Arc Hydro Tech Update

Dean Djokic (ddjokic@esri.com)

Arc Hydro Tech Update

- What IS Arc Hydro
- What's new with Arc Hydro
- Arc Hydro in ArcGIS Pro
- Arc Hydro-based services
- Stormwater capabilities
- Floodplain delineation and model integration

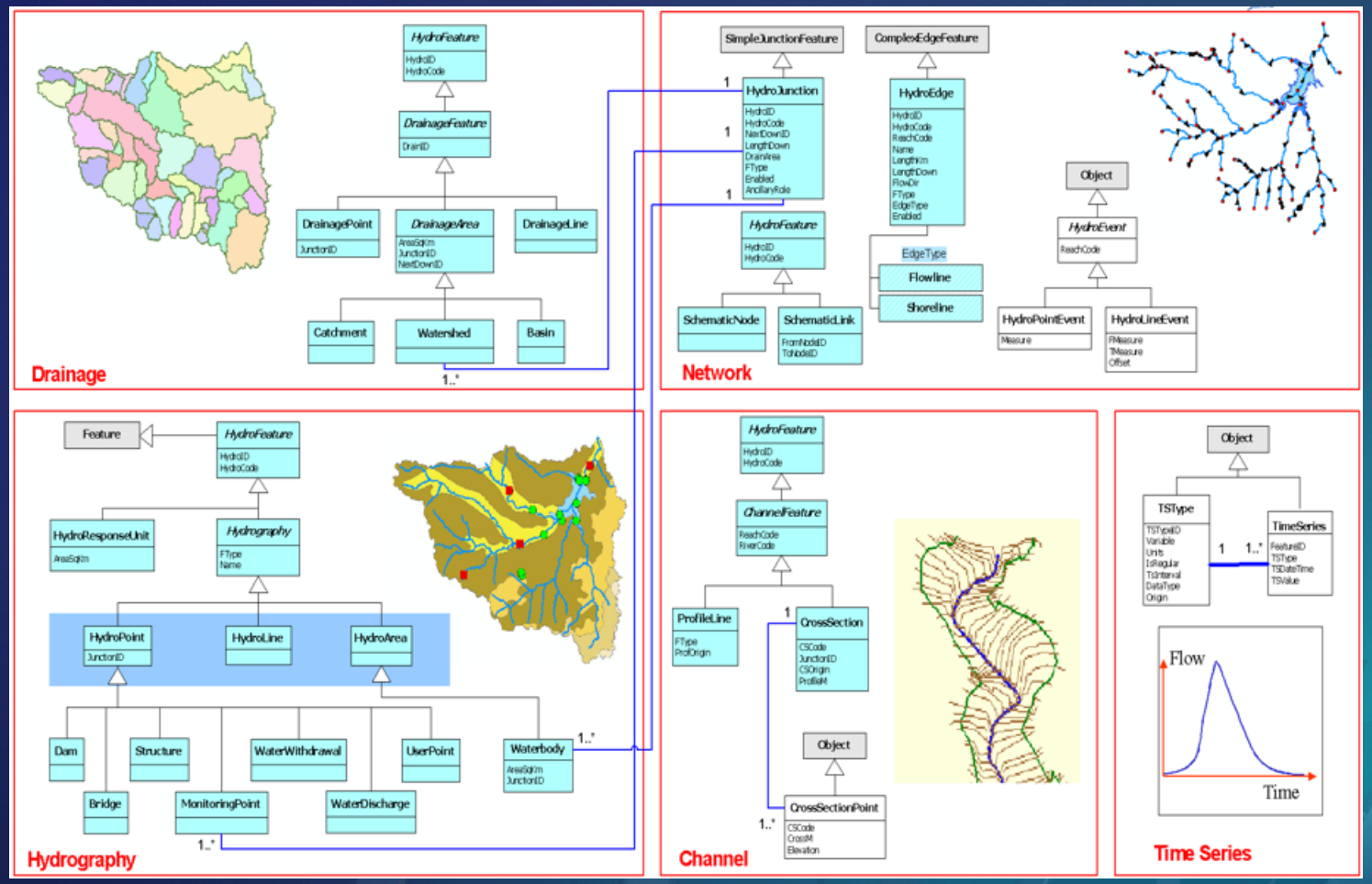
Arc Hydro Whirlwind Tour

What is Arc Hydro

- Implementation of ArcGIS platform in water resources domain with focus on analytical capabilities
- Components:
  - Data model
  - Tools
  - Workflows
  - Data
  - Services
  - Best practices – building analytical systems
- Distribution – free (except premium services)
- Maintenance – 10.3.1, 10.4.1, 10.5.1, 10.6, ArcGIS Pro
  - Legacy – from 8.3 on

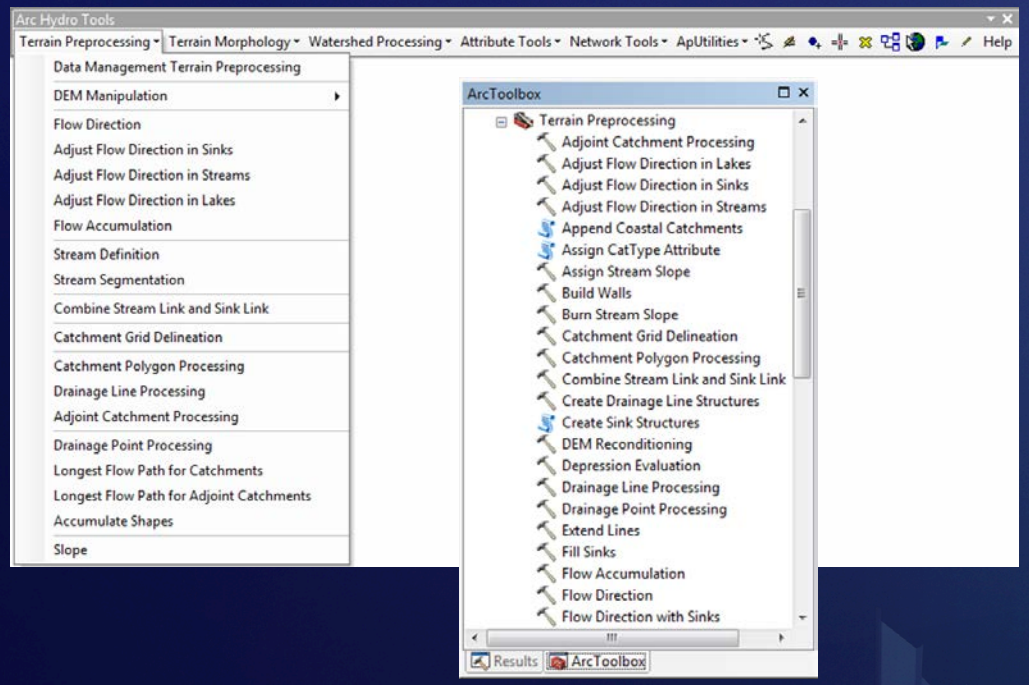
Data model

- Simplicity
  - Unique identifiers
  - Geometric network
  - Relationships
- Stability
- Extensibility
- Needs driven
  - Tools
  - User needs

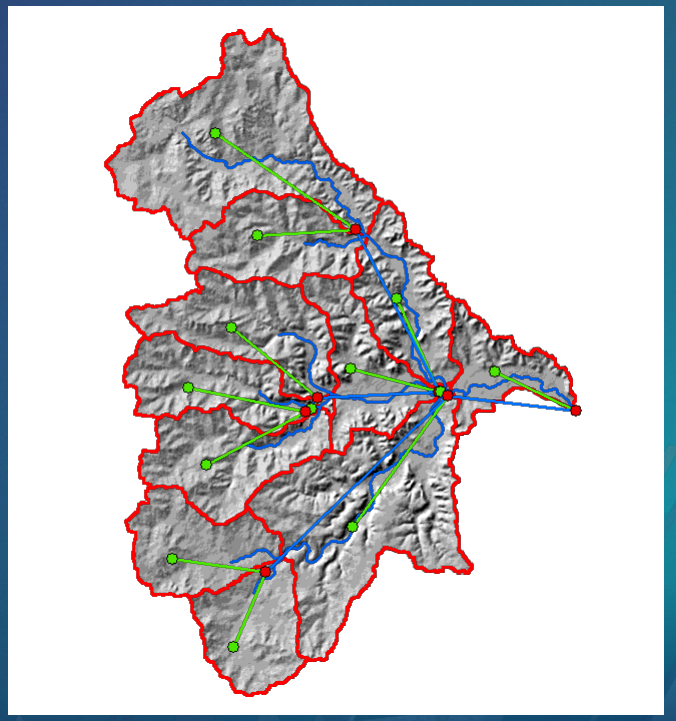


Tools

- 300+ tools developed over many years (>15)
  - Community driven development (projects)
  - Esri maintenance & support

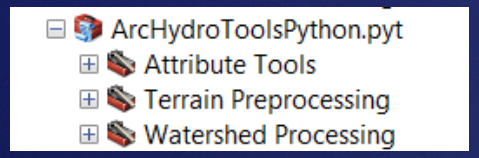


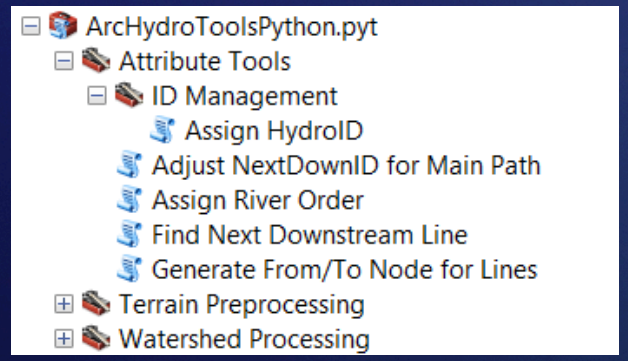
- Build foundation for analytical capabilities
- New tools for flood modeling

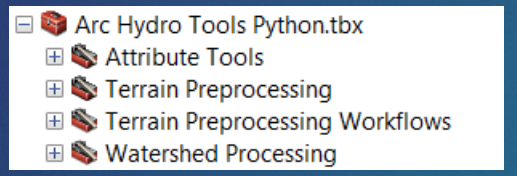


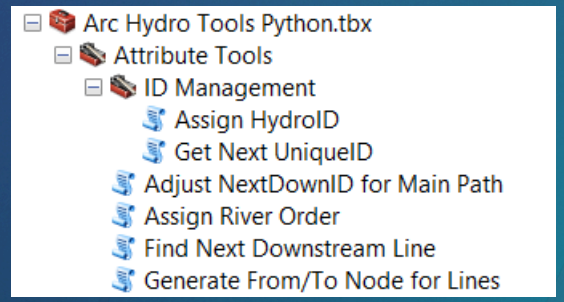
Tools

- **Move to Python (.pyt, py + tbx)**
  - **Openness**
  - **Move forward (Pro)**
  - **Ease of dissemination (*)**









Tools

- Modularization – blocks of functionality grouped into single collection
  - Terrain preprocessing for watershed delineation and characterization
  - Flood analyses and visualization
- Automated testing
  - Functionality/upgrades
  - Scalability

No	Tool	Execution	Comparison	CPU (s)
1	FlowDirection 1	Pass	Pass	67.6
2	FlowAccumulation 1	Pass	Pass	86.3
3	Stream definition	Pass	Fail	128.3
4	Stream segmentation	Pass	Pass	63.9
5	CatchmentGridDelineation	Pass	Pass	48.0
6	DrainageLineProcessing	Pass	Pass	105.3
7	CatchmentPolygonProcessing	Pass	Pass	63.7
8	AdjointCatchmentProcessing	Pass	Fail	224.1
9	DrainageLineProcessing	Pass	Pass	90.1
10	AppendCoastalCatchments	Pass	Fail	120.0

Arc Hydro in ArcPro

- Taking it easy ☺
  - Key capabilities in Pro evolving (networks)
- Move of key functions from .net to Python as gp tools
  - A toolbox in Pro
  - 2.* vs. 3.* Python issues
- Arc Hydro Pro “ribbon”
  - Early discussions

- Open to suggestions !!!

