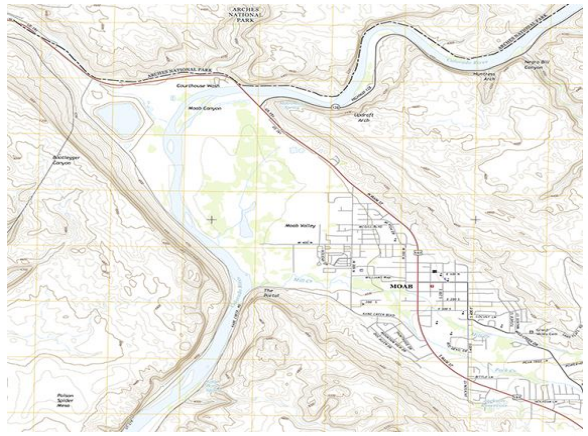
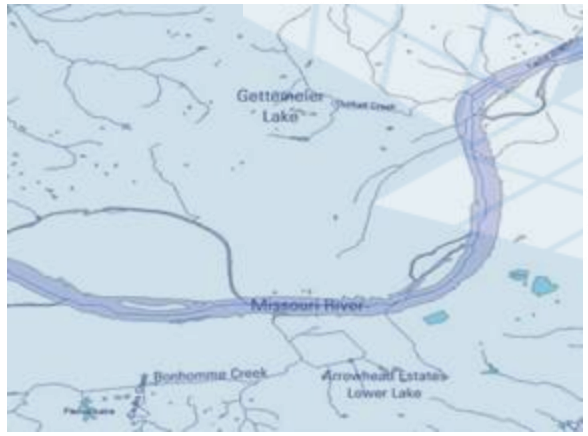
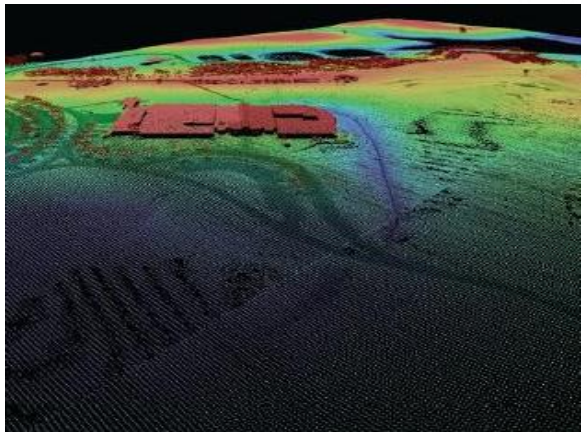
New Developments in Elevation-Derived Hydrography Acquisition Specifications and Validation







Silvia Terziotti
Hydrography Science and Applications Lead
National Geospatial Program
U.S. Geological Survey
February 21, 2024

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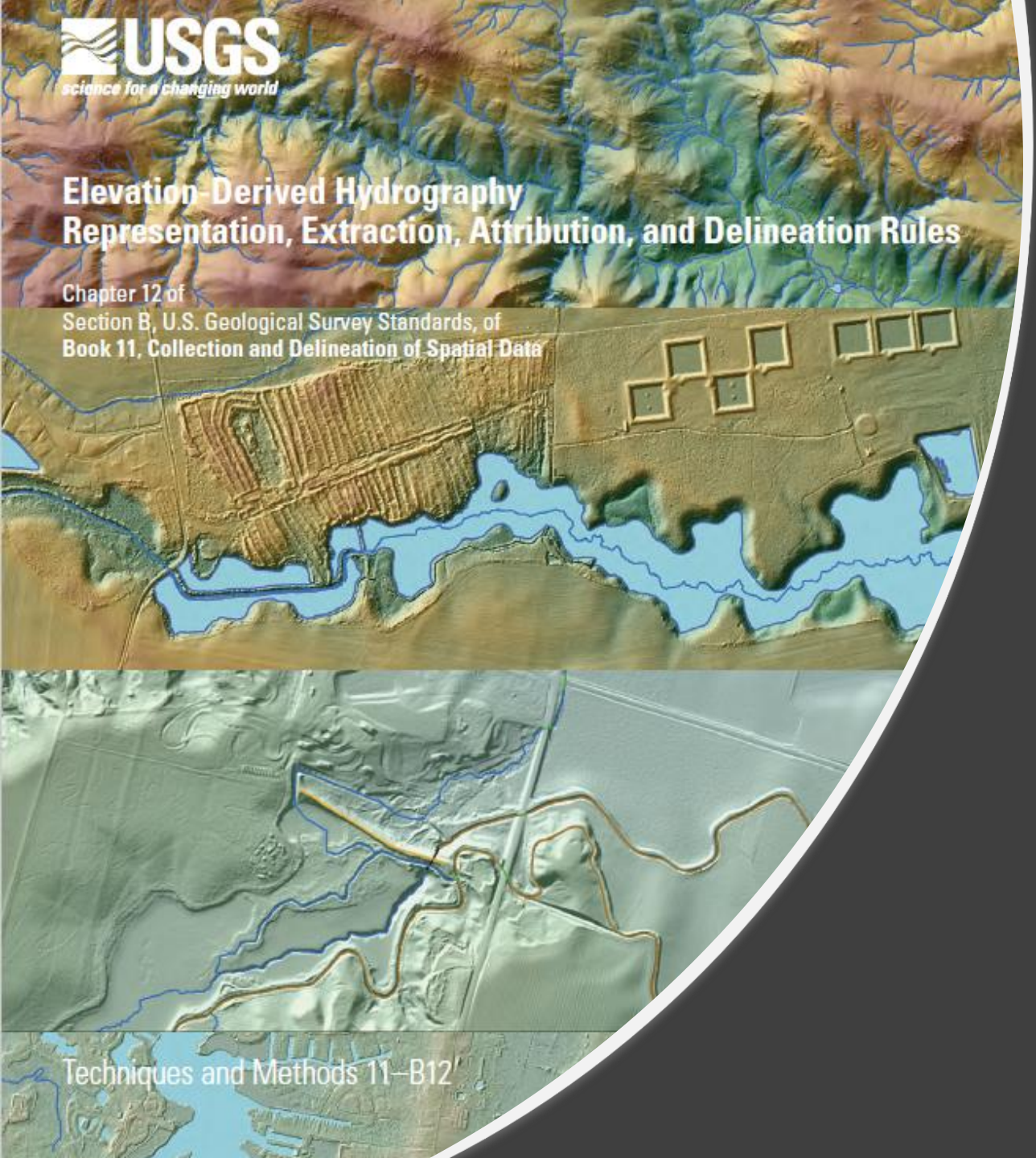
Elevation-derived Hydrography Specifications and Requirements

- Recent updates to the Elevation-derived Hydrography Acquisition Specifications and READ rules
- New guideline documents
- Validation of EDH dataset updates

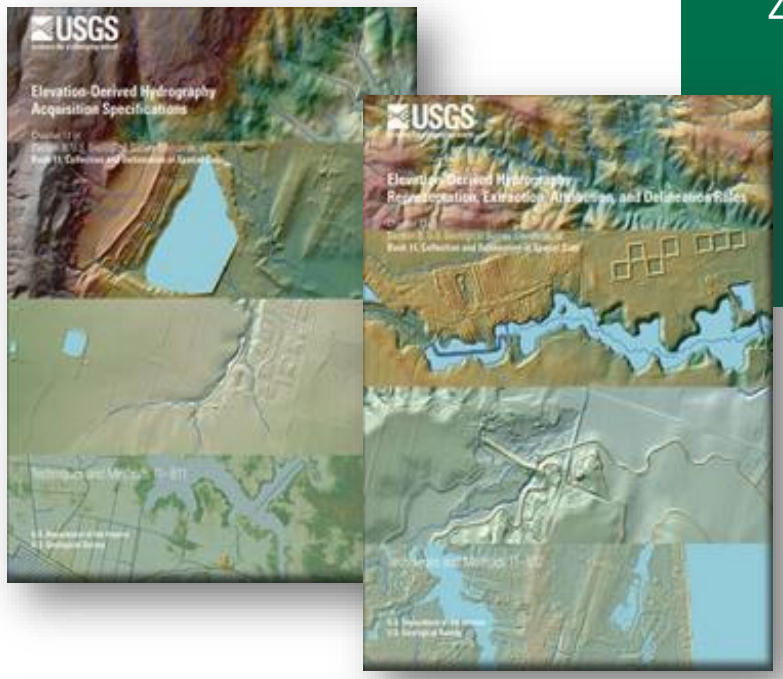


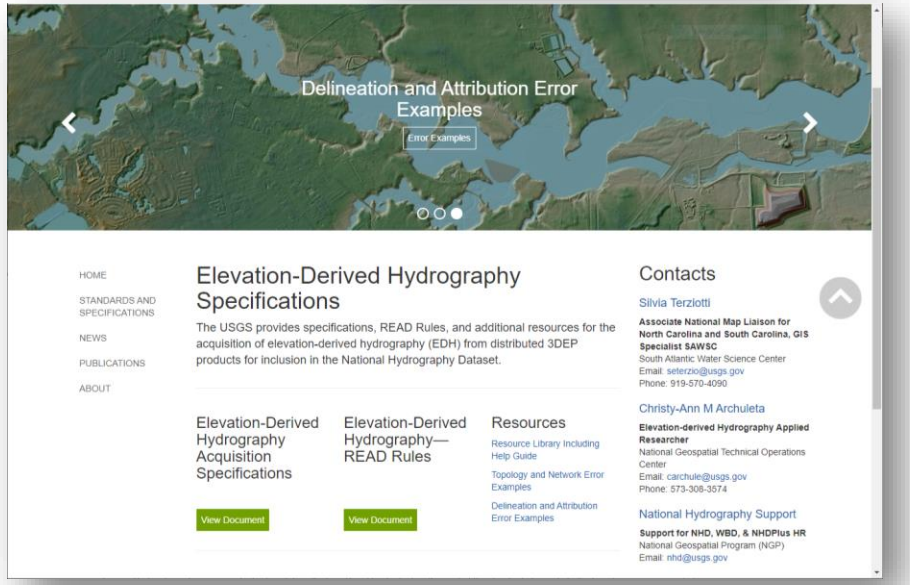
Updates to Elevation-Derived Hydrography Specifications

Hydrography Specifications

Published July 2020, **last update 2023 rev A2**

- USGS Techniques and Methods 11–B11: Elevation-Derived Hydrography Acquisition Specifications
- USGS Techniques and Methods 11–B12: Elevation-Derived Hydrography—Representation, Extraction, Attribution, and Delineation Rules
- Specification resources online – UPDATES available
  - Elevation-Derived Hydrography Specifications | U.S. Geological Survey (usgs.gov)
  - **Elevation-Derived Hydrography Acquisition Specifications 2023 rev. A** (pdf)
  - Elevation-Derived Hydrography Acquisition Specifications 2022 rev. A (pdf)
  - Elevation-Derived Hydrography Acquisition Specifications 2021 rev. A (pdf)
  - Elevation-Derived Hydrography Acquisition Specifications 2020 rev. A (pdf)
  - Elevation-Derived Hydrography Acquisition Specifications - Original Report





Updates to the Specification documents

Highlights of changes in 2023 rev 2A

- Reservoir FCode is now combined with Lake/Pond
- Flowclass added to define whether a feature is flowing in a downstream direction
- EClass contains more polygon feature types – helping with validation
- Revisions to naming and descriptions of fields
- Added the Limitation field and defined separate DEM limitation polygons
- Require the source DEM to be in Albers and GEOID18 before deriving EDH

All Updates to the Specification documents

- Corrected **Indefinite Surface Connector channelized segment length** special case to include a length for the CONtiguous United States (CONUS) and Alaska.
- The **Low Confidence Area** features are removed from the elevation-derived hydrography feature types.
- The **reservoir feature type is removed** from the elevation-derived hydrography feature types.
- Stream/river special condition added for **complex interlacing channels**.
- Changed or added additional **EClass Domain Codes**.
- Updated the Feature Type Description, Associated Geometry, and Use Classification Table with new **EClass and FClass combinations** as needed.
- Added **FlowClass** field to line feature class attributes.
- Add **Limitation** field to point, line, and polygon feature class attributes.
- Changed **name of Sink/rise** feature to **sink**.
- **Removed references to the National Hydrography Dataset** (NHD) and replaced with elevation-derived hydrography or 3D Hydrography Program (3DHP) where appropriate.
- **FClass changed from 1 to 2** for Ice Mass, Pipeline, and Non-NHD Connector.
- Changed geoid model to **require GEOID18** specifically instead of most recent.
- Clarified that **Sink features may overlap a Playa feature**.

Can be found on the specs page or at the header of the pdf

New public guideline documents

The USGS provides specifications, READ Rules, and additional resources for the acquisition of elevation-derived hydrography (EDH) from distributed 3DEP products for inclusion in the 3D Hydrography Program (3DHP).

