**River Network Preparation for Watershed Analysis in ArcGIS Pro**

**Complete Step-by-Step Workflow**

**Overview**

This document provides detailed instructions for converting a basic river network shapefile into a topologically correct network suitable for watershed analysis, stream ordering, and flow direction analysis in ArcGIS Pro.

**Prerequisites**

* ArcGIS Pro with Spatial Analyst and Network Analyst extensions enabled
* River network shapefile (line features)
* Digital Elevation Model (DEM) for the study area (optional but recommended)
* Basic understanding of ArcGIS Pro interface

**Phase 1: Data Preparation and Cleaning**

**Step 1: Create Project and Setup Workspace**

1. Open ArcGIS Pro and create a new project
2. Navigate to **Insert → New Map** to create a new map
3. Add your river network shapefile to the map
4. Save your project with a descriptive name
5. Create a new File Geodatabase for this project:
   * In Catalog Pane, right-click on Folders
   * Select **New → File Geodatabase**
   * Name it "WatershedAnalysis.gdb"

**Step 2: Examine Your Data**

1. Right-click the river layer → **Attribute Table**
2. Review the attributes and note:
   * Total number of features
   * Any existing flow-related fields
   * River names or classification fields
3. Use **Zoom to Layer** to examine the spatial extent
4. Check for obvious gaps, overlaps, or disconnected segments

**Step 3: Clean Geometry**

1. In Geoprocessing pane, search for **Repair Geometry**
2. Run **Data Management Tools → Features → Repair Geometry**
   * Input Features: Your river shapefile
   * Delete records with null geometry: Checked
   * Output: WatershedAnalysis.gdb/Rivers\_Clean
3. Search for **Check Geometry**
4. Run **Data Management Tools → Features → Check Geometry**
   * Input Feature Class: Rivers\_Clean
   * Output Table: Geometry\_Issues
   * Review the output table for any remaining issues

**Step 4: Simplify Lines (Optional)**

1. Search for **Simplify Line**
2. Run **Data Management Tools → Generalization → Simplify Line**
   * Input Features: Rivers\_Clean
   * Output: Rivers\_Simplified
   * Simplification Algorithm: Point Remove
   * Tolerance: 5 meters (adjust based on your data scale)

**Step 5: Create Feature Dataset**

1. In Catalog Pane, right-click WatershedAnalysis.gdb
2. Select **New → Feature Dataset**
3. Name it "RiverNetwork"
4. Set the Coordinate System to match your river data
5. Click **Next** → **Next** → **Finish**

**Step 6: Import Cleaned Data**

1. Right-click RiverNetwork feature dataset
2. Select **Import → Feature Class (single)**
3. Import Rivers\_Clean or Rivers\_Simplified into the feature dataset
4. Name the output "Rivers\_Network"

**Phase 2: Network Creation and Configuration**

**Step 7: Create Geometric Network**

1. Right-click RiverNetwork feature dataset
2. Select **New → Geometric Network**
3. Network Name: "StreamNetwork"
4. In the dialog:
   * Select Rivers\_Network as a Simple Edge feature class
   * Set Flow Direction: **With Digitized Direction**
   * Enable Complex Edges: Unchecked
   * Click **Next**
5. Create Junction feature class:
   * Name: "Stream\_Junctions"
   * Set junction snapping tolerance (default is usually fine)
   * Click **Next** → **Finish**

**Step 8: Set Flow Direction Properties**

1. Right-click the StreamNetwork → **Properties**
2. Go to the **Flow** tab:
   * Flow Direction: Digitized
   * Flow Support: Against Flow
   * Check "Enabled" for flow direction
3. Click **OK**

**Step 9: Validate Network Connectivity**

1. Open **ArcToolbox → Network Analyst Tools → Analysis**
2. Run **Validate Topology**
   * Input Network: StreamNetwork
   * This will identify connectivity issues
3. Review and fix any topology errors using the **Error Inspector**