Interacting with user community

- User interaction – sharing experiences, techniques, best practices
  - GeoNet
    - User communication
    - Communication with users
- Tool/code/documentation dissemination
  - Transition from ftp to:
    - GitHUB
    - Scripts

HEC-GeoRAS and GeoHMS status

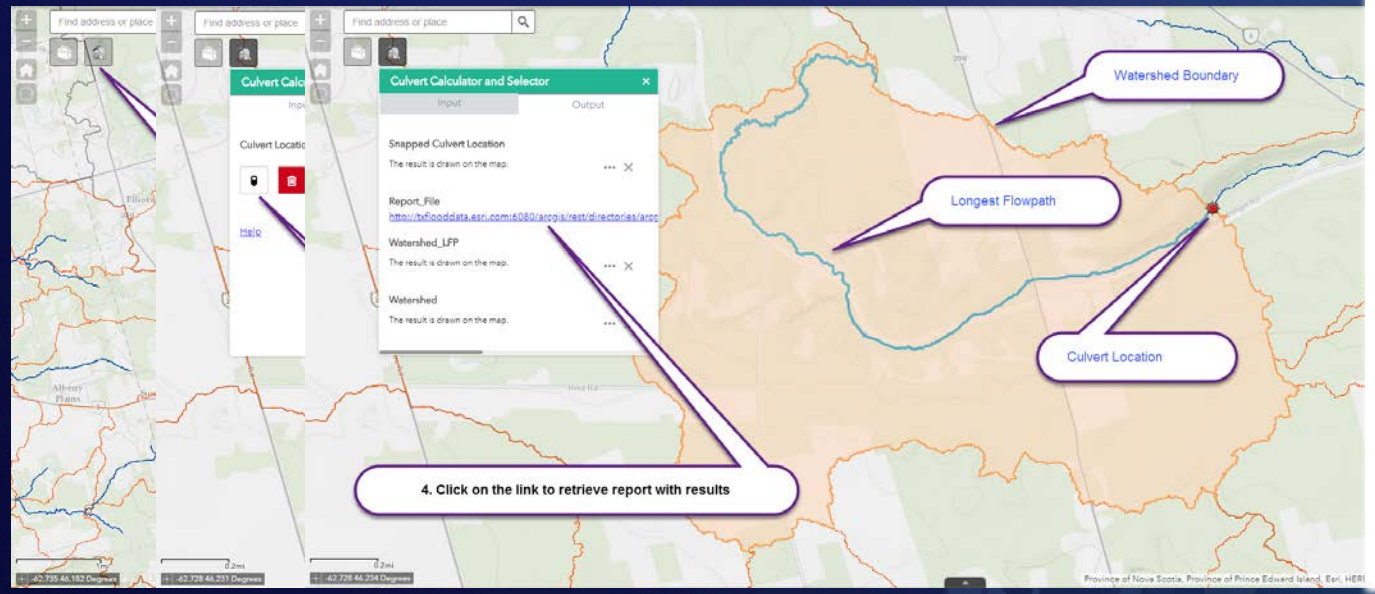
- HEC decided not to support ArcGIS apps in higher versions
  - Difficulty in keeping up with ArcGIS release cycle (1/2 year)
  - Rolling some functionality into RAS directly
- Esri is maintaining the code through ArcGIS version releases
  - Providing latest versions of GeoRAS and GeoHMS (currently through 10.6)
  - Use standard Arc Hydro download sites for latest versions

Services

- **Base maps**
- **Data**

Services/Apps

- **Analytical services (global 90m, USA 30m):**
  - **Watershed delineation (http://hydrology.esri.com/v**
  - **Downstream tracing**
  - **BYO – leverage existing or develop yours**
    - **PEI Culvert Calculator (WAB)**
    - **(NHD LR)**



Culvert Calculation Results

Date and Time Prepared: 6/7/2018 11:59:06 AM

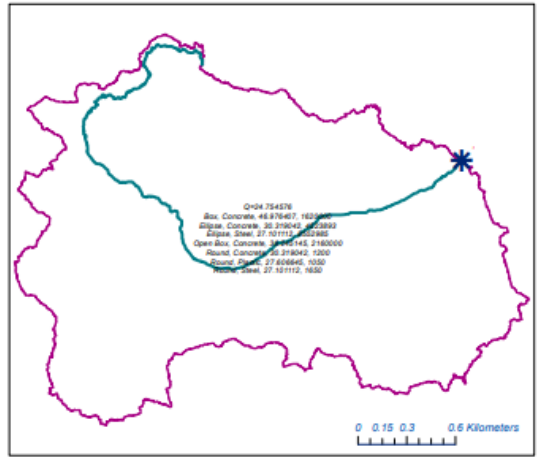
Provincial Property Number: 479642

Community: HEAD OF CARDIGAN

Location:

Latitude: 46.238545

Longitude: -62.672400



Catchment Data:

Land catchment area: A = 4.752549 sqkm

Distance from most remote point to structure: Dist = 4781.26 m

Elevation difference from most remote point to structure: Dh = 19.13 m

Time of concentration (Kirpitch formula): tc = 100.016929 min

Runoff coefficient: C = 0.5

Intensity (from climate change adjusted IDF): i(100)= 37.47 mm/hr

Weather Station utilized: Charlottetown

Calculated Flow Rate (Rational formula): Q = 24.755 m3/s

Structure Options*:

Round Culvert

Corrugated metal: minimum 1650.0 mm diameter

Concrete: minimum 1200.0 mm diameter

Plastic: minimum 1050.0 mm diameter

Box Culvert (closed bottom)

Concrete: minimum 1620000 mm2 cross-sectional area

Box Culvert (open bottom)

Concrete: minimum 2160000 mm2 cross-sectional area

Ellipse

Corrugated Metal: minimum 8552985 mm2 cross-sectional area

Concrete: minimum 4523893 mm2 cross-sectional area

* Structure must be installed at a slope of 0.5% or less.

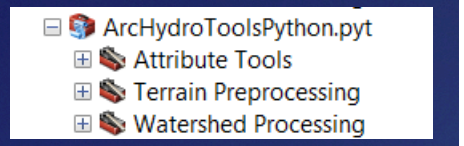
Culverts must be installed either by a licensed contractor or under a valid Watercourse and Wetland Activity Permit.
Culverts installed as per permit conditions and licensed contractor standards is not a guarantee against failure due to weather events or any other cause.

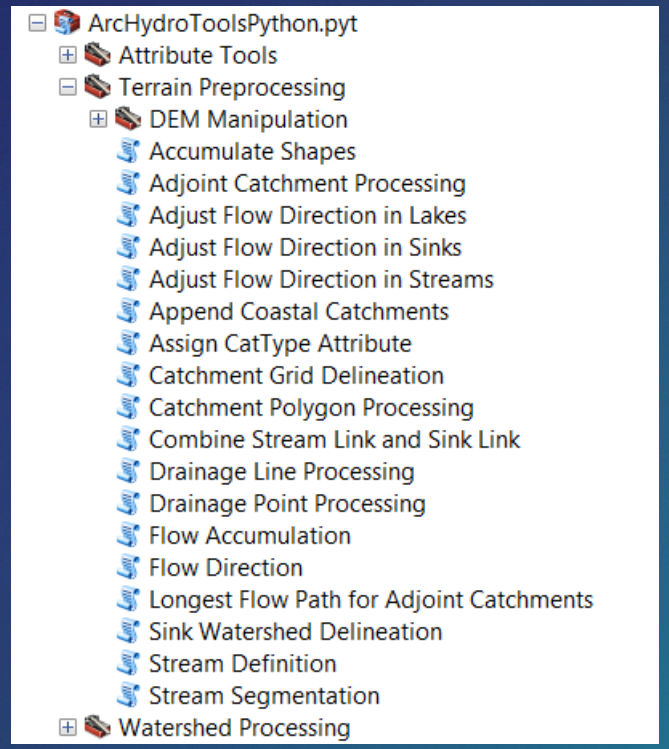
Functional blocks

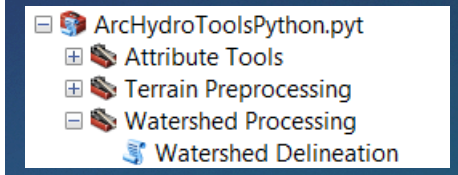
- Focused:
  - Tools
  - Workflows
  - Services
- Areas:
  - Terrain processing for watershed delineation and characterization
    - Support for global services
    - Use for local higher resolution terrains
  - Stormwater
    - Data processing
    - Watershed delineation
  - Flood analyses and visualization
    - Planning
    - Forecasting

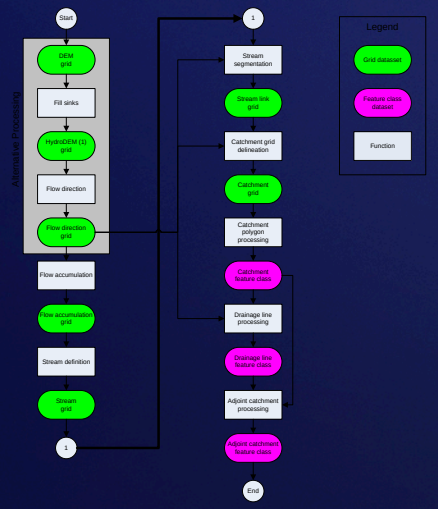
Terrain processing for watershed delineation and characterization

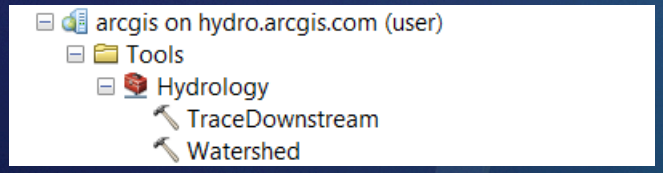
- Tools
- Workflows
- Services
- Areas:
  - Support for global services
  - Use for local higher resolution terrains











Stormwater

Stormwater Concepts

- Two “systems” in play:
  - Collection system – takes overland flow and places it into the conveyance system.
  - Conveyance system – takes the collected water and moves it through
- These systems interact through open channels and inlets.
  - Overland flow does NOT interact with pipes directly

Stormwater Concepts

- Database design
- Data processing workflows
  - Data driven!
- Terrain preprocessing tools (standard Arc Hydro)

Data processing workflows

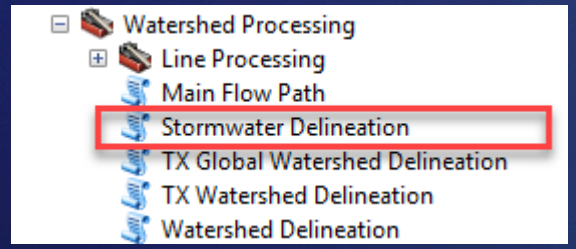
- **Once data roles are defined, the data development process is (fairly) well defined:**

