What's New with Arc Hydro?

Christa Campbell & Dean Djokic

Connecting with Esri Water Resources

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Water Resources Team

Industry Solutions

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James Filloramo

Living Atlas

Caitlin Scopel

Gonzalo Espinoza

Professional Services

Dean Djokic

Gina O'Neil

Christine Dartiguenave

Zichuan Ye

Ezra Bosworth-Ahmet

Paul Burgess

Training Services…

Conferences

Esri's hydro experts will be supporting several events this year with an exhibit and / or presentations.

- National Mitigation of Ecosystem Banking, May 2 - 6
- Association of State Floodplain Managers Conference, May 15 - 19
- AWRA Geospatial Water Technology Conference, May
- AWRA Annual Water Resources Conference, November 7 - 9

Connect with our team to ask questions and share your work.

Navigating Esri Web Sites

Finding information on Esri websites

- Water Resources
- Arc Hydro

Water Resources web page

Arc Hydro web page

Esri Water Resources Community

Connecting with industry professionals

- Online Q&A
- Bogs
- Videos
- Technical documents

Water Resources Community

Water Resources Office Hours (Virtual)

Esri's hydro experts host virtual office hours to discuss common water resources workflows and answer questions.

- February 22, 2022
- April 21, 2022
- June 16, 2022
- August 18, 2022
- September 15, 2022

Join us to ask questions, contribute to the community, and vote on Office Hour topics.

Esri Water Meetup

Esri UC: Hydro Meeting (In person)

Save the Date – Sunday, July 10, 2022

Topics will include:

- Hydrology tools in Spatial Analyst
- Hillslope tools
- Hydro content in the Living Atlas…and more

Esri Water Meetup

Stay Connected with Esri's Water Team

@EsriWater

Esri Water Resources

Esri Water Meetup

Esri Water eNewsletter

Arc Hydro: What's New

Dean Djokic

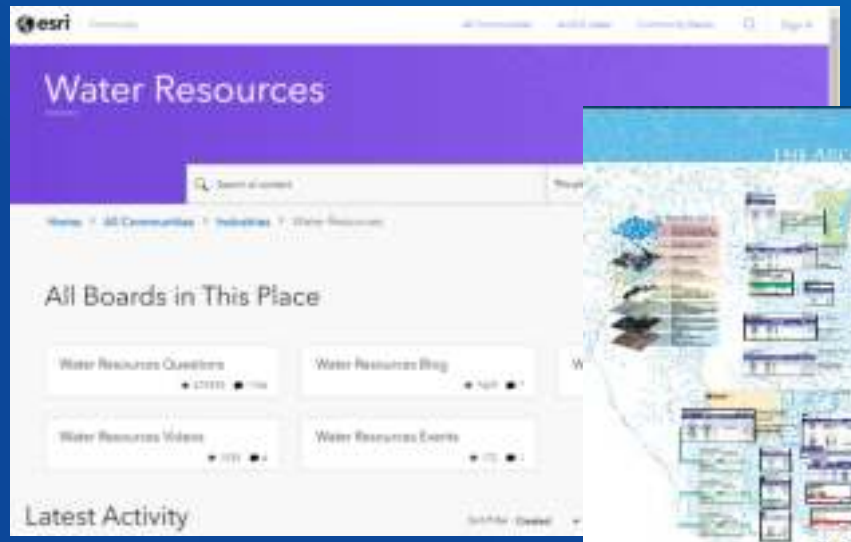
Topics

- AH overview
- Status of Arc Hydro Pro transition
- Hydro feature extraction
- H&H modeling
- Community engagement

Arc Hydro Product Icon and Glyph

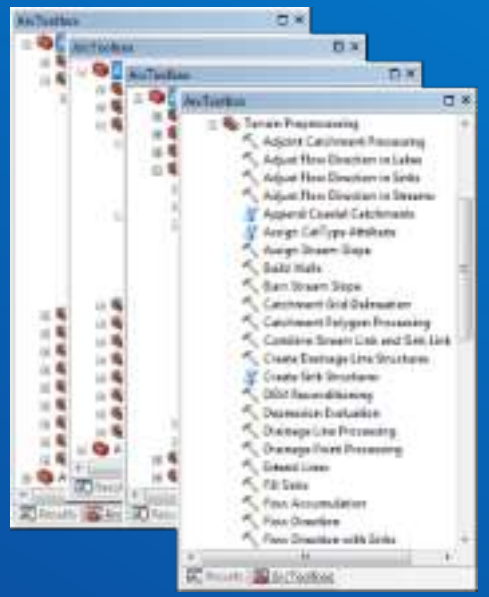
Arc Hydro: Vision

"Provide practical GIS framework for development of integrated analytical systems for water resources market."