Elevation-Derived Hydrography Data Acquisition Specifications

Current Data Acquisition Specifications

Elevation-Derived Hydrography — READ Rules

Current READ Rules

Resources

- Elevation-Derived Hydrography READ Rule Guidelines
- Resource Library Including Help Guide
- Topology and Network Error Examples
- Delineation and Attribution Error Examples

JUNE 30, 2023
Guideline for Hydrography Acquisition Representation, Extraction, Attribution, and Delineation Rules Update for Alaska and CONUS* Elevation-Derived Hydrography Network Connectivity through Ice Masses (version 1)

JUNE 30, 2023
Guideline for Hydrography Acquisition Representation, Extraction, Attribution, and Delineation Rules Update for Alaska and CONUS* Elevation-Derived Hydrography Vertical Integration of Linear Features Through Depressions (version 4)

JULY 3, 2023
Guideline for Hydrography Acquisition Representation, Extraction, Attribution, and Delineation Rules Update for Alaska and CONUS Elevation-Derived Hydrography Stream River Special Condition: Complex Interlacing Channels (version 3)

JULY 3, 2023
Guideline for Hydrography Acquisition Representation, Extraction, Attribution, and Delineation Rules Update for Alaska and CONUS* Elevation-Derived Hydrography for Sea/Ocean (version 3)

DECEMBER 4, 2023
Guideline for Hydrography Acquisition Representation, Extraction, Attribution, and Delineation Rules Update for Alaska and CONUS* Elevation-Derived Hydrography Connector through Infrastructure Areas (version 2)

DECEMBER 18, 2023
Guideline for Hydrography Acquisition Representation, Extraction, Attribution, and Delineation Rules Update for Alaska and CONUS* Elevation-Derived Hydrography X, Y, and Z Coordinate Precision (version 5)

New public guideline documents

Infrastructure Connectors

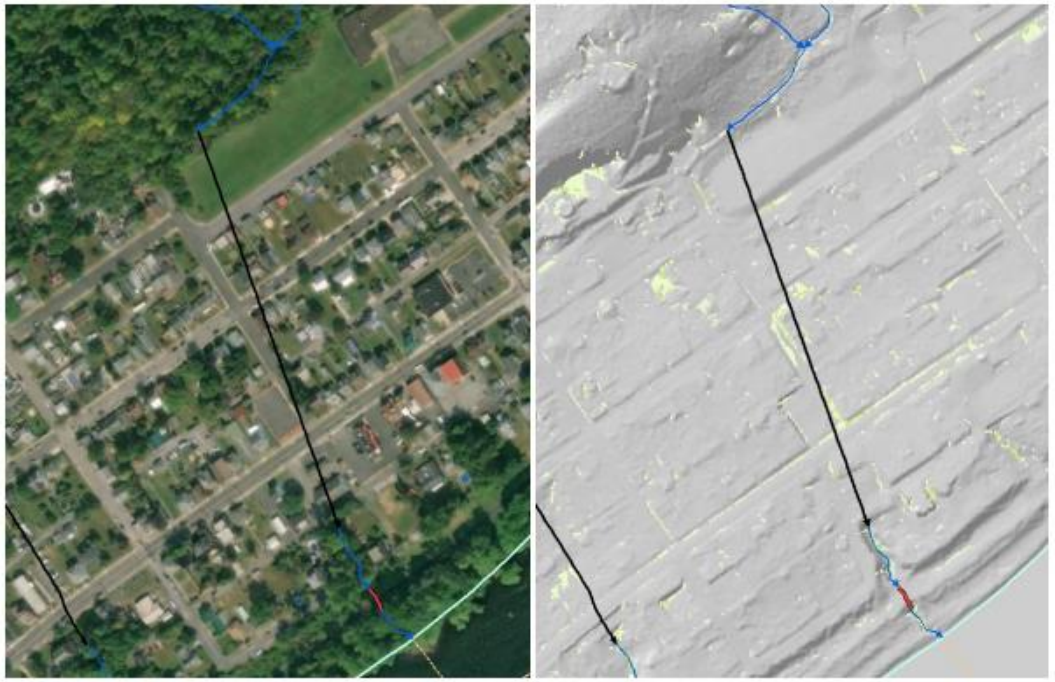


Figure 1. Example of a Connector used to connect infrastructure through an area with little channelization and developed landcover. The blue lines represent stream features, the black lines represent infrastructure connectors, and red segments represent culvert connectors.

X, Y, and Z precision

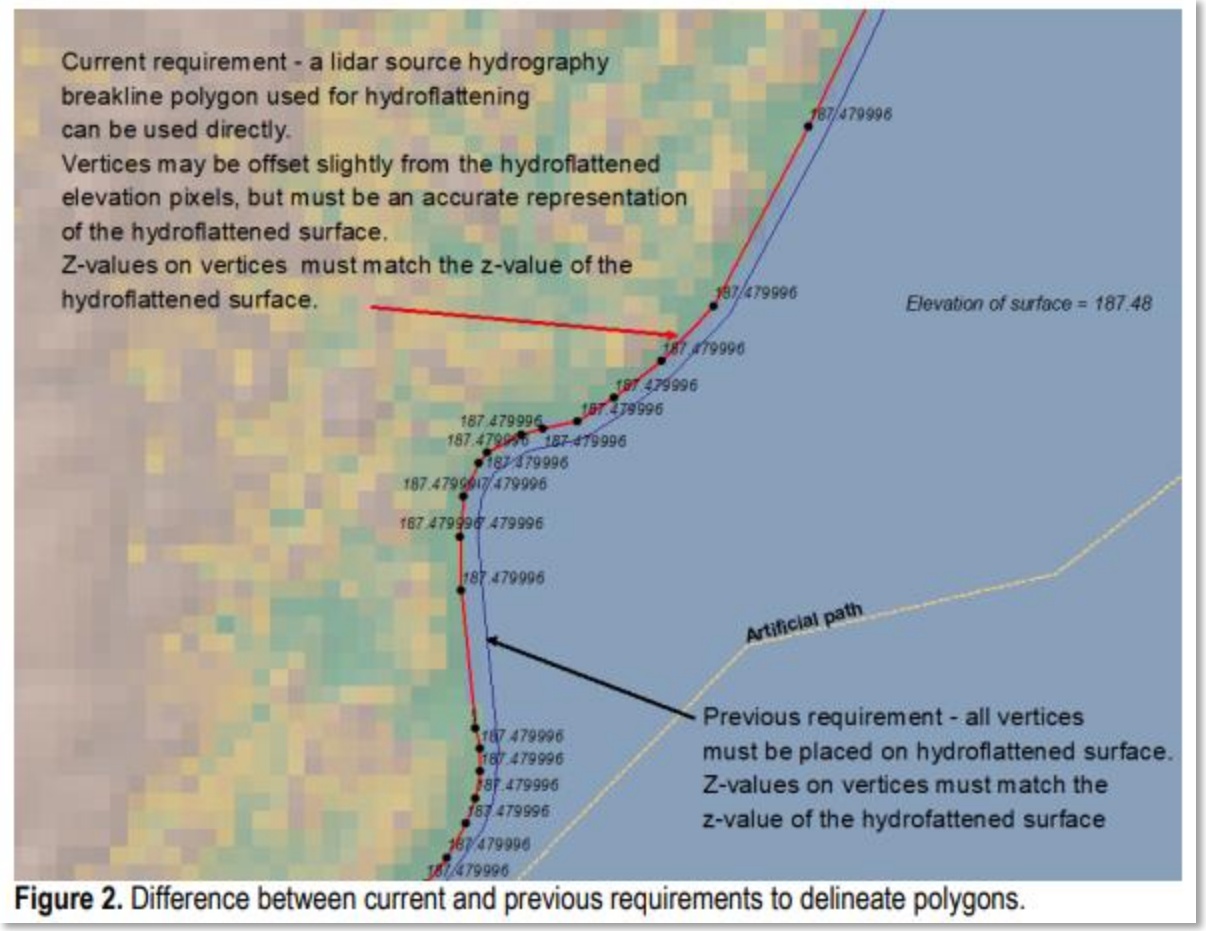


Figure 2. Difference between current and previous requirements to delineate polygons.

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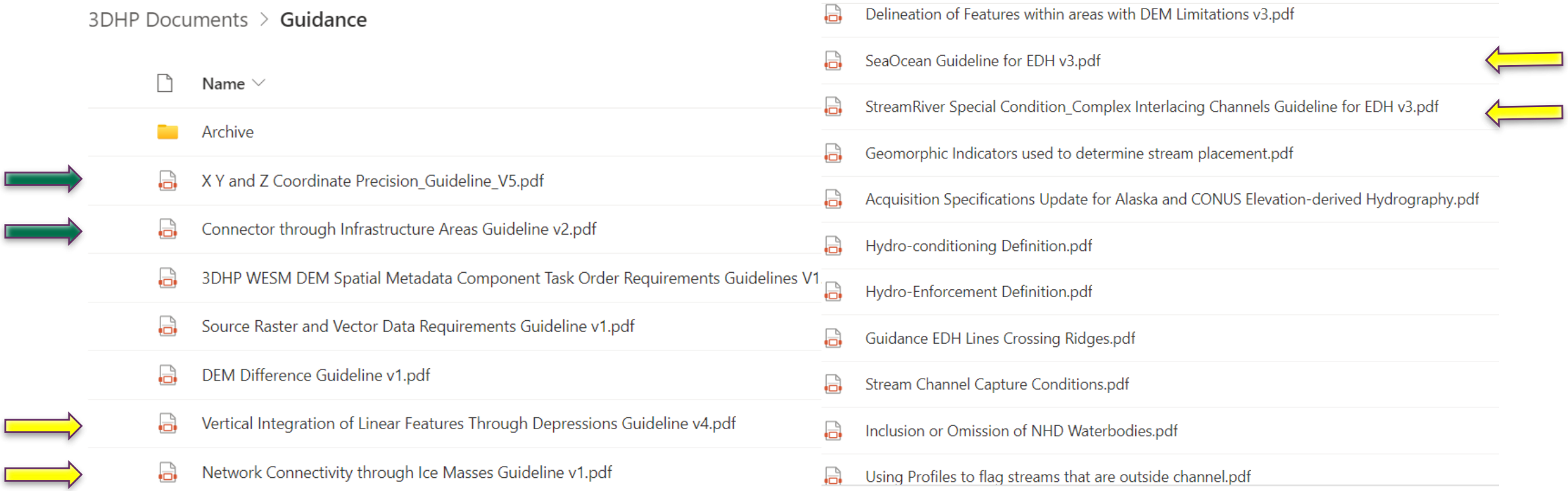
Contractor guidelines reorganized

Removed superseded or updated guideline documents in the contractor area - all documents are subject to updates



Attempting to push the guideline documents through review so that they can be published on the website shortly after contractors can access them.

3DHP source data:

