinks.
- 5) Sink Watershed Delineation.
- 6) Append Coastal Catchments.
- 7) Assign CatType Attribute to Catchment FC (optional).

Use case 2: Completely deranged terrain with unknown sink location and some filling of sinks (always needs filling when not keeping all sinks)

- 1) Sink Evaluation.
- 2) Selection of sinks process (**this is NOT an Arc Hydro tool but rather a process**). Any technique for selecting sinks can be used. The end result is a “polygon” feature class with polygon features defining sink polys to keep as sinks.
 - a. Use Arc Hydro Sink Selection tool.
 - b. Interactively pick polys.
 - c. ...
- 3) Create Sink Structures.
- 4) Fill Sinks.
- 5) Flow Direction.
- 6) Adjust Flow Direction in Sinks.
- 7) Sink Watershed Delineation.
- 8) Append Coastal Catchments.
- 9) Assign CatType Attribute to Catchment FC (optional).

Use case 3: Completely deranged terrain with known sink location and some filling of sinks (always needs filling when not keeping all sinks)

- 1) Create Sink Structures.
- 2) Level DEM. (Potentially, this needs to be executed twice with elevation in sinks “dropped” below neighboring elevation in order to mitigate issues due to the nearby deeper depressions that are not identified as sinks).
- 3) Fill Sinks.
- 4) Flow Direction.
- 5) Adjust Flow Direction in Sinks.
- 6) Sink Watershed Delineation.
- 7) Append Coastal Catchments.
- 8) Assign CatType Attribute to Catchment FC (optional).

Use case 4: Combined dendritic/deranged terrain with unknown initial sink and stream locations

- 1) Sink Evaluation.
- 2) Selection of sinks process.
- 3) Create Sink Structures.
- 4) Fill Sinks.
- 5) Flow Direction.
- 6) Adjust Flow Direction in Sinks.
- 7) Adjust Flow Direction in Lakes. This is an optional step if there are lakes that are being drained by the streams (these are NOT sink lakes).
- 8) Sink Watershed Delineation.
- 9) Flow Accumulation.
- 10) Stream Definition.
- 11) Stream Segmentation.
- 12) Combine Stream Link and Sink Link.
- 13) Drainage Line Processing.
- 14) Catchment Grid Delineation.
- 15) Catchment Polygon Processing.
- 16) Adjoint Catchment Processing.
- 17) Append Coastal Catchments.
- 18) Assign CatType Attribute to Catchment FC (optional).

Use case 5: Combined dendritic/deranged terrain with known sink and stream locations (using synthetic streams)

- 1) Create Drainage Line Structures.
- 2) DEM Reconditioning.
- 3) Create Sink Structures.
- 4) Level DEM.
- 5) Fill Sinks.
- 6) Flow Direction.
- 7) Adjust Flow Direction in Sinks.
- 8) Adjust Flow Direction in Streams.
- 9) Adjust Flow Direction in Lakes (optional).
- 10) Sink Watershed Delineation.
- 11) Flow Accumulation.
- 12) Stream Definition.
- 13) Stream Segmentation.
- 14) Combine Stream Link and Sink Link
- 15) Drainage Line Processing.
- 16) Catchment Grid Delineation.

- 17) Catchment Polygon Processing.
- 18) Adjoint Catchment Processing.
- 19) Append Coastal Catchments.
- 20) Assign CatType Attribute to Catchment FC (optional).

Use case 6: Combined dendritic/deranged terrain with known sink and stream locations (using user specified streams) - this needs to be verified on Iceland dataset

- 1) Create Drainage Line Structures.
- 2) DEM Reconditioning.
- 3) Create Sink Structures.
- 4) Level DEM.
- 5) Fill Sinks.
- 6) Flow Direction.
- 7) Adjust Flow Direction in Sinks.
- 8) Adjust Flow Direction in Streams.
- 9) Adjust Flow Direction in Lakes (optional).
- 10) Sink Watershed Delineation.
- 11) Combine Stream Link and Sink Link.
- 12) Catchment Grid Delineation.
- 13) Catchment Polygon Processing.
- 14) Adjoint Catchment Processing.
- 15) Append Coastal Catchments.
- 16) Assign CatType Attribute to Catchment FC (optional).

