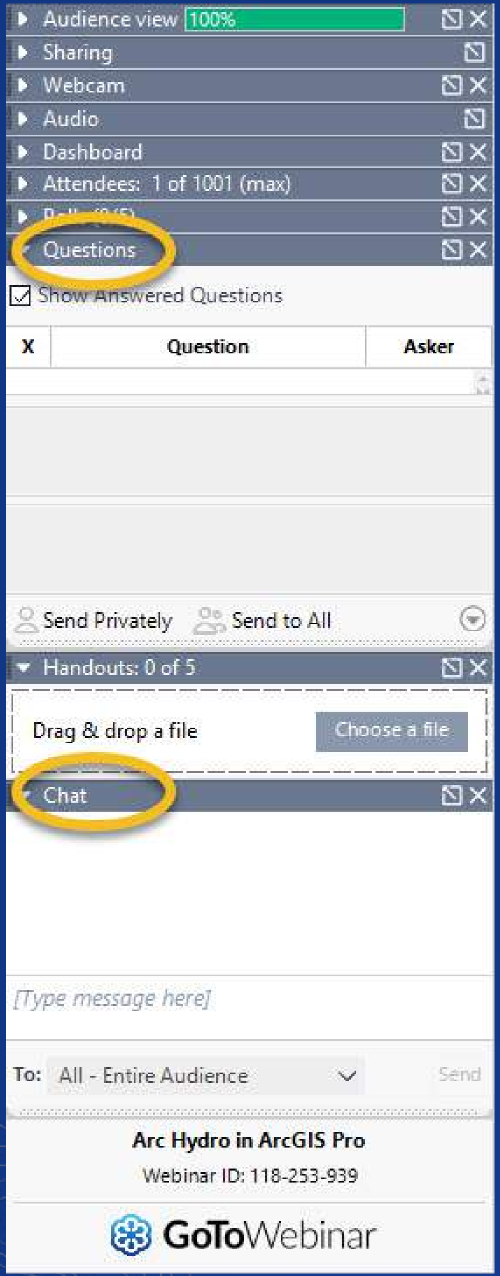
Arc Hydro in Action Webinar Series

2/25/21: Arc Hydro in ArcGIS Pro

3/11/21: Arc Hydro: Flooding & Forecasting

3/25/21: Arc Hydro: Hydrology & Hillslope

4/15/21: **Arc Hydro: Support for Hydrologic and Hydraulic Modeling**



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Arc Hydro in ArcGIS Pro
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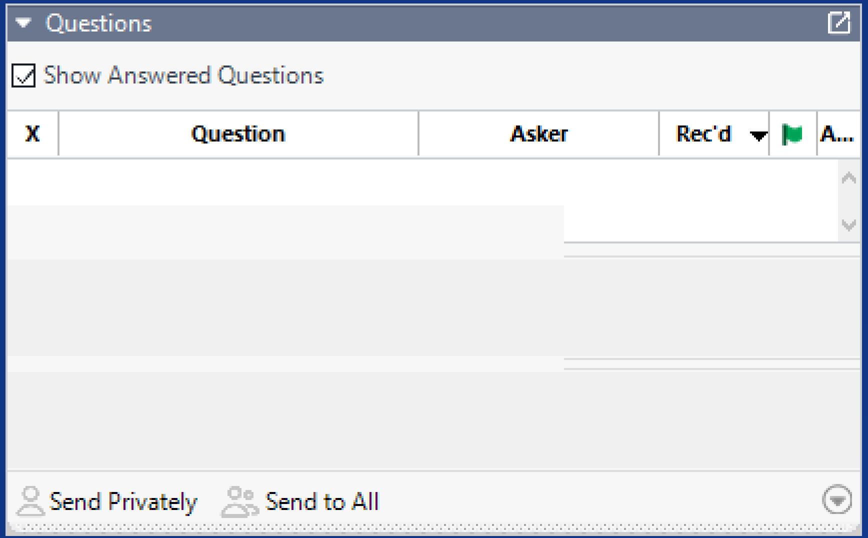

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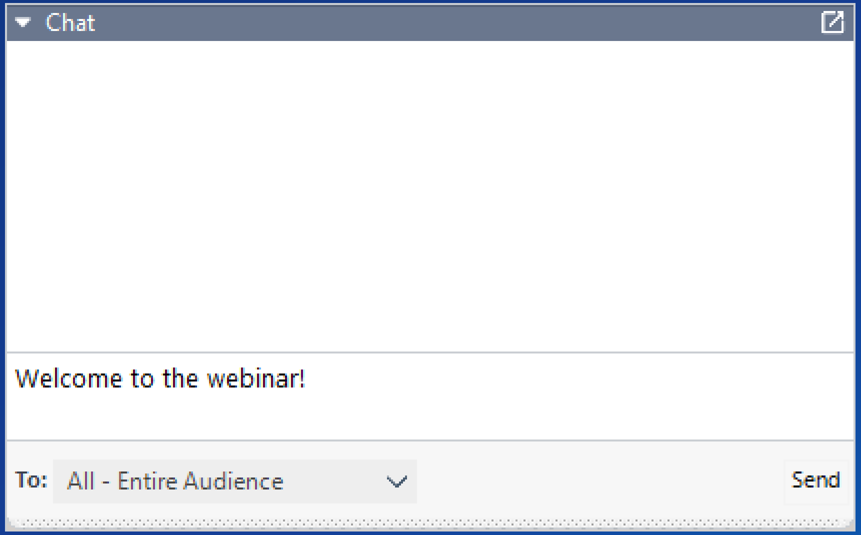

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Welcome to the webinar!
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Announcements

Watch first three webinars at your convenience

- Arc Hydro in ArcGIS Pro
- Arc Hydro: Flooding & Forecasting
- Arc Hydro: Hydrology & Hillslope

- Applied Meteorology Using ArcGIS (webinar series)

Polling Questions

Did you attend or watch any of the first three webinars?

- Yes, Arc Hydro in ArcGIS Pro
- Yes, Arc Hydro: Flooding and Forecasting
- Yes, Arc Hydro: Hydrology & Hillslope
- No

Presenters:

Pete Singhofen, PE

President

Streamline Technologies

Warren McKinnie

Senior Water Resources Engineer

Streamline Technologies

Dean Djokic, PhD

Water Resources Practice Manager

Esri

Arc Hydro:
Support for Hydrologic and Hydraulic Modeling

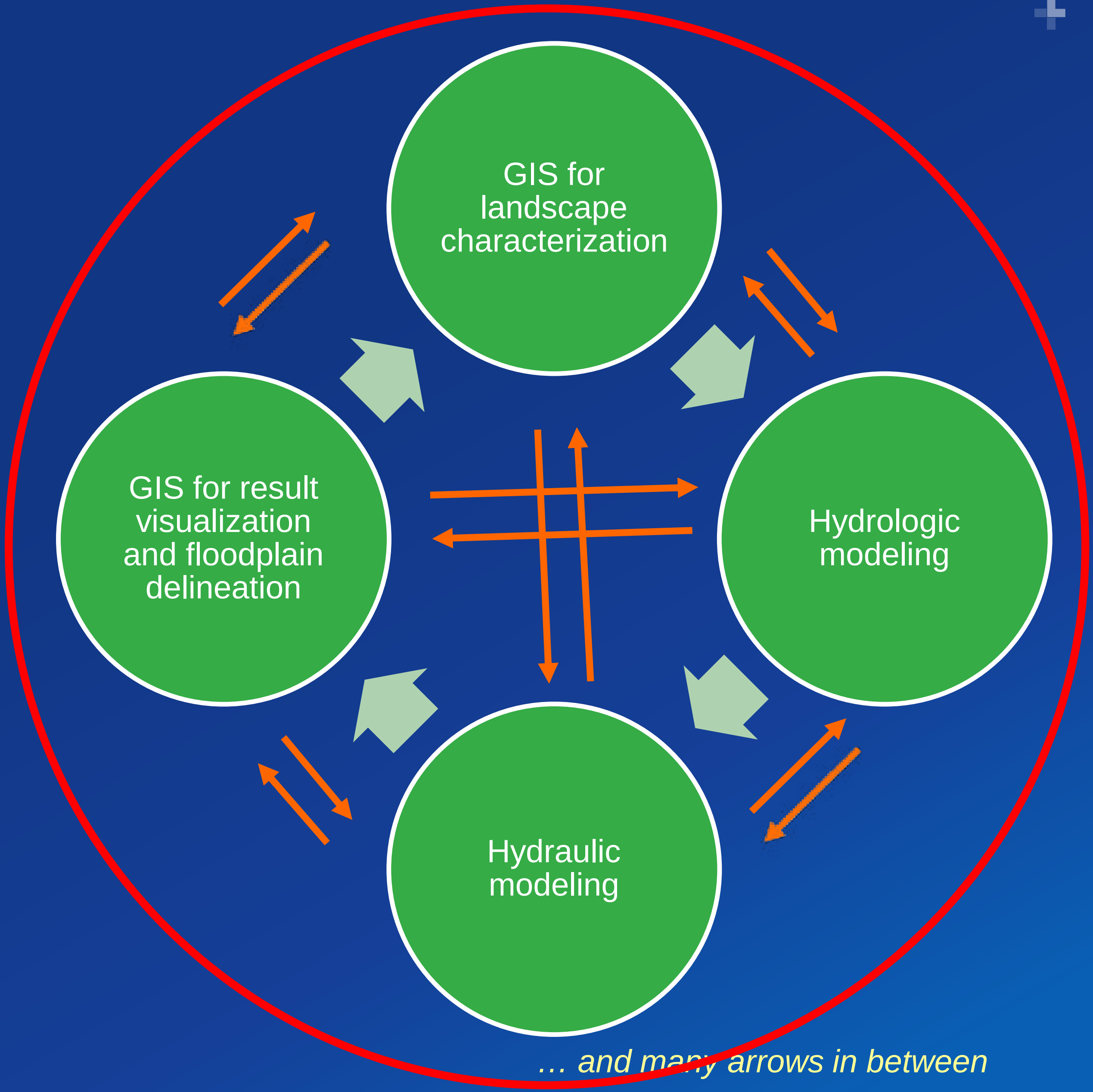
2021 “Arc Hydro in Action” Webinar Series

Webinar 4 Topics

- Review of the series.
  - Arc Hydro Groundwater
- Fundamentals of model integration
- H&H modeling through use cases
- Final thoughts
- Questions

GIS for Hydro Modeling "Cycle"

- **GIS is used for landscape characterization and model parametrization.**
- **Hydrology and Hydraulics (H&H) is used for determination of flows, depths and velocities.**
- **GIS is used for result postprocessing and visualization.**
- **GIS and H&H modeling are closely connected as one impacts the other**