Elevation-derived Hydrography

Validation updates

Inspection Workflow

Streamlined process

Receive Data from Contractor

- Based on task order requirements
- Follows specifications

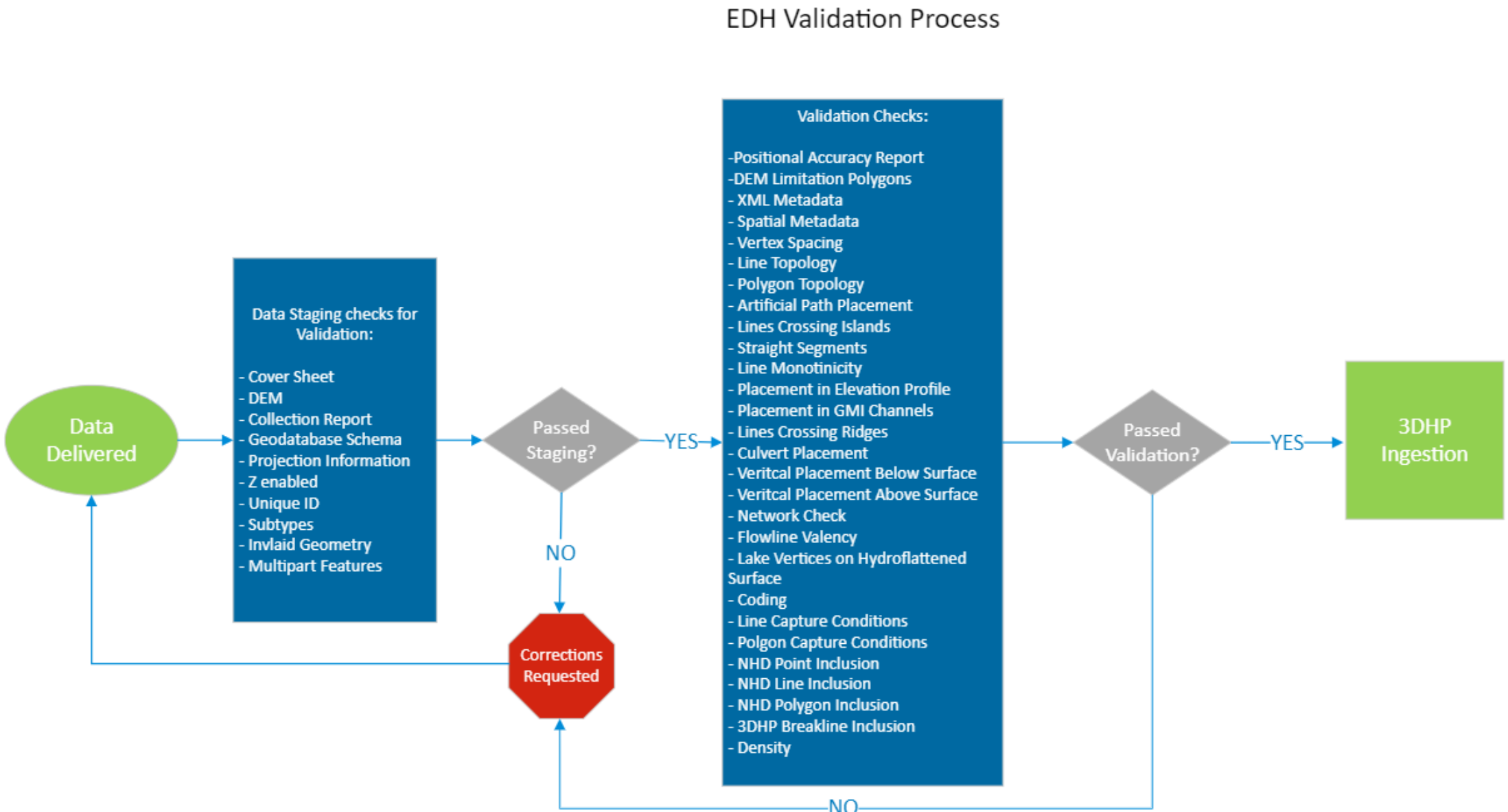
Staging

- Looking for requirements that would break the tools
- No errors accepted

Validation tools

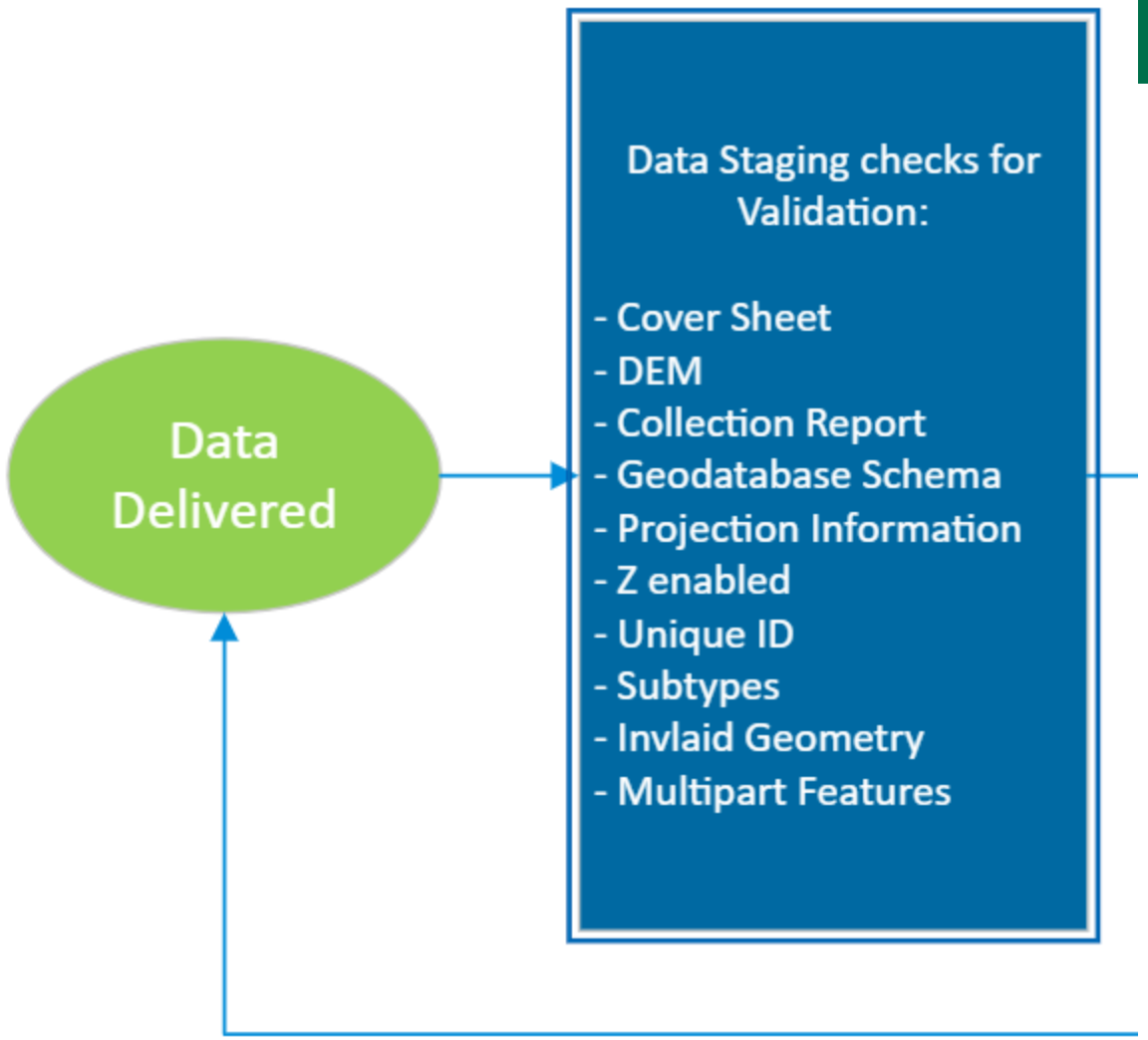
- Uses tool output to measure against thresholds for acceptance
- Informs contractors about methods effectiveness

EDH validation streamlined process



EDH validation - Staging

- Sets up datasets for validation workflow
- Pass/Fail tests
  - Is the EDH data a complete delivery
  - DEM delivered
  - Correct schema
  - Geometry and topology checks
  - Is the DEM in correct coordinate reference system and with no artifacts



EDH validation - Staging

New emphasis on DEM checks

- DEM delivered will be used in **the 1-meter seamless** product
- It **must match in coordinate reference, units, snapping, geoid, and cell size**
- A **spatial metadata dataset and metadata report** describing the methods used for integration in overlap areas, and source of lidar data is required
- **Resampling methods** must be documented
- **No striping or cross-hatching should be visible** in the surface

Guideline for Elevation-Derived Hydrography Acquisition Specifications Update for CONUS

Elevation Source Raster and Vector data Requirements

Purpose

This guideline will define elevation source raster requirements. This includes the spatial reference system (SRS) required to create a Digital Elevation Model (DEM) used to generate elevation-derived hydrography in the contiguous United States (CONUS). Defining the DEM(s) SRS prior to generating elevation-derived hydrography ensures the delineated hydrography vector features, and their associated z-values, will align between adjacent project areas. This guideline also includes how to select the appropriate source data for use in the final mosaic.

Description of Issue

One goal of the 3D Hydrography Program (3DHP) is to produce a seamless national dataset of raster and vector data that depict elevation and hydrography. The updated elevation-derived hydrography process is intended to use the best available elevation source data (U.S. Geological Survey, 2022), projected to a common national SRS. Hydrography will be derived from the elevation source after it is projected to the national SRS to avoid horizontal and vertical mismatches that can occur when vector data is aligned to a raster dataset in a different SRS.

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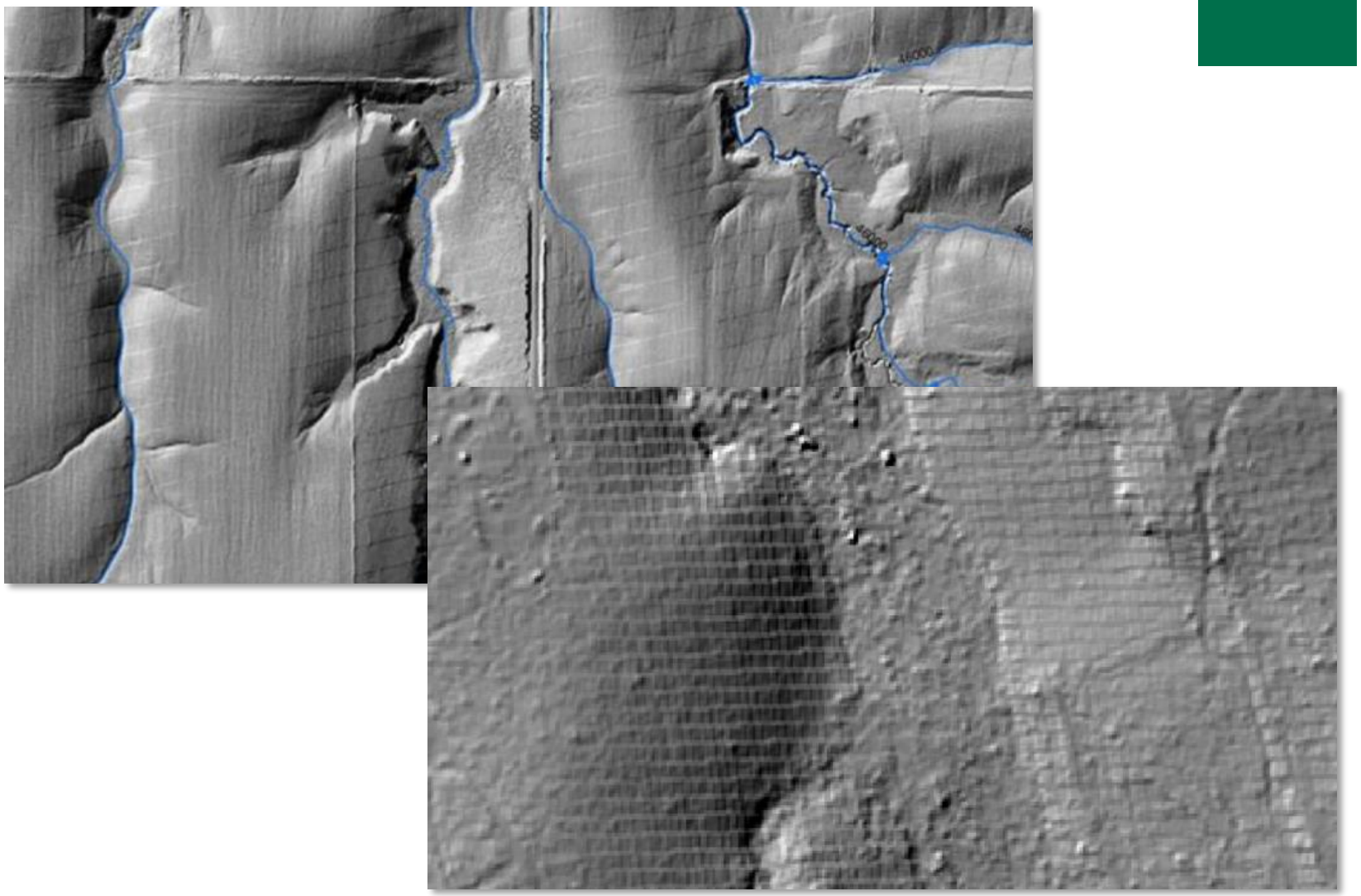
EDH validation

DEM checks

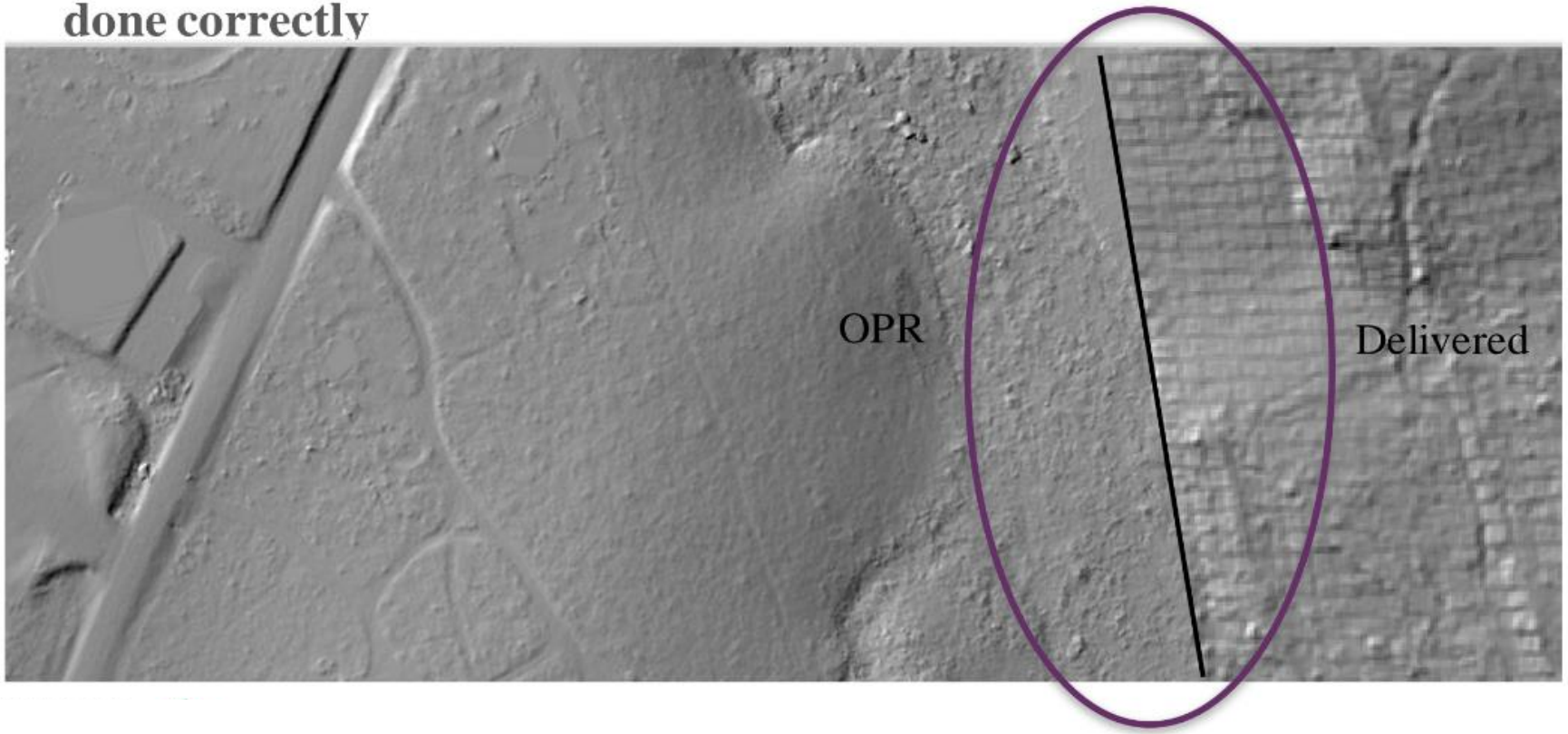
- Eventually all source DEMs will be part of the seamless 1-meter dataset that 3DNTM and 3DHP will be built on.
- Important for all the raster data to be referenced to the same origin, coordinate reference system and geoid
- Proper resampling to avoid introduction of artifacts



EDH validation

DEM checks – should be completed by the contractor

- **Compare to OPR – if no artifacts were present in the original source, review the processing steps to make sure projections were done correctly**



EDH validation – Validation tools

- Validation checks are now fully automated
- Manual review of validation checks outside of our allowed thresholds
- Streamlined report
- Providing flagged features to contractors for review

```
--------------------------------------------------------------------------------
*                                                                              *
*             FCodeChecks - Attributes and Network Relationships               *
*                        Start: 06/13/2023, 09:49:43                           *
*                                                                              *
--------------------------------------------------------------------------------

-----INFO (09:50:18): Point Schema Mismatch Errors:      0 Errors / 1 Features = 0.0 Percent Error
-----WARNING (09:50:18): Point contains 1 User-defined features (FCode = 0)
-----INFO (09:50:48): Line Schema Mismatch Errors:       10 Errors / 34746 Features = 0.03 Percent Error
-----INFO (09:50:49): Polygon Schema Mismatch Errors:    26 Errors / 216 Features = 12.04 Percent Error
-----INFO (09:50:49): Line FCode Network Errors:         0 Errors / 34746 Line Features = 0.0 Percent Er
Network Errors by FCode:
                            Name  Errors  FeatureCount  PercentError
FCode
33400                  Connector       0             1           0.0
33401                    Culvert       0          3190           0.0
33404  Indefinite Surface Connector       0           125           0.0
33405                Terrain Breach       0            58           0.0
46000                  Stream/river       0         29955           0.0
```

Validation Checks:

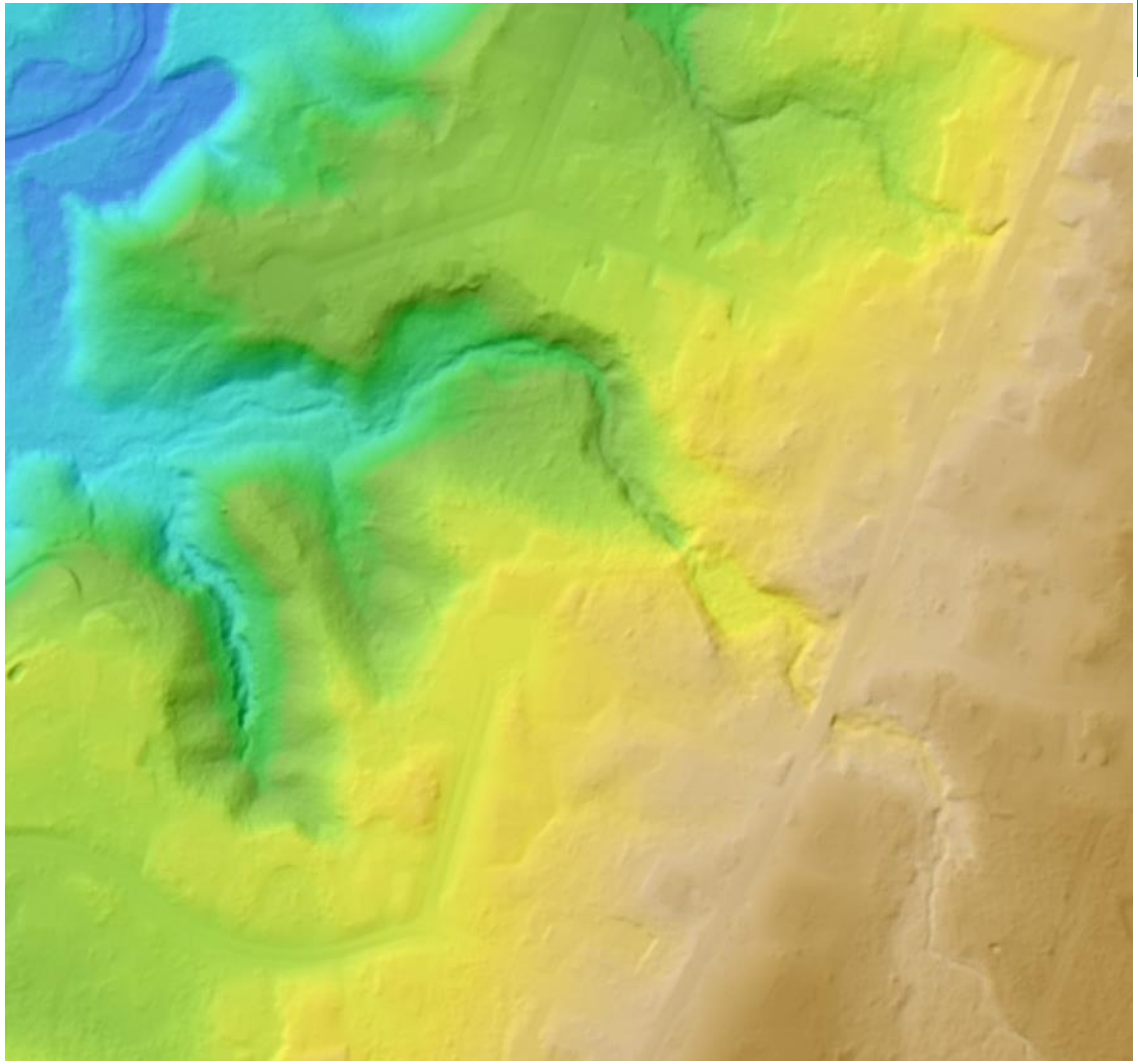
-Positional Accuracy Report
-DEM Limitation Polygons
- XML Metadata
- Spatial Metadata
- Vertex Spacing
- Line Topology
- Polygon Topology
- Artificial Path Placement
- Lines Crossing Islands
- Straight Segments
- Line Monotinicity
- Placement in Elevation Profile
- Placement in GMI Channels
- Lines Crossing Ridges
- Culvert Placement
- Veritcal Placement Below Surface
- Veritcal Placement Above Surface
- Network Check
- Flowline Valency
- Lake Vertices on Hydroflattened Surface
- Coding
- Line Capture Conditions
- Polgon Capture Conditions
- NHD Point Inclusion
- NHD Line Inclusion
- NHD Polygon Inclusion
- 3DHP Breakline Inclusion
- Density

Geomorphic derivatives – Geomorphic Index (GMI)

- Every project area is characterized with a GMI - this is the combination of 1 to 4 elevation derivatives
- The GMI can be used to model where channelization, or low areas, are within the elevation surface
- In this example, the elevation channelization and stream features are difficult to identify in the imagery

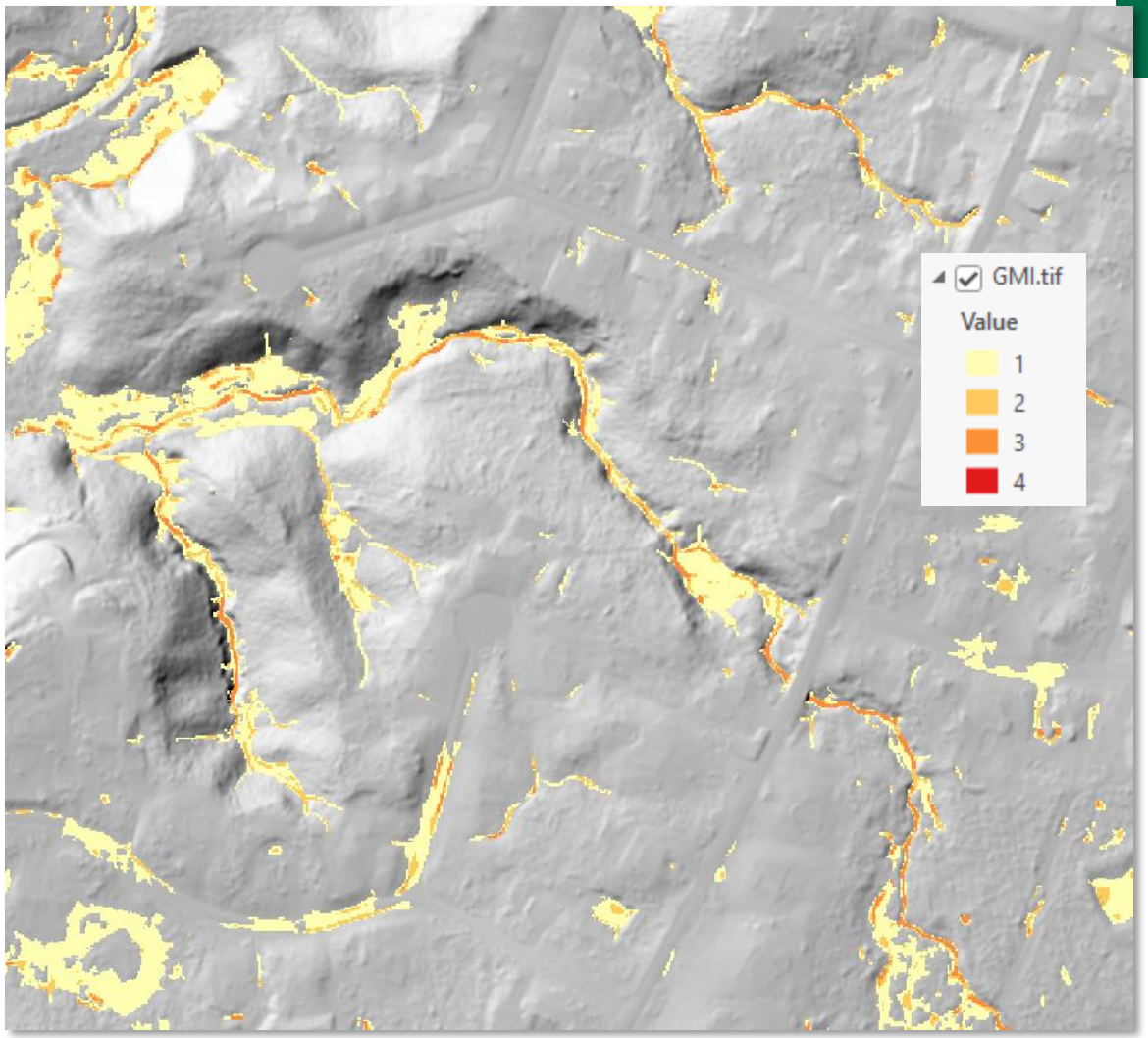
Geomorphic derivatives – Geomorphic Index (GMI)

The elevation surface highlights the channels



Geomorphic derivatives – Geomorphic Index (GMI)

- The GMI further defines the most channelized parts of flowpaths
- Floodplains with a wider channel often have a clear primary channel within them
- The colors correspond to 1, 2, 3 or 4 geomorphic derivatives present
- Darker colors (higher number of geomorphic indicators) identify the most likely channel



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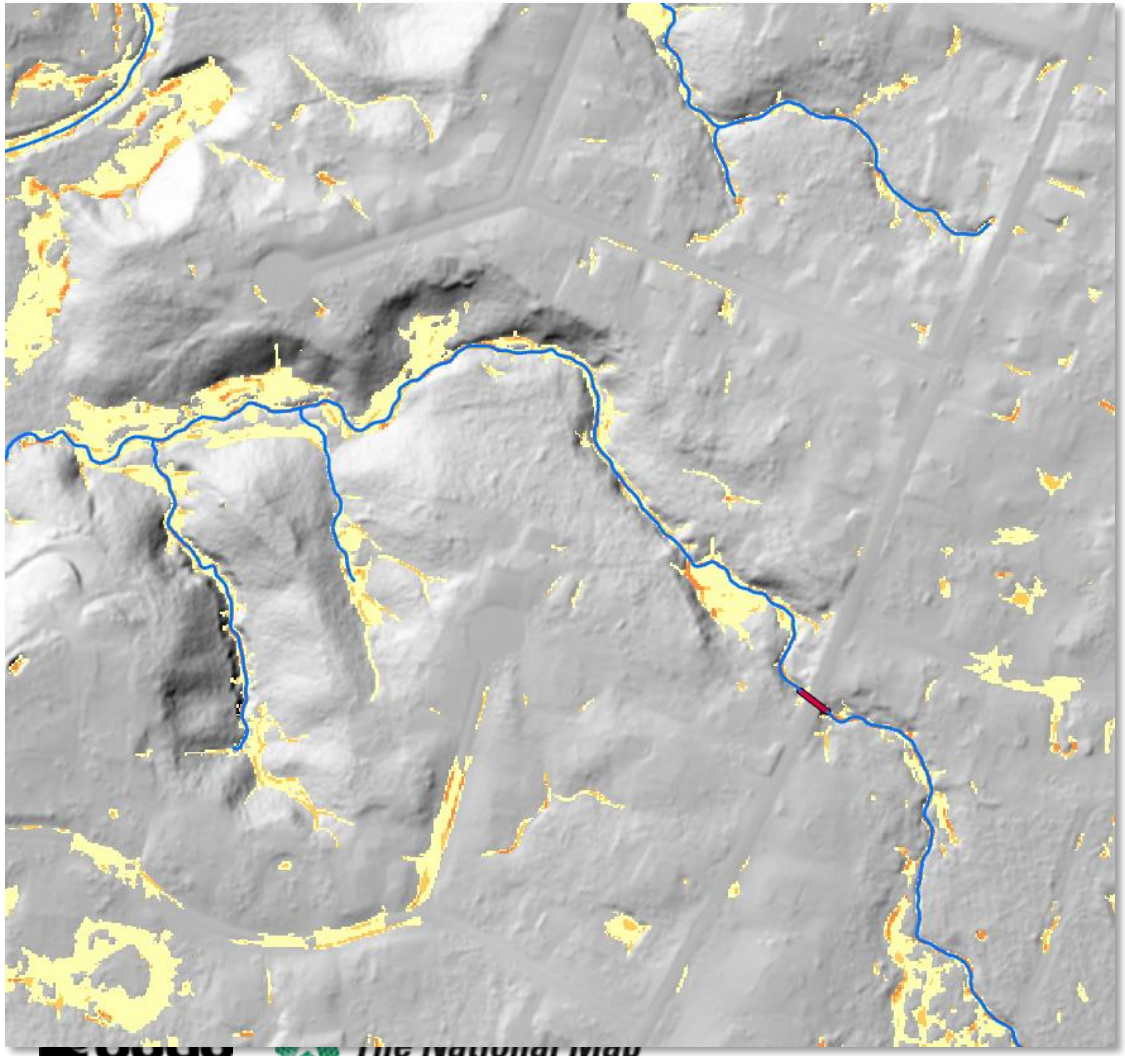
Geomorphic derivatives – Geomorphic Index (GMI)



Post-GMI Processing – how we use the GMI

Post GMI Processing	G2	Streams Out of Channel	This check looks for StreamRiver and CanalDitch features that are outside of the geomorphic indicator raster (GMI) by a percentage of their length.	Count of features >25% outside GMI		Percent of StreamRiver and Canal features >25% outside GMI
	Watershed Boundary	Streams Crossing Ridges	This check looks for lines that cross geomorphon ridges	Number of line features crossing a ridge line		Percent of total lines crossing ridges
	G3	Connectors In Channel	This tool checks whether EDH Line Drainageway and Indefinite Surface Connector (ISC) features are within channels as indicated by the Geomorphic Indicator (GMI) raster.	Count of Drainageways and Indefinite Surface Connectors in channels		Percent of DW and ISC features in channels