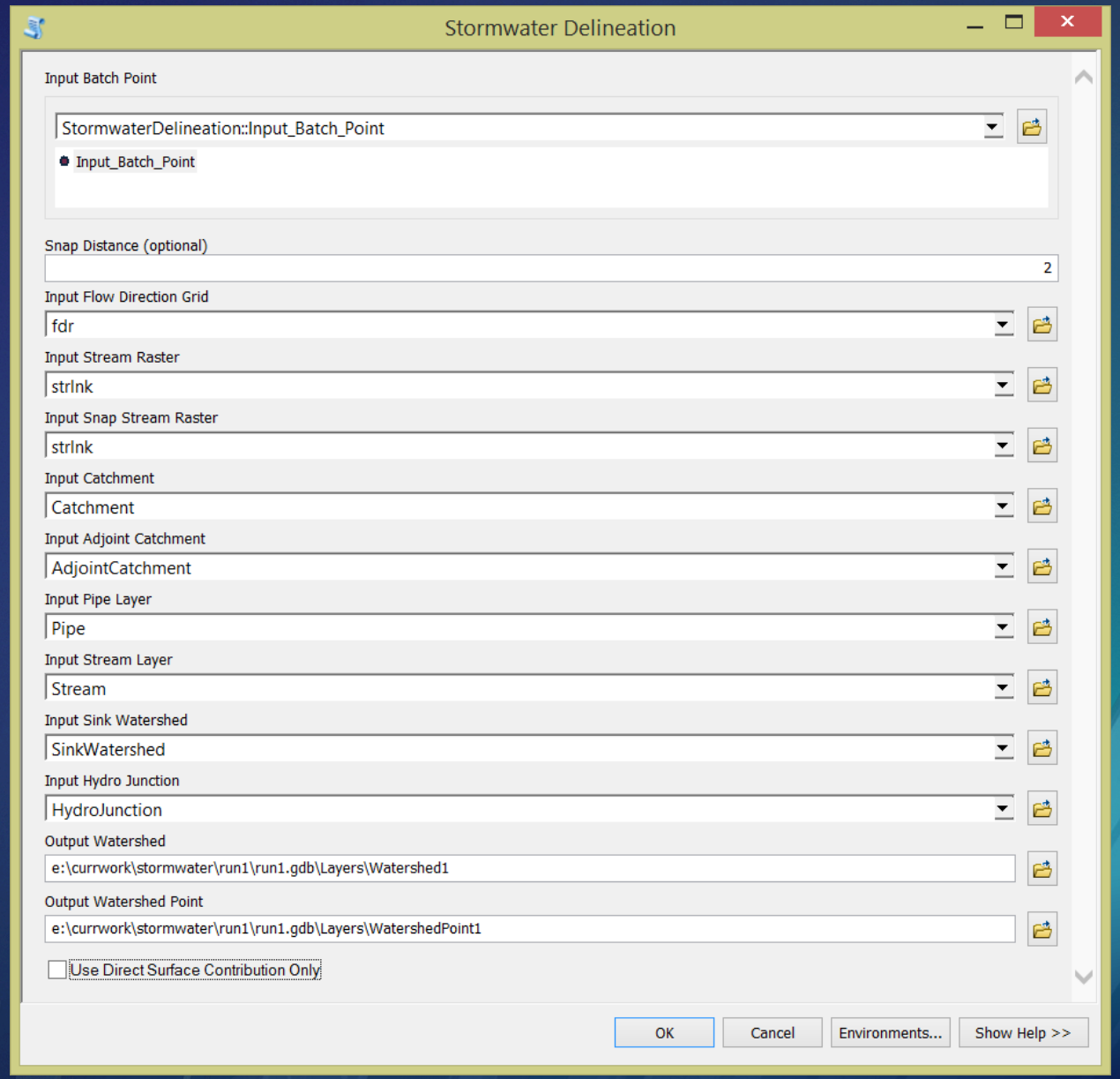
Step	Tool	Objective
1	Create Drainage Line Structures	Create rasterized vector representation of the input streams as Drainage Line features.
2	DEM Reconditioning from Stream Grid	Burn the stream grid generated in step 1 in the DEM to enforce the location of the streams and force water near the streams to flow toward the closest stream.
3	Create Sink Structures	Create Sink Points and Polygons associated to draf sink poly (structure inlets and sinks created at end of DrainageLine.
4	Level DEM	Level DEM within terrain and structure sink polygons using the lowest elevation along the sink polygon boundary – 10000 offset.
5	Fill Sinks	Fill the DEM at all locations except within the sink polygons (both terrain and structure).
6	Flow Direction	Generate flow direction grid.
7	Adjust Flow Direction in Sinks	Modify flow direction within sink polygons so that water flows toward the sink point in the sink polygon.
8	Adjust Flow Direction in Stream	Modify flow direction in the streams so that the water flows in the digitized direction along the streams.

Step	Tool	Objective
9	Combine Stream Link and Sink Link	Combine link grids generated from the streams and from the sinks.
10	Catchment Grid Delineation	Delineate catchments for each link.
11	Catchment Polygon Processing	Convert catchment grid to vector.
12	Adjoint Catchment Processing	Generate Adjoint Catchment associated to each input Catchment and set the connectivity between Catchments.
13	Sink Watershed Delineation	Delineate watershed associated to terrain sinks.
14	Link Sink Watershed to HydroJunction	Create and populate JunctionID in SinkWatersheds with HydroID of associated HydroJunction. Create relationship.
15	Create Stormwater Network	Create geometric network from HydroJunction, Pipe and Stream layers and set flow direction in digitized direction.
16	Flow Accumulation	Create Flow Accumulation to support next step, Create Snap Data.
17	Create Snap Data	Create snap raster to support snapping when delineating.

Stormwater delineation

- New Arc Hydro gp tool to capture different options in contributing area determination
  - Single point
  - Multiple points





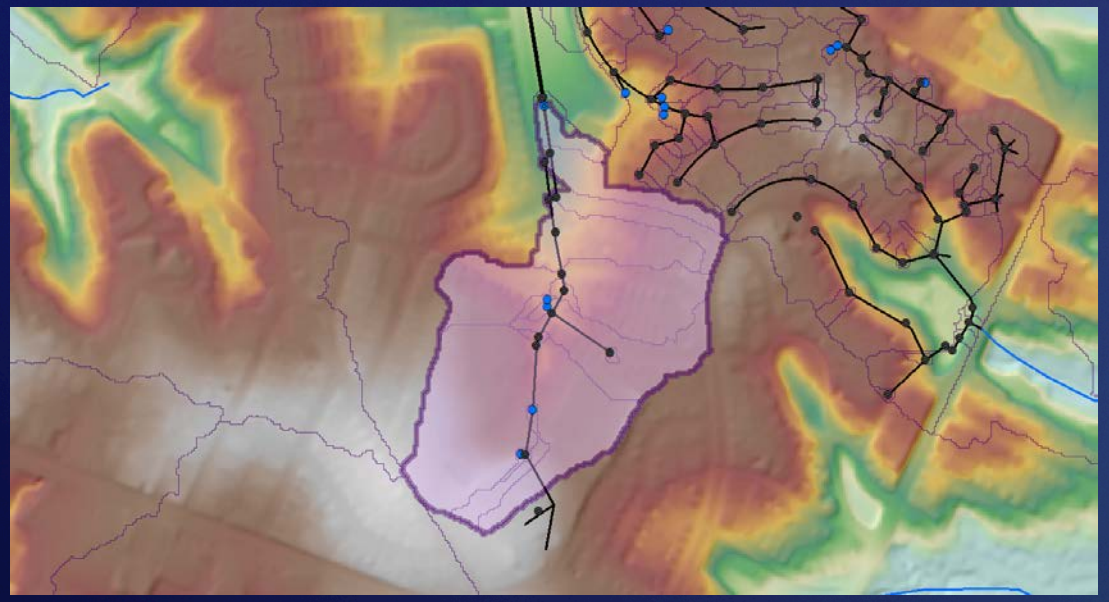
Stormwater delineation

- **Tool functionality matrix:**
  - **Where the point is?**
  - **Where the line is?**
  - **Local or global contribution (surface or full conveyance)?**

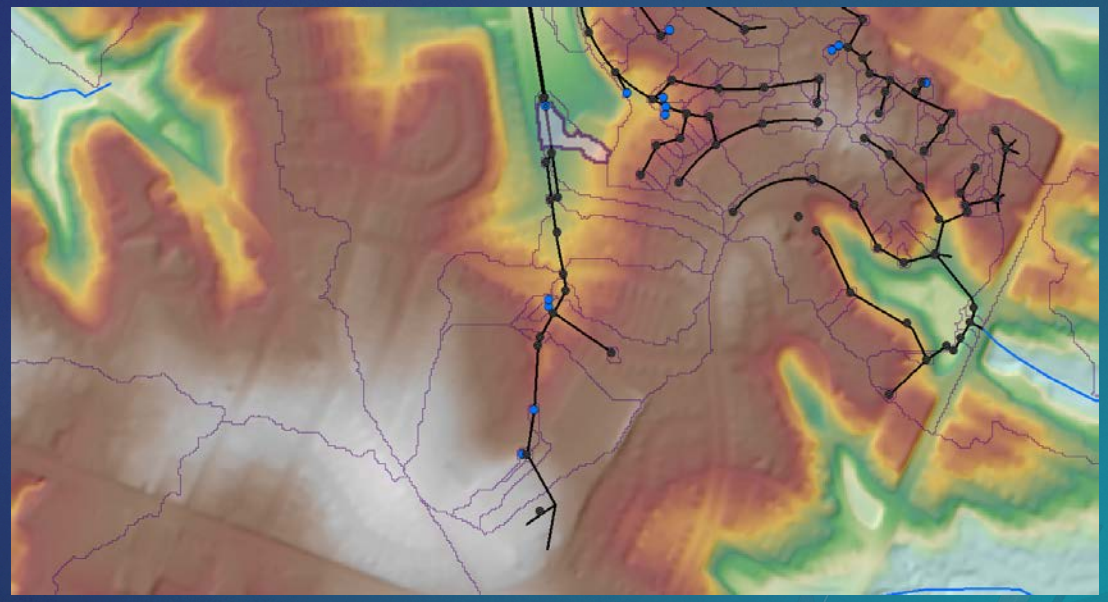
Clicking on	Use Direct Surface Contribution Only: False (Default)	Use Direct Surface Contribution Only: True
Inlet	SinkWatersheds linked to selected + traced upstream HydroJunctions	SinkWatershed related to selected HydroJunction only.
Pipe	SinkWatershed linked to traced upstream HydroJunctions only.	Watershed draining to the surface location.
Stream	Directly connected Surface Area Watershed + SinkWatersheds related to traced upstream HydroJunctions.	Directly connected Surface Area Watershed only.
Land	Directly connected Surface Area Watershed.	Directly connected Surface Area Watershed.

Stormwater delineation - inlet

Global

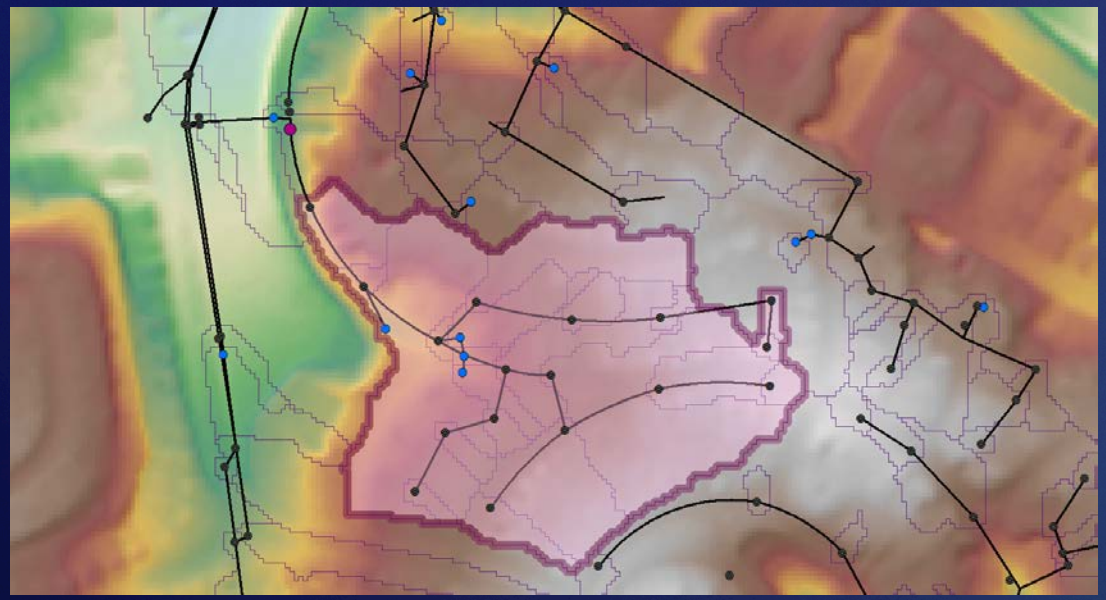


Local

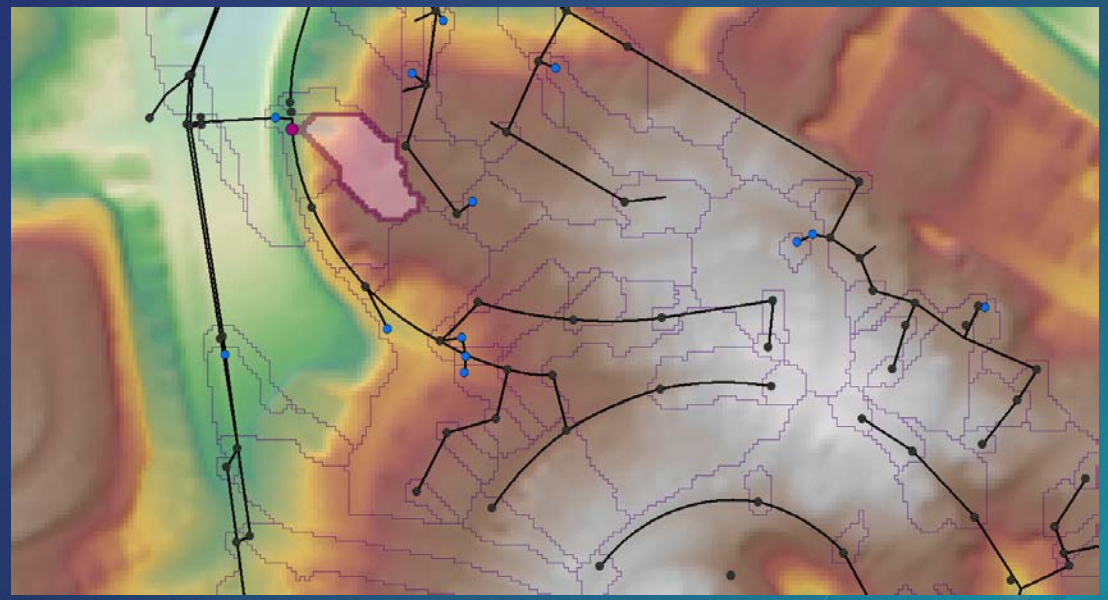


Stormwater delineation - pipe

Global (in the pipe)