**Phase 3: Flow Direction Assignment**

**Step 10: Check Current Flow Direction**

1. Add the Rivers\_Network layer to your map if not already added
2. Open the **Symbology** pane for Rivers\_Network
3. Change to **Unique Values** using "Enabled" field
4. Add flow arrows:
   * Click **Advanced Symbology Options → Representation**
   * Add arrow markers at line endpoints

**Step 11: Set Correct Flow Direction (Using DEM - Recommended)**

If you have a DEM:

1. Add your DEM to the map
2. Run **Spatial Analyst Tools → Hydrology → Flow Direction**
   * Input: DEM
   * Output: Flow\_Dir\_Raster
   * Force edges to flow outward: Checked
3. Run **Spatial Analyst Tools → Hydrology → Flow Accumulation**
   * Input: Flow\_Dir\_Raster
   * Output: Flow\_Acc\_Raster
4. Use **Network Analyst Tools → Analysis → Set Flow Direction**
   * Network: StreamNetwork
   * Flow Direction Raster: Flow\_Dir\_Raster

**Step 12: Manual Flow Direction Correction**

If no DEM available or for fine-tuning:

1. Start an **Edit session**
2. Select **Modify Features → Flip**
3. Click on incorrectly flowing river segments to reverse their direction
4. Work systematically from outlets upstream
5. Save edits frequently

**Phase 4: Attribute Enhancement**

**Step 13: Add Essential Fields**

1. Right-click Rivers\_Network → **Design → Fields**
2. Add new fields:
   * FROM\_NODE\_ID (Long Integer)
   * TO\_NODE\_ID (Long Integer)
   * STREAM\_ORDER (Short Integer)
   * UPSTREAM\_LENGTH (Double)
   * DOWNSTREAM\_LENGTH (Double)
   * LEVEL\_PATH (Long Integer)
3. Save changes

**Step 14: Calculate Junction IDs**

1. Open **Python** window in ArcGIS Pro
2. Run this script to populate FROM\_NODE and TO\_NODE:

import arcpy

# Enable overwrite output

arcpy.env.overwriteOutput = True

# Set workspace

arcpy.env.workspace = r"path\to\your\WatershedAnalysis.gdb\RiverNetwork"

# Get network info

geometric\_network = "StreamNetwork"

edge\_feature = "Rivers\_Network"

junction\_feature = "Stream\_Junctions"

# Create temporary feature layer

arcpy.MakeFeatureLayer\_management(edge\_feature, "edge\_lyr")

arcpy.MakeFeatureLayer\_management(junction\_feature, "junction\_lyr")

# Use Search cursor to get junction IDs and Update cursor to update edge features

with arcpy.da.UpdateCursor("edge\_lyr", ["FROM\_NODE\_ID", "TO\_NODE\_ID", "SHAPE@"]) as u\_cursor:

for row in u\_cursor:

edge\_geom = row[2]

# Get first and last points

first\_point = edge\_geom.firstPoint

last\_point = edge\_geom.lastPoint

# Find junction at first point

arcpy.SelectLayerByLocation\_management("junction\_lyr", "INTERSECT", first\_point, "1 Meters")

with arcpy.da.SearchCursor("junction\_lyr", ["OBJECTID"]) as s\_cursor:

for junc\_row in s\_cursor:

row[0] = junc\_row[0] # FROM\_NODE\_ID

break

# Find junction at last point

arcpy.SelectLayerByLocation\_management("junction\_lyr", "INTERSECT", last\_point, "1 Meters")

with arcpy.da.SearchCursor("junction\_lyr", ["OBJECTID"]) as s\_cursor:

for junc\_row in s\_cursor:

row[1] = junc\_row[0] # TO\_NODE\_ID

break

u\_cursor.updateRow(row)

print("Junction IDs calculated successfully")