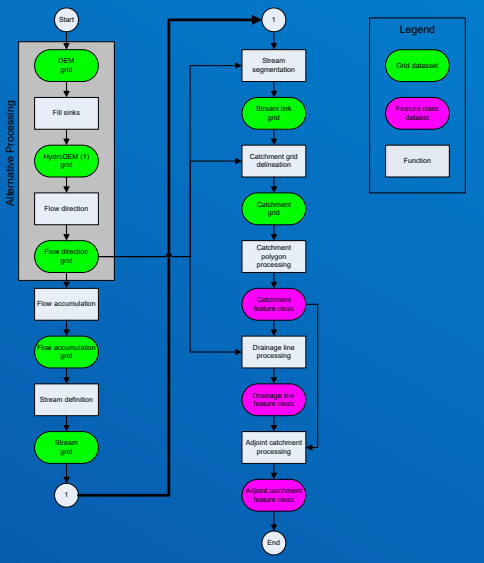


Community

Data Model



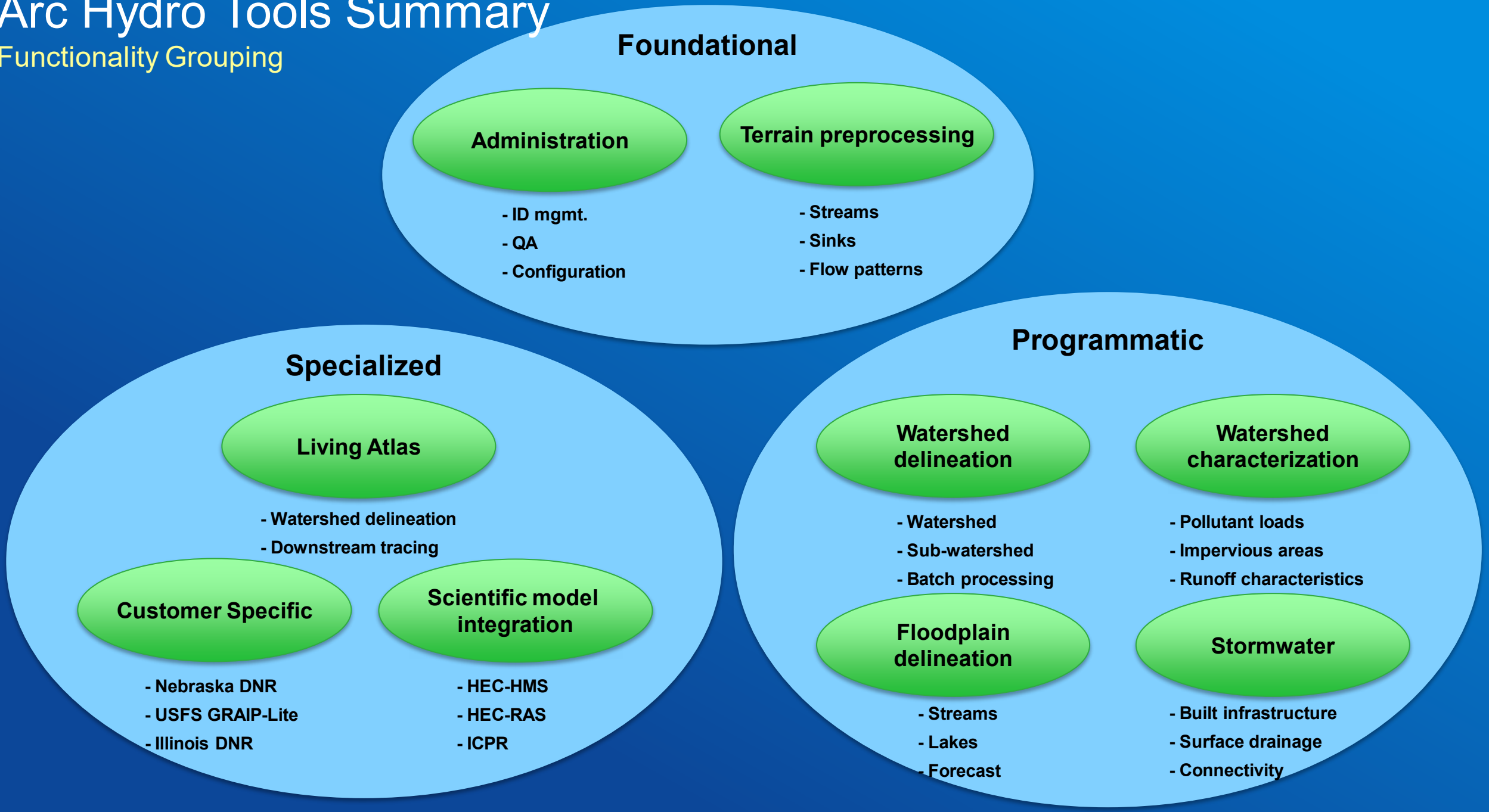
Tools



Workflows

Arc Hydro Tools Summary

Functionality Grouping

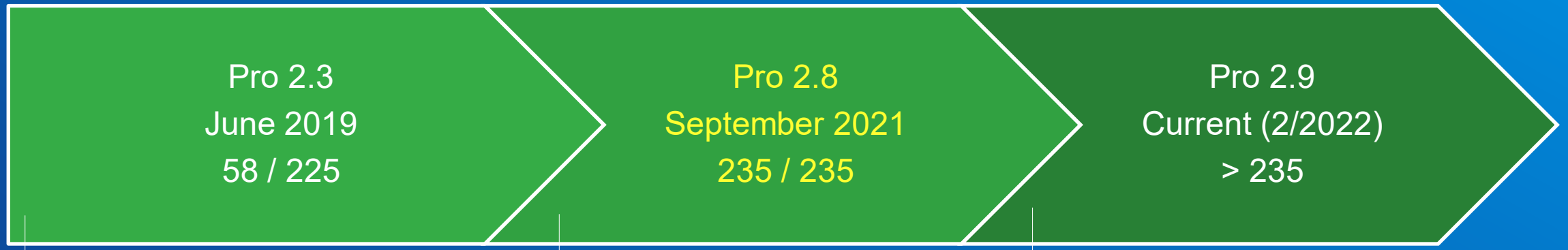


Arc Hydro in Action Webinar Series (2021)

- All webinar recordings are available on demand.

Arc Hydro in Pro Release Overview

Baseline Critical Functionality – 235 tools



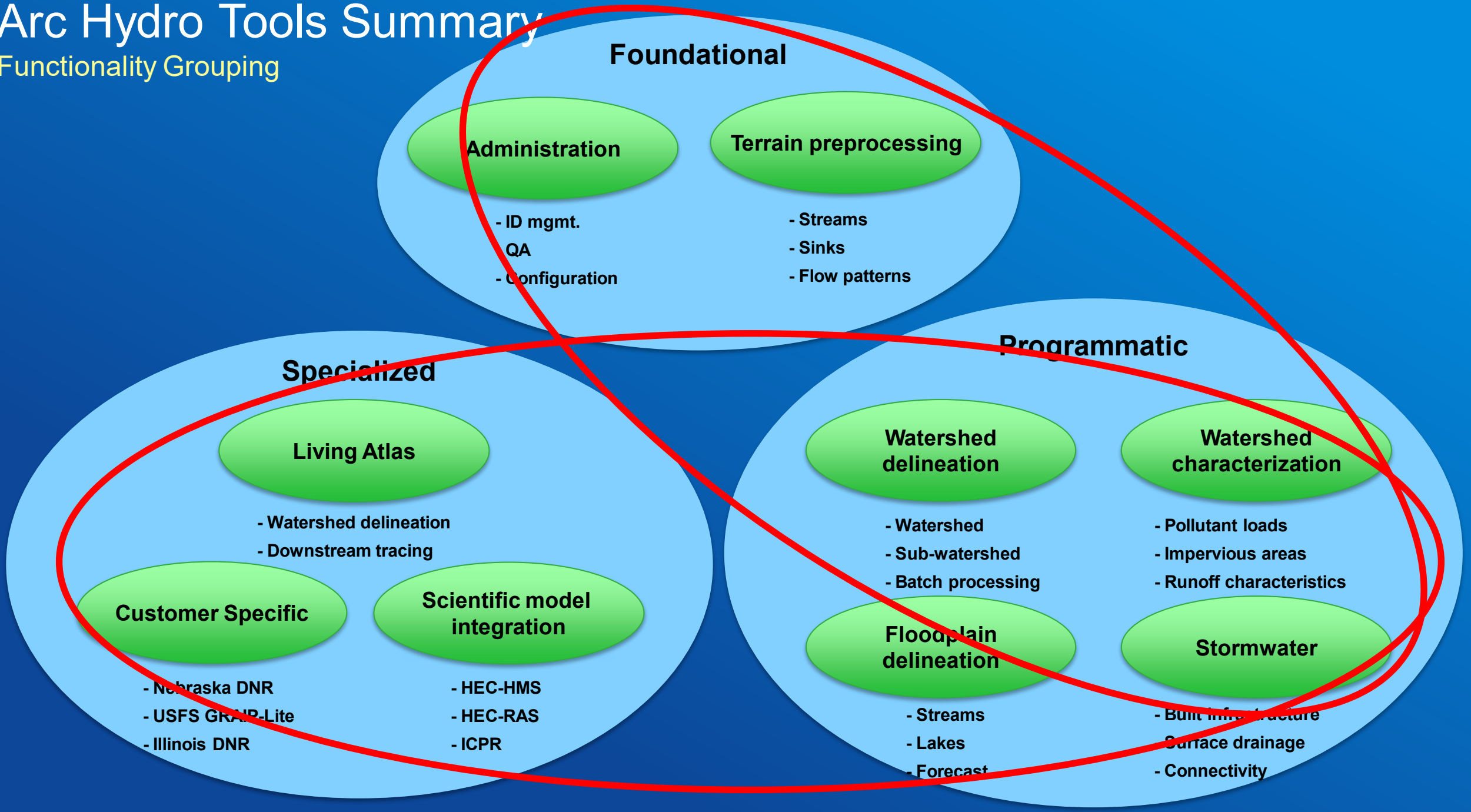
- Initiated focused migration to Pro
- Core started developing Trace Network capabilities to support migration

Completed Baseline Critical Functionality in Pro 2.8 release

Ongoing transition and maintenance of additional tools

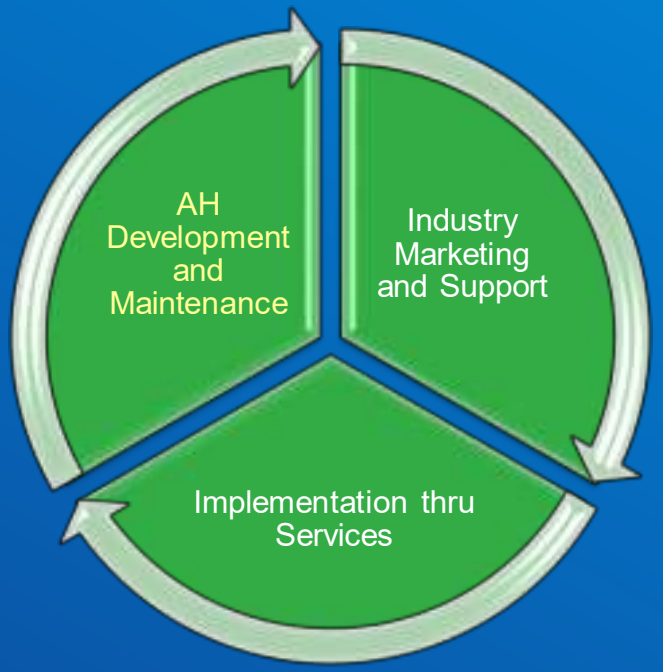
Arc Hydro Tools Summary

Functionality Grouping



Arc Hydro 2022 Planed Development

- Arc Hydro on the Web
  - “Template” to leverage Living Atlas flow forecasting services and Pin2Flood flood stack
- Additional function transition / new development
  - Hydro feature extraction, H&H modeling support
  - Support for new Spatial Analyst/Trace Network functionality
- Maintenance:
  - Pro (2.9/3.0/3.1)
  - ArcMap
- Documentation and training
  - AH workflows for key use areas
  - Training materials (Learn Lessons)



Arc Hydro Development Process

Hydro Feature Extraction

- Existing - hydro feature extraction for floodplain modeling
  - Flood modeling – terrain processing for flood support and flood forecasting (US/global/local)
    - Project work with a number of agencies. Now a well-established workflow.
- New
  - Prototyping new capabilities for WIM with FWS
  - Stream extraction – mix of AI/ML/traditional (but rule based) techniques