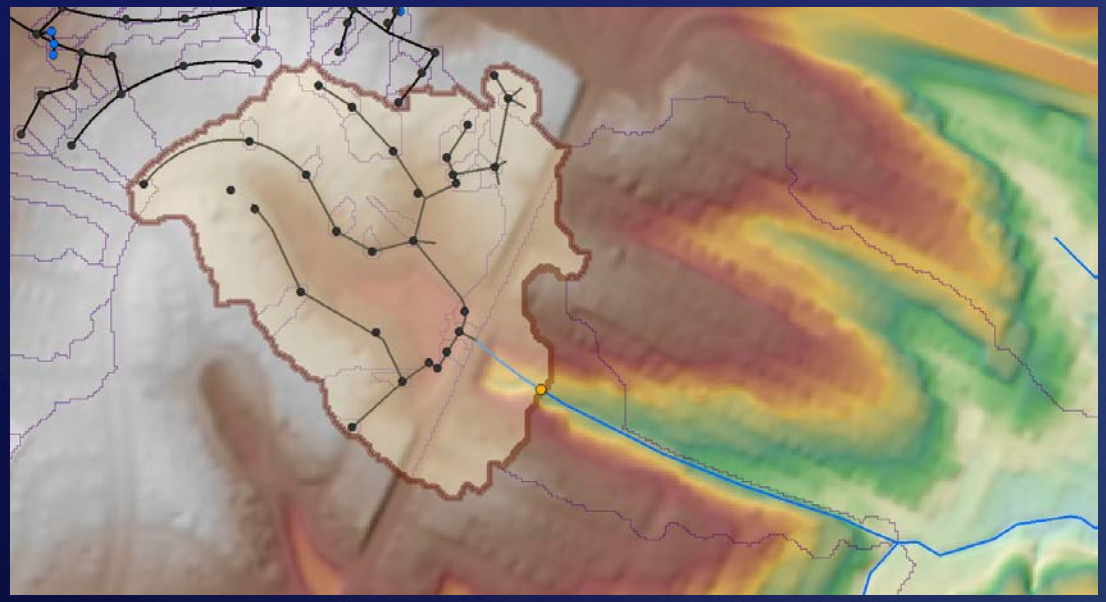


Local (same as land)

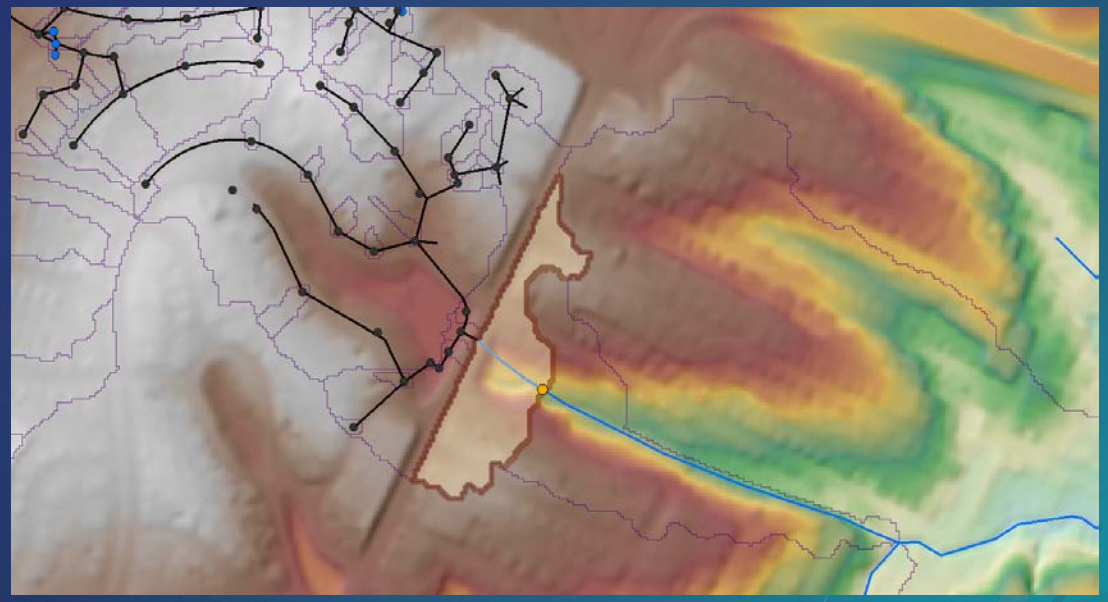


Stormwater delineation - stream

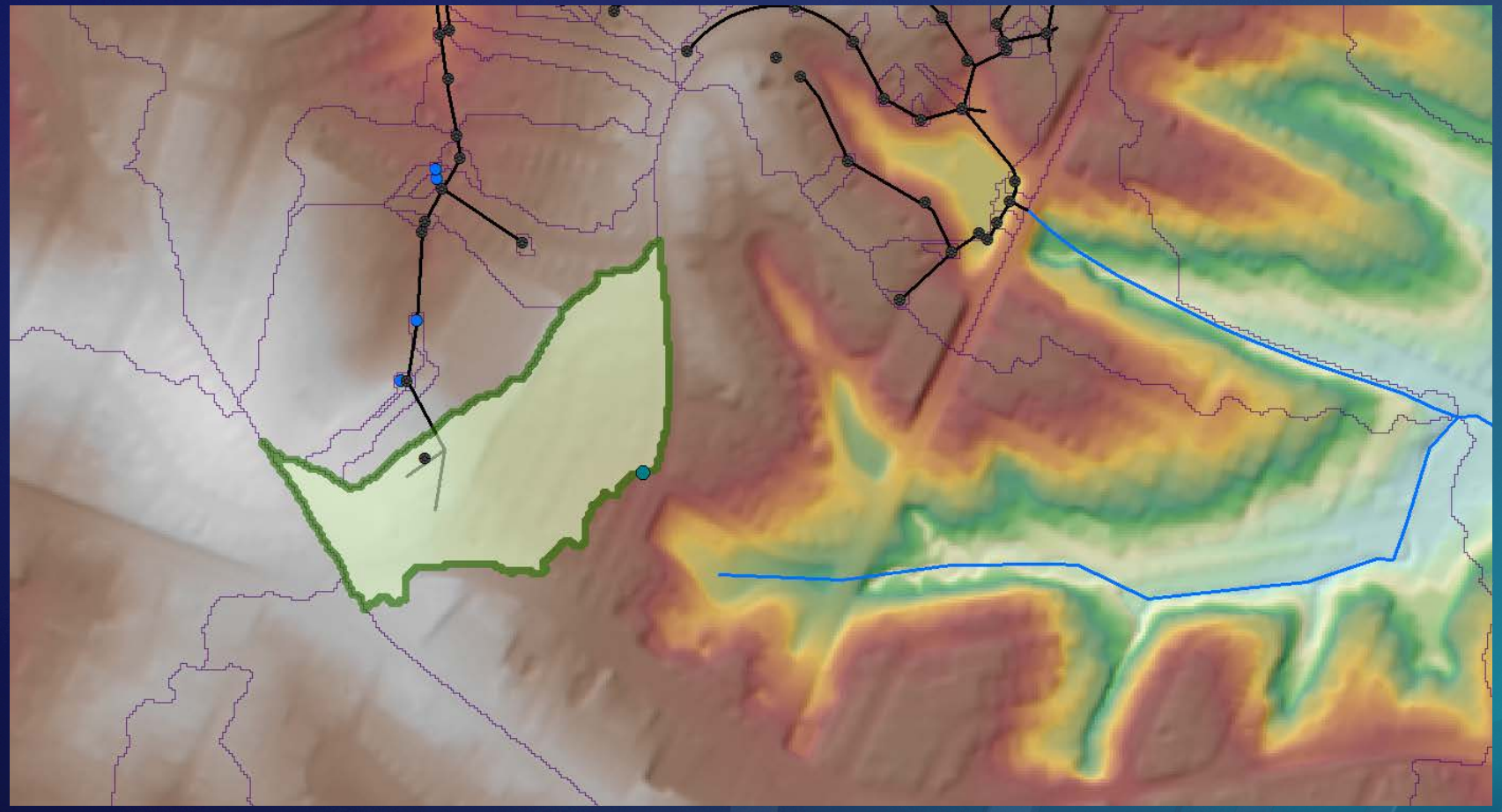
Global



Local

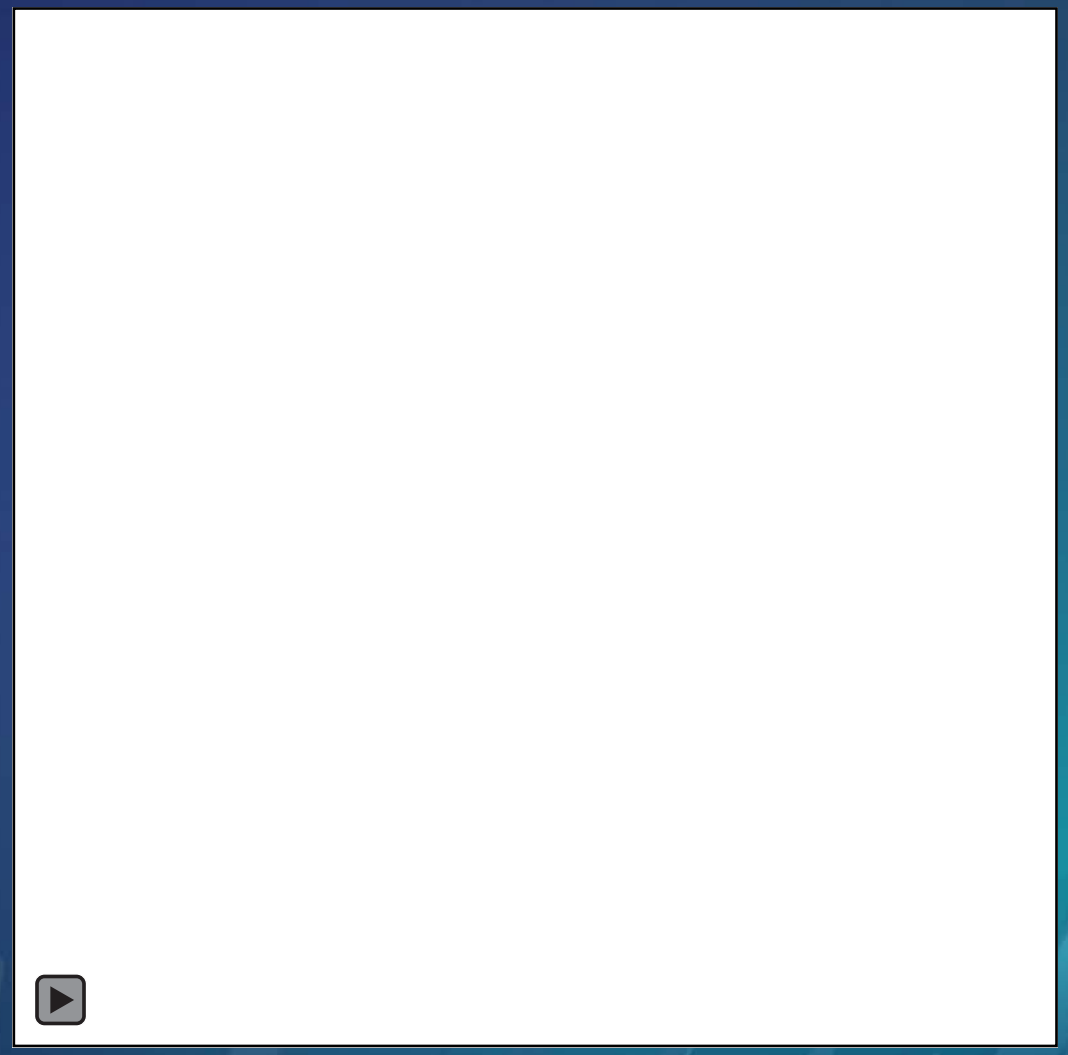


Stormwater delineation - land



But wait, there is more!