Use case 7: Completely dendritic terrain with unknown stream locations

- 1) Fill Sinks.
- 2) Flow Direction.
- 3) Flow Accumulation.
- 4) Stream Definition.
- 5) Stream Segmentation.
- 6) Drainage Line Processing.
- 7) Catchment Grid Delineation.
- 8) Catchment Polygon Processing.
- 9) Adjoint Catchment Processing.
- 10) Append Coastal Catchments.
- 11) Assign CatType Attribute to Catchment FC (optional).

Use case 8: Completely dendritic terrain with known stream locations (using synthetic streams)

- 1) Create Drainage Line Structures.
- 2) Fill Sinks.
- 3) DEM Reconditioning.
- 4) Fill Sinks (to get rid of the sinks potentially introduced by the DEM Reconditioning).
- 5) Flow Direction.
- 6) Flow Accumulation.
- 7) Stream Definition.
- 8) Stream Segmentation.
- 9) Drainage Line Processing.
- 10) Catchment Grid Delineation.
- 11) Catchment Polygon Processing.
- 12) Adjoint Catchment Processing.
- 13) Append Coastal Catchments.
- 14) Assign CatType Attribute to Catchment FC (optional).

Use case 9: Completely dendritic terrain with known stream locations (using user specified streams)

- 1) Create Drainage Line Structures.
- 2) Fill Sinks.
- 3) DEM Reconditioning.
- 4) Fill Sinks.
- 5) Flow Direction.
- 6) Adjust Flow Direction in Streams.
- 7) Catchment Grid Delineation.
- 8) Catchment Polygon Processing.
- 9) Adjoint Catchment Processing.
- 10) Append Coastal Catchments.
- 11) Assign CatType Attribute to Catchment FC (optional).

Use case model builder implementation in Arc Hydro tools (Terrain Preprocessing Workflows toolset)

Use Case	Description	Model Builder Name
1	Completely deranged terrain with unknown sink location and no filling of sinks	Deranged terrain with unknown sink location and no filling
2	Completely deranged terrain with unknown sink location and some filling of sinks (always needs filling when not keeping all sinks)	Deranged terrain with unknown sink location and some filling
3	Completely deranged terrain with known sink location and some filling of sinks (always needs filling when not keeping all sinks)	Deranged terrain with known sink location and some filling
4	Combined dendritic/deranged terrain with unknown initial sink and stream locations	Combined terrain with unknown sink and stream locations
5	Combined dendritic/deranged terrain with known sink and stream locations (using synthetic streams)	Combined terrain with known sink locations
6	Combined dendritic/deranged terrain with known sink and stream locations (using user specified streams)	Combined terrain with known sink and stream locations
7	Completely dendritic terrain with unknown stream locations	Dendritic terrain with unknown stream locations
8	Completely dendritic terrain with known stream locations (using synthetic streams)	Dendritic terrain with known stream locations using synthetic drainage lines
9	Completely dendritic terrain with known stream locations (using user specified streams)	Dendritic terrain with known stream locations using user specified drainage lines

Table 2. Model builder model names for specific terrain preprocessing use cases.

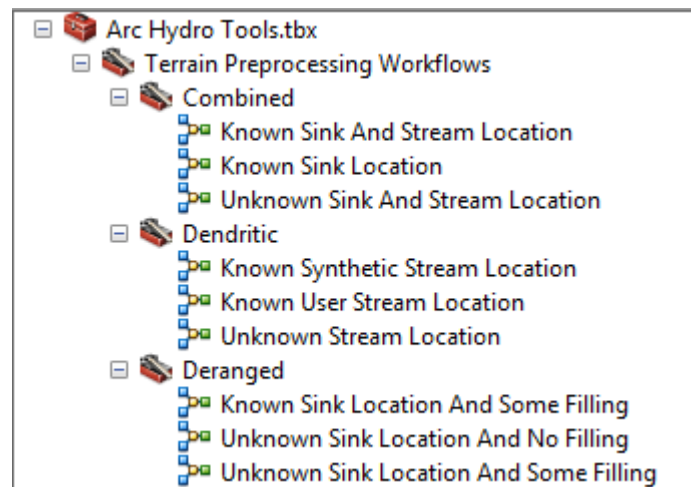


Figure 1. Toolbox/toolset organization structure for specific terrain preprocessing use cases.