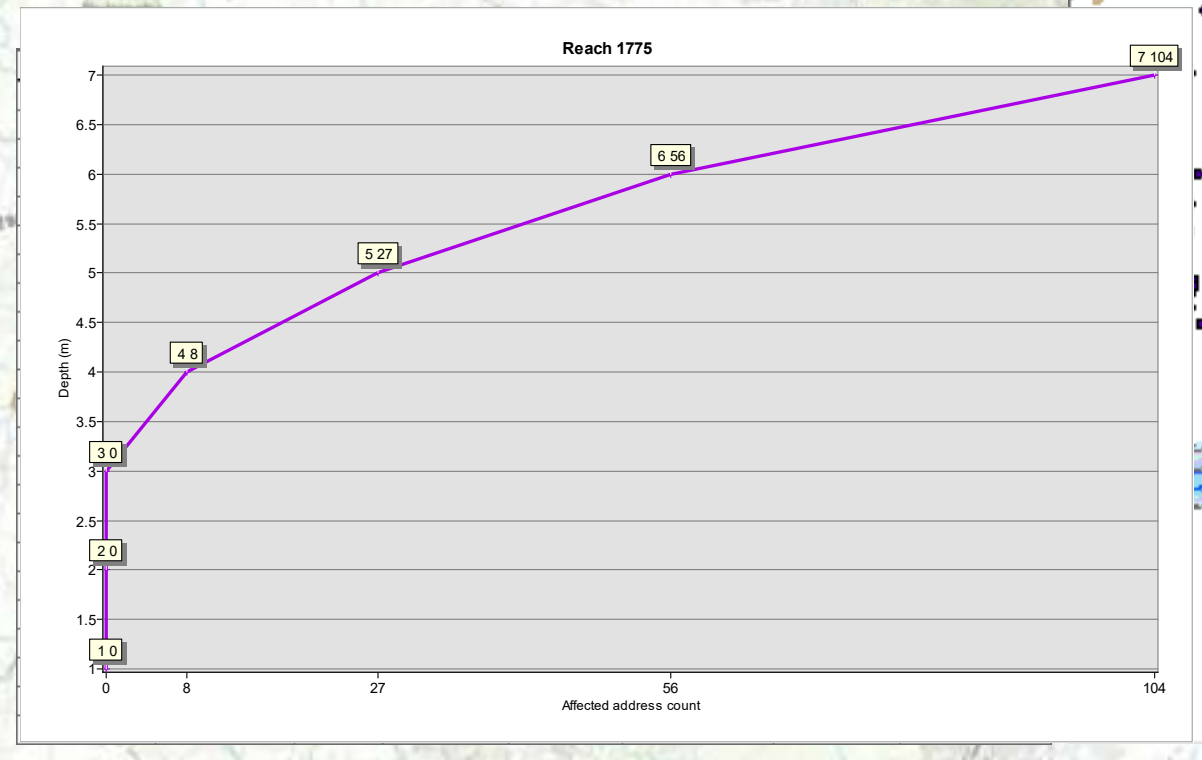
Hydro Feature Extraction for Floodplain Modeling

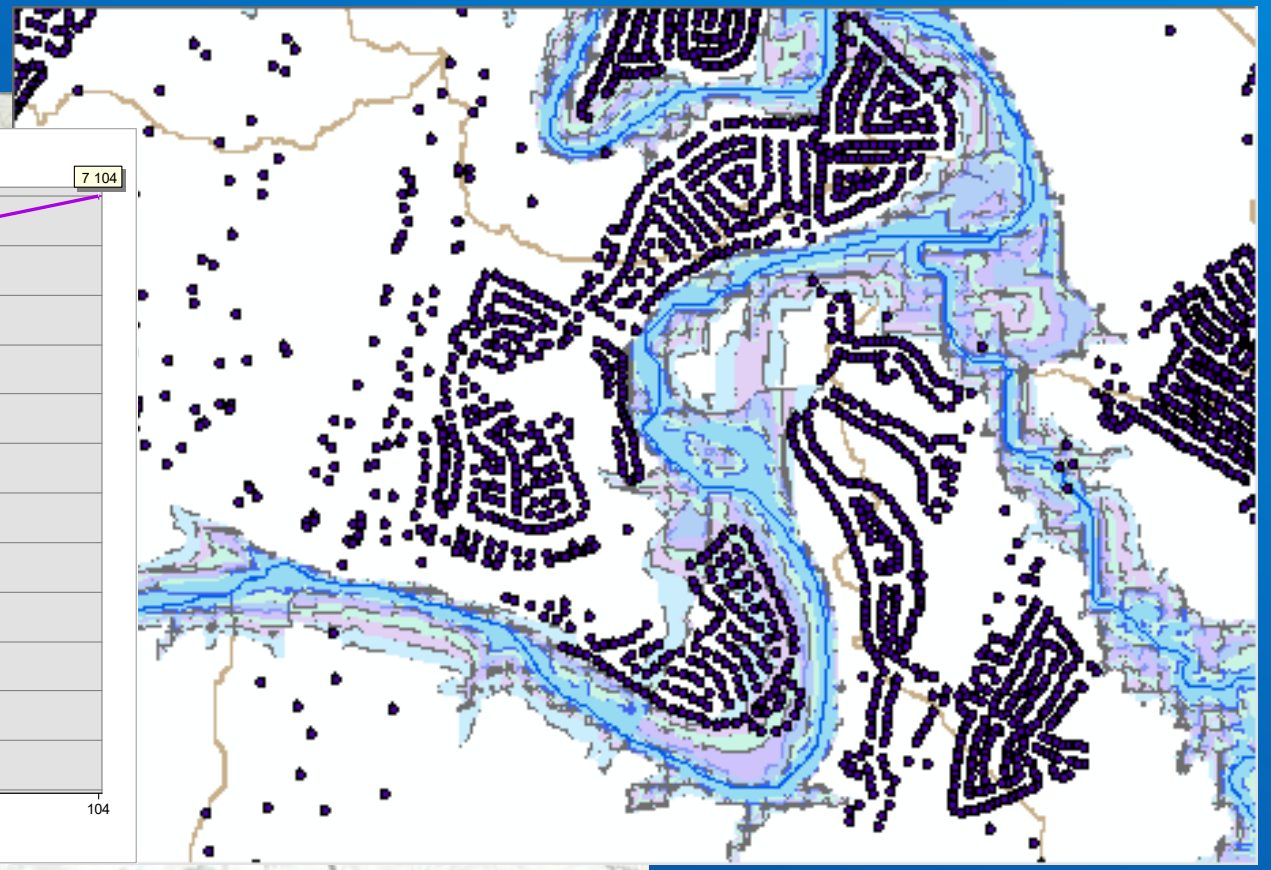
- Combining NHDPlust HR with NWM to support floodplain delineation.
- Develop horizontally and vertically integrated dataset to be used for floodplain modeling and integration with NWM flow forecasts.
- Using as starting point:
  - NHDPlusHR (DEM, NHDFlowlines)
  - NWM channel reaches (NHDPlus flowlines – NOT HR, but 100K) and catchments
  - Optionally, local channel and topo data
- HAND based flood stack derivation.
- Development of full “flood datastack” that includes flood extent polygons for each foot of depth increment, synthetic rating curves, crossover to NWM forecast reaches, etc.

Geoenable runoff forecast

Relate stages to local topography and impact assets

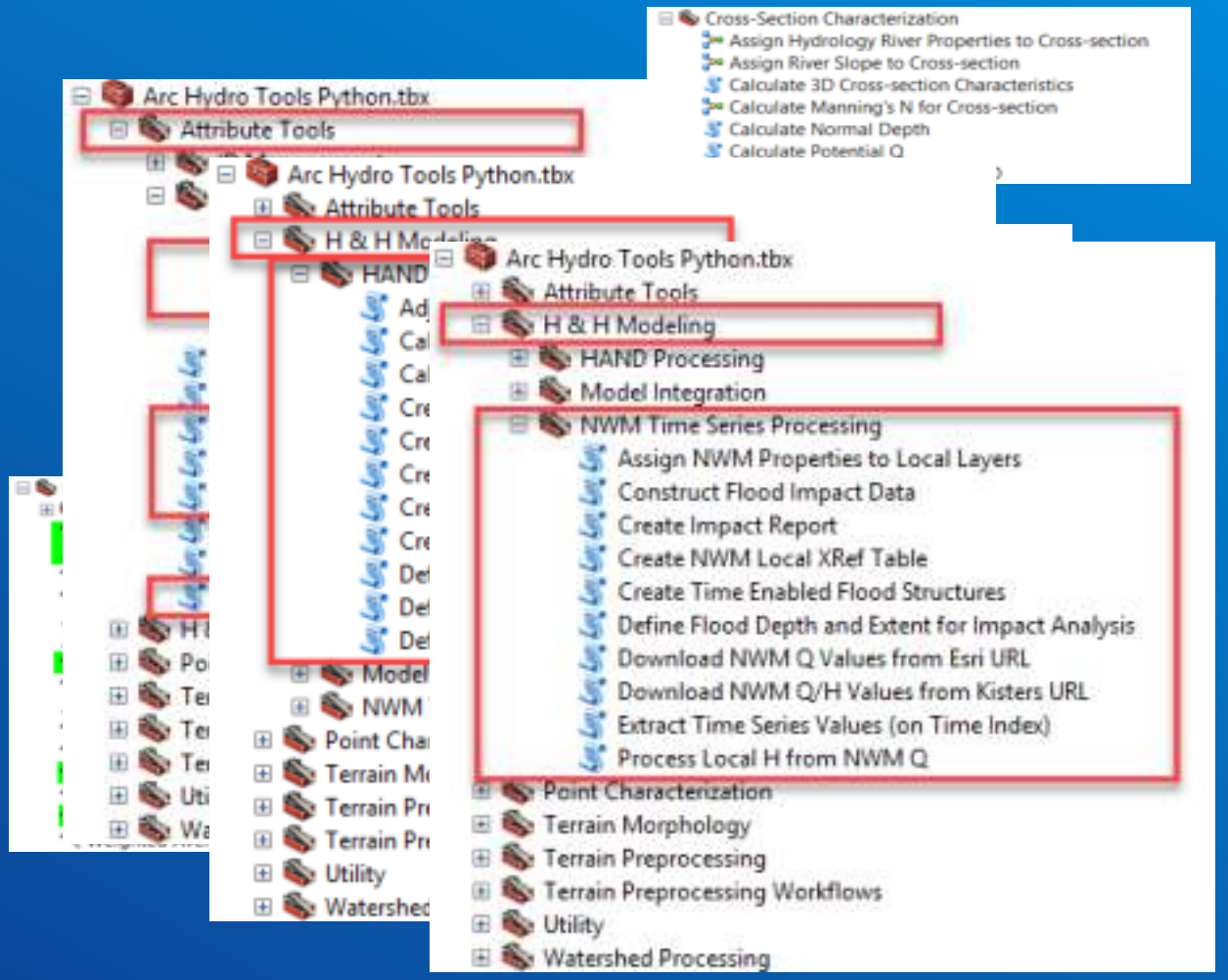
- Relating stage/water surface elevation to depth and extent of flooding.