- If full solution of flow equations is required, GIS can be used to interface with detailed stormwater H&H models (e.g. ICPR 4).
  - GIS used as pre- and post-processor for the models.
- Design and operational scenarios.

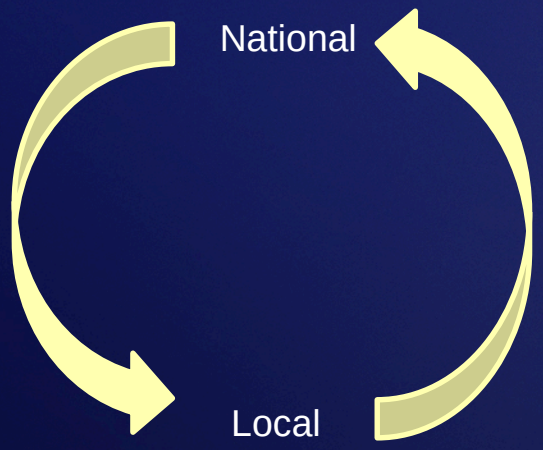


ICPR4 Model: Cross Bayou - Mariners Cove Area
Flood Depth Animation: T.S. Hermine (Aug 31 – Sept 1, 2016)

Floodplain Analyses

Close the gap between national flood forecasting and local flood emergency response

- **Demonstrate forecasting of flood impacts at “stream and street level”**
- **Develop actionable information products useful for flood planning and response systems**

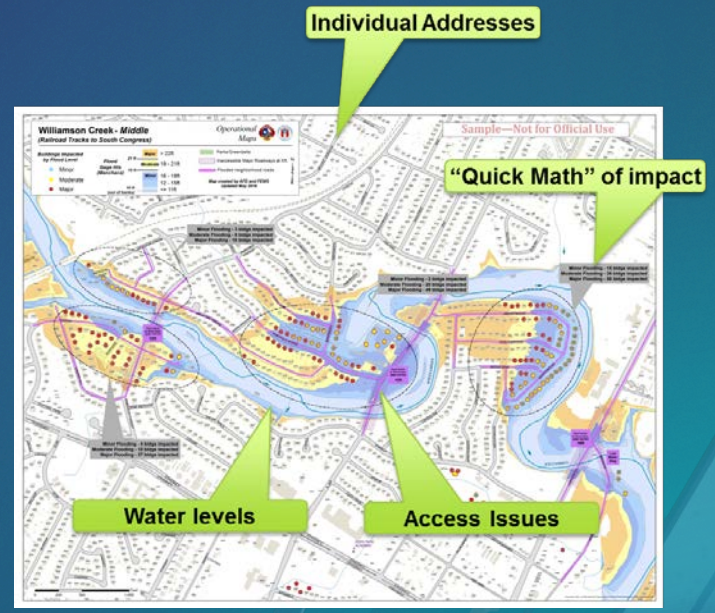


Weather and Hydrology

National Weather Service and federal agencies
National Water Center

River Flooding and Emergency Response

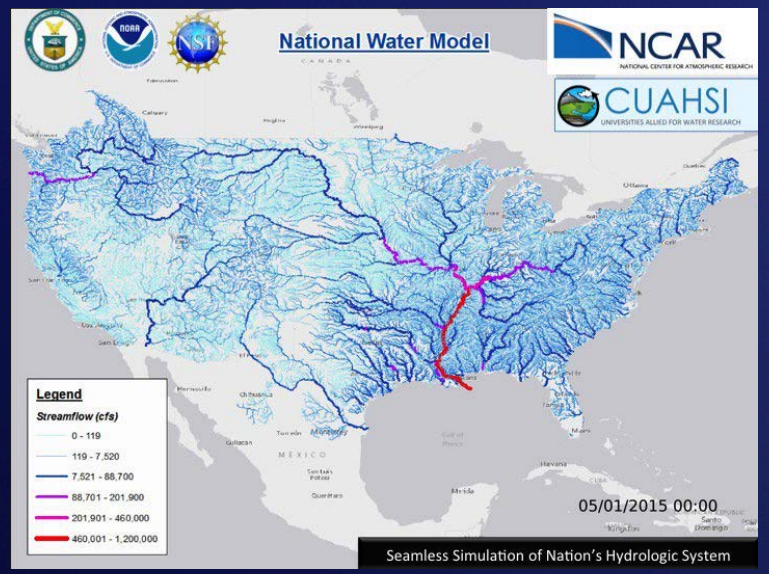
Local, State and Regional Agencies, Citizens



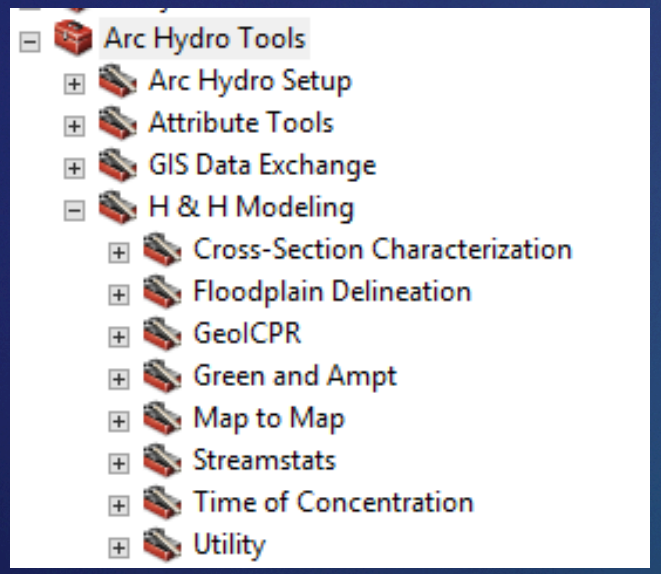
David R. Maidment & Harry R. Evans, UT Austin