Post-GMI tools compare linework to the GMI

Streams should fall within channels identified with the GMI

Lines should not cross ridges

GMI's are pre-processed to make inspection faster

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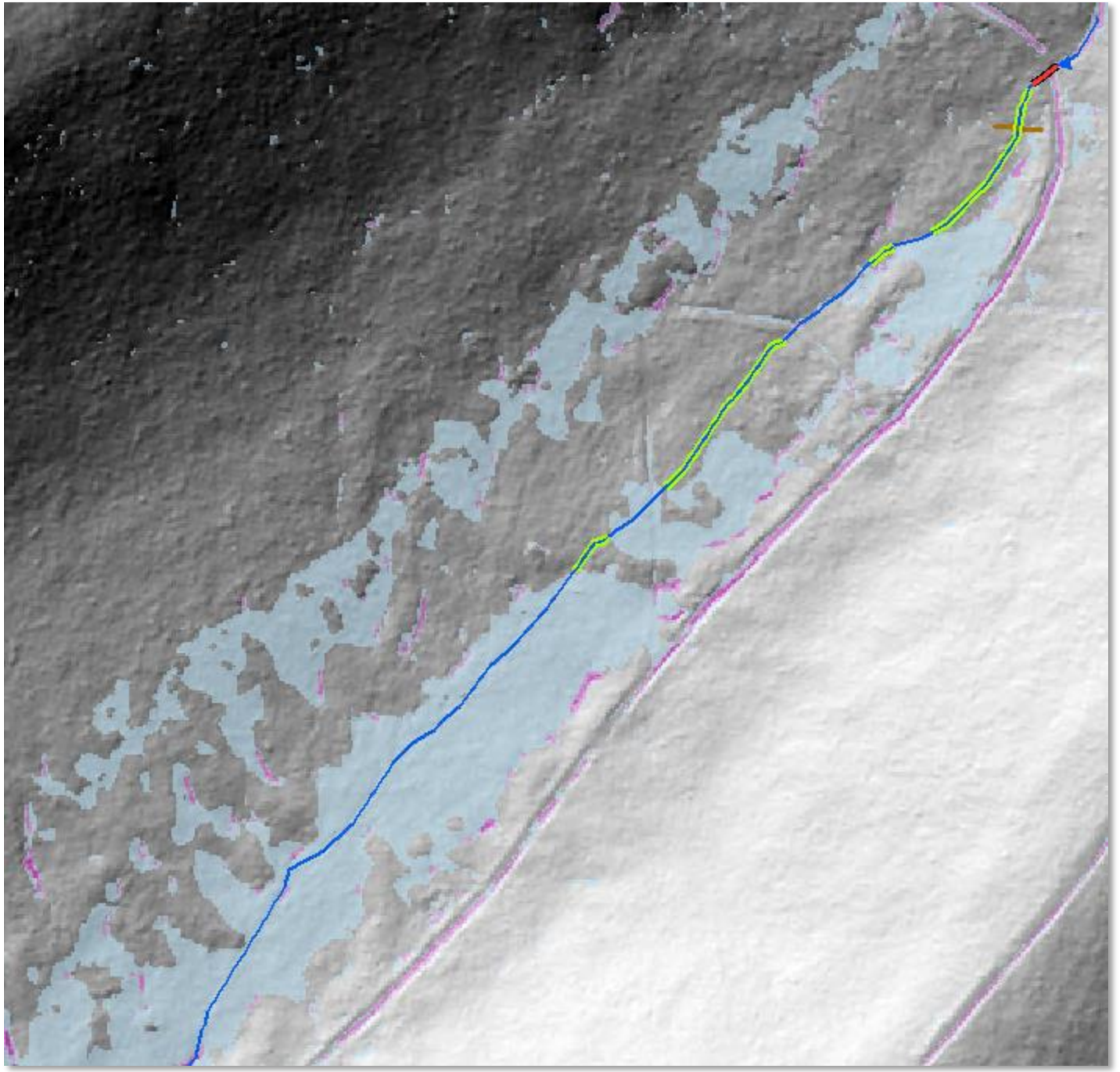
Elevation Derivatives

Use in validation

- Differentiating between Drainageways, Indefinite Surface Connectors, and Stream/river or Canals is done with the GMI
- *If a Stream/river or Canal is more than 100 meters outside a GMI, or more than 25% of the features is outside a GMI, it is flagged as a potential error*
- These may be unnecessary features, placed outside the channel, or coded incorrectly



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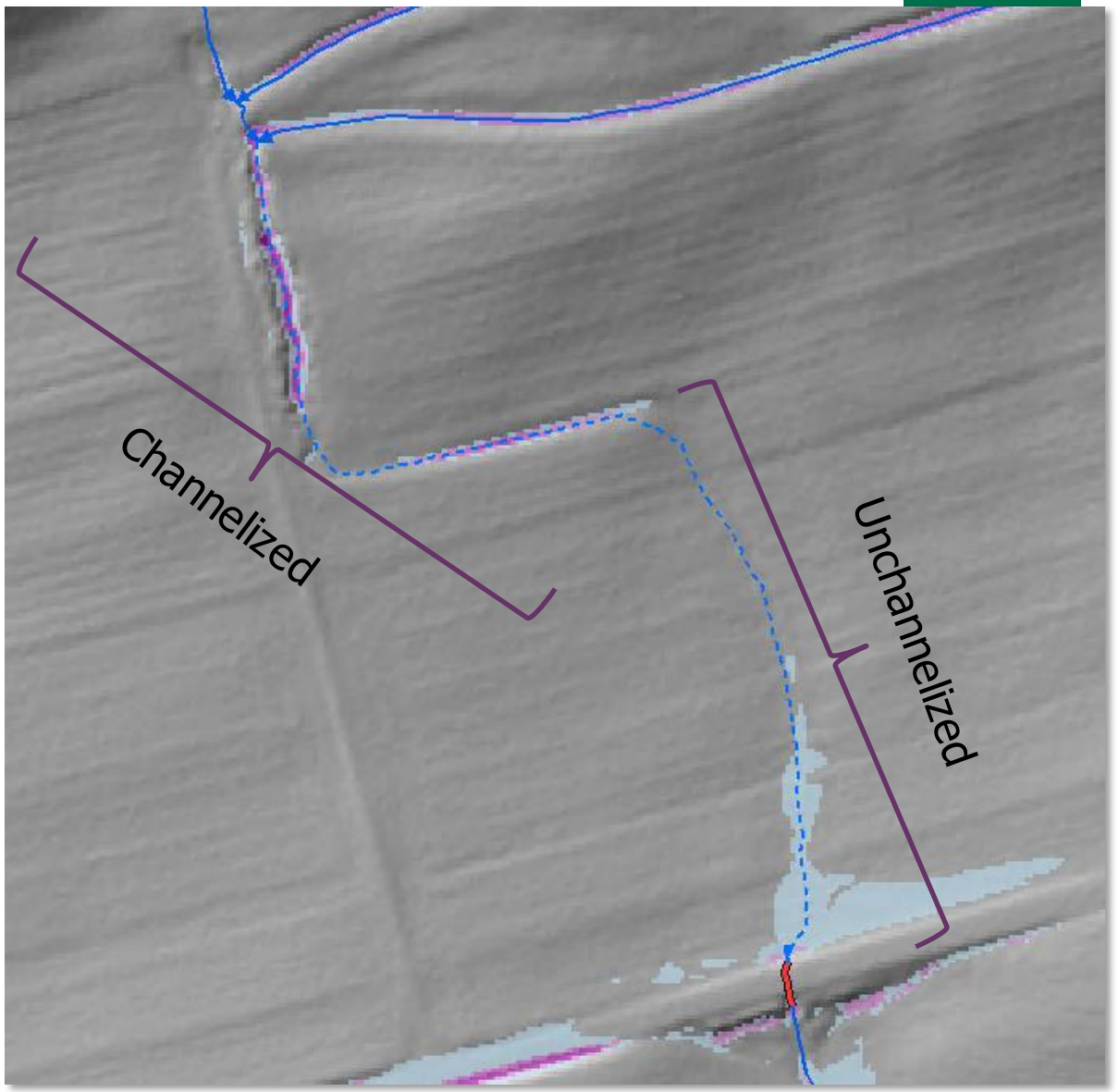
Elevation Derivatives

Use in validation

- Since Drainageways and Indefinite Surface Connectors are not channelized features, if they are *within* a channel, they are flagged as the wrong FCode
- Often long segments will be coded as Stream/rivers, but a long section will flow outside of a channelized areas
- These features can be split so that the unchannelized areas are ‘Indefinite Surface Connectors’
- The opposite is true for Indefinite Surface Connectors and Drainageways: the sections that are channelized should be recoded as canal or stream/river



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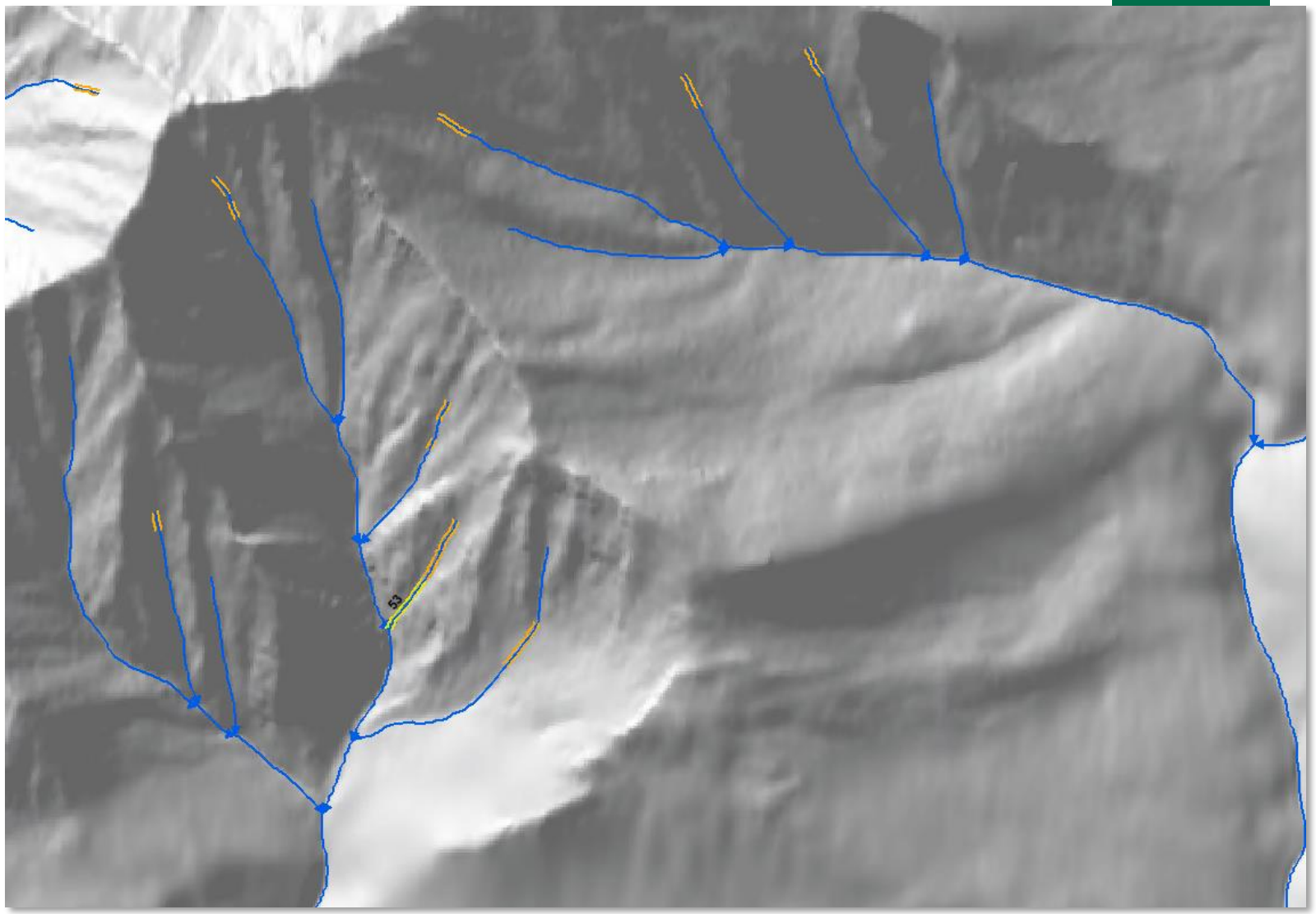
Elevation Derivatives

Use in validation

Example 1 – lots of headwater sections are outside of a channel – is there a problem with the way the contractor is extending the linework?

Should it be clipped where it exits the channel?

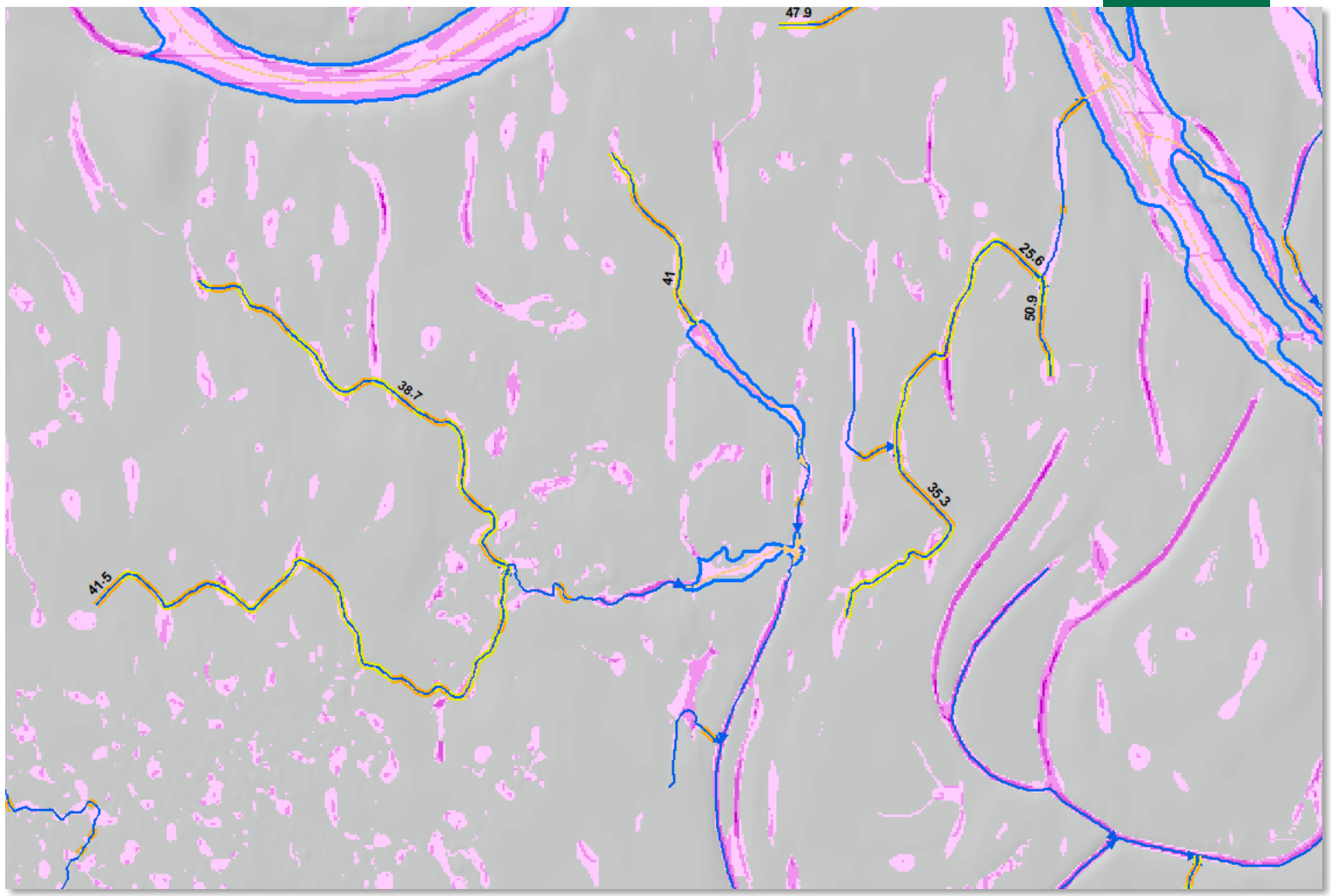


Elevation Derivatives

Use in validation

Example 2: Many streams with discontinuous channels (oranges on the yellow); also major channels not picked up that are connected to the network