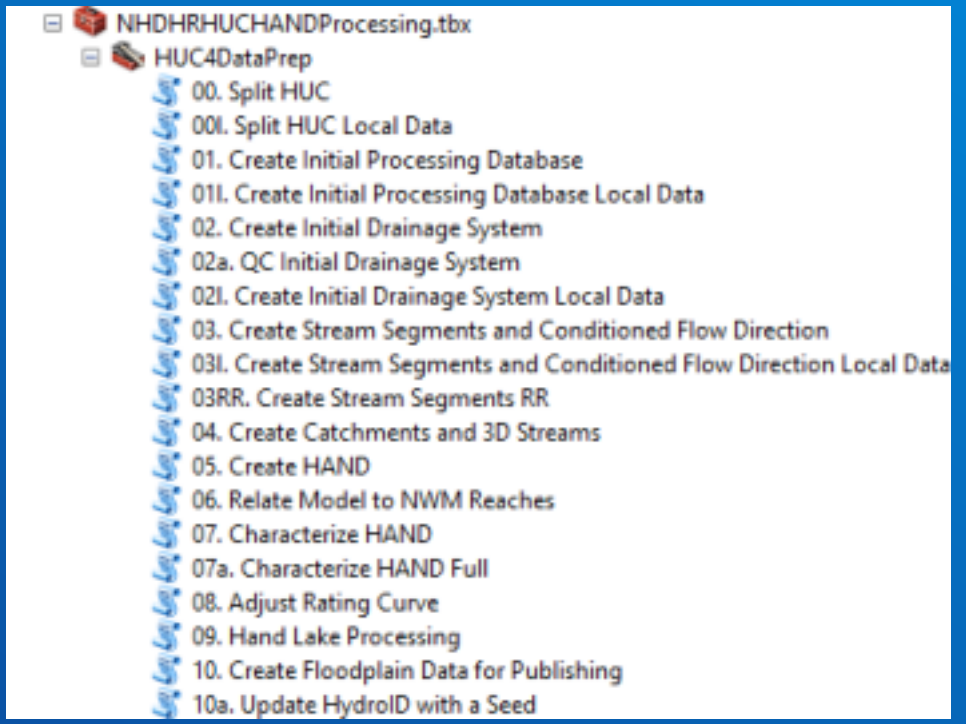
Tools For “Flood Stack” Development

- Variety of tools to accommodate available data
  - Python / Model Builder
  - Ready for “tweaking”
  - Part of Arc Hydro tools
- Workflows for landscape characterization
  - Data specific
- Custom workflows for:
  - NHDPlusHR
  - Local data



NHDPlus HR flood stack processing

- Existing custom toolbox is being rolled into Arc Hydro Pro
  - Focused on NHDPlus HR first
    - With ability to use local data following shortly
  - Streamlining the UI (less tools and parameters)
  - Optimizing for Pro



Automated Hydro Feature Extraction – Hybrid Approach

- A hybrid approach with a mix of AI and traditional GIS feature derivation techniques might offer better opportunity for automated feature extraction
- AI – Machine Learning
  - WIM & Random Forests for wetland extraction
  - MTRE Deep Learning for stream extraction
- AI – knowledge-based system
  - All about rules driving traditional GIS operations

AI - components

- Artificial Intelligence – “A branch of computer science dealing with the simulation of intelligent behavior in computers” (Merriam-Webster Dictionary)
- Branches of AI (some):
  - Machine learning and pattern recognition
  - Search
  - Knowledge representation
  - Logic-based / rule-based / knowledge-based AI
  - Heuristics
  - …

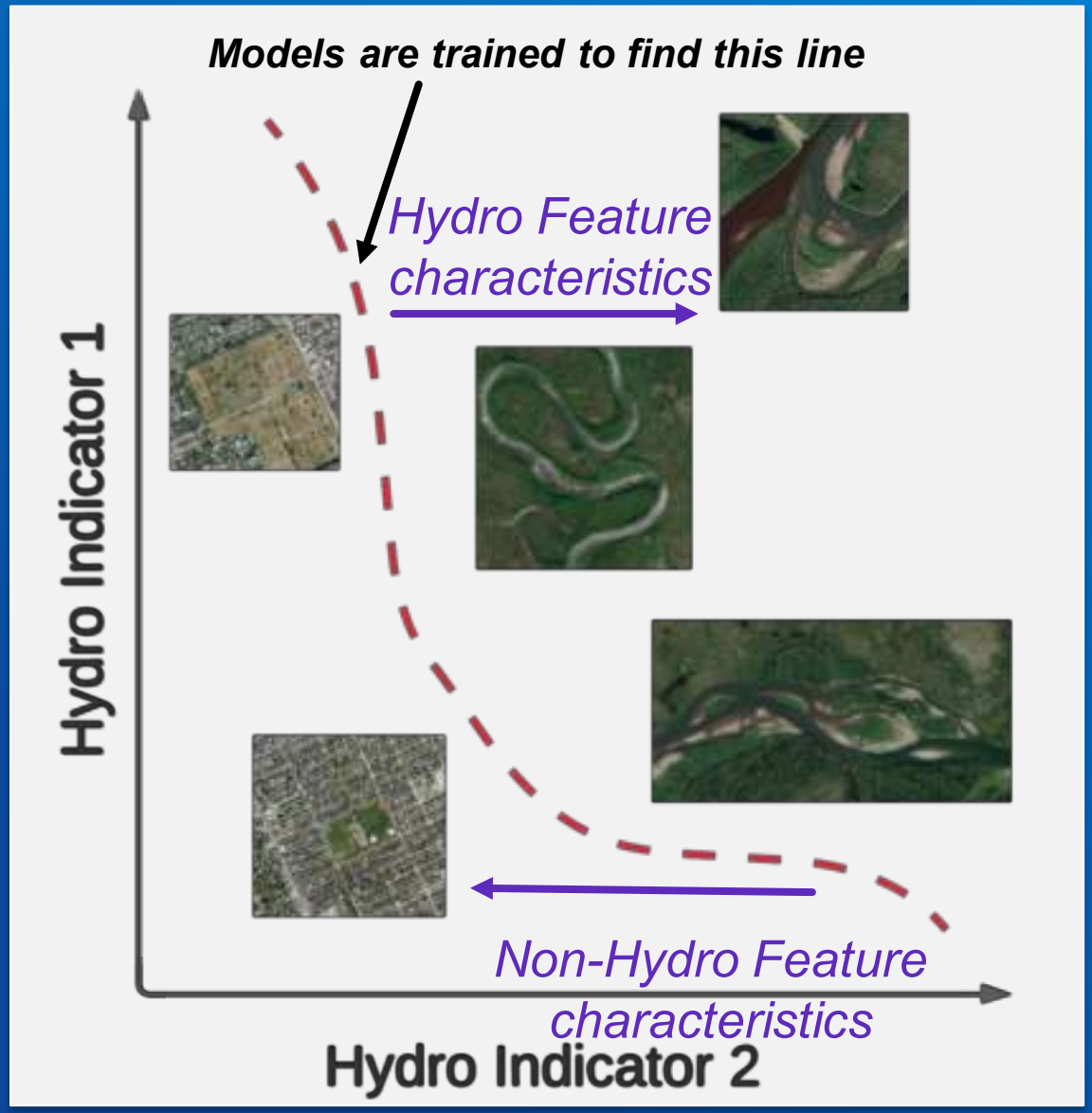
How Do AI Techniques Support More Efficient Hydro Feature Extraction?