Arc Hydro preprocessing functions

This is a list of Arc Hydro preprocessing functions identified through use cases 1-9. There are other preprocessing functions that are not presented here but might be needed for implementation of additional capabilities.

Function \ Use Case	Deranged			Combined			Dendritic		
	UC1	UC2	UC3	UC4	UC5	UC6	UC7	UC8	UC9
Sink Evaluation	X	X		X					
Create Sink Structures	X	X	X	X	X	X			
Flow Direction	X	X	X	X	X	X	X	X	X
Adjust Flow Direction in Sinks	X	X	X	X	X	X			
Sink Watershed Delineation	X	X	X	X	X	X			
Append Coastal Catchments	X	X	X	X	X	X	X	X	X
Assign CatType Attribute to Catchment FC	X	X	X	X	X	X	X	X	X
Fill Sinks		X	X	X	X	X	X	X	X
Level DEM			X		X	X			
Flow Accumulation				X	X		X	X	
Stream Definition				X	X		X	X	
Stream Segmentation				X	X		X	X	
Combine Stream Link and Sink Link				X	X	X			
Drainage Line Processing				X	X		X	X	
Adjust Flow Direction in Lakes				X	X	X			
Catchment Grid Delineation				X	X	X	X	X	X
Catchment Polygon Processing				X	X	X	X	X	X
Adjoint Catchment Processing				X	X	X	X	X	X
Create Drainage Line Structures					X	X		X	X
DEM Reconditioning					X	X		X	X
Adjust Flow Direction in Streams					X	X			X

Table 3. Overview of functions used per use case/workflow.

Indirectly called Arc Hydro functions

The above mentioned preprocessing functions call some additional Arc Hydro functions:

- 1) Assign HydroID
- 2) Generate From/To Nodes for Lines
- 3) Find Next Downstream Line

Function input and output

This section presents inputs and outputs for each listed preprocessing function.

- 1) **Sink Evaluation:**
 - a. Input: Raw DEM
 - b. Output: Sink Polygon Feature Class
 - c. Output: Sink Drainage Area
- 2) **Create Sink Structures.** This generates DEM-compliant sink elements. HydroID, FeatureID, SinkID, IsSink fields (and potentially others) need to be managed. The input sink polygon FC can have selected set that will be “obeyed”:
 - a. Input: Raw DEM
 - b. Input: Sink Polygon (this can be user digitized or result from “Sink Evaluation” function)
 - c. Output: Sink Polygon (jagged poly based on the input polys and selected set. IsSink = 1)
 - d. Output: Sink Polygon Grid (what we call now Sink Link Grid)
 - e. Output: Sink Point Feature Class
 - f. Output: Sink Point Grid
 - g. Input (optional): Stream Feature Class (use the TO_NODE of the stream as the sink if the stream ends in the sink poly)
 - h. Input (optional): Draft Sink Point Feature Class (use those points as sinks if they fall into the sink poly)
- 3) **Flow Direction:**
 - a. Input: DEM
 - b. Output: Flow Direction Grid
 - c. Input (optional): Outer Wall Polygon
- 4) **Adjust Flow Direction in Sinks:**
 - a. Input: Flow Direction Grid
 - b. Input: Sink Point Grid
 - c. Input: Sink Polygon Grid
 - d. Output: Flow Direction Grid (adjusted)
- 5) **Sink Watershed Delineation:**
 - a. Input: Flow Direction Grid
 - b. Input: Sink Point Grid
 - c. Input: Sink Point Feature Class
 - d. Output: Sink Watershed Grid
 - e. Output: Sink Watershed Polygon
- 6) **Append Coastal Catchments.** This is an optional step that should be done for larger DEM with large portion of coastal areas – areas defined as not draining into the “streams”. This function defines coastal catchments and appends them to the catchment feature class.
 - a. Input: DEM Grid
 - b. Input: Catchment Grid
 - c. Input/Output: Catchment Feature Class