… and many arrows in between

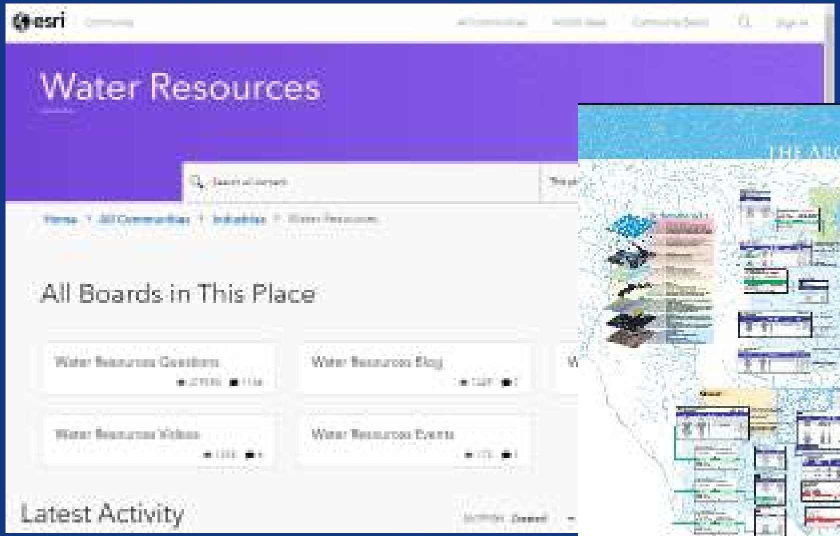
Model Integration Use Cases

- Tight coupling
  - StreamStats (tight, but not so tight)
  - PEI Culvert Calculator
- Groundwater – MODFLOW
- Lose coupling
  - HEC-GeoHMS, HEC-GeoRAS
  - ICPR4

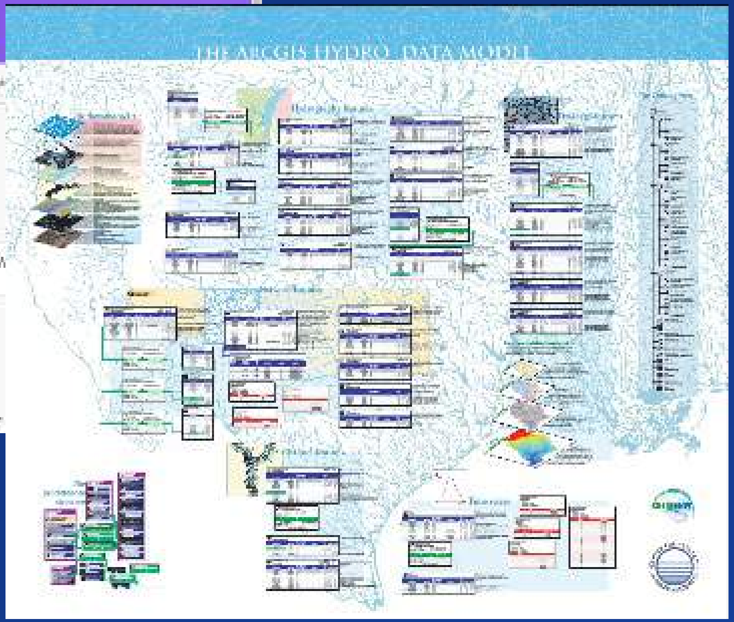
Review of Series

Arc Hydro: Vision

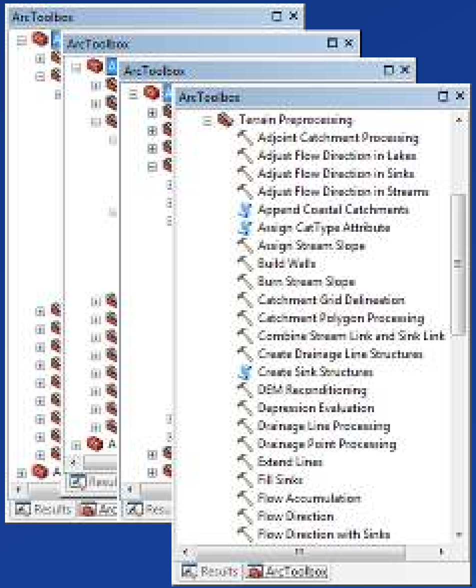
“Provide practical GIS framework for development of **integrated analytical systems** for water resources market.”



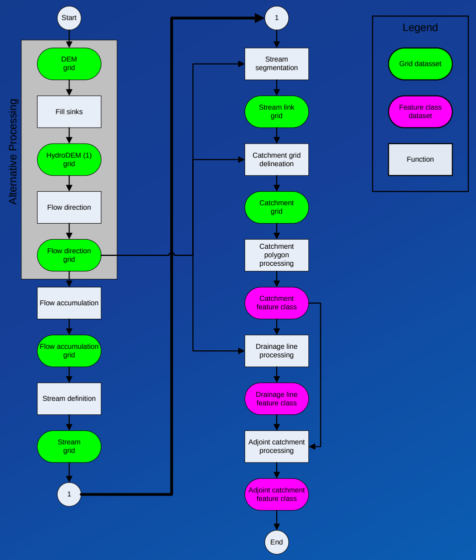
Community



Data Model



Tools



Workflows

Arc Hydro Tools Summary

Functionality Grouping

Foundation

Administration
- ID mgmt.
- QA
- Configuration

Terrain preprocessing
- Streams
- Sinks
- Flow patterns

Specific implementations

Living Atlas
- Watershed delineation
- Downstream tracing
- Floodplain delineation

Customer Specific
- Nebraska DNR
- USFS GRAIP-Lite
- Illinois DNR

Scientific model integration
- HEC-HMS
- HEC-RAS
- ICPR

General implementation domains

Watershed delineation
- Watershed
- Sub-watershed
- Batch processing

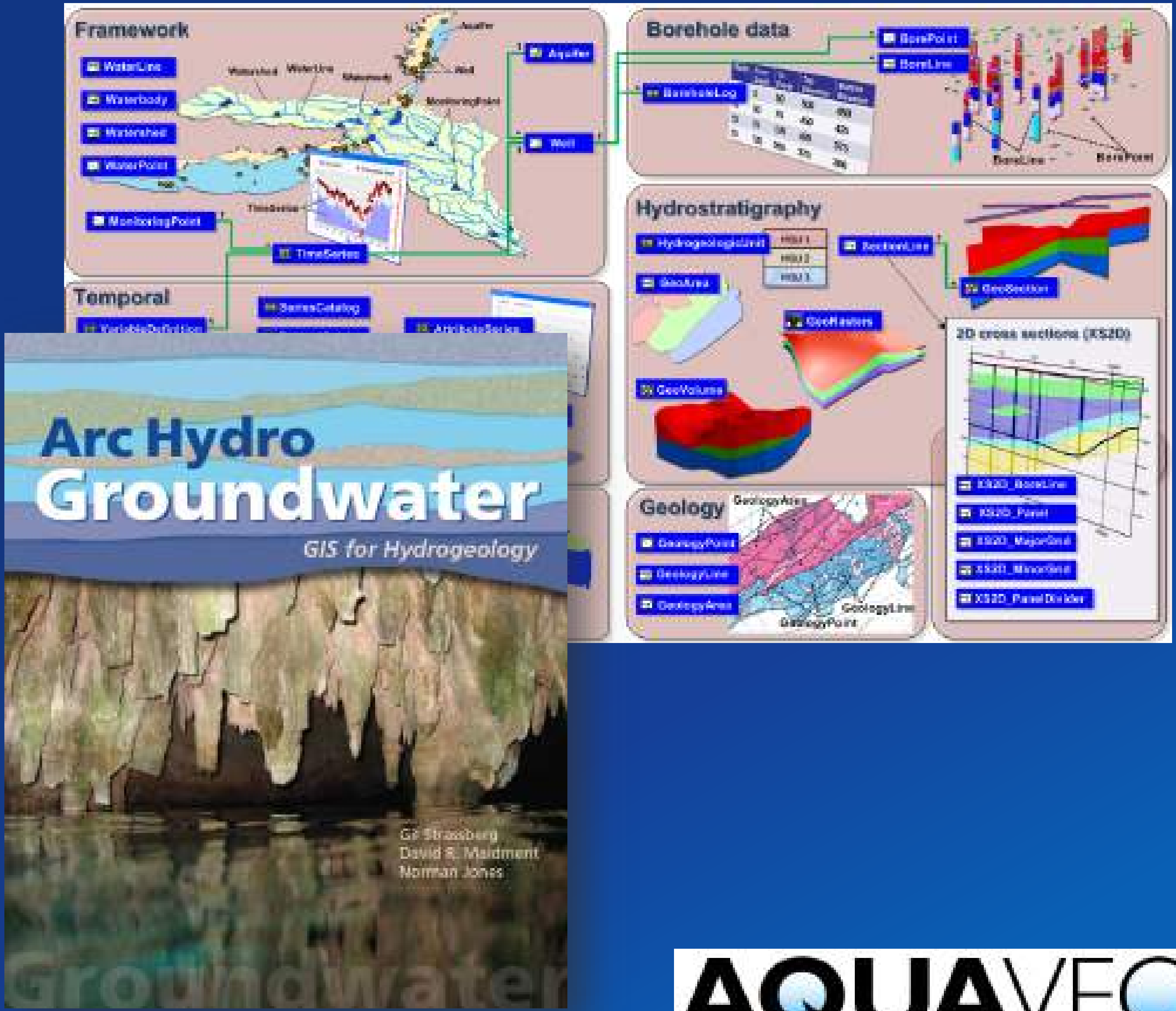
Watershed characterization
- Pollutant loads
- Impervious areas
- Runoff characteristics

Floodplain delineation
- Streams
- Lakes
- Forecast

Stormwater
- Built infrastructure
- Surface drainage
- Connectivity

Arc Hydro Groundwater

- Project launched in 2004:
  - Dr. David Maidment @ Texas
  - Dr. Norm Jones @ BYU
  - Dr. Gil Strassberg @ Aquaveo
- 2006 – first draft (Gil’s Ph.D. work)
- 2007 – Aquaveo – Esri agreement on tool development
- 2009 – AHGW tools released
- 2011 – book published