- Automated framework
  - Repeatable across areas of interest
  - Incorporate new data or model specific scenarios
  - Integrate factual and knowledge-based processes
- Distills hydrologic indicators to their most significant components
  - Ingest many topographic derivatives and other ancillary data
  - Highlight combinations most likely to indicate hydro features
- Guides subsequent field work and manual mapping
  - Initial screening for high priority areas
  - Starting point for manual confirmation of characteristics and refinement of geometries

What is Machine Learning?

Random Forests

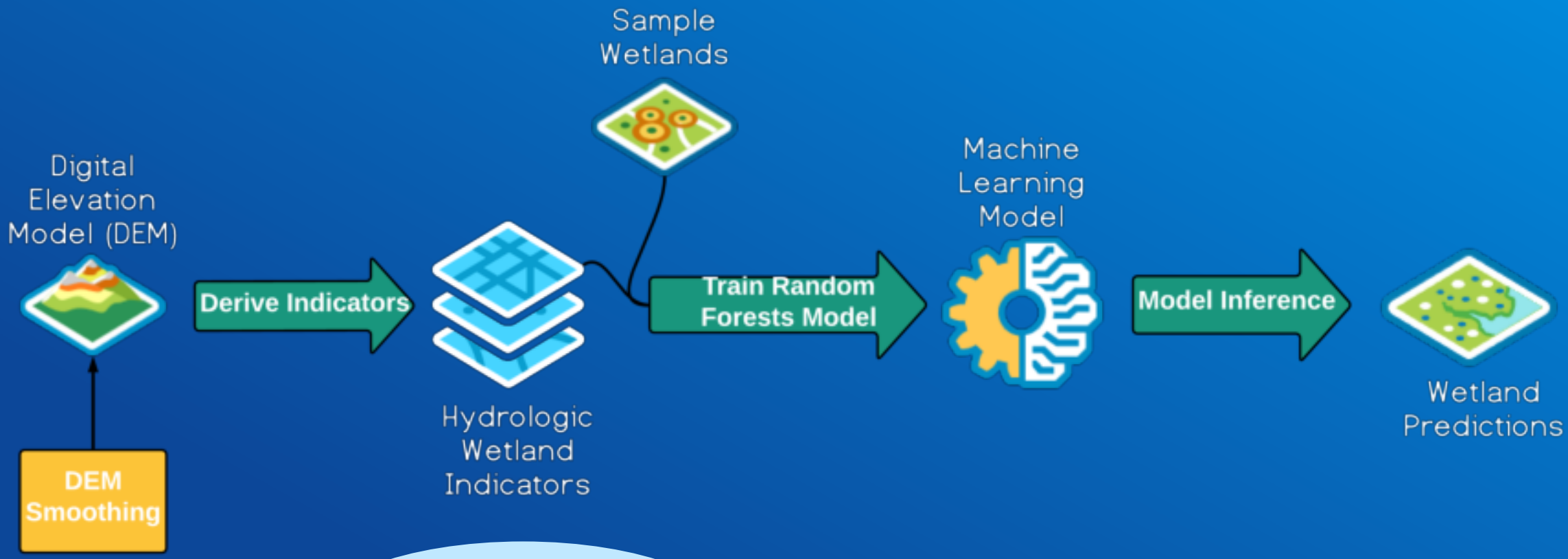
- **Pixel-by-pixel basis**
- **Learn how to identify target with decision trees**
- **We are using for areal features (wetlands, water bodies)**



Deep Learning

- **Pixel "scene"**
- **Learns how to identify target through spatial patterns**
- **We are using for connected, linear features (streams)**

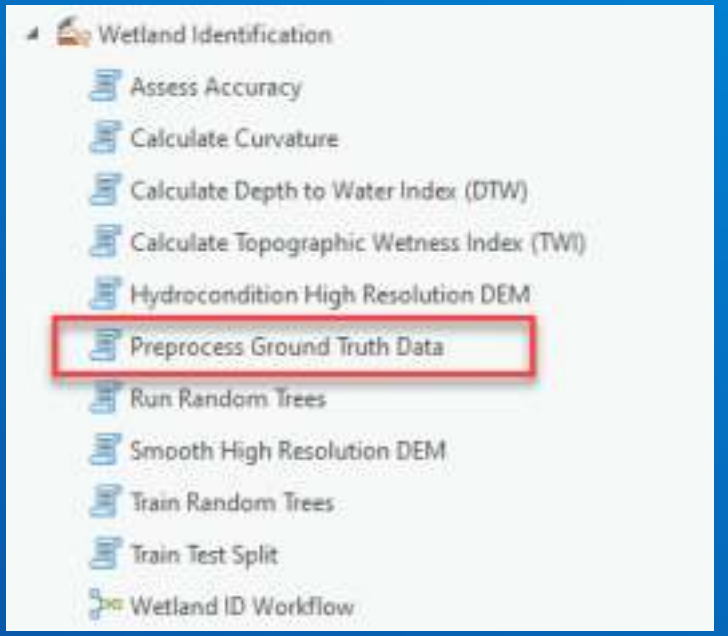
Basic Principles for AI Feature Extraction



Geomorphology as a proxy for near-surface inundation and soil moisture

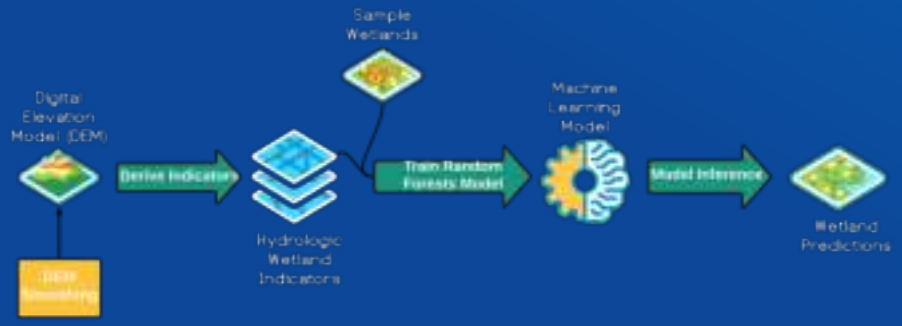
What's new with WIM

- Wetland Identification Model has been part of Arc Hydro Pro for several years now.
  - New tool for ground truth data process automation
- Current FWS NWI collaboration focusing on:
  - Calibrating model configuration for wetlands in complex landscapes
    - Recommendations for users
    - Expanded set of wetland indicators
    - Built-in automation to derive new wetland indicators
  - June completion
    - Possibly a webinar afterwards (fall/winter 2022)



Deep Learning for Streams: Multi-Task Road Extractor

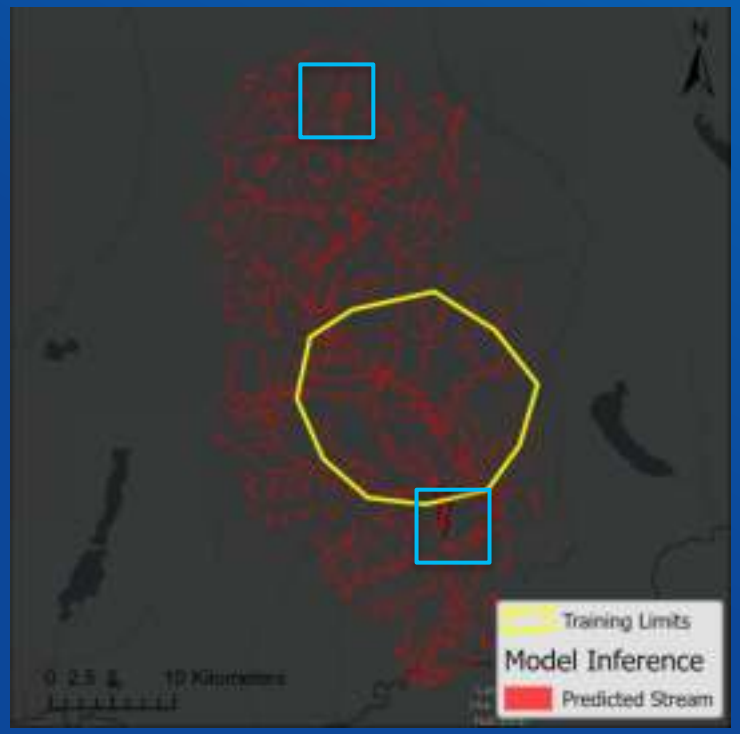
- Inspired by human learning patterns
- Learns sub-tasks in parallel
- When applied to roads, sub-tasks are:
  - How to identify road pixels
  - How to trace lines to connect them
- Proof of concept for applying this to streams