Flood Impact Forecasting

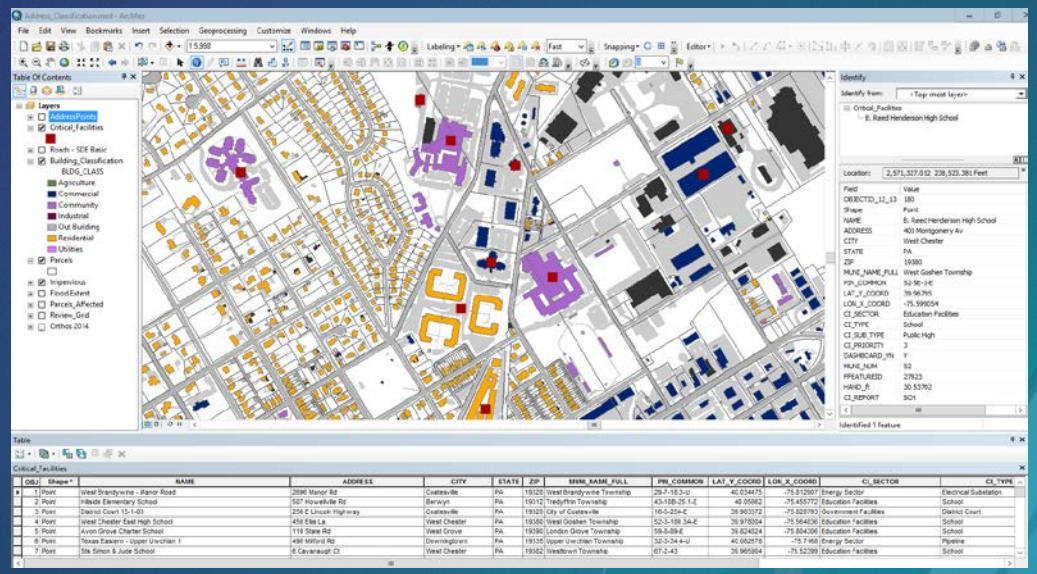
WHEN:
National Water Model



WHERE:
Arc Hydro Tools

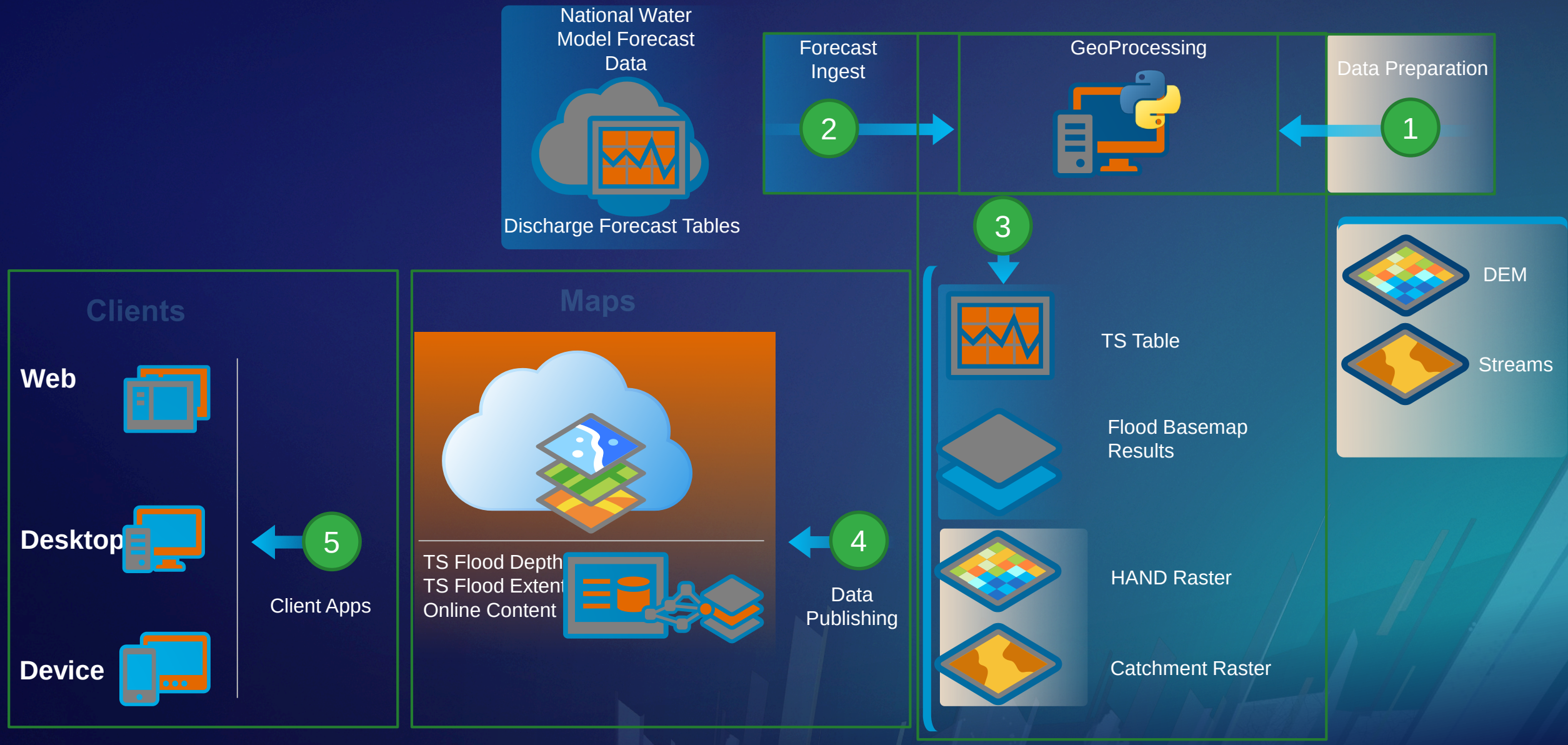


WHO:
Local County GIS Data

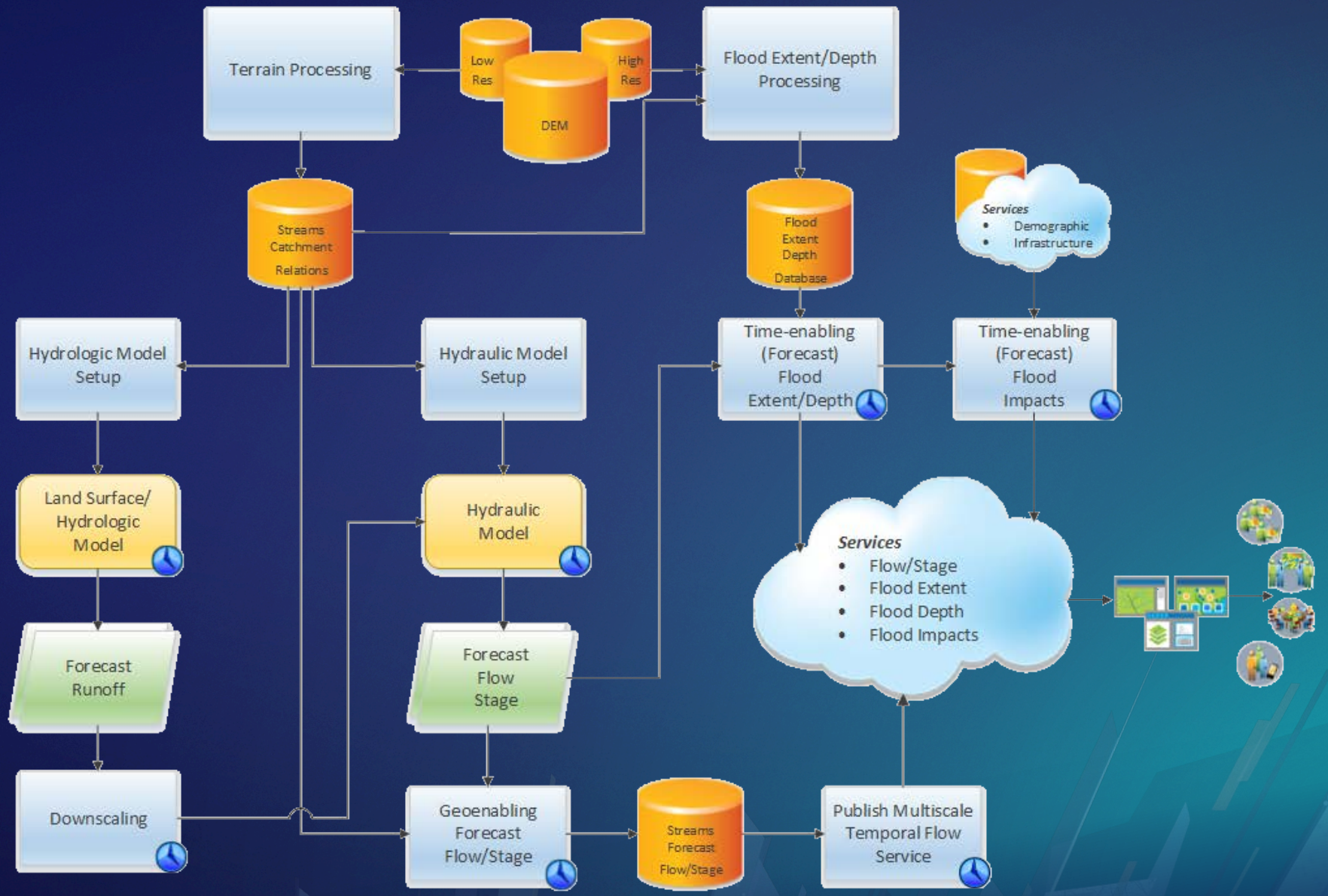


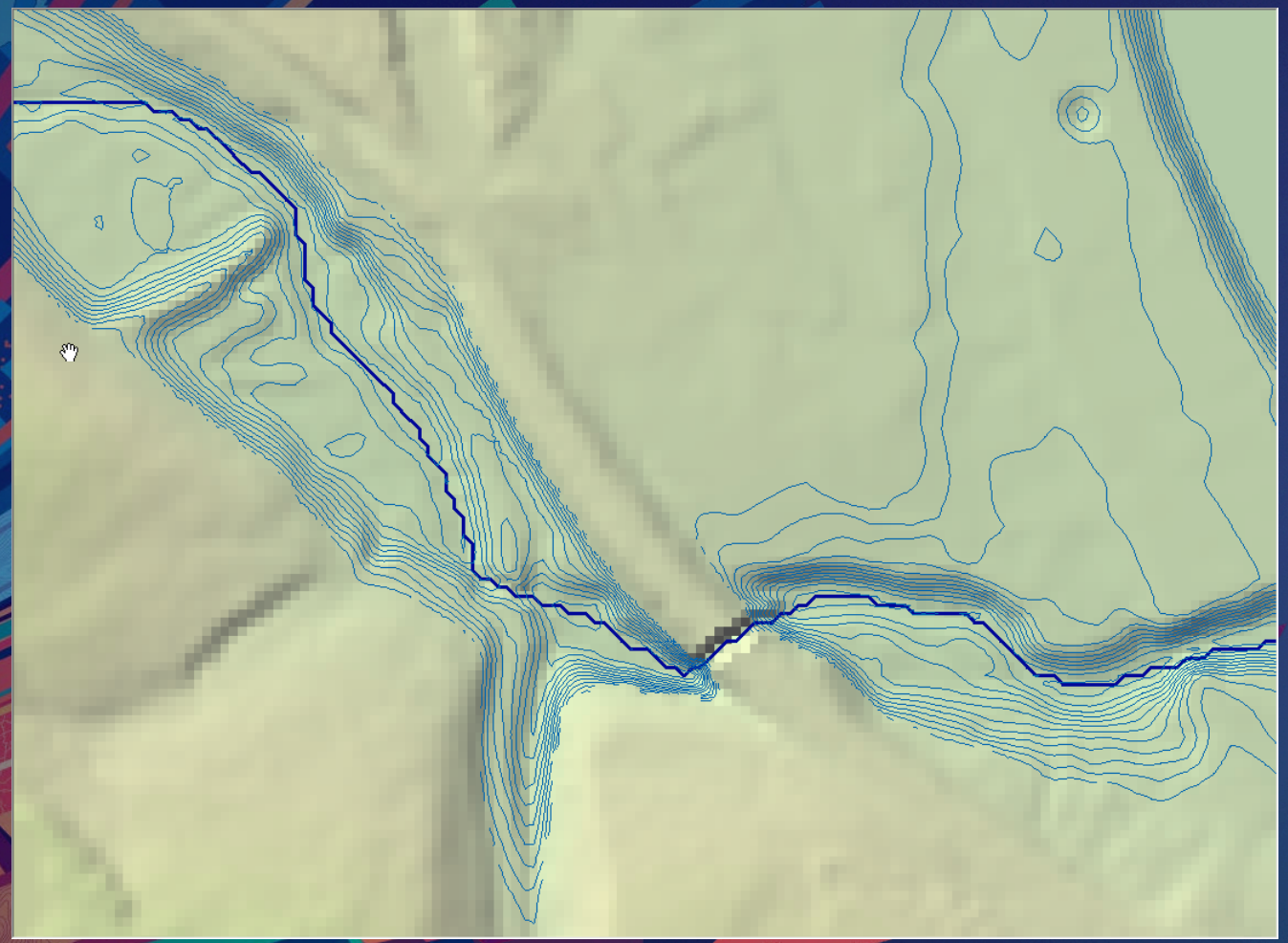
Dave Sekkes, Chester County EOC

NWM Integration Concept Diagram (HAND approach)



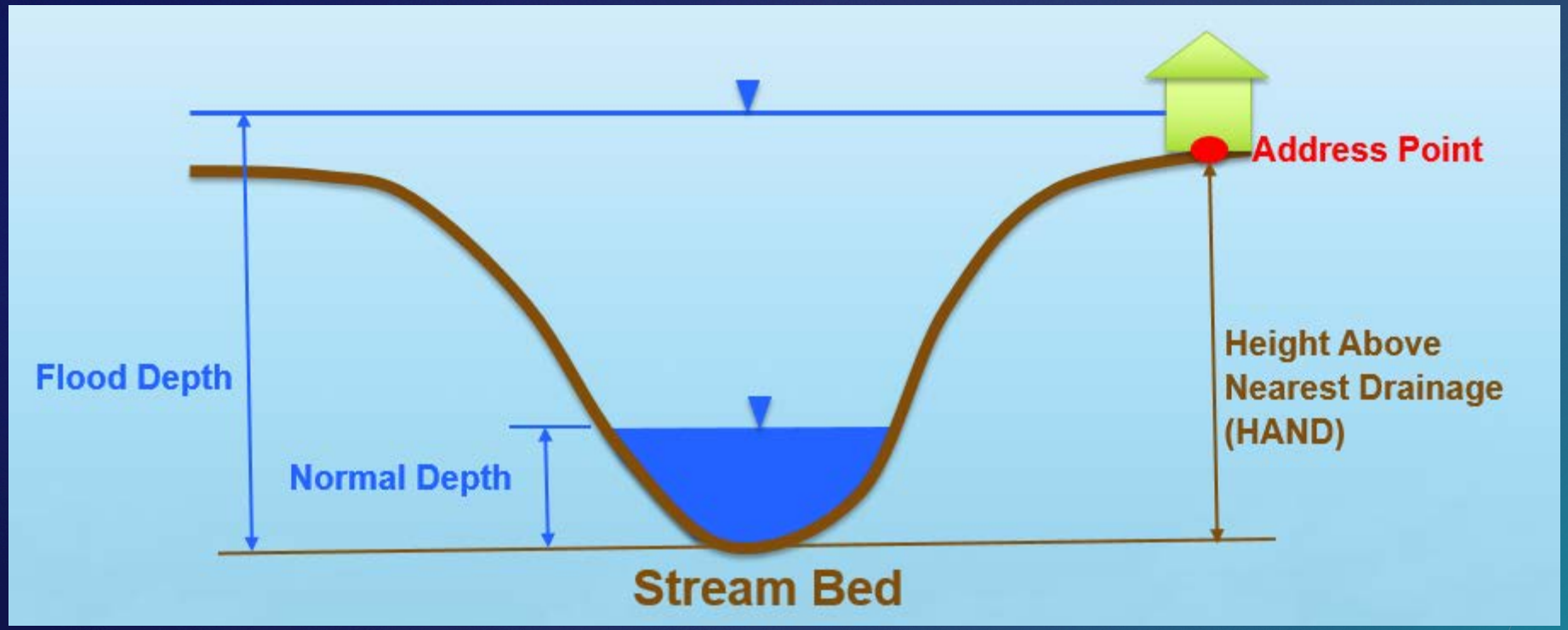
Components


Terrain Processing
Low Res
High Res
DEM
Flood Extent/Depth Processing
Streams Catchment Relations
Flood Extent Depth Database
Services
Demographic
Infrastructure
Hydrologic Model Setup
Hydraulic Model Setup
Time-enabling (Forecast) Flood Extent/Depth
Time-enabling (Forecast) Flood Impacts
Land Surface/ Hydrologic Model
Hydraulic Model
Services
Flow/Stage
Flood Extent
Flood Depth
Flood Impacts
Forecast Runoff
Forecast Flow Stage
Downscaling
Geoenabling Forecast Flow/Stage
Streams Forecast Flow/Stage
Publish Multiscale Temporal Flow Service



Flood workflow mind map walk-through

Height Above Nearest Drainage (HAND)