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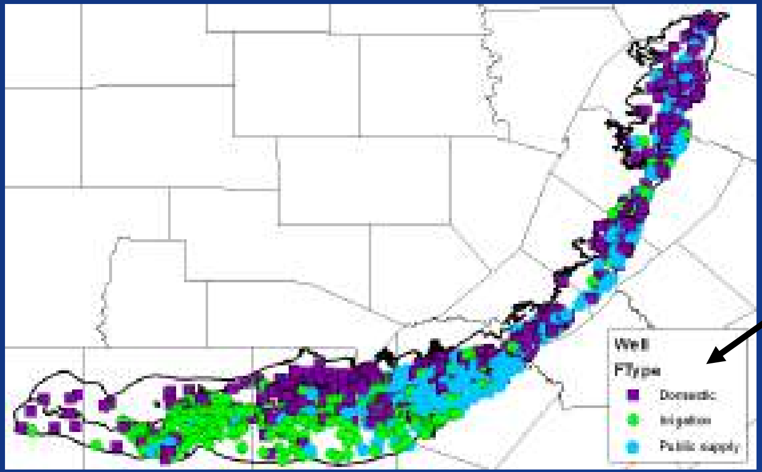
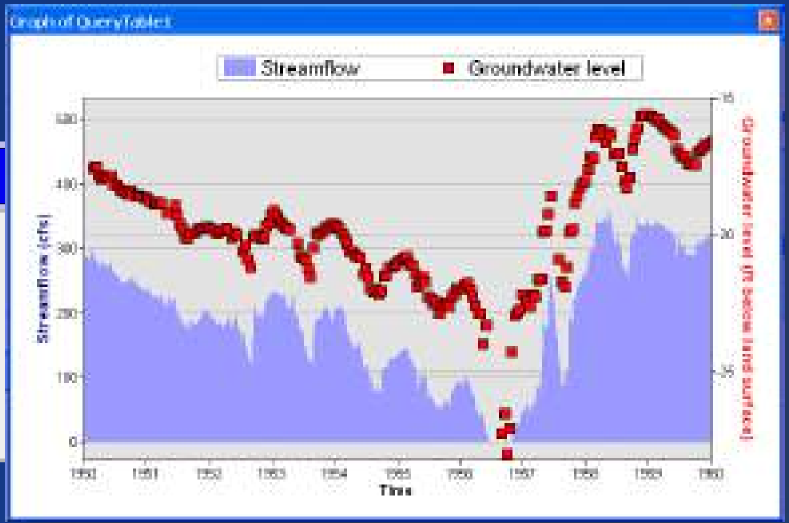
Arc Hydro Groundwater – Groundwater Analyst

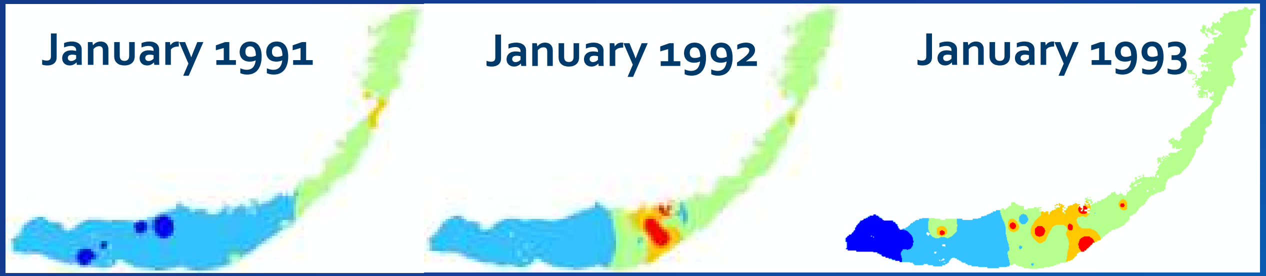
- Well data management and visualization
- Time series plots
- Raster management



Point dataset
Well

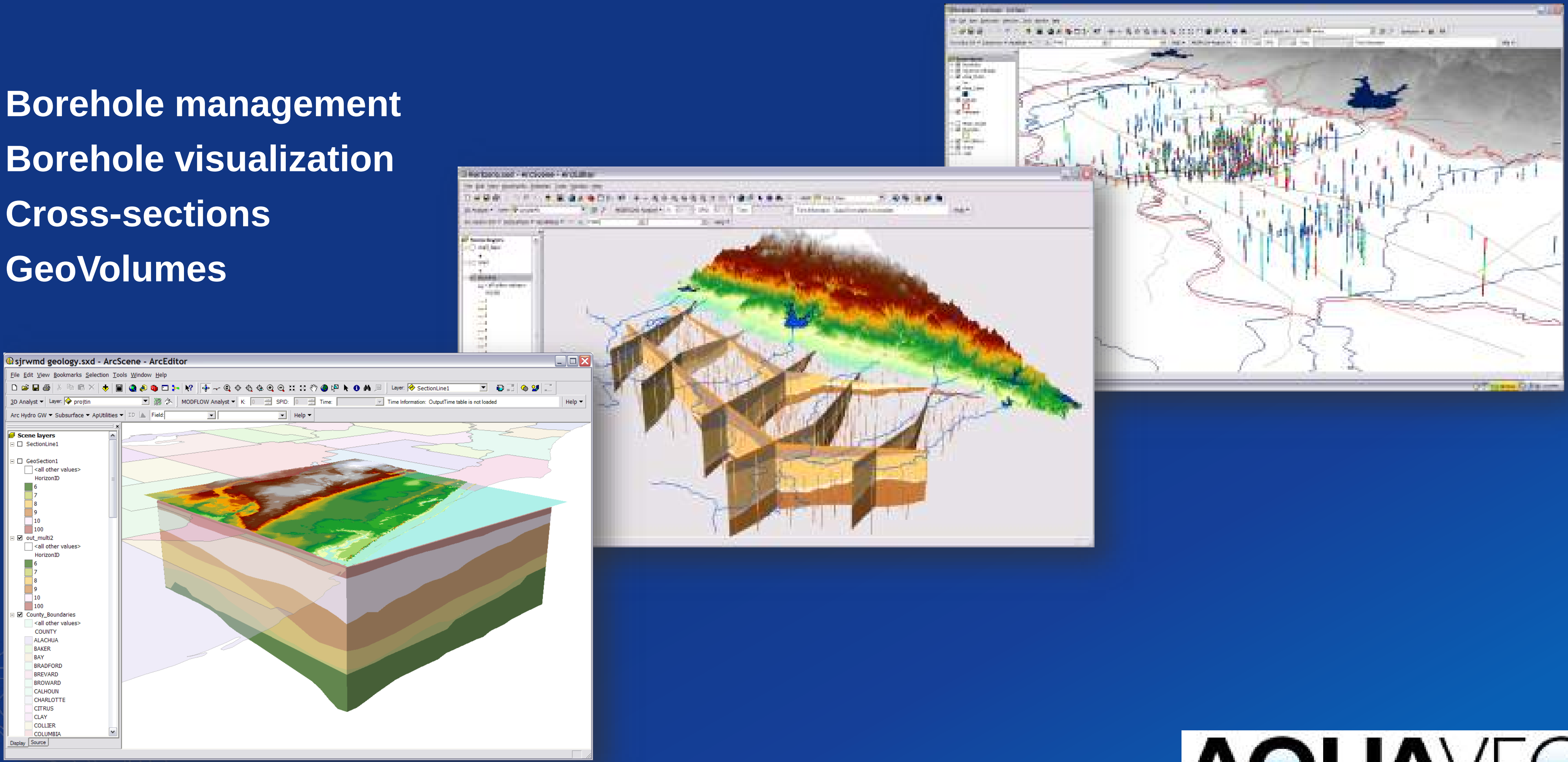
HydroID
HydroCode
LandElev
WellDepth
AquiferID
AqCode
HGUID
FType





Arc Hydro Groundwater – Subsurface Analyst

- Borehole management
- Borehole visualization
- Cross-sections
- GeoVolumes



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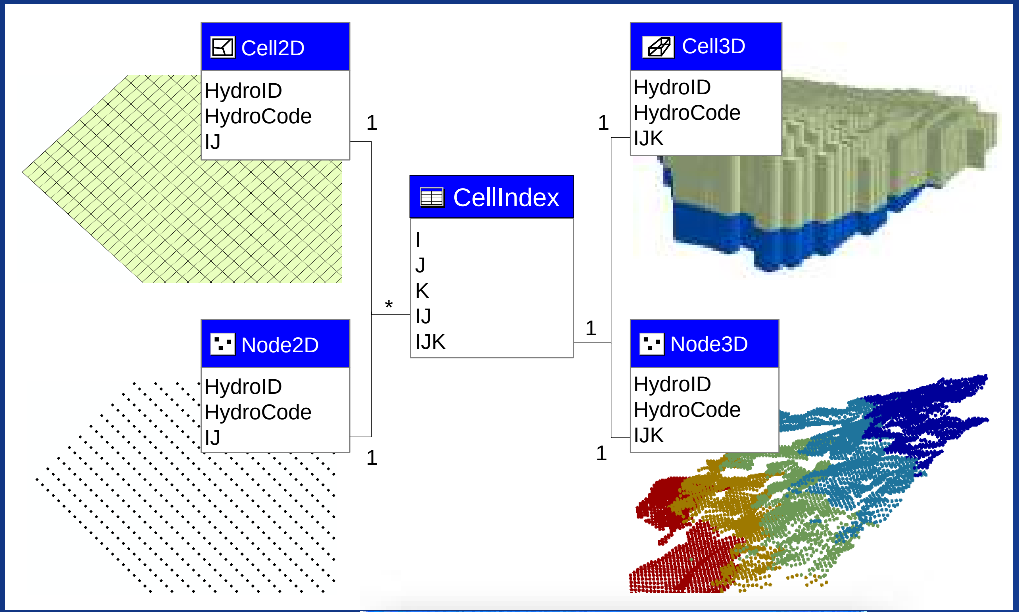
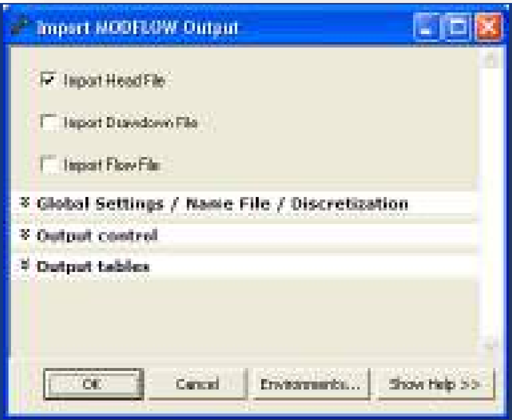
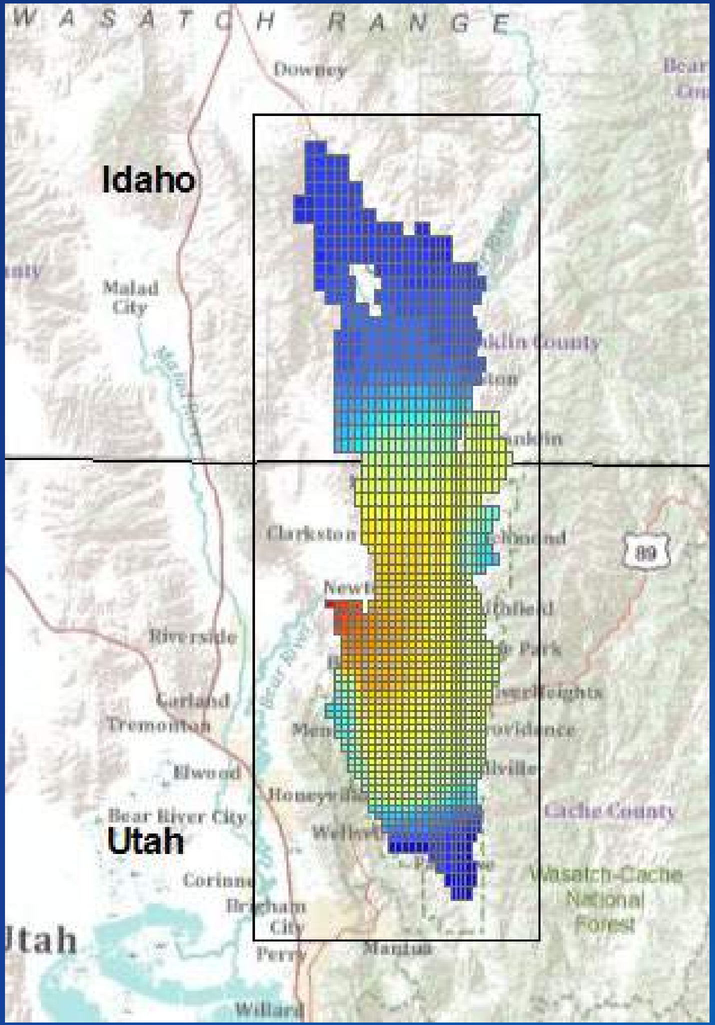
Arc Hydro Groundwater – MODFLOW Analyst