Could discuss with contractor how they are finding the channels and removing the ones that are flowing outside channels (or recode)

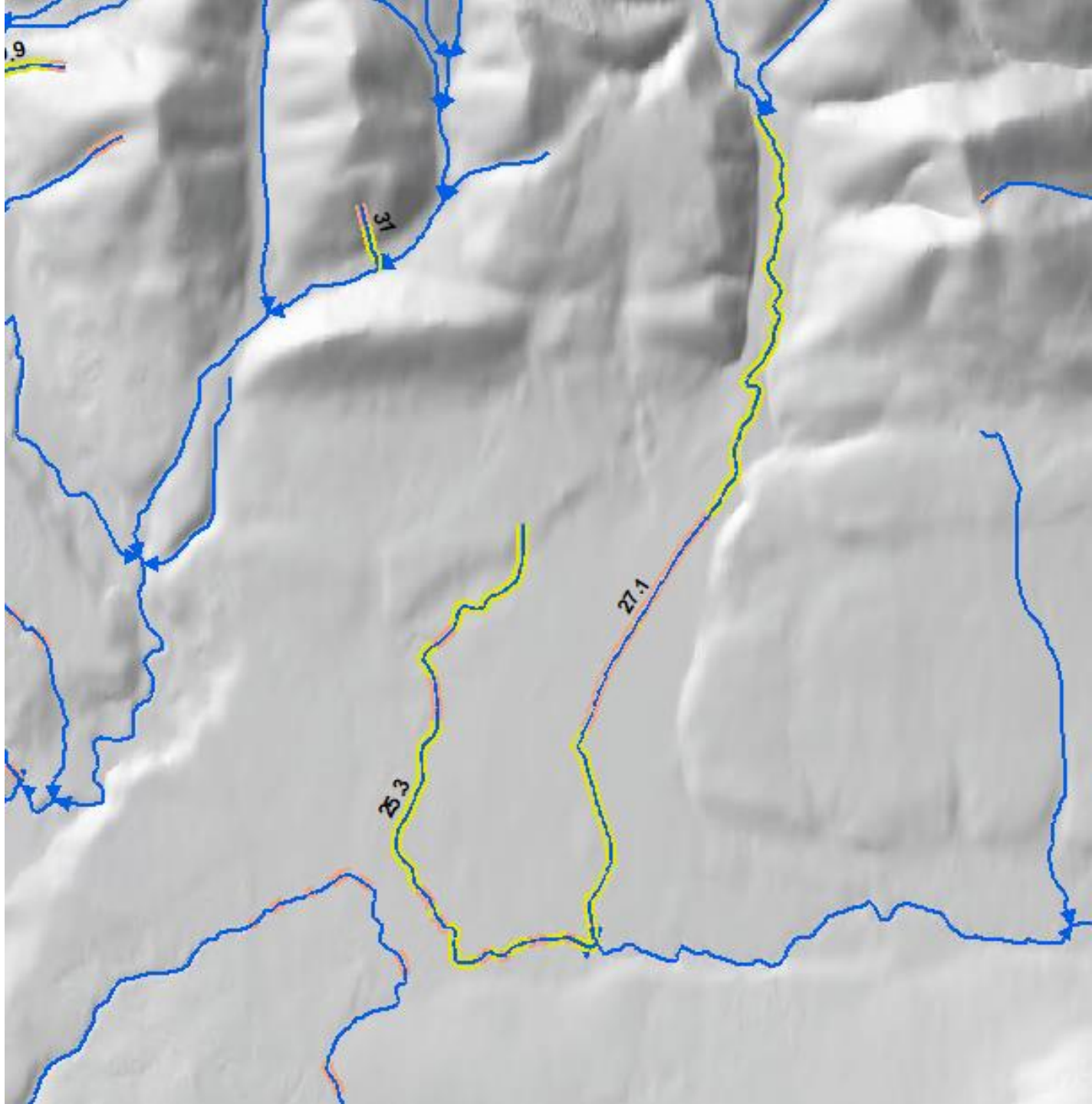


Elevation Derivatives

Use in validation

Example 3: Large section of stream outside a channel.

Contractor should split the channel and code the section that is unchannelized as an ‘Indefinite Surface Connector’



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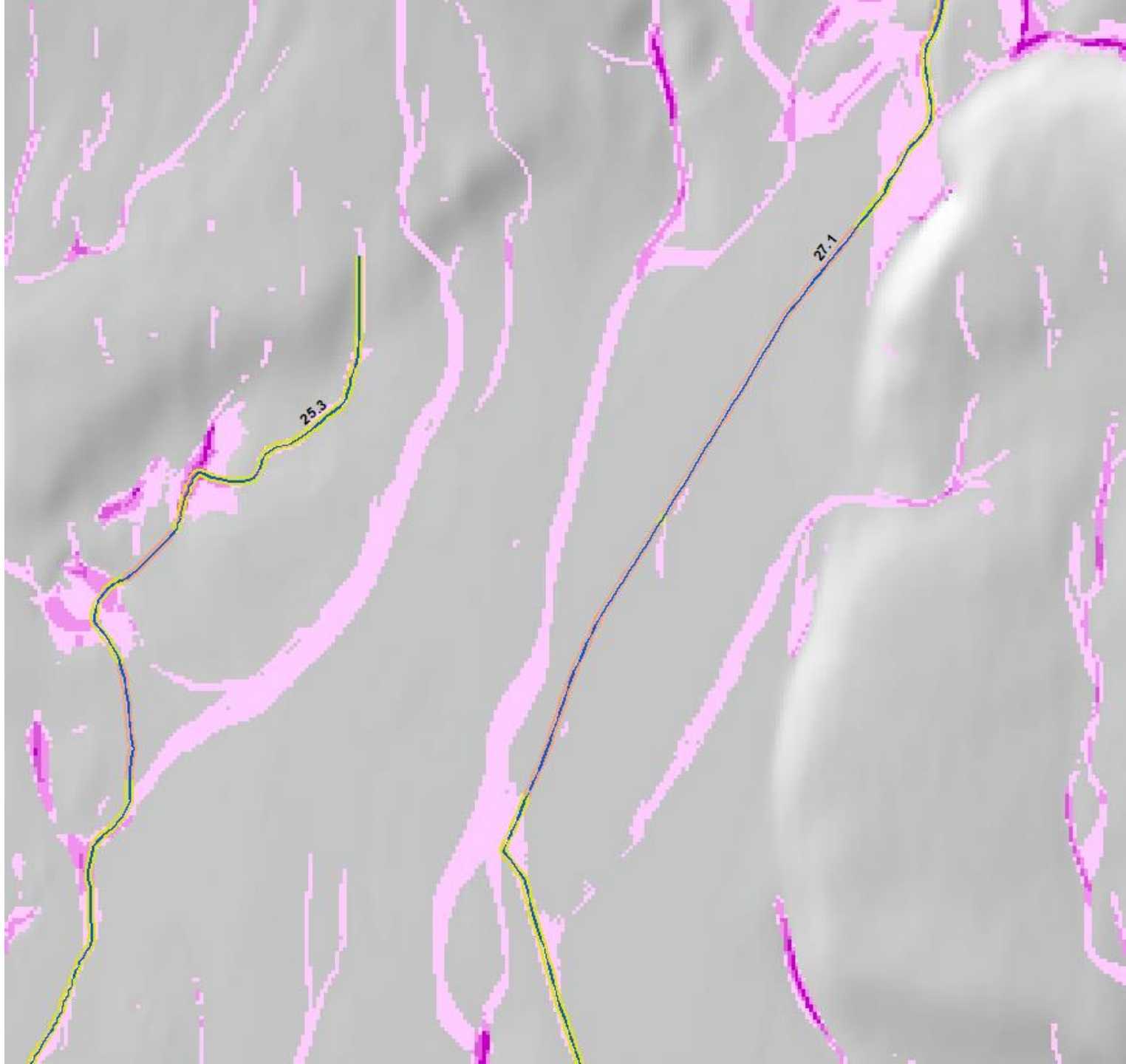
Elevation Derivatives

Use in validation

Example 3: Large section of stream outside a channel

Or if when looking at the GMI another path is apparent, this could be a horizontal placement error



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Culverts – COD tools

Culverts	COD – Culvert, Omission, Depression s	This tool checks whether culverts are placed in low spots above and below a transportation feature, and that there is some rise in terrain beneath the culvert.	Count of culverts		
			count of culverts where end node z-value > begin node z-value		Percent of culverts
			count of culverts where rasterval z range is < .1 for span of culvert		Percent of culverts
			number of sink polygons > 1/2 acre left in surface after a dem difference that are adjacent to roads		evaluate during manual inspection
			Linear features whose begin node is within 100 feet of a road		evaluate during manual inspection

Finding depressions on the landscape that may be from:

1. Streams not extended with culverts through roads or other barriers
2. Improperly delineated culverts
3. Sinks in the landscape that indicate network ends
4. Sinks/depressions that don't need to be cleared

Currently not used with thresholds as we test the tools

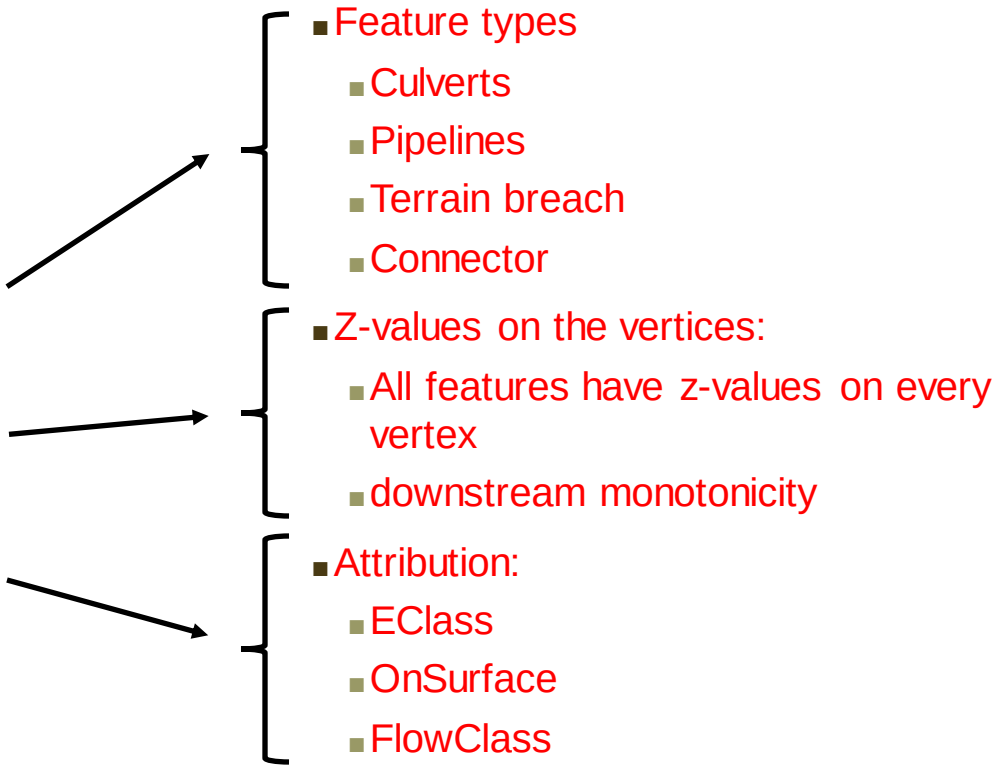
Culverts and hydro-enforcement

EDH Specification designed to integrate with elevation

The specification was written to accommodate the hydrography treatment of elevation surfaces

The hydrography has:

1. features that allow breaching the elevation surface,
2. z-values that allow elevation integration and correction, and
3. attributes that define features suitable for hydro-enforcement



Culverts and hydro-enforcement

EDH Specification is designed to integrate with elevation

Feature type Culvert Connector:

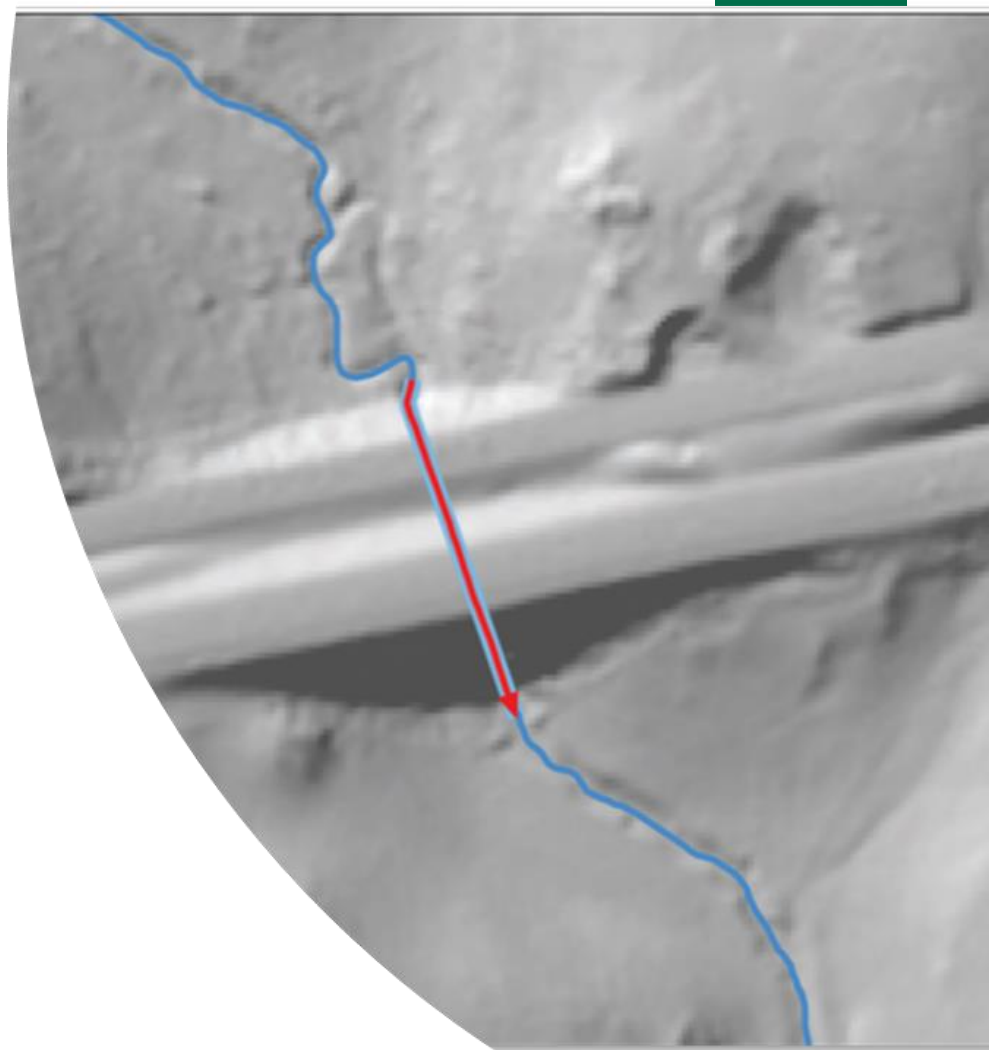
From a fifth to a third of the lidar-derived delivery's features are culverts