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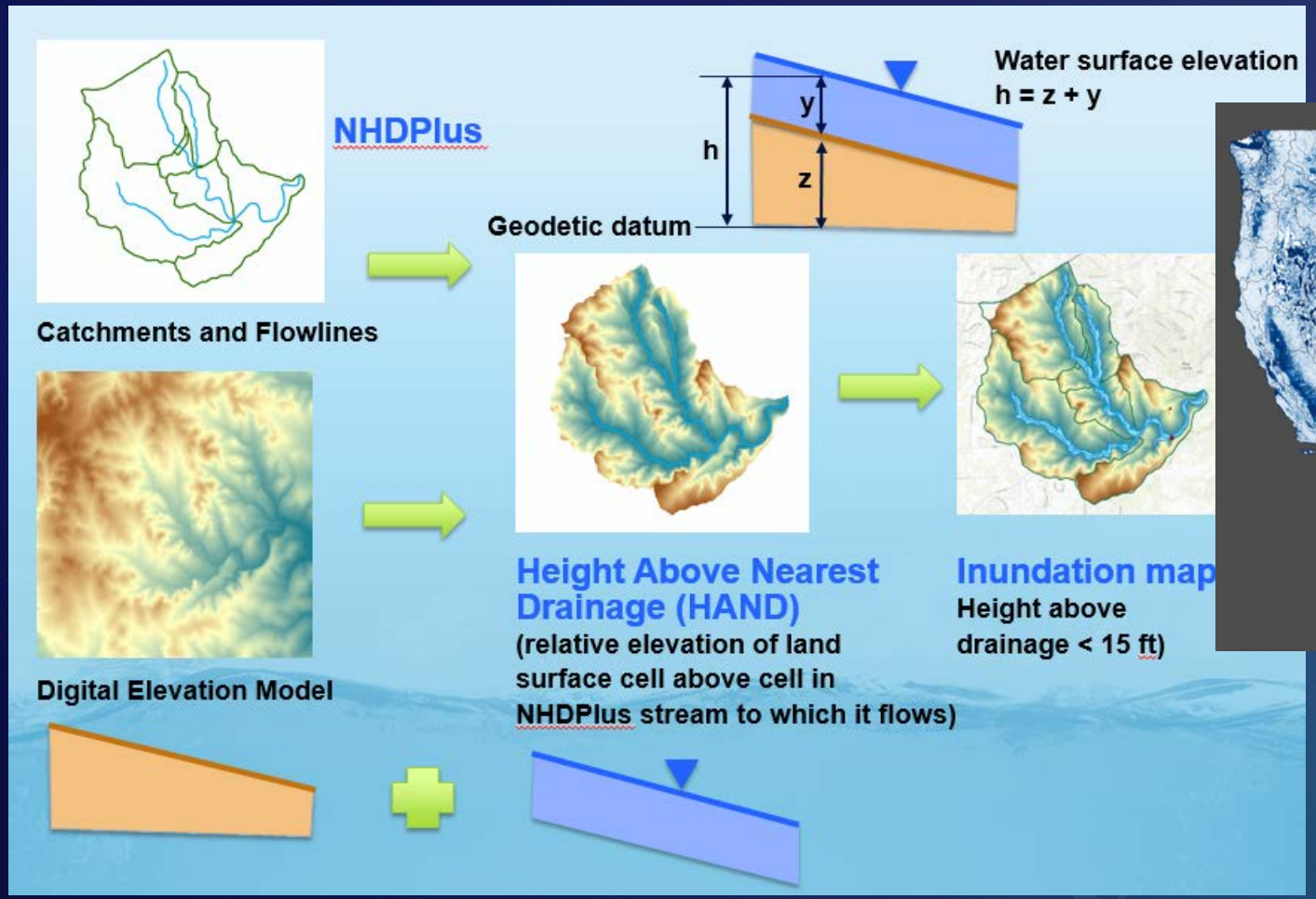
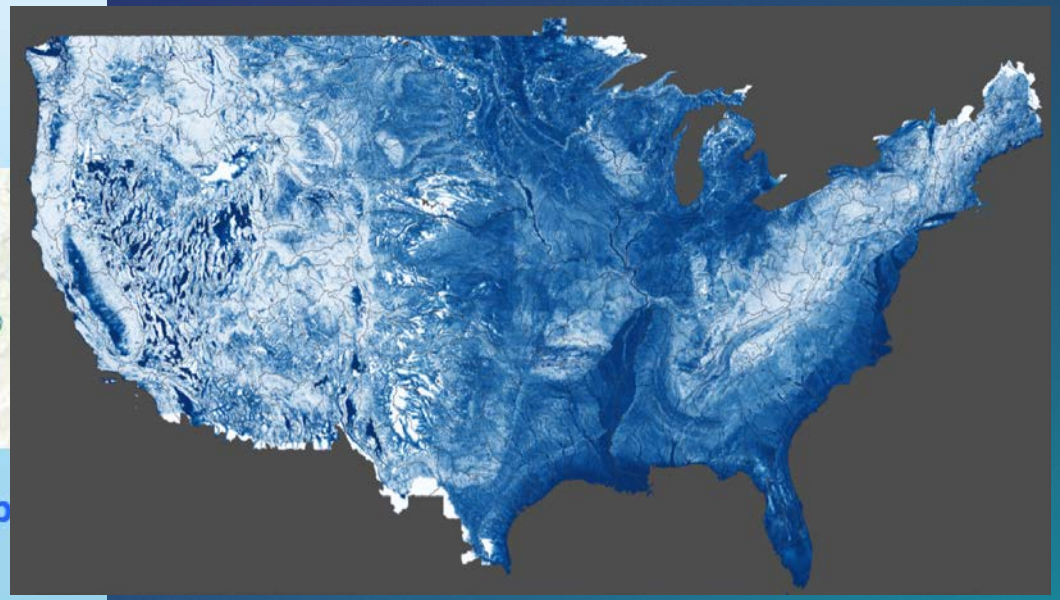
Flood Inundation Mapping – NHDPlus-HAND Method



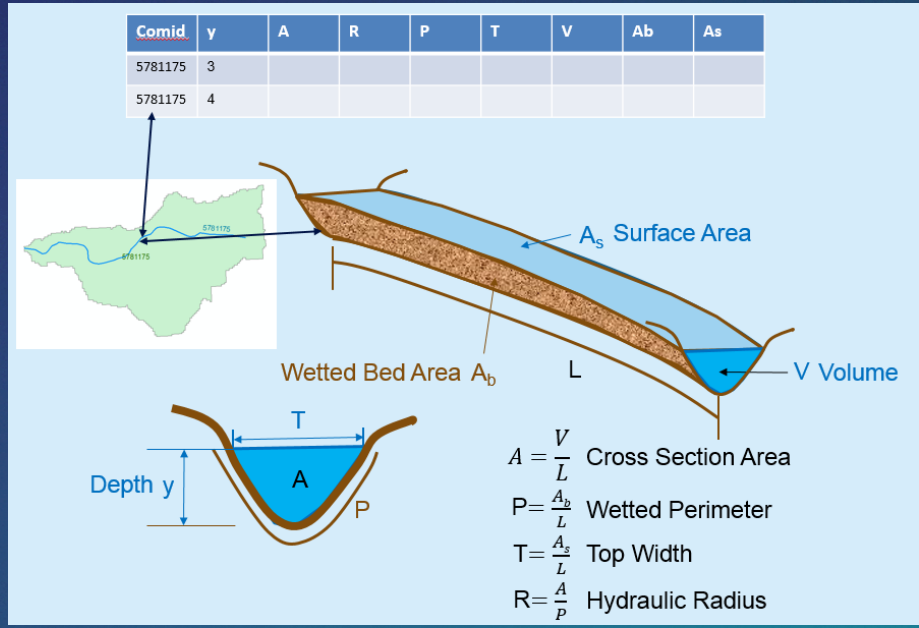


Source: Yan Liu, University of Illinois at Urbana-Champaign

David R. Maidment, UT Austin

Landscape characterization

- **Streams**
  - DEM alignment and thalweg adjustment
  - Longitudinal WSE interpolation based on point values
- **Cross-sections/reach**
  - Characterization: h, A, B, P, R curve
  - Synthetic rating curve (based on normal depth with n and S_0 assumption)
  - WSE Interpolation
- **Floodplain (for incremental or specific stages)**
  - Depth of flooding
  - Water surface elevations
  - Flood extent



Source: David R. Maidment, UT Austin

XID	Z	H	A	P	R	B	Q
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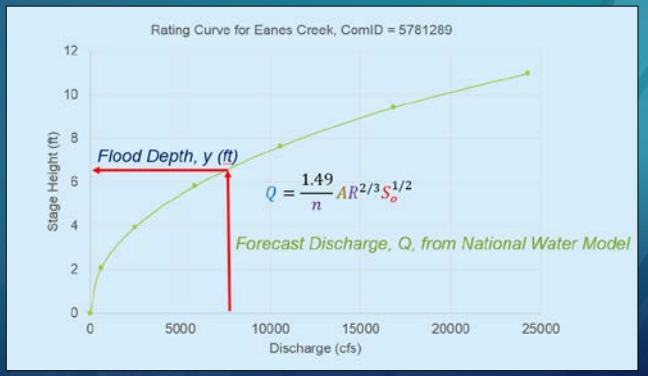
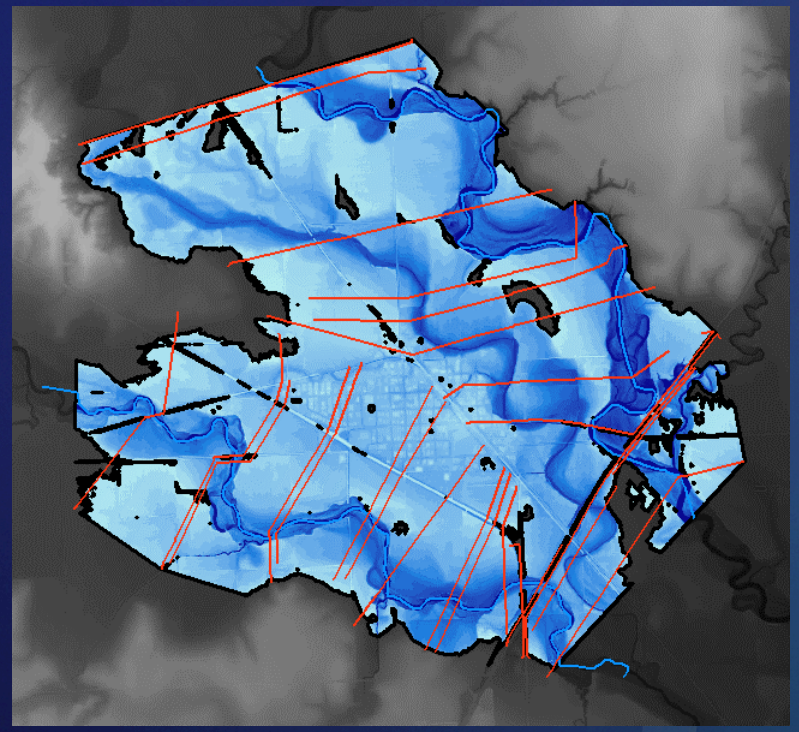
1451	1671.19	23.19	27689.7	1867	14.8	1850	39551.4
1451	1665.4	17.4	17209	1759	9.8	1746.6	24581
1451	1659.6	11.6	9212.7	1967.1	4.7	1957.4	13159.2
1451	1653.8	5.8	855.2	1075.3	0.8	996.4	1221.5
1452	1688.18	35.9	64511.6	2733.8	23.6	2710.2	85305.9
1452	1681	28.72	45492	2563.3	17.7	2542.4	60155.6
1452	1673.82	21.54	28000	2335.9	12	2315.7	37025.4
1452	1666.64	14.36	19863	2893.6	6.9	2873.7	26265.5
1452	1659.46	7.18	2891.5	2040.4	1.4	1877	3823.5