- **MODFLOW**
  - Develop
  - Import
  - Visualize
  - Run







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Quotes of the day/month/year/…

- “All models are wrong, but some are useful” (George Box ~1976)
- “Perfect is the enemy of the good” (Voltaire ~1770)
- “A fool with a tool is still a fool”
  - (reported by Ken Lanfear, USGS ret.)

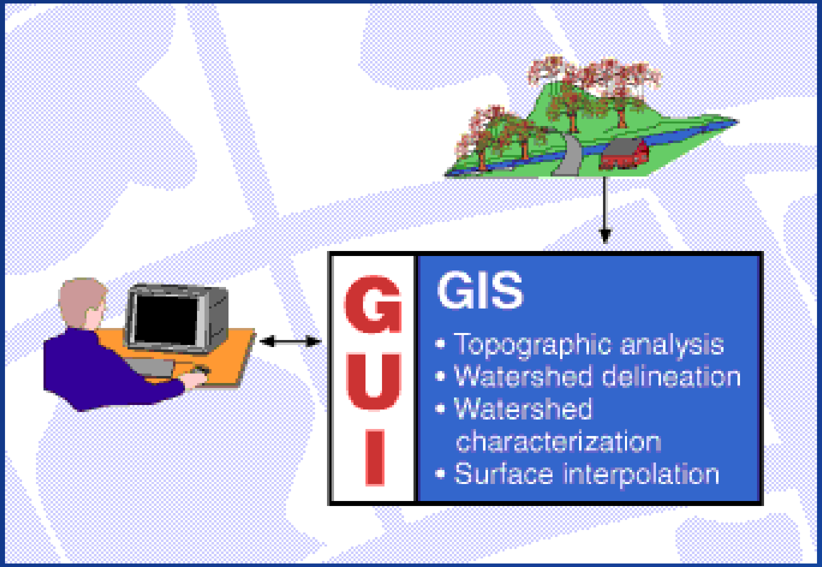
Principles of Model Integration

Model Integration Components

- Data exchange
  - How will the applications/models share the data
- User interface
  - How will the applications manage user interaction
- Model/application control
  - How will the applications control (each other’s) execution
- SW/HW infrastructure
  - What infrastructure is available to support the integration process

Types of Model Integration - Modeling Support

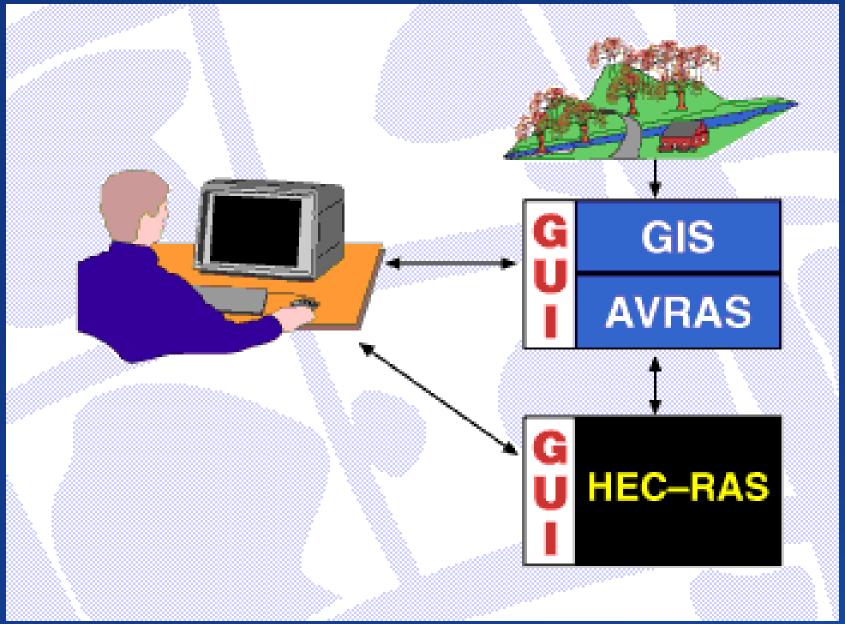
- **Standard GIS tools are used to derive data and information used in water resources modeling (e.g. watershed boundaries, watershed characteristics, etc.)**
- **Data exploration and processing (e.g. develop layer of curve numbers based on land use and soil type layers)**



Types of Model Integration - Linked

Loosely Coupled

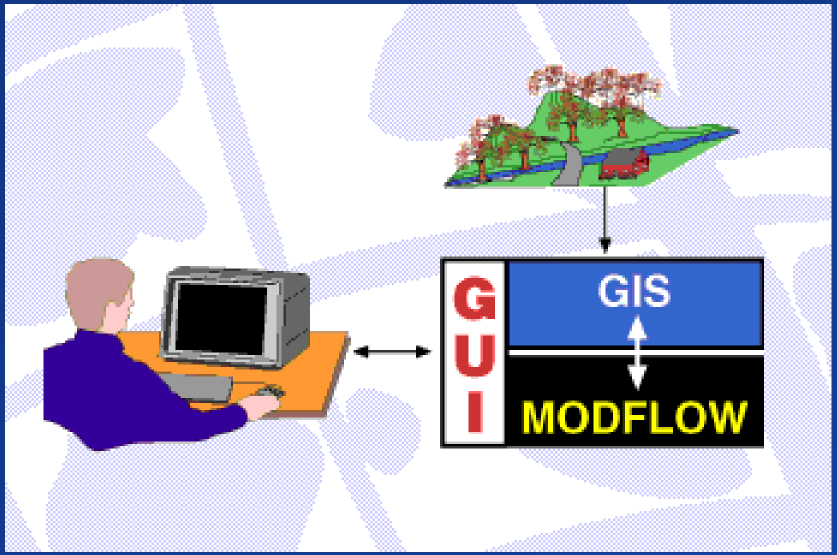
- **GIS is linked to external models**
- **GIS preprocess and post-process model data for cost-efficient and visually effective results**
- **GIS and models maintain their distinctive user interfaces**



Types of Model Integration - Integrated

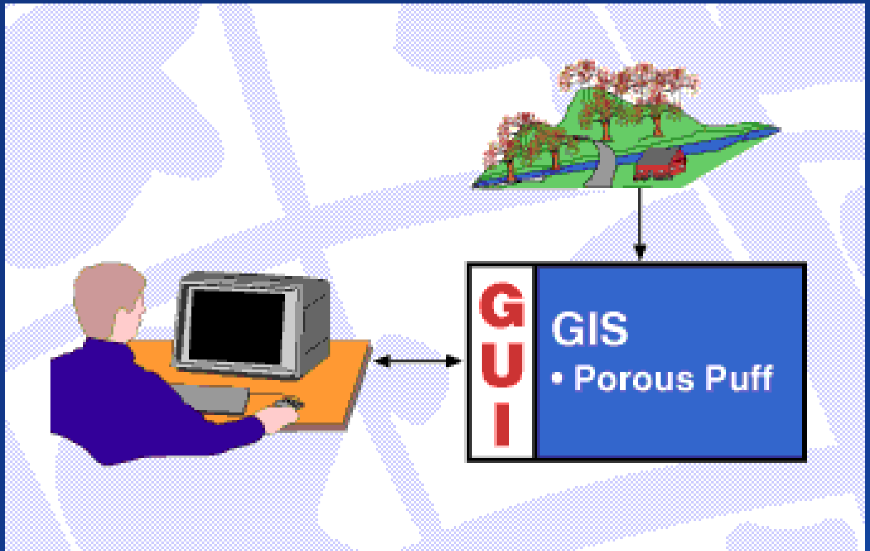
Tightly Coupled

- **GIS is integrated with external models**
- **GIS preprocess and post-process model data for cost-efficient and visually effective results**
- **GIS and models share the same user interface**



Types of Model Integration - Embedded

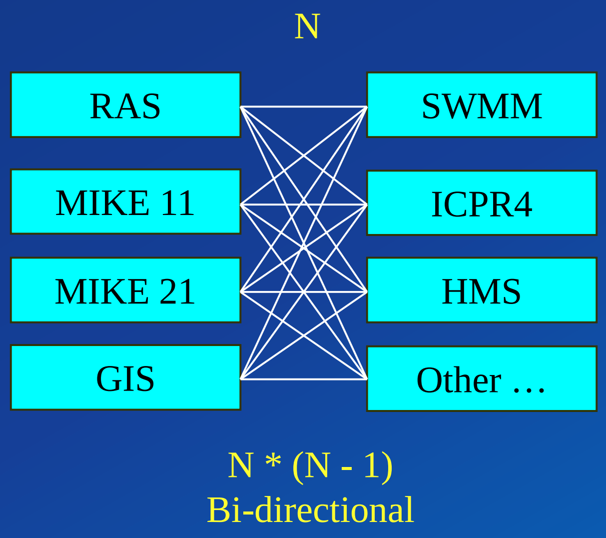
- **Model functionality is implemented as a core GIS tool (e.g. Porous Puff dispersion model has been implemented as a Spatial Analyst function)**