- 7) **Assign CatType Attribute to Catchment FC.** This is an optional step. This function assigns CatType attribute to catchment features.
- a. Input: Catchment Feature Class
 - b. Input (optional): Drainage Line Feature Class
 - c. Input (optional): Sink Point Feature Class
 - d. Output: Catchment Feature Class
- 8) **Fill Sinks:**
- a. Input: Raw DEM
 - b. Output: Filled DEM
 - c. Input (optional): Fill Threshold (depth)
 - d. Input (optional): Deranged Polygon (sink polygon form "Create Sink Structures")
- 9) **Level DEM:**
- a. Input: Raw DEM
 - b. Input: Lake Polygon (in this case sink polygon from "Create Sink Structures" function)
 - c. Output: Level DEM
 - d. Input (optional): Fill Elevation Field (for this workflow, this is a mandatory field that should contain a "deep burn" elevation (depth))
- 10) **Flow Accumulation:**
- a. Input: Flow Direction Grid
 - b. Output: Flow Accumulation Grid
- 11) **Stream Definition:**
- a. Input: Flow Accumulation Grid
 - b. Input: Number of Cells to Define Stream (or area in km2)
 - c. Output: Stream Grid
- 12) **Stream Segmentation:**
- a. Input: Stream Grid
 - b. Input: Flow Direction Grid
 - c. Output: Stream Link Grid
 - d. Input (optional): Sink Watershed Grid
 - e. Input (optional): Sink Link Grid
- 13) **Combine Stream Link and Sink Link:**
- a. Input: Stream Link Grid
 - b. Input: Sink Link Grid (this should be sink point grid)
 - c. Output: Link Grid (combined)
- 14) **Drainage Line Processing:**
- a. Input: Stream Link Grid (in this case link grid with streams and sinks)
 - b. Input: Flow Direction Grid
 - c. Output: Drainage Line Feature Class
- 15) **Adjust Flow Direction in Lakes.** This is an optional step if there are lakes that are being drained by the streams (these are NOT sink lakes; sink lake fdr adjustment was done in step 6):
- a. Input: Flow Direction Grid

- b. Input: Lake Polygon Feature Class (note that these are “lake” polygons that are NOT sink lakes)
 - c. Input: Stream Grid (or Stream Link If Stream Grid is not available – used to mask the stream cells)
 - d. Output: Bowled Flow Direction Grid
- 16) Catchment Grid Delineation:**
- a. Input: Flow Direction Grid
 - b. Input: Link Grid (in this case Link Grid from previous step)
 - c. Output: Catchment Grid
- 17) Catchment Polygon Processing:**
- a. Input: Catchment Grid
 - b. Output: Catchment Feature Class
- 18) Adjoint Catchment Processing:**
- a. Input: Drainage Line Feature Class
 - b. Input: Catchment Feature Class
 - c. Output: Adjoint Catchment Feature Class
- 19) Create Drainage Line Structures:**
- a. Input: Raw DEM
 - b. Input: Stream
 - c. Output: Stream Flow Direction Grid
 - d. Output: Stream Link Grid
 - e. Output: Drainage Line Feature Class
 - f. Option: Clear Right Angles
- 20) DEM Reconditioning:**
- a. Input: Raw DEM
 - b. Input: AGREE stream
 - c. Input: Number of Cells for Stream Buffer
 - d. Input: Smooth Drop in Z Units
 - e. Input: Sharp Drop in Z Units
 - f. Output: AGREE DEM
- 21) Adjust Flow Direction in Streams:**
- a. Input: Flow Direction Grid
 - b. Input: Stream Flow Direction Grid
 - c. Output: Adjusted Flow Direction Grid