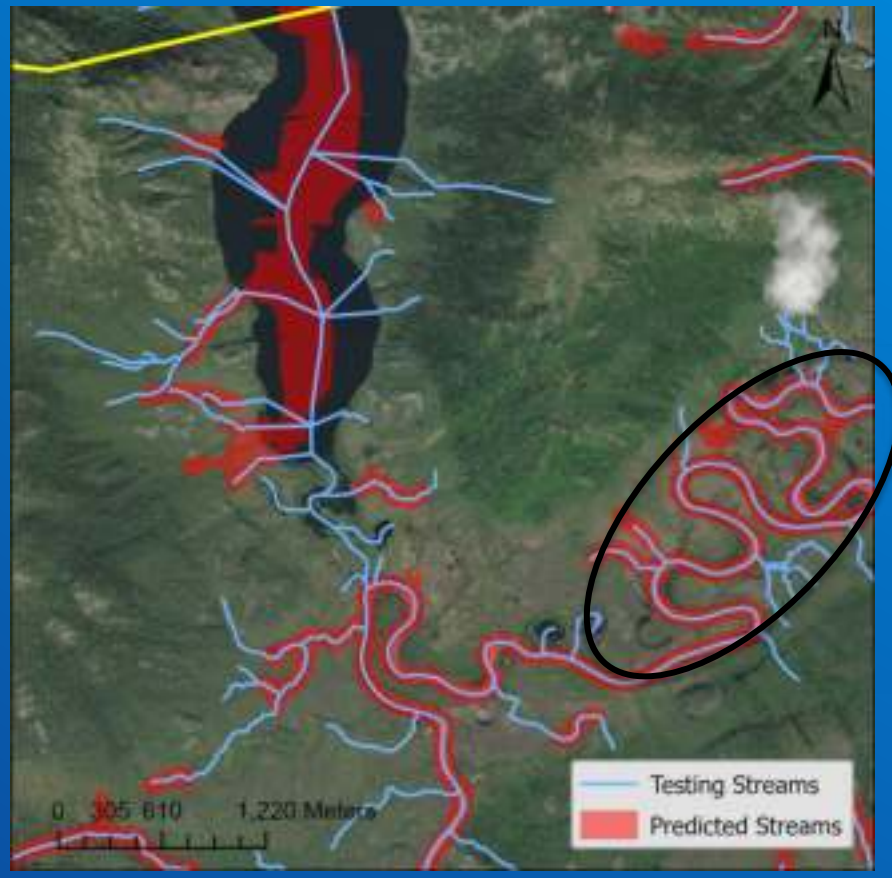


Orientation

Segmentation

MTRE for Streams in Alaska (Beaver Creek) - Results





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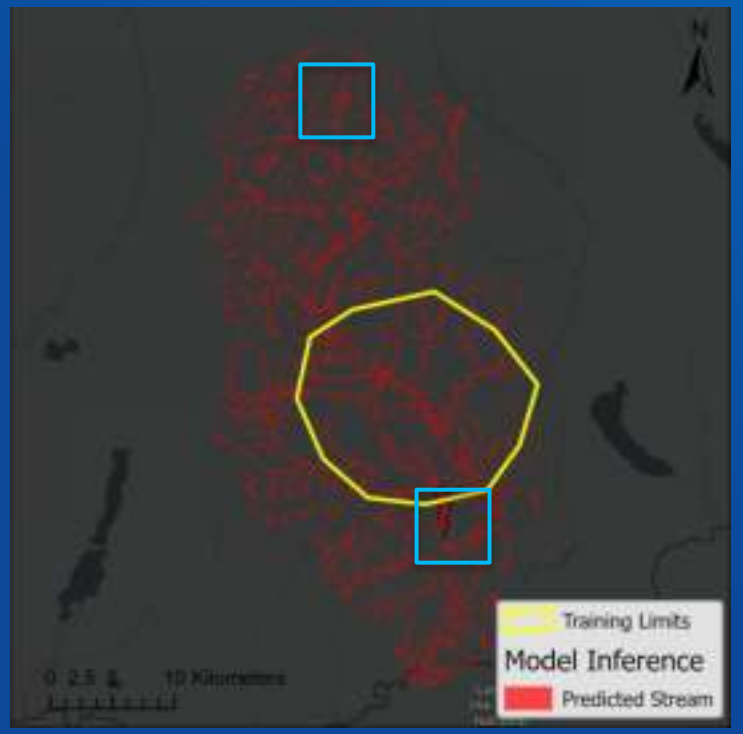
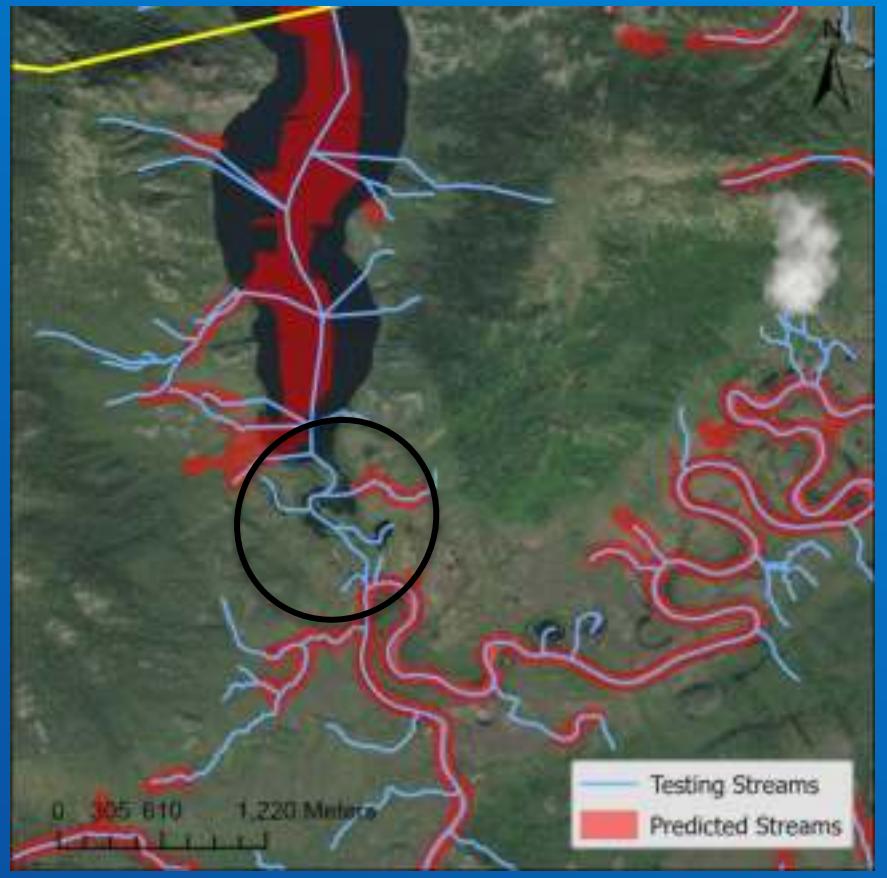




Components of “Processing”

Definition of Expert Systems

- “An expert system is regarded as the embodiment within a computer of a knowledge-based component from an expert skill in such a form that the system can offer intelligent advice or take an intelligent decision about a processing function” (British Computer Society).