Integration Issues

- Models:
  - Data providers
  - Data consumers
  - Often both
- Unspecified at the beginning of the integration exercise
- Proprietary
  - Data
  - Control
- Independence from integration platform

- Development out of "control"
- Maintenance "curse"
  - Long term cost of ownership
- Complexity increase (multiplicative) as you add more models



Model Integration Approach

- Model integration “platforms”.
  - Stella
  - GoldSim
  - Vensim
  - MATLAB
  - …
- Esri universe
  - Model Builder
  - Data Interoperability / FME
- Custom solutions

Model Integration Approach

- Whatever works for particular situation – different conditions even for the same integration “problem” can result in a different integration method(s)
  - Tight or loose coupling
    - Technical issues
    - Legal issues
  - Access to the underlying model structure or not (NSS vs. Excel)
- Check out the existence of 3rd party solutions
  - Almost always cheaper to buy a solution than to develop one (except for simple tasks)
- Python and ArcPy as framework for developing complex integrated systems

StreamStats

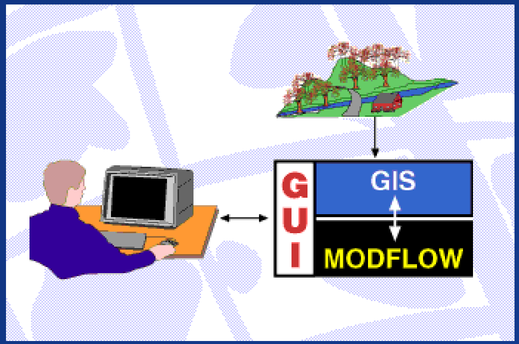
Regression Equations – USGS StreamStats

- **Used to estimate streamflow statistics, both high and low flows, for ungaged sites (in uncontrolled flow environment)**
- **Relate streamflow statistics to measured basin characteristics**
- **Developed by all 48 USGS districts on a state-by-state basis through the cooperative program (usually sponsored by DOT)**
- **Regression equations take the form:**

$$Q_{100} = 0.471 * A^{0.715} * E^{0.827} * SH^{0.472}$$

Regression equation for indicated Q_{AEP}	MEV (log units)	AVP (log units)	SEM (percent)	SEP (percent)	Pseudo-R^2 (percent)
Region 1_2; n = 59					
$Q_{[illegible]} = 0.000815\, A^{[illegible]} P^{[illegible]}$	0.065	0.069	64.3	66.7	91.6
$Q_{[illegible]} = 0.00141\, A^{[illegible]} P^{[illegible]}$	0.063	0.067	63.0	65.3	91.6
$Q_{[illegible]} = 0.00238\, A^{[illegible]} P^{[illegible]}$	0.063	0.066	62.8	65.0	91.4
$Q_{[illegible]} = 0.00294\, A^{[illegible]} P^{[illegible]}$	0.062	0.066	62.3	64.5	91.4
$Q_{[illegible]} = 0.00616\, A^{[illegible]} P^{[illegible]}$	0.065	0.069	64.3	66.7	90.4
$Q_{[illegible]} = 0.00962\, A^{[illegible]} P^{[illegible]}$	0.070	0.074	66.8	69.4	89.4
$Q_{4} = 0.0148\, A^{[illegible]} P^{[illegible]}$	0.075	0.080	70.0	72.9	88.2
$Q_{2} = 0.0191\, A^{[illegible]} P^{[illegible]}$	0.080	0.086	72.7	75.8	87.2
$Q_{1} = 0.0239\, A^{[illegible]} P^{[illegible]}$	0.086	0.093	76.2	79.7	85.9
$Q_{0.5} = 0.0288\, A^{[illegible]} P^{[illegible]}$	0.093	0.100	79.7	83.5	84.7
$Q_{0.2} = 0.0355\, A^{[illegible]} P^{[illegible]}$	0.101	0.108	84.0	88.2	83.1
Region 3; n = 13					
$Q_{[illegible]} = 8.15\, A^{[illegible]}$	0.135	0.158	102	114	78.3
$Q_{[illegible]} = 11.7\, A^{[illegible]}$	0.117	0.137	92.6	103	80.3
$Q_{[illegible]} = 17.2\, A^{[illegible]}$	0.097	0.114	82.2	91.2	82.7
$Q_{[illegible]} = 20.1\, A^{[illegible]}$	0.090	0.106	78.2	86.7	83.6
$Q_{[illegible]} = 35.6\, A^{[illegible]}$	0.064	0.076	63.5	70.4	87.5
$Q_{[illegible]} = 51.8\, A^{[illegible]}$	0.048	0.059	54.0	60.4	90.1
$Q_{4} = 75.7\, A^{[illegible]}$	0.032	0.040	42.7	48.8	93.2
$Q_{2} = 95.9\, A^{[illegible]}$	0.022	0.030	35.2	41.5	95.1
$Q_{1} = 117\, A^{[illegible]}$	0.014	0.021	27.8	34.5	96.8
$Q_{0.5} = 140\, A^{[illegible]}$	0.009	0.015	21.5	29.1	98.0
$Q_{0.2} = 171\, A^{[illegible]}$	0.003	0.010	13.0	22.8	99.2
Region 4; n = 28					
$Q_{[illegible]} = 0.000592\, A^{[illegible]} (F/100 + 1)^{[illegible]} P^{[illegible]}$	0.059	0.069	60.8	66.4	92.1
$Q_{[illegible]} = 0.00126\, A^{[illegible]} (F/100 + 1)^{[illegible]} P^{[illegible]}$	0.051	0.060	55.9	61.0	92.8
$Q_{[illegible]} = 0.00272\, A^{[illegible]} (F/100 + 1)^{[illegible]} P^{[illegible]}$	0.044	0.051	51.2	55.8	93.5
$Q_{[illegible]} = 0.00370\, A^{[illegible]} (F/100 + 1)^{[illegible]} P^{[illegible]}$	0.040	0.047	48.5	52.9	94.0
$Q_{[illegible]} = 0.0123\, A^{[illegible]} (F/100 + 1)^{[illegible]} P^{[illegible]}$	0.030	0.035	41.2	45.2	95.2
$Q_{[illegible]} = 0.0279\, A^{[illegible]} (F/100 + 1)^{[illegible]} P^{[illegible]}$	0.025	0.031	38.0	42.0	95.6
$Q_{4} = 0.0773\, A^{[illegible]} (F/100 + 1)^{[illegible]} P^{[illegible]}$	0.022	0.027	34.8	38.9	96.1
$Q_{2} = 0.149\, A^{[illegible]} (F/100 + 1)^{[illegible]} P^{[illegible]}$	0.020	0.025	33.1	37.5	96.3
$Q_{1} = 0.292\, A^{[illegible]} (F/100 + 1)^{[illegible]} P^{[illegible]}$	0.019	0.025	32.7	37.3	96.3
$Q_{0.5} = 0.534\, A^{[illegible]} (F/100 + 1)^{[illegible]} P^{[illegible]}$	0.019	0.024	32.3	37.2	96.3
$Q_{0.2} = 1.09\, A^{[illegible]} (F/100 + 1)^{[illegible]} P^{[illegible]}$	0.019	0.026	32.9	38.2	96.0

System/Integration Architecture



- Integrated / tight coupling.
  - GIS used for watershed delineation and characteristics extraction.
  - National Stream Statistics (NSS) application used for regression calculations.
- While GIS and regression engine are separated and run independently, the (web) user interface “hides” that and a single front end is presented to the user.
- But is a black-box – no ability to control model parameter extraction methodology, data, or equations.