The position on the surface is very important if used for hydro-enforcement

We test to make sure that the culvert is in the low point up and downstream of a transportation feature

<Heading>	FCode	60882
55800	Artificial path	8083
33600	Canal/ditch	18541
33400	Connector	262
33401	Connector: Culvert	14609
33404	Connector: Indefinite Surfac	567
33405	Connector: Terrain Breach	481
46800	Drainageway	685
42800	Pipeline	130
46000	Stream/river	17524

<Heading>	FCode	83442
55800	Artificial path	4701
33600	Canal/ditch	29
33400	Connector	295
33401	Connector: Culvert	17353
33404	Connector: Indefinite Surfac	2524
33405	Connector: Terrain Breach	138
34300	Dam/weir	9
46800	Drainageway	755
46000	Stream/river	57638



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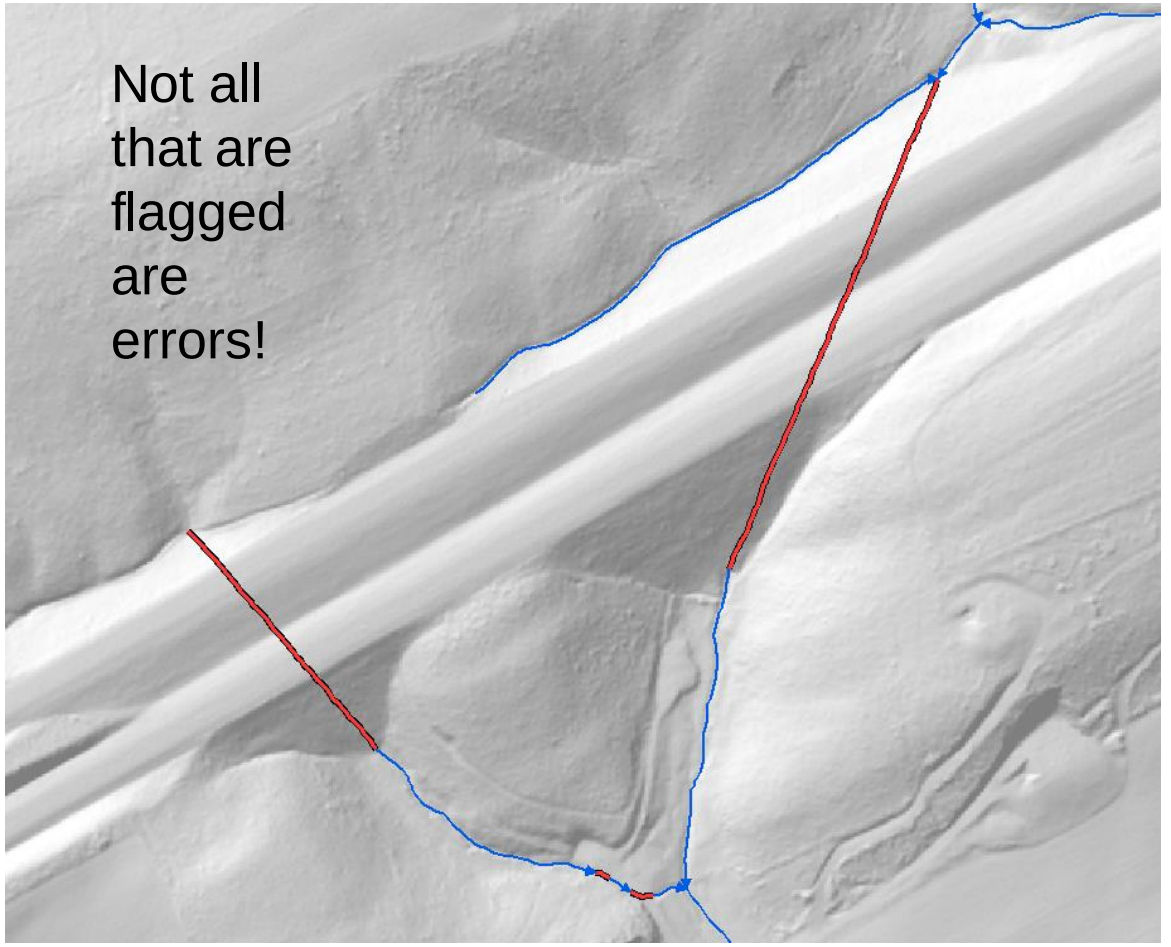
Culvert tool (C)

Checks the placement of culverts, connectors and terrain breaches

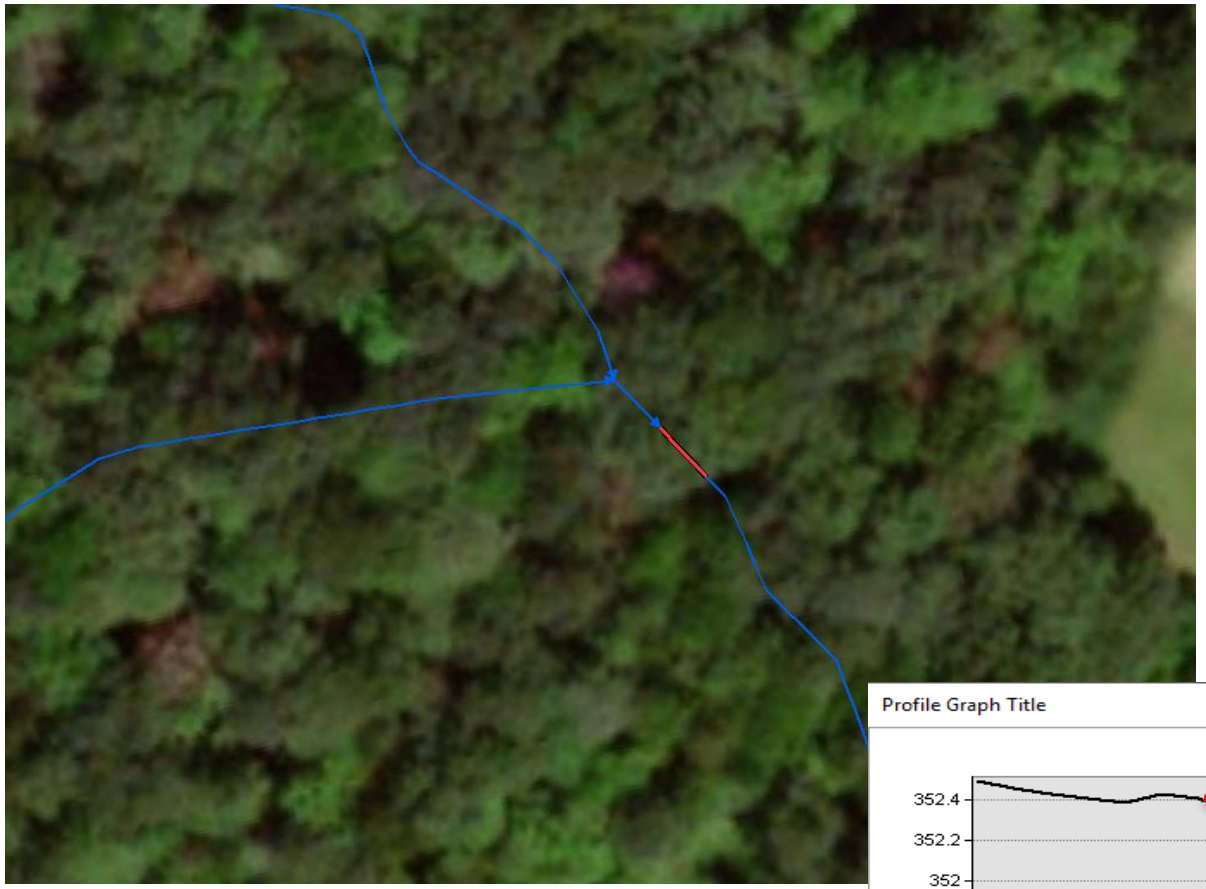
The Culvert tool checks for three types of potential errors:

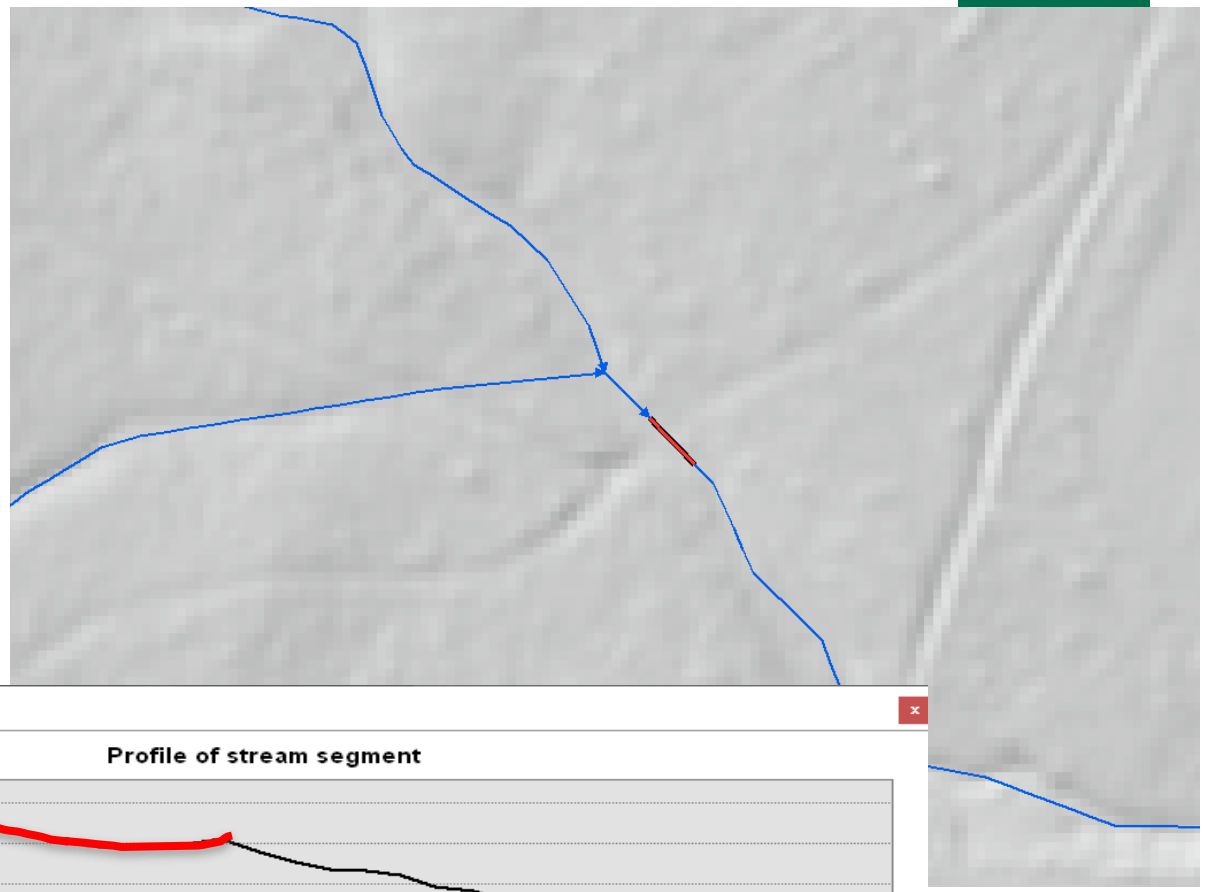
1. Whether the end-node is at or below the start-node
2. Whether the elevation rise on the surface is at least .2 meters
3. If the length is greater than 100 meters

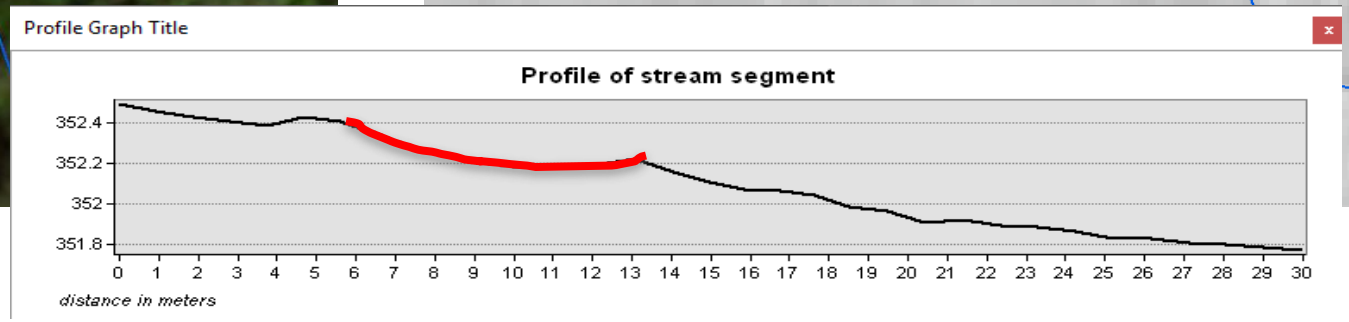


Culvert tool (C)