**Step 15: Calculate Stream Order**

1. In Geoprocessing pane, search for **Stream Order**
2. Run **Spatial Analyst Tools → Hydrology → Stream Order**
   * Input Flow Direction Raster: Flow\_Dir\_Raster (from Step 11)
   * Input Stream Raster: (Convert Rivers\_Network to raster first)
   * Method: Strahler
   * Output: Stream\_Order\_Raster
3. Use **Spatial Analyst Tools → Zonal Statistics as Table** to transfer stream order values back to Rivers\_Network

**Step 16: Calculate Network Distances**

1. Use **Network Analyst → Closest Facility** to calculate upstream lengths:
   * Network Dataset: StreamNetwork
   * Incidents: Stream outlets (junctions with no downstream connection)
   * Facilities: All junctions
   * Direction: Against traffic (upstream)
2. Export the results and join back to Rivers\_Network using FROM\_NODE\_ID

**Phase 5: Quality Control and Validation**

**Step 17: Validate Network Connectivity**

1. Run **Network Analyst Tools → Analysis → Trace Network**
   * Network: StreamNetwork
   * Trace Type: Find Connected
   * Start from known outlets
   * Verify all streams are connected

**Step 18: Check Flow Direction**

1. Create a new map with Rivers\_Network
2. Symbolize using graduated symbols based on STREAM\_ORDER
3. Add flow arrow symbols to verify direction
4. Manually inspect confluences to ensure tributaries flow into main stems

**Step 19: Test Watershed Analysis Capability**

1. Run a test watershed delineation:
   * **Spatial Analyst Tools → Hydrology → Watershed**
   * Input: Flow\_Dir\_Raster
   * Pour Points: Select a stream junction
   * Verify the watershed boundary makes sense

**Phase 6: Final Export and Documentation**

**Step 20: Create Final Network**

1. Export the completed Rivers\_Network to a new feature class
2. Name it "Rivers\_Network\_Final"
3. Ensure all attributes are properly populated

**Step 21: Create Metadata**

1. Right-click Rivers\_Network\_Final → **Edit Metadata**
2. Document:
   * Processing steps performed
   * Flow direction method used
   * Coordinate system
   * Data sources
   * Processing date

**Step 22: Create Network Analysis Package (Optional)**

1. Go to **Share → Package → Geoprocessing Package**
2. Include the RiverNetwork feature dataset
3. Add processing tools used
4. Create documentation

**Common Issues and Troubleshooting**

**Flow Direction Issues**

* **Problem**: Streams flowing uphill
* **Solution**: Use DEM-based flow direction or manually flip segments

**Connectivity Problems**

* **Problem**: Streams not properly connected
* **Solution**: Adjust snapping tolerance, use **Extend Line** tool, or **Snap** tool to connect endpoints

**Missing Tributaries**

* **Problem**: Tributaries not connecting to main streams
* **Solution**: Create explicit junctions using **Create Junction** tool, adjust network building rules

**Stream Order Calculation Errors**

* **Problem**: Incorrect stream orders
* **Solution**: Verify flow directions are correct, ensure proper network topology

**Next Steps for Watershed Analysis**

Once your network is properly configured, you can:

1. **Delineate Watersheds**: Use the prepared network with hydrology tools
2. **Calculate Flow Statistics**: Determine flow accumulation, stream power, etc.
3. **Perform Stream Segmentation**: Create homogeneous stream segments
4. **Analyze Stream Networks**: Calculate network density, drainage patterns
5. **Model Flow Routing**: Use the network for flow modeling and analysis

**Conclusion**

This workflow transforms a basic river network shapefile into a topologically correct, flow-enabled network suitable for advanced watershed analysis. The key steps include cleaning geometry, creating a geometric network, establishing proper flow direction, and adding essential attributes for network analysis.

Remember to save your work frequently and document your process for reproducibility. The resulting network can now be used for comprehensive watershed and stream network analysis in ArcGIS Pro.

*Document Version*: 1.0  
*Date*: May 14, 2025  
*Created for*: ArcGIS Pro Watershed Analysis Workflow