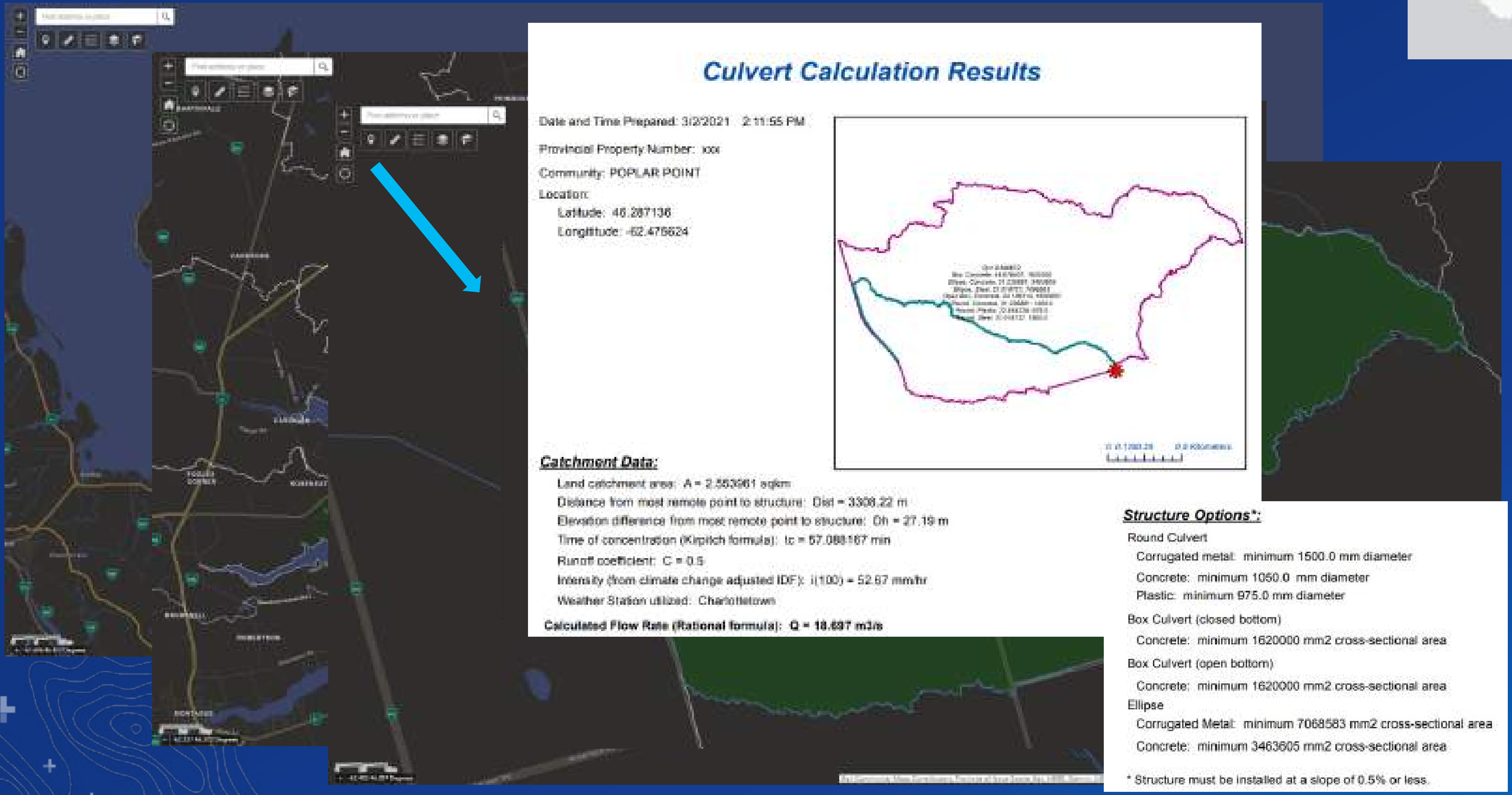
PEI Culvert Calculator

Prince Edward Island Culvert Calculator Project Overview

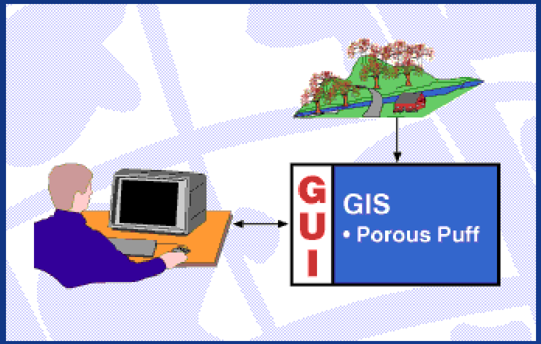
- User: PEI Department of Communities, Land and Environment
- Goal: Streamline road maintenance during short construction season. Automate small culvert repair and installation.
- Implementation components:
  - Data:
    - Topography/hydrography:
      - Local DEM and hydrography (DEM at 1m).
  - Hydrology/hydraulics/design:
    - Rational method including climate change precipitation adaptation (Q100).
    - Manning’s equation (open channel) for sizing.
    - Road construction manual (DOT) for culvert design.
  - Geoprocessing service for watershed delineation, characterization, and culvert sizing.
  - Web application (simple WAB app) for end user interaction.

PEI Culvert Calculator Demo

Prince Edward Island Culvert Calculator Demo



System/Integration Architecture



- **Embedded.**
- **GIS processing, hydrologic model, and engineering design are built into a single application (geoprocessing service).**
- **The (web) user interface provides a single front end for the user.**
- **But is a black-box – no ability to control model parameter extraction methodology, data, or equations.**

Structure Options*:

Round Culvert

Corrugated metal: minimum 1500.0 mm diameter

Concrete: minimum 1050.0 mm diameter

Plastic: minimum 975.0 mm diameter

Box Culvert (closed bottom)

Concrete: minimum 1620000 mm2 cross-sectional area

Box Culvert (open bottom)

Concrete: minimum 1620000 mm2 cross-sectional area

Ellipse

Corrugated Metal: minimum 7068583 mm2 cross-sectional area

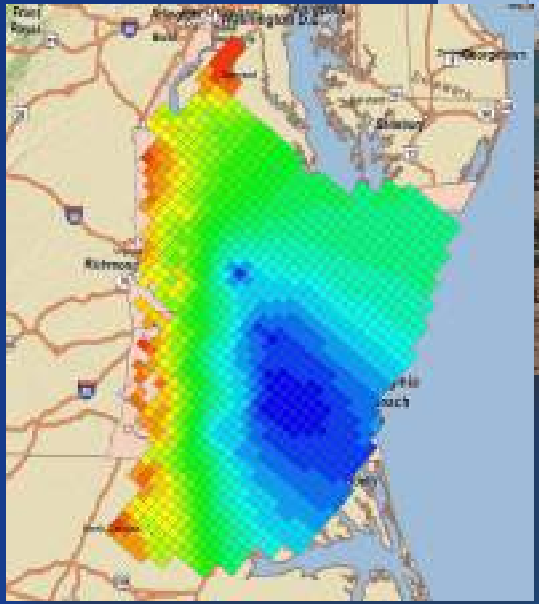
Concrete: minimum 3463605 mm2 cross-sectional area

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

Groundwater Integration

Automated Well Permitting – MODFLOW Analyst

- Calibrated regional model is imported to ArcGIS as a "baseline" model.
- Candidate wells are added to baseline model using well package.
- Impact of new well is analyzed using MODFLOW
- Results are imported into ArcGIS for presentation



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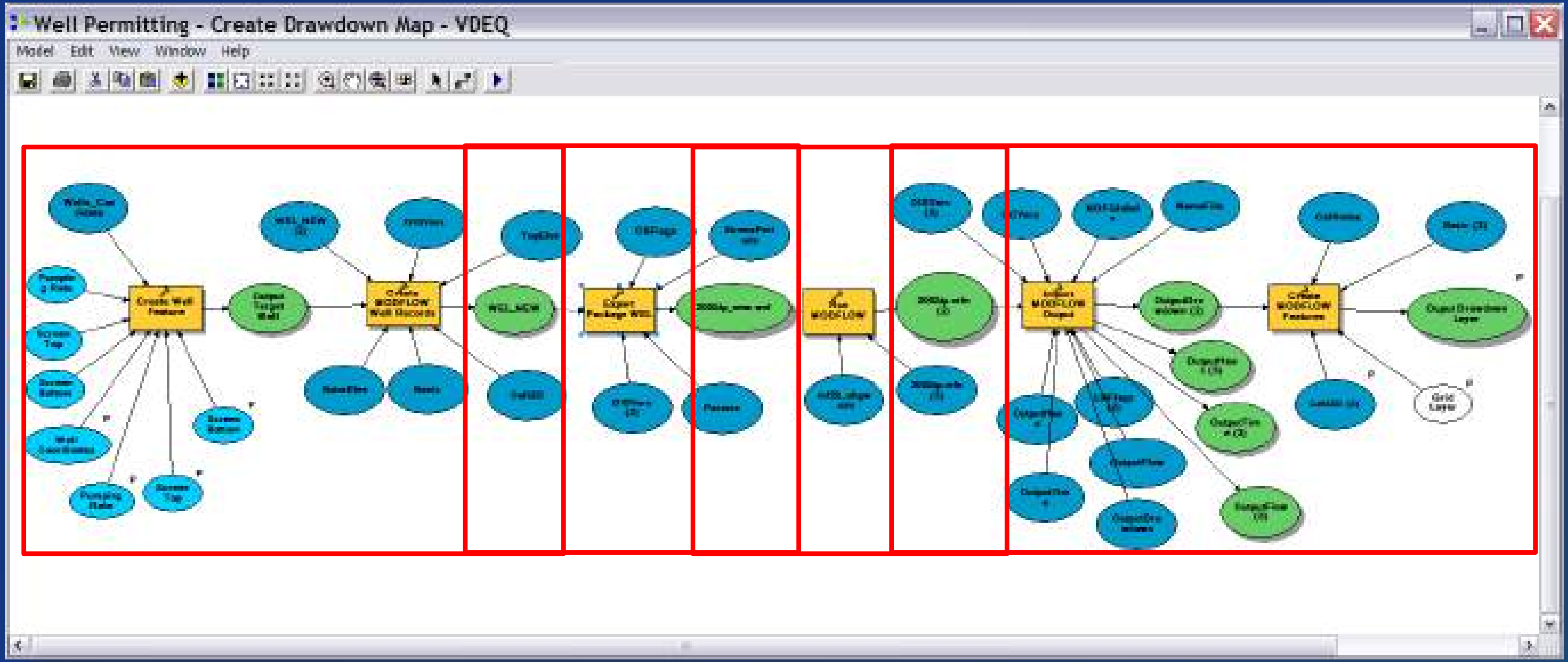
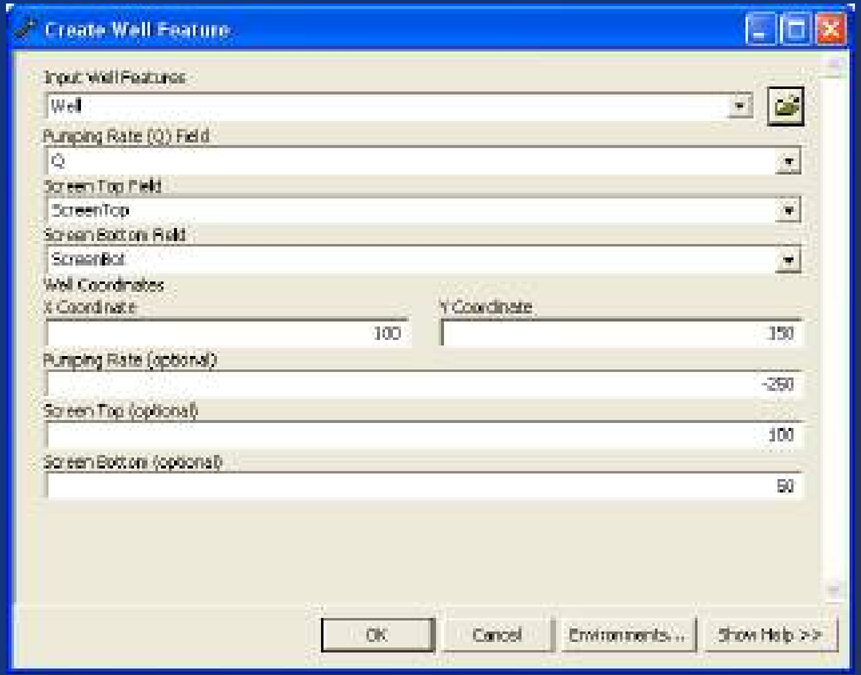
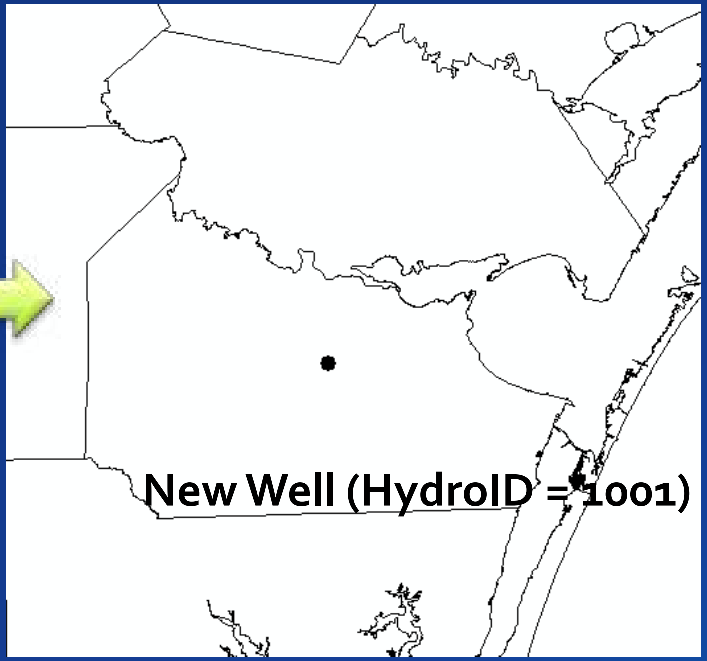
Workflow