Example of low rise in elevation – indicates a potential error







USGS science for a changing world

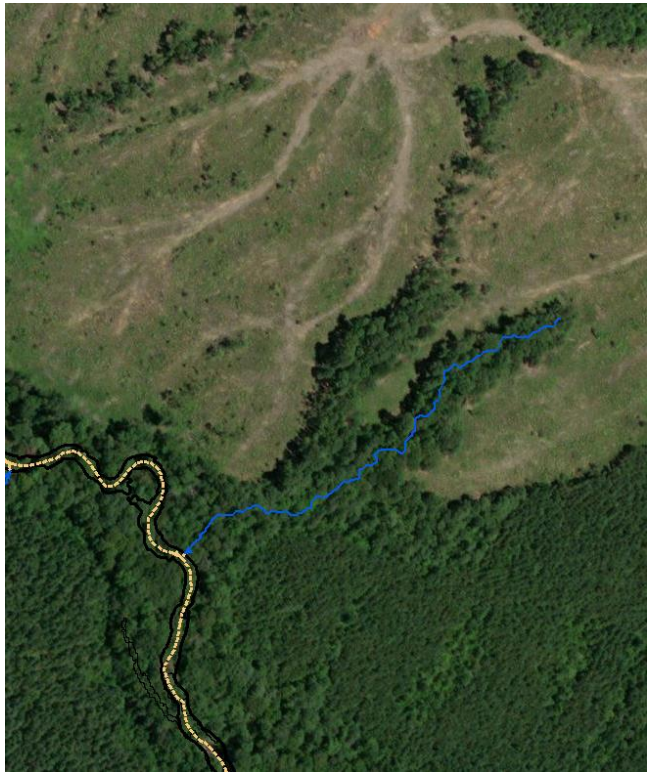
The National Map
Your Source for Topographic Information

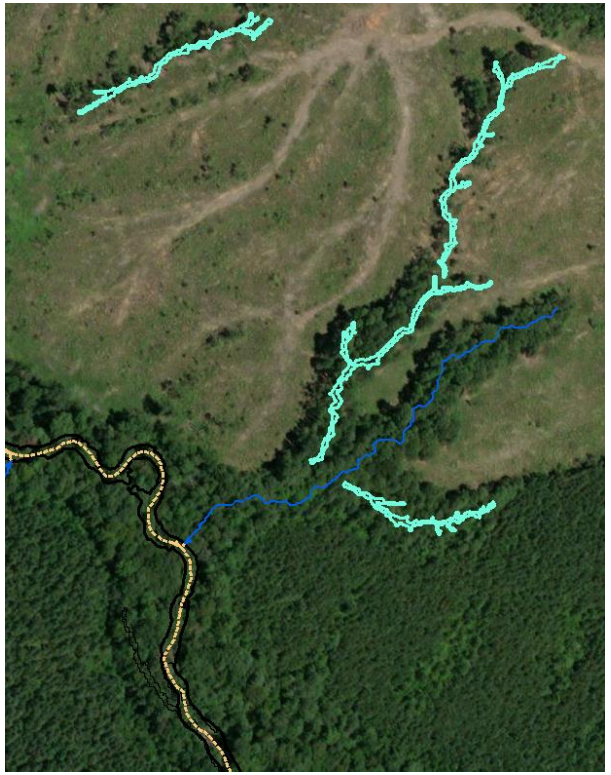
Omission tool (O)

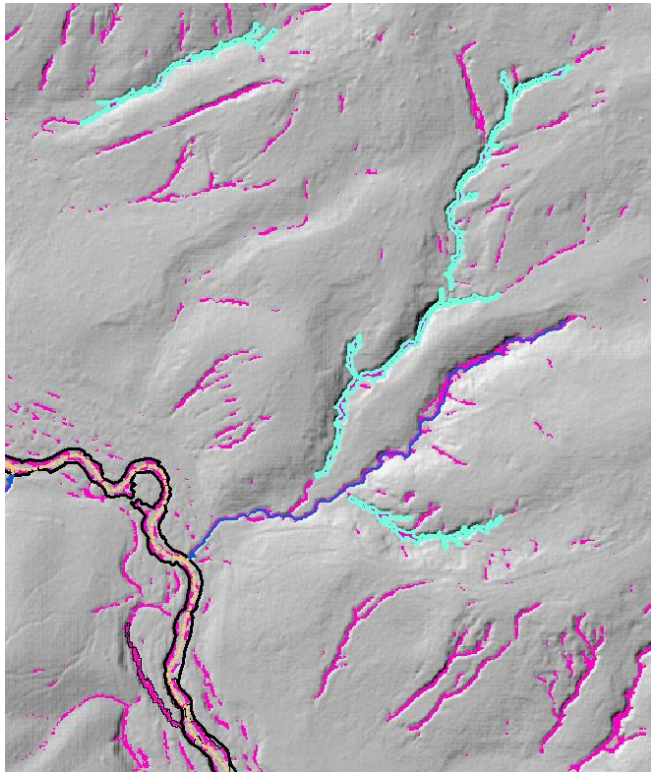
Finds channelized areas of a threshold size and depth with no Streams

The Omission tool clumps or groups cells within the GMI that have are at least .25 meter mean depth and an area of at least 500 square meters (500 cells)

If those areas are not intersected by a derived stream, they will be flagged as potential omissions







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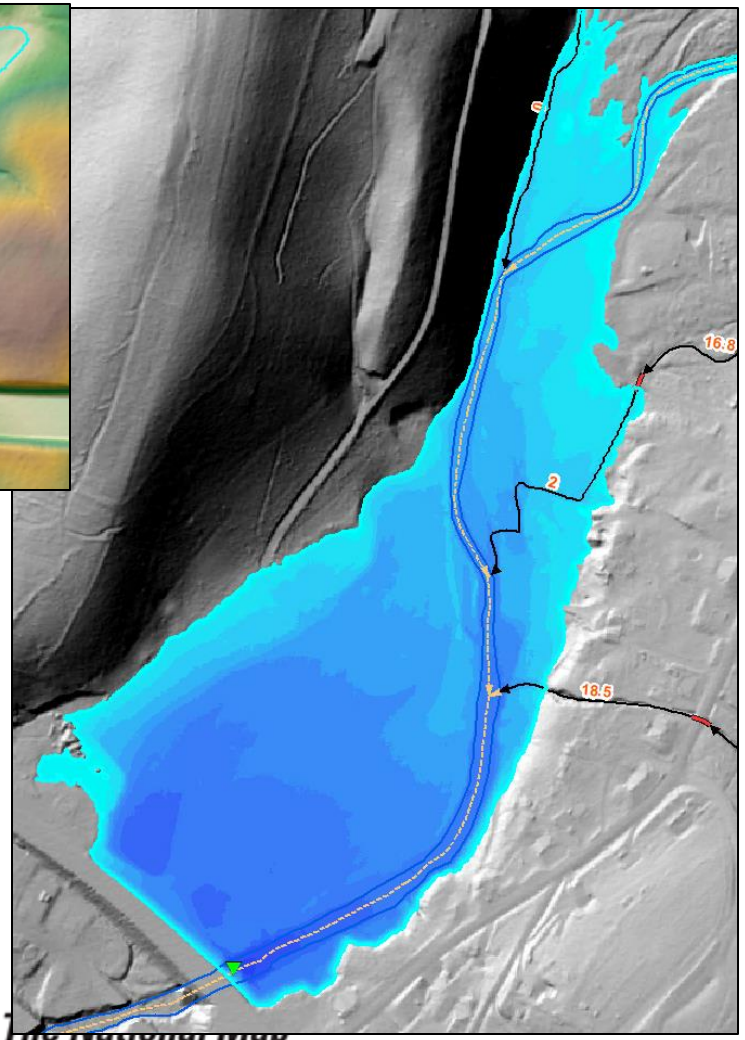
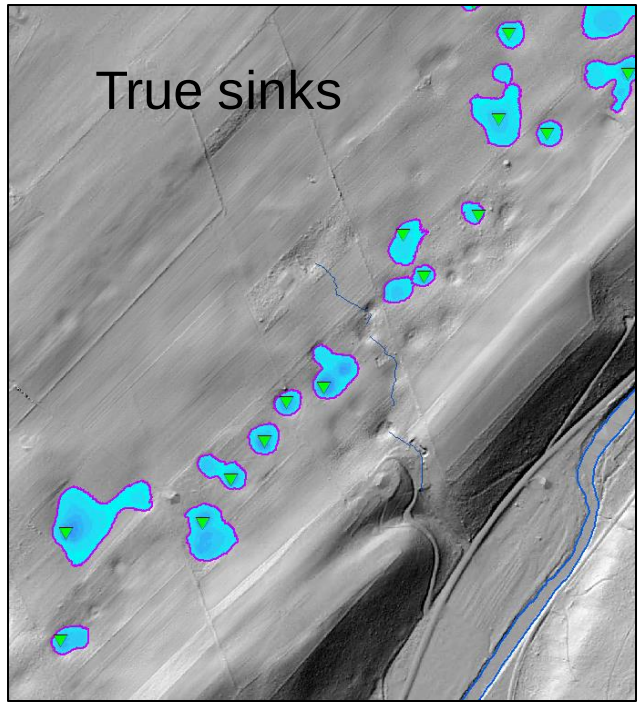
Depressions tool (D)

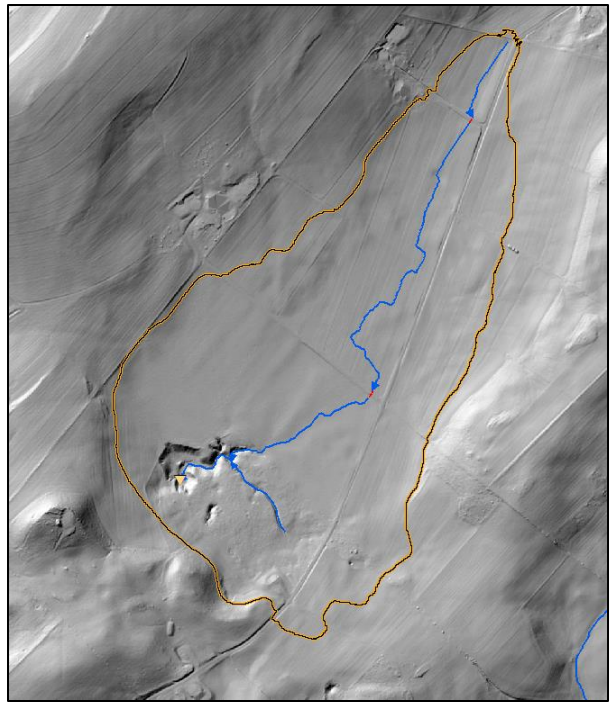
Depressions/sinks are found by filling the culvert enforced DEM and subtracting the source DEM from the filled. Areas with change > 0 are potential sinks

Sinks in Karst terrain – shallow sinks and deep sinks are treated differently. A depth is calculated and if > 3meters deep it is a terminus point



Sinks near roads – culverts missed



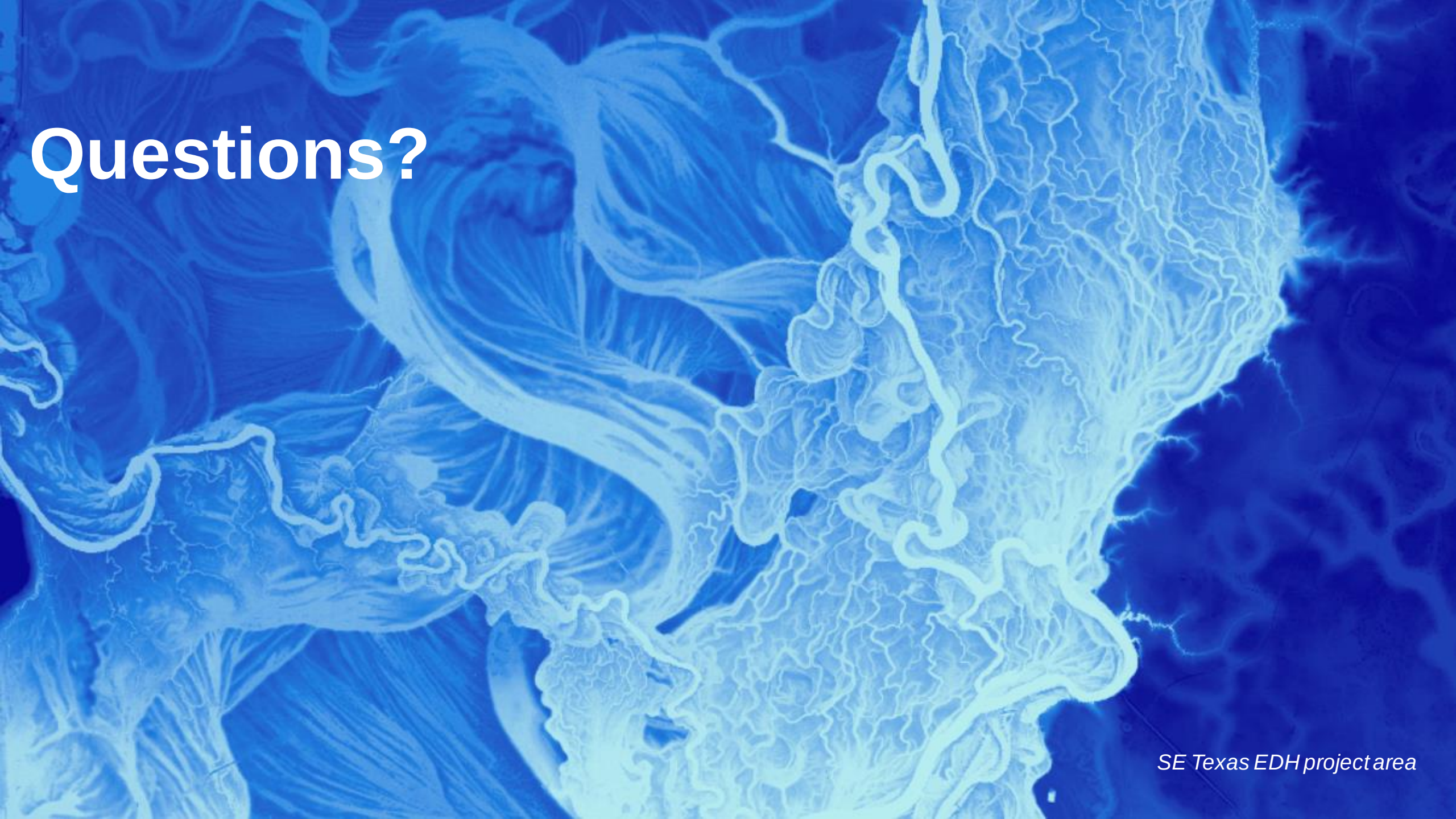


Other Validation Process Enhancements

A work in progress

- Tightening up the definition of ‘channelization’ so that it is more consistent across deliveries and can be measured with the GMI
- Testing thresholds to speed turnaround of datasets
- Workflow coordinators reviewing tools and coordination between deliveries
- Streamlining Guideline review so that guidelines can be made public
- Limiting update to specifications to twice a year
- Working on tool availability for others to use to validate EDH against the specifications

Questions?



SE Texas EDH project area