Flood analyses and visualization

- Tools
- Workflows
- Services
- Areas:
  - Planning
  - Forecasting



- Cross-Section Characterization
  - Assign Hydrology River Properties to Cross-section
  - Assign River Slope to Cross-section
  - Calculate 3D Cross-section Characteristics
  - Calculate Manning's N for Cross-section
  - Calculate Normal Depth
  - Calculate Potential Q
  - Define 3D Cross-section from 2D
- Floodplain Delineation
  - Calculate WSE for Selected Model
  - Create 3D Stream WSE Line
  - Create 3D WSE Stream Line Grid
  - Derive BFE - no smoothing
  - Derive BFE - with smoothing
  - Derive Extended BFE - No Smoothing
  - Find Intersect Points
  - Flood from Cross-Section
  - Flood from Stream WSE Py
  - Interpolate WSE at Cross-Sections
  - Merge Cross-Section Feature Classes
  - Select WSE To Process
- Map to Map
  - Export to DSS
  - Flood From Stream WSE
  - GeoRAS to Flood
  - HMS to GeoRAS
  - Import from DSS
  - Run HMS
  - Run RAS
  - SDF to XML
  - Stream WSE From Point WSE Measurements
  - Update RAS Flow

Flood analyses and visualization

- Tools (new)
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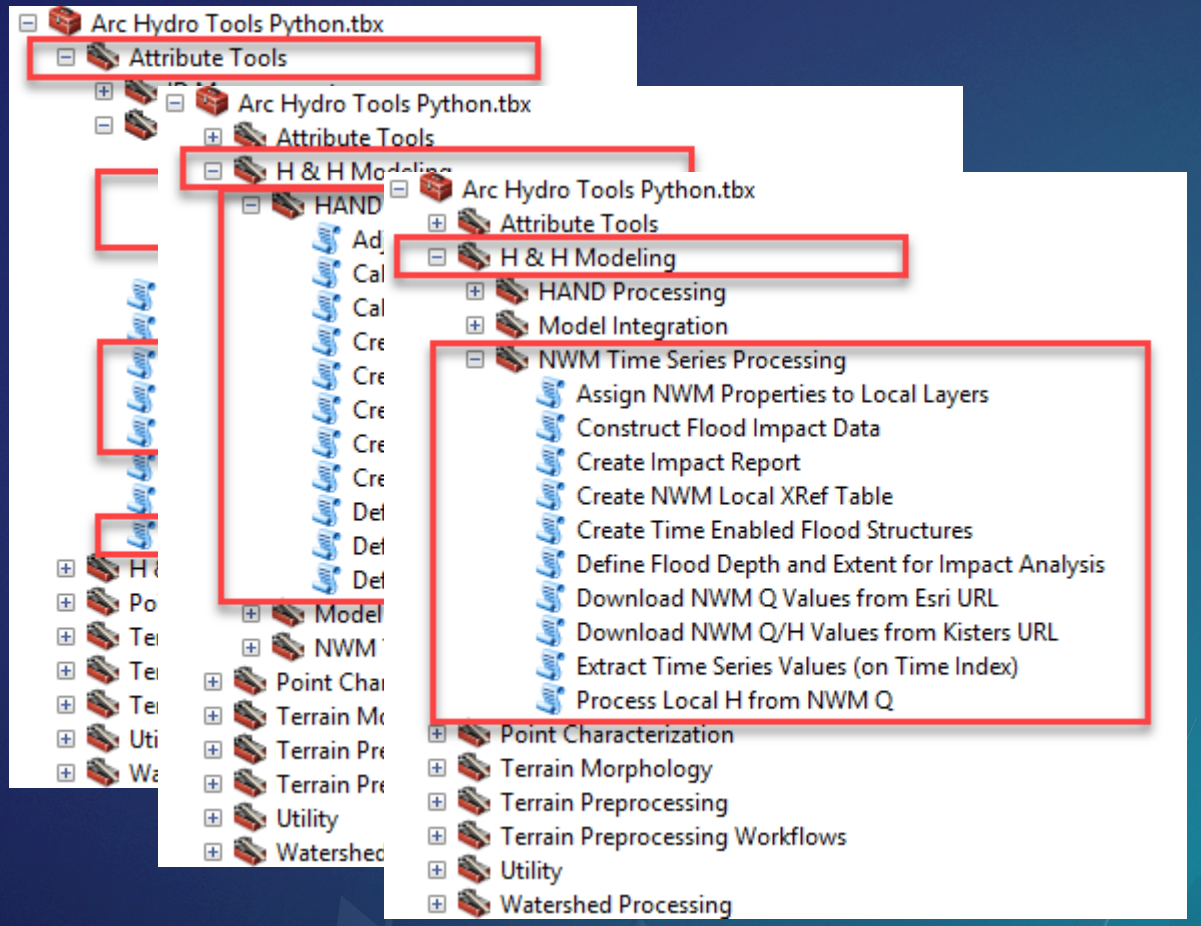

Flood analyses and visualization

- Tools (new)
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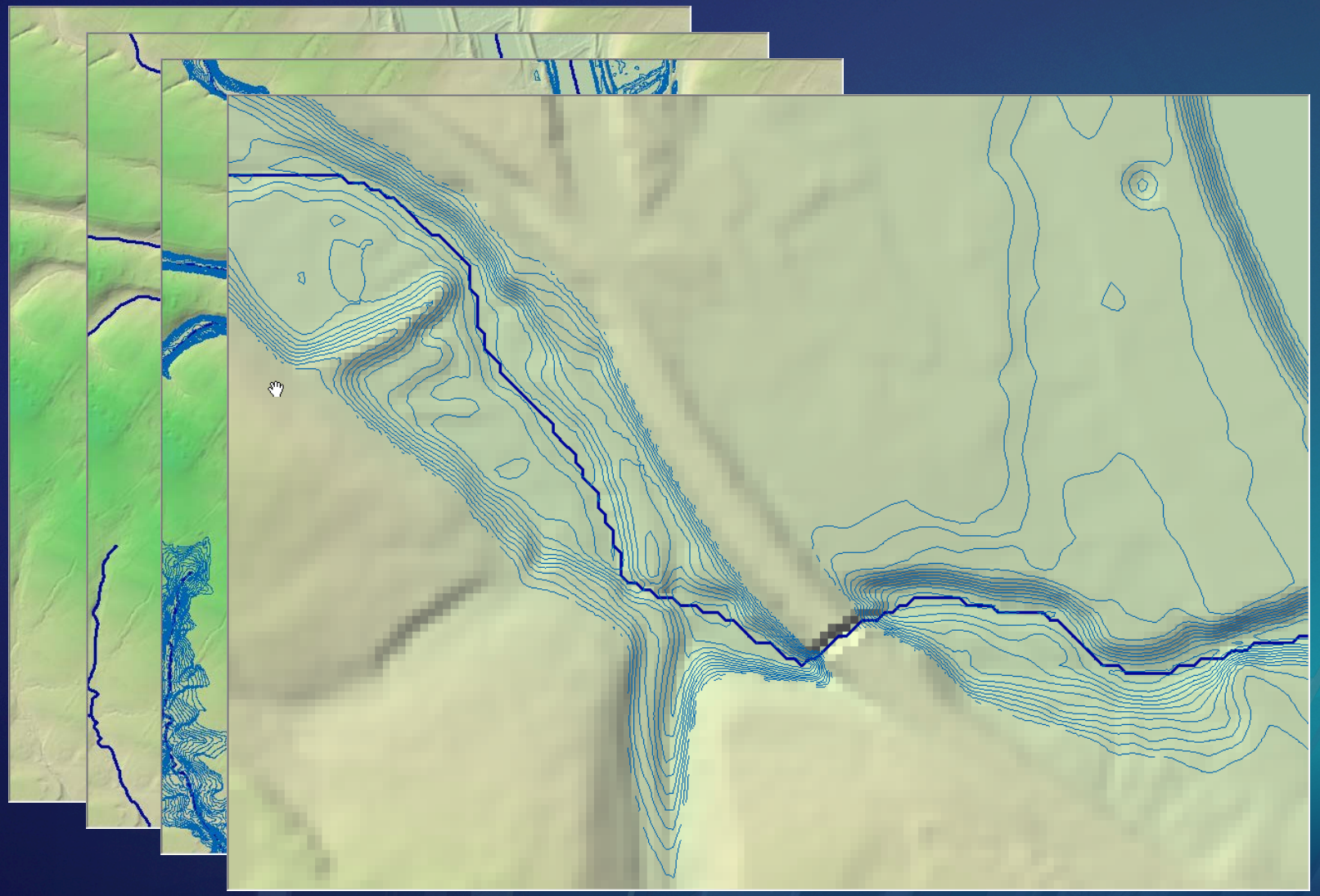

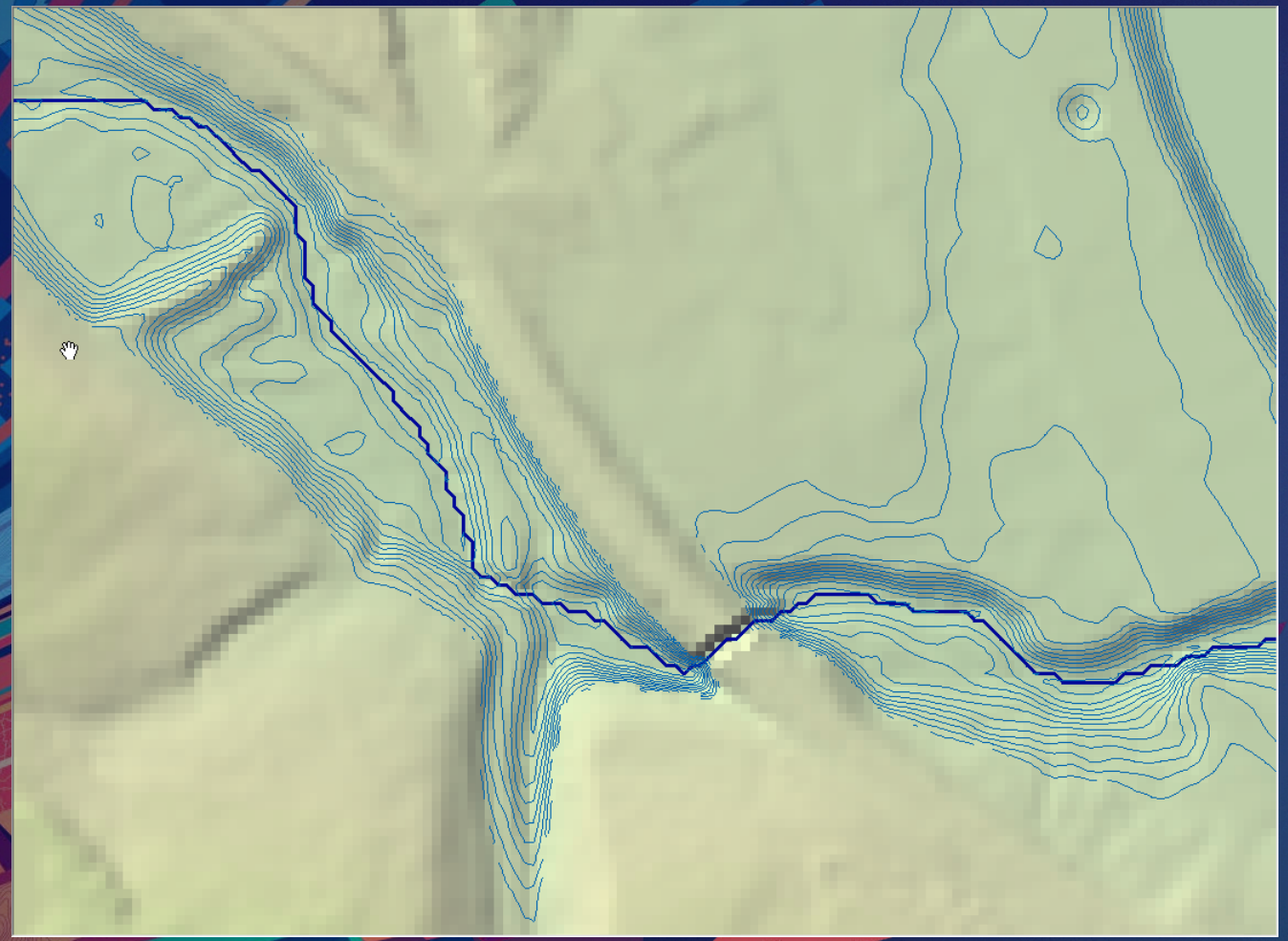

Arc Hydro tools for flooding walk-through

Summary

- **Arc Hydro provides a database schema, tools, and processing workflows to make implementation of GIS in water resources easier.**

Thank you…

- **Questions ?**


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