- Create new well
- Update well table
- Export well package file
- Run MODFLOW
- Import solution
- Build drawdown map layer
- Generate final map products



Step 1 – Create New Well





Step 2 – Create New Instances in WEL Table

CellID represents MODFLOW i, j, k values

Attributes of WEL

Object ID *	CellID	SPID	Q	Qfact	IFACE	SourceID
1	5024	1	-2830	<Null>	0	999
2	955	1	-680	<Null>	0	1000
3	1030	1	-150.2	<Null>	0	1001

Record: 3 Show: All Selected Records (1 out of 3 Selected)

SourceID is the HydroID of the well feature

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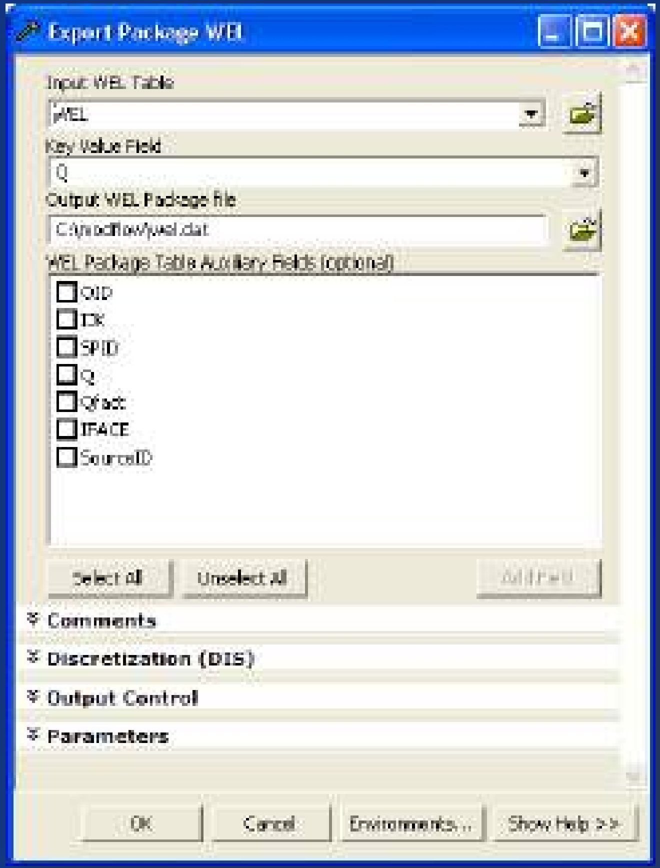
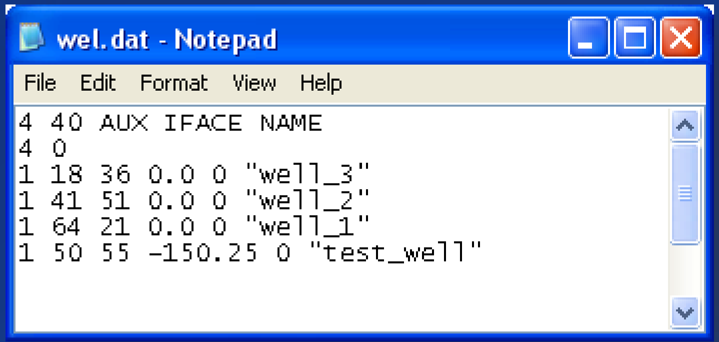
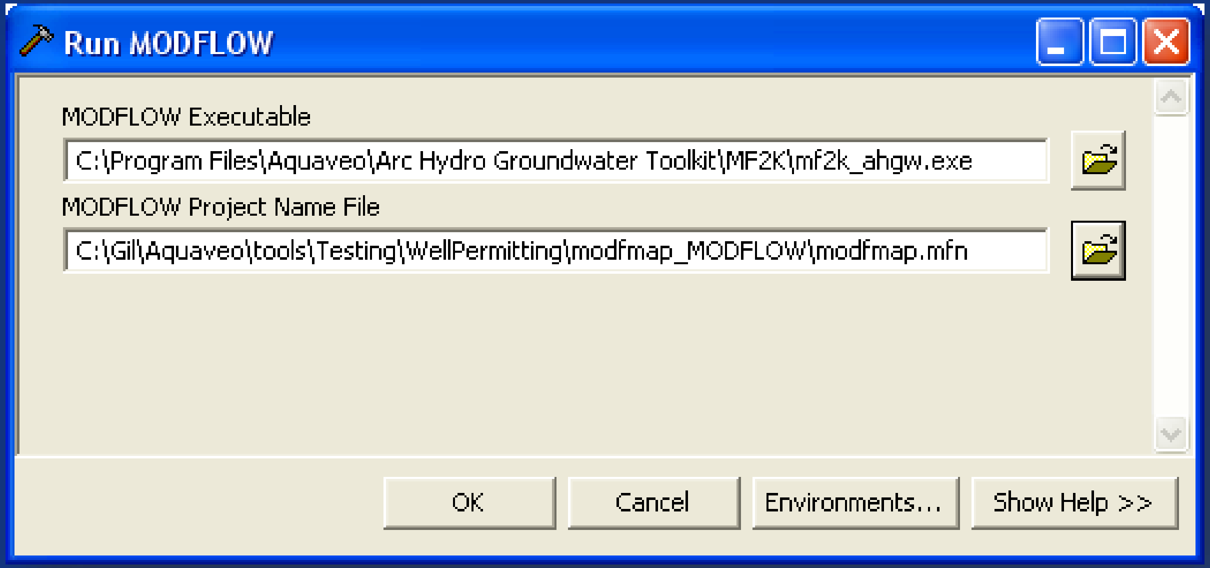
Step 3 – Export the New Well Data to MODFLOW Text File