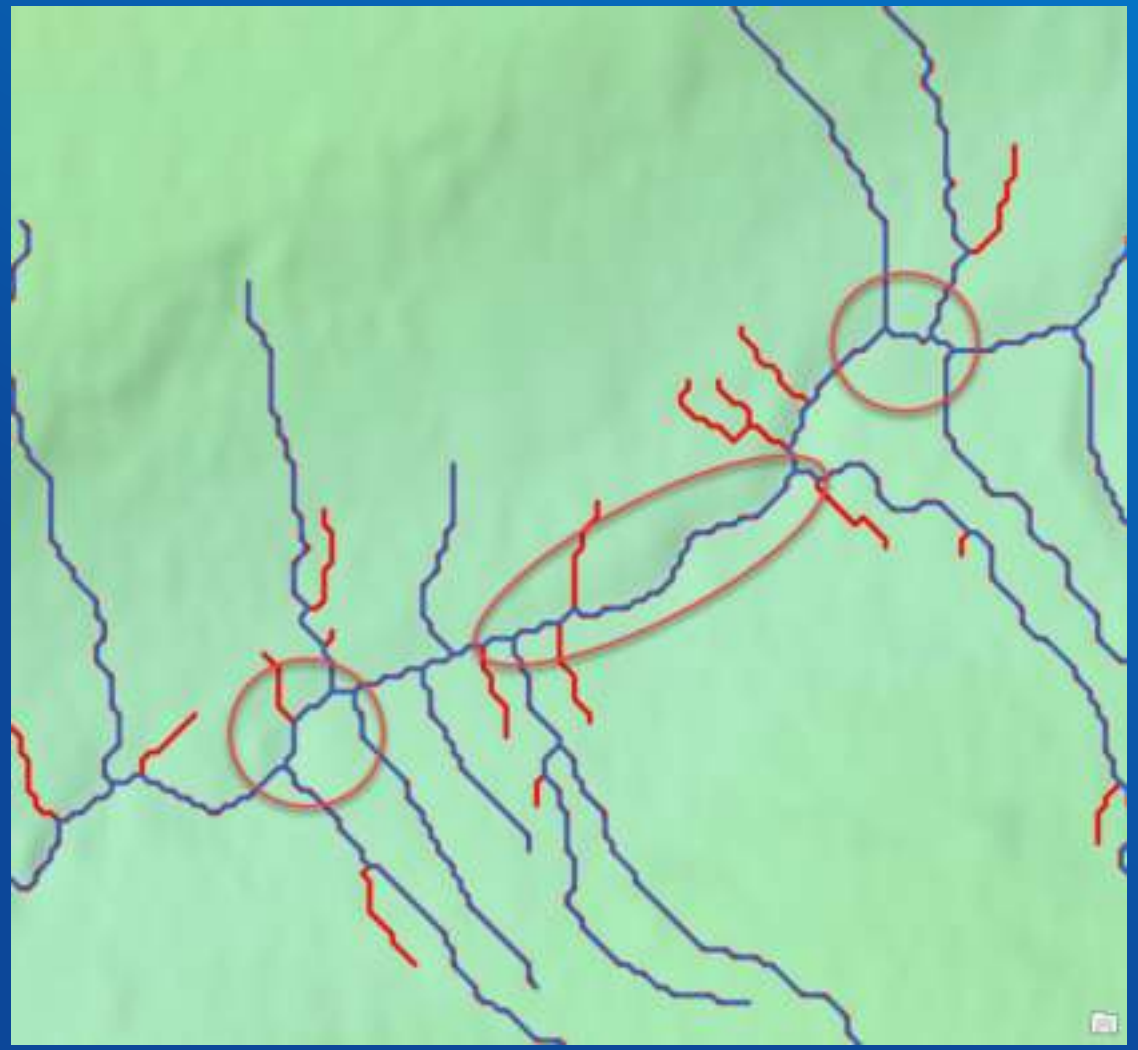
Siddall, 1990; Robinson and Frank, 1986

Features of Expert Systems

- Separation of knowledge-base and control.
  - The knowledge-bas, consisting of reasoning world (rules) and material world (objects), is separate from the control – inference engine that determines the order in which rules are evaluated.
- Transparency of knowledge representation.
  - The rules should be readable and understandable to some degree by just looking at their written form.
- Incremental growth capability.
  - The expert system should be useable with only a subset of the knowledge-base, and the knowledge-base can be extended over time without any need for restructuring it.

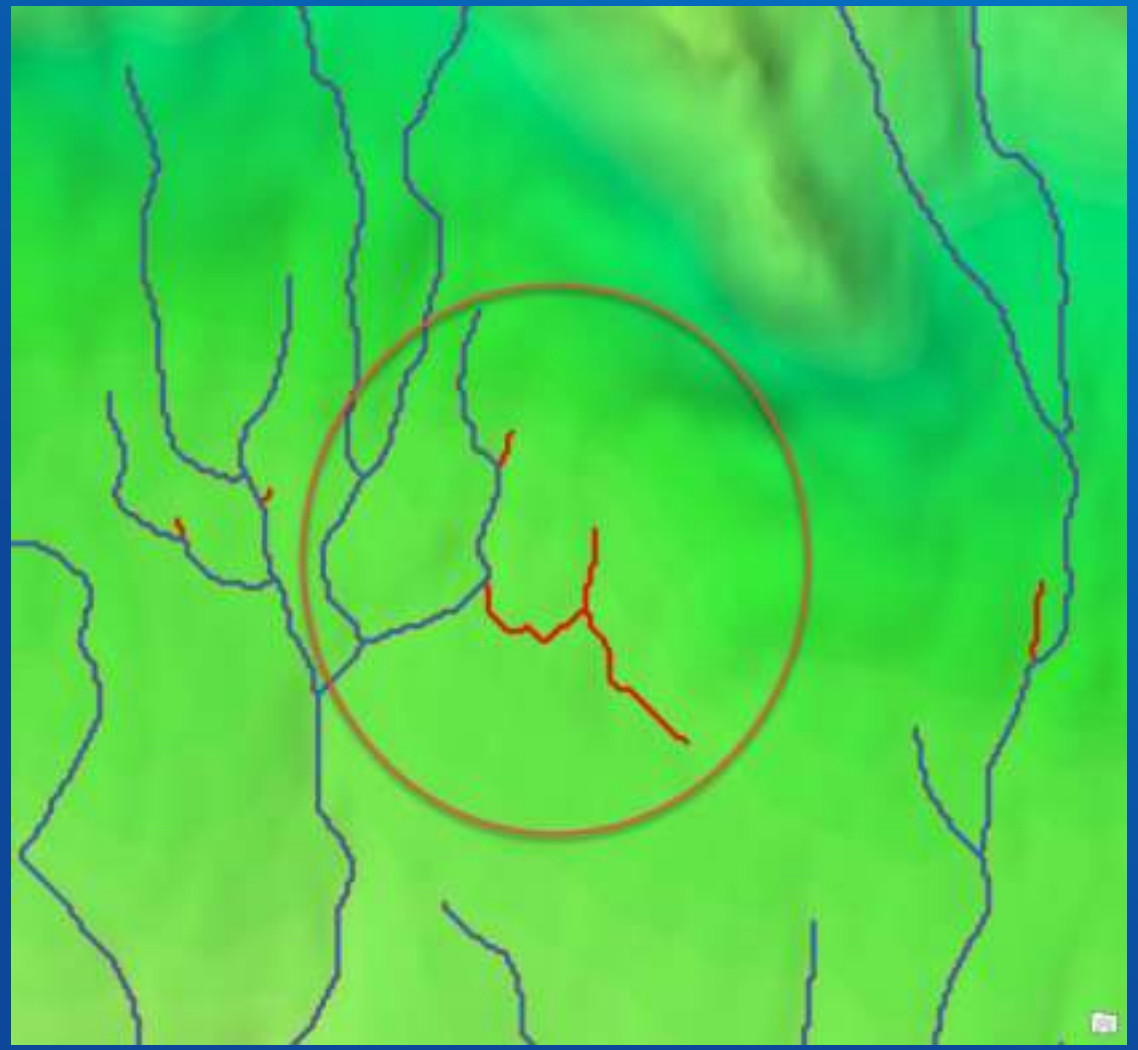
Fenves, 1986

Examples of Where we Need Rules



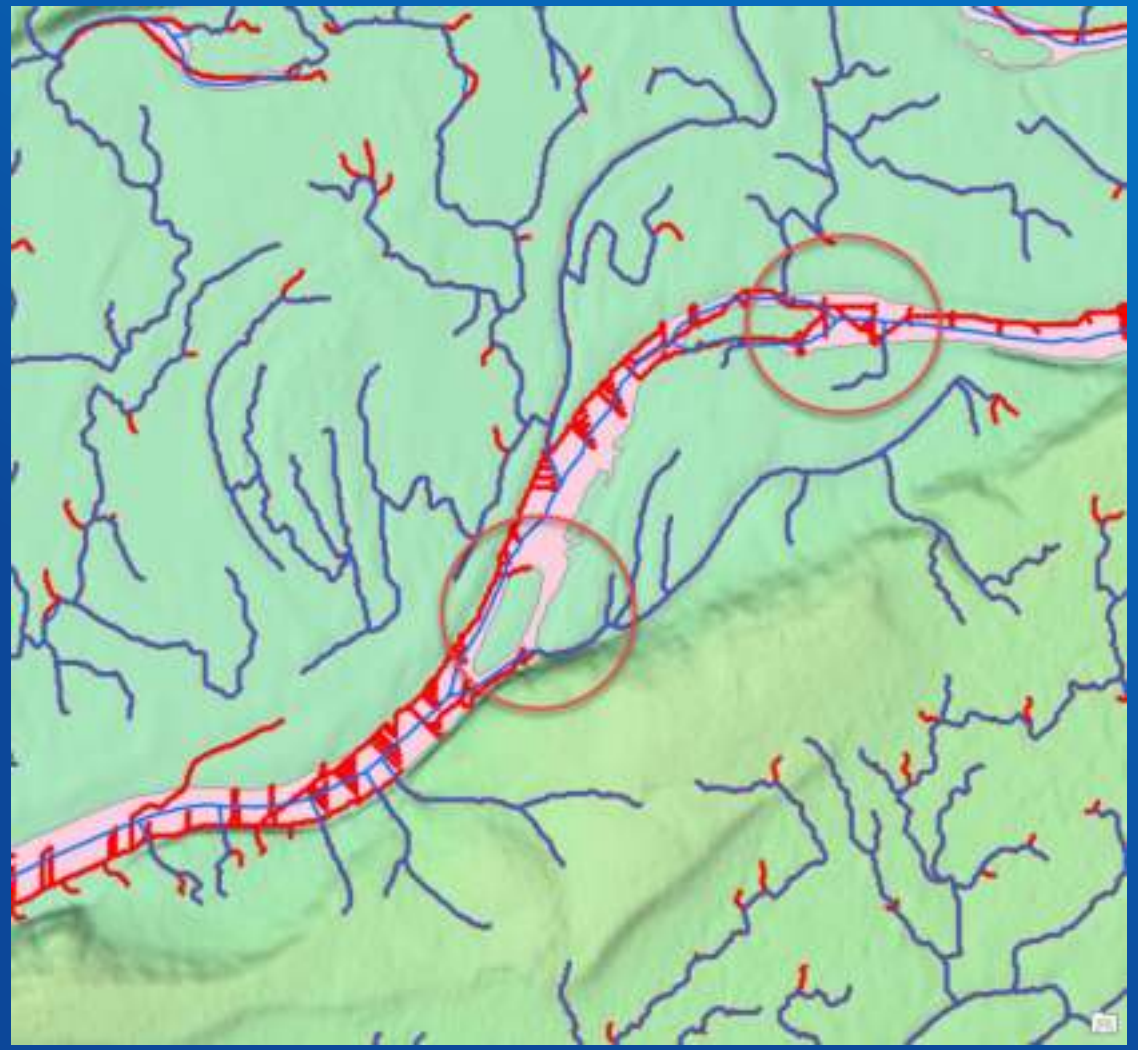
- Easy:
  - “Small” segments (head/middle)
    - Length?
    - Drainage area?
    - Stream order?
  - Compound/combination rules (“and” statements)

Examples of Where we Need Rules



- Not so easy:
  - Which one?
    - Why?
  - Why keep right and not left?
    - More in the middle?
  - Where did the branch go?
    - Is this the “same” as the previous problem?

Examples of Where we Need Rules



- And there is this:
  - Fuzziness within flat areas
    - Getting rid of fuzzies
    - Realigning the “centerline”
  - Branches
    - Why one but not the other?

Examples of Potential Rules

- All about rules (can vary based on scale, region – that can also be captured in the rules)
- Stream density (e.g. km/km2)
  - But at what watershed size
- Contributing area (downstream progression)
- Length (min and/or max)
- Arbolate length/sum
- Stream order
- …

Hybrid “Processing”

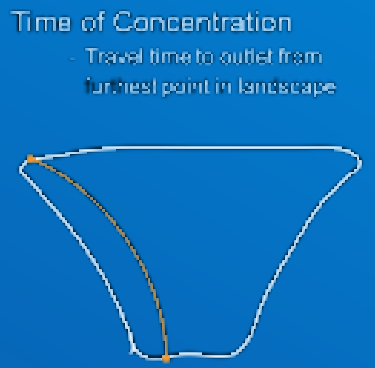
Machine Learning AI

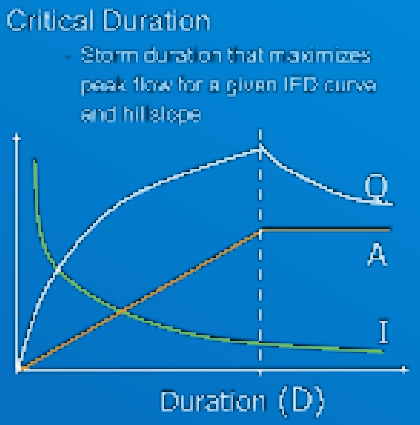
Rule-based AI

“Good hydrography”

H&H modeling

- New capabilities for hydrology (tweaks to hillslope method)

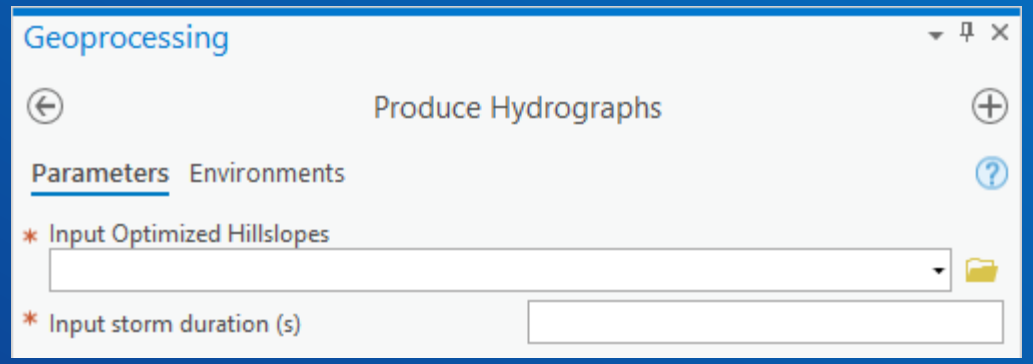




- Hydraulics (addition to RAS export capabilities)

Hillslope and Critical Duration Toolset

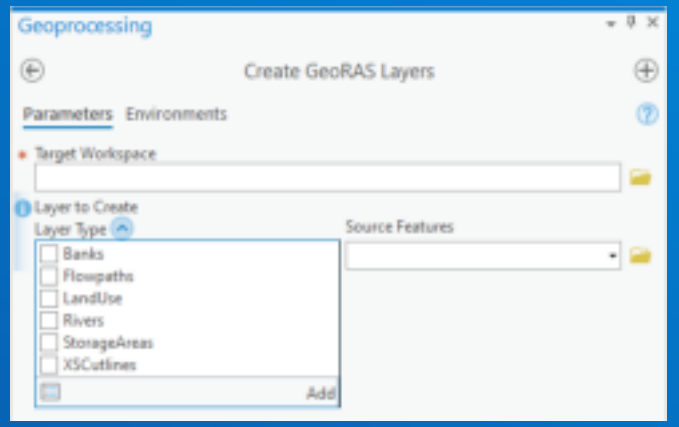
- New tool – “Produce Hydrographs” (in Critical Duration toolset).

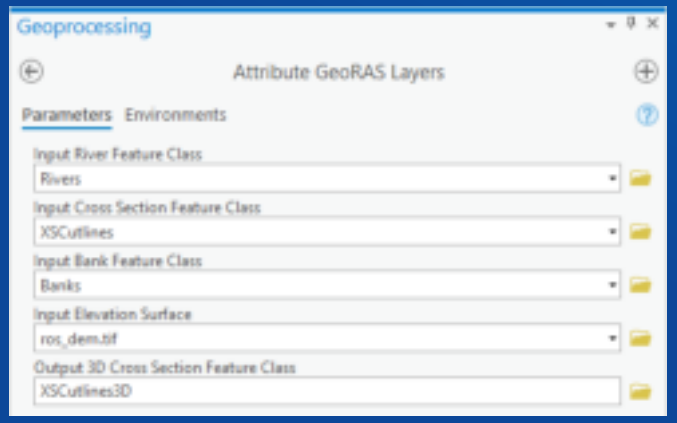


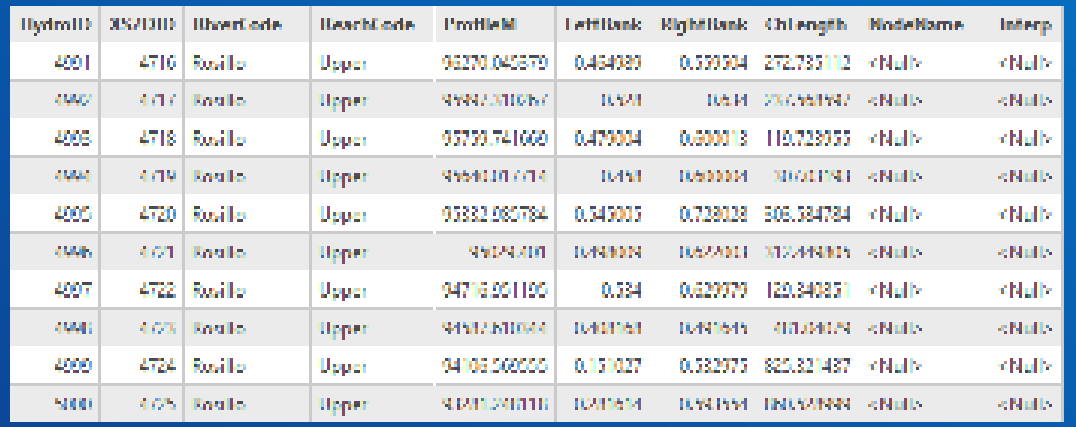
- Additional tweaks to the code and workflow to minimize user inputs and more robust hillslope width calculation.
- Updated documentation (user guide and sample dataset).

HEC-RAS Preprocessing – New Tools

- Two new tools
  - Create GeoRAS Layers
    - Create empty or import from existing layers following predefined data schema
  - Attribute GeoRAS Layers
    - Populate most popular attributes







HEC-RAS Preprocessing – Planned Capabilities

- Cross-sections:
  - Calculating roughness coefficients and exporting them.
  - Calculating left/right flowpath lengths and exporting them.

Community Engagement (Dev Perspective)

- “Getting started”
- Documentation
  - Tools
  - Workflows
- Training
  - Self
  - Instructor led (standard, custom)
- Ad-hoc support
  - Installation
  - Specific implementation problems

Arc Hydro: Getting Started

Learning about Arc Hydro: Resources and Documentation

- https://go.esri.com/AH_Resources

Getting Started with Arc Hydro

- https://go.esri.com/AH_Getting_Started