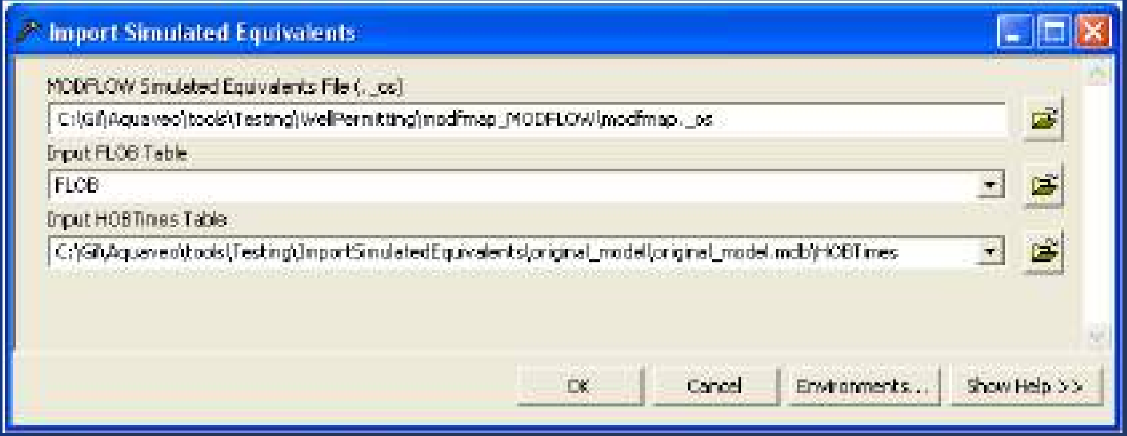




Step 4 – Run MODFLOW

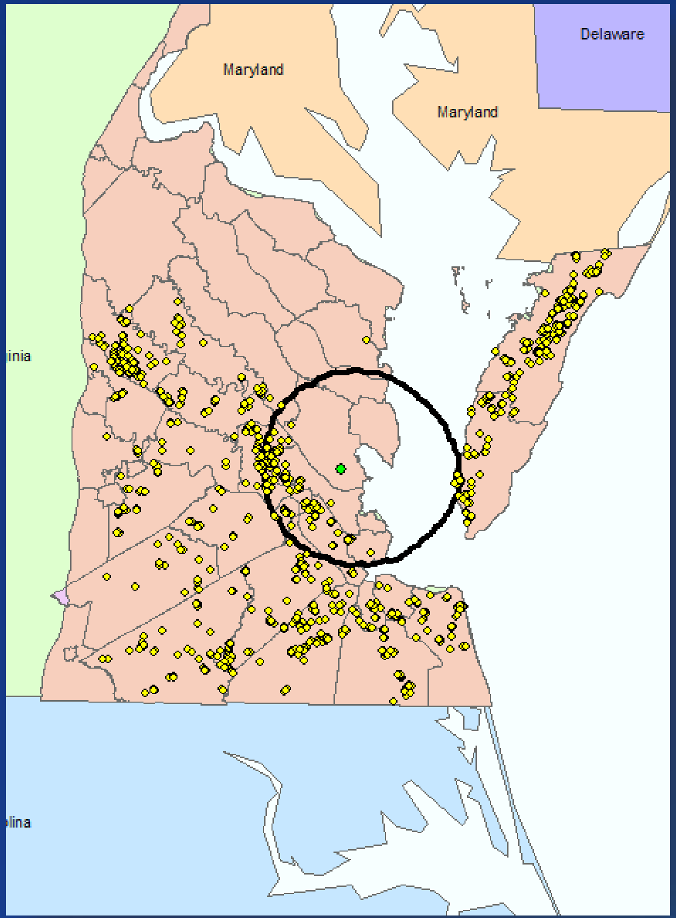


Step 5 – Read-in the Results



GIS Products

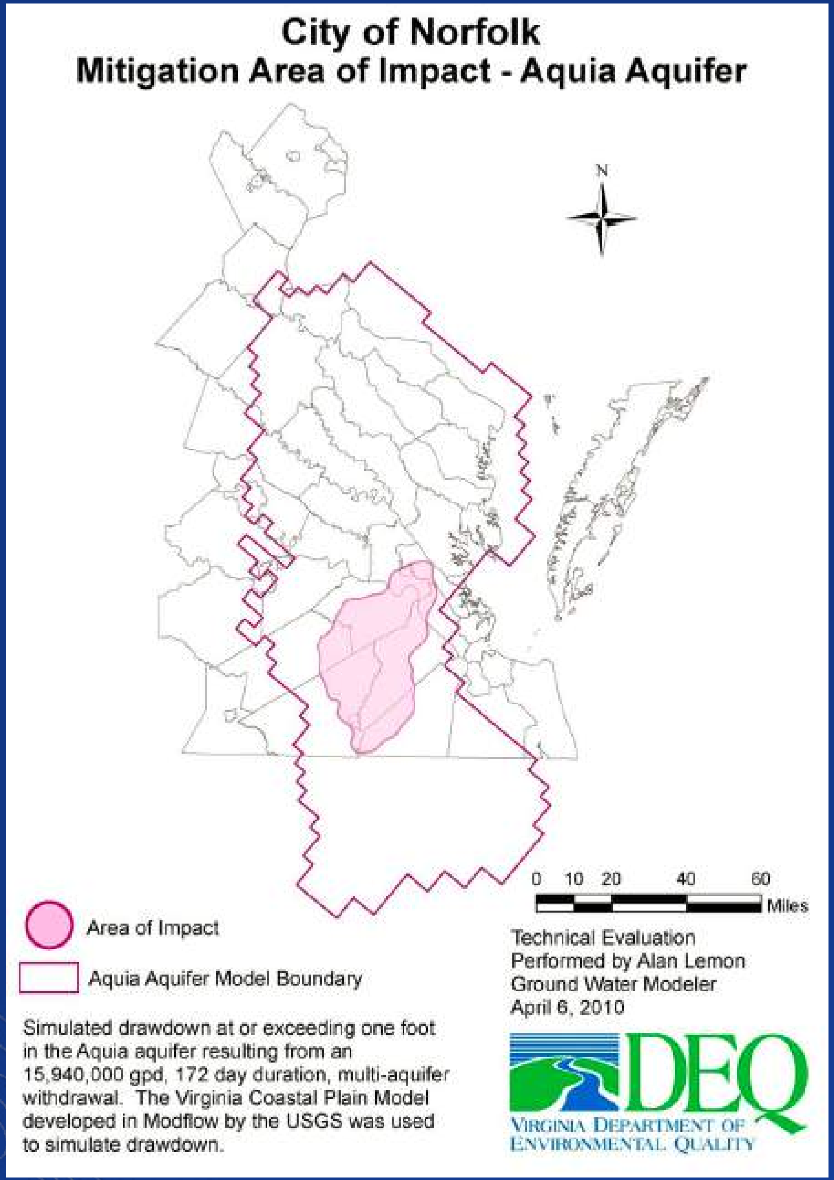
Area of Impact Cells

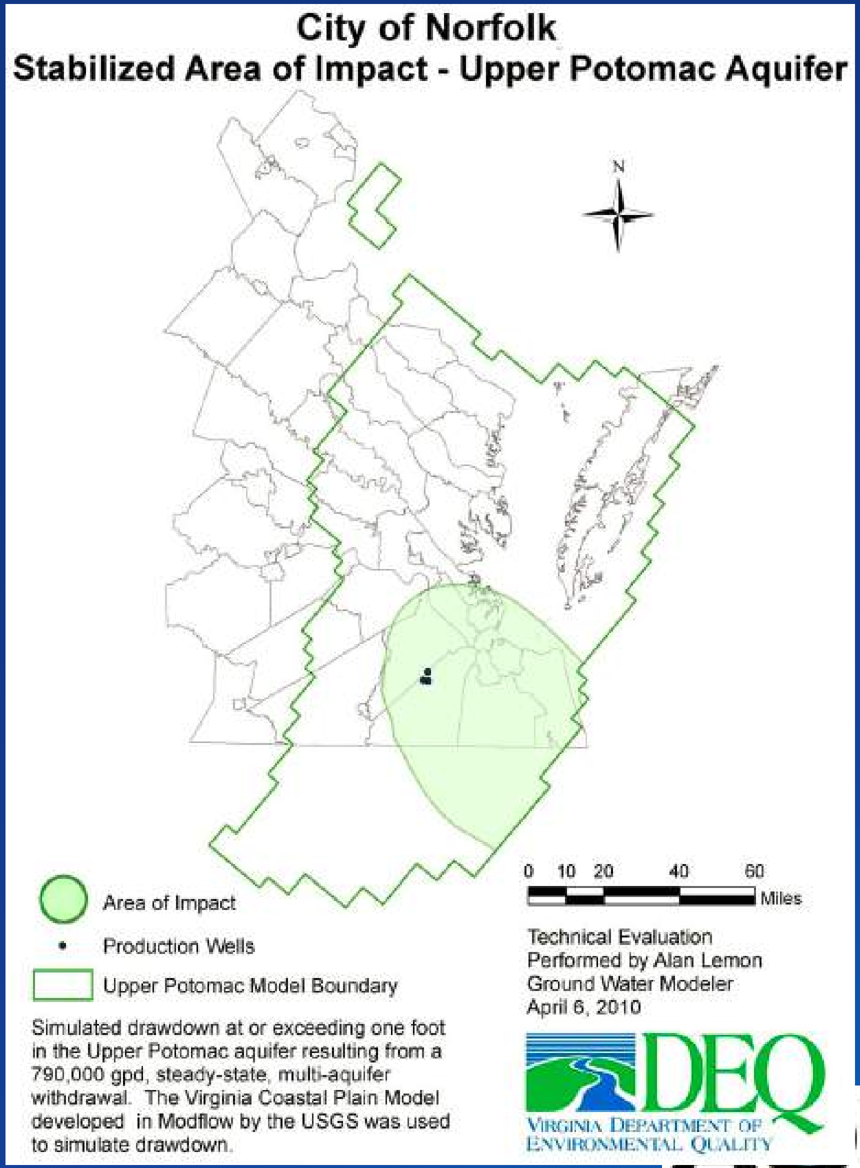


Area of Impact Contour

AQUAVEO

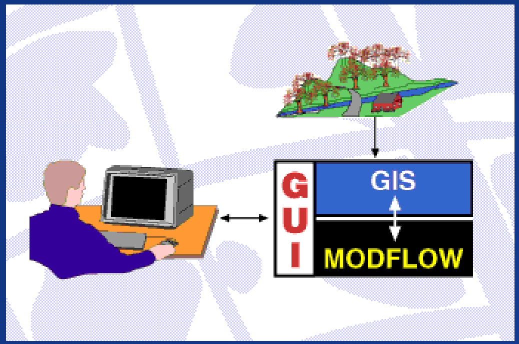
Report





AQUAVEO

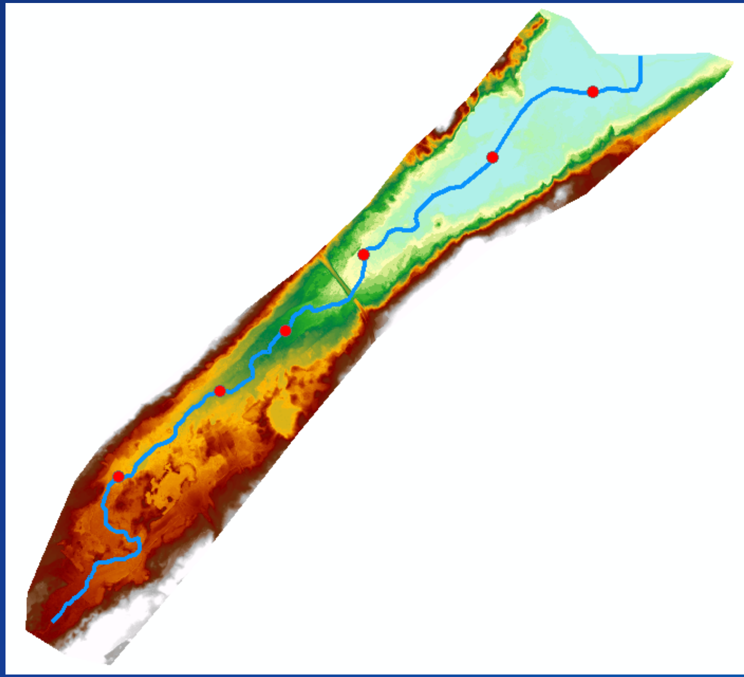
System/Integration Architecture



- Integrated / tight coupling.
  - GIS used for well placement and well characteristics extraction.
  - MODFLOW is used for groundwater modeling.
- While GIS and MODFLOW engine are separated and run independently, the model builder user interface “hides” that and a single GIS front end is presented to the user.
- MODFLOW Analyst exposes many of MODFLOW capabilities through GIS interface so you have good control over MODFLOW and capacity to tweak it without having to be a MODFLOW expert.

Floodplain Delineation Solutions Matrix

- **Different levels of complexity are possible/needed to determine flood extents**
- **Simple, based on terrain and observations only:**
  - **“Flooding out” based on DEM, stream centerline, and point data**
  - **HAND approach (constant depth of flooding per reach)**
- **Complex, based on hydraulic modeling (using external hydraulic models):**
  - **1D**
  - **2D**
  - **Full or simplified equations (Navier-Stokes / Saint-Venant / …)**



Previous Polling Questions Results

Do you use hydraulic models for floodplain delineation?

- Yes = 47%
- No = 53%

If you are doing hydraulic modeling, what software do you use (81 - multi**):**

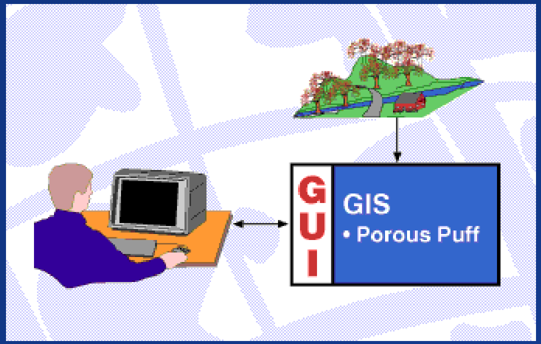
- DHI = 9%
- HEC-RAS = 65%
- ICPR4 = 6%
- INNOVYZE = 6%
- SWMM = 15%
- Other = 31%

HEC-GeoHMS and HEC-GeoRAS

HEC-GeoHMS and HEC-GeoRAS Status

- Products:
  - HEC-GeoHMS – GIS companion product to HEC-HMS (pre-processing)
  - HEC-GeoRAS – GIS companion product to HEC-RAS (pre- and post-processing)
- Development
  - ArcGIS version (development by ESRI for HEC). Final HEC releases with version of ArcMap 10.2
  - No new functionality in many years
- Maintenance
  - Ongoing code maintenance by Arc Hydro team (through 10.8)
  - Support through Water Resources Community pages
- Downloads
  - Through Arc Hydro ftp site
- No plans for porting to Pro in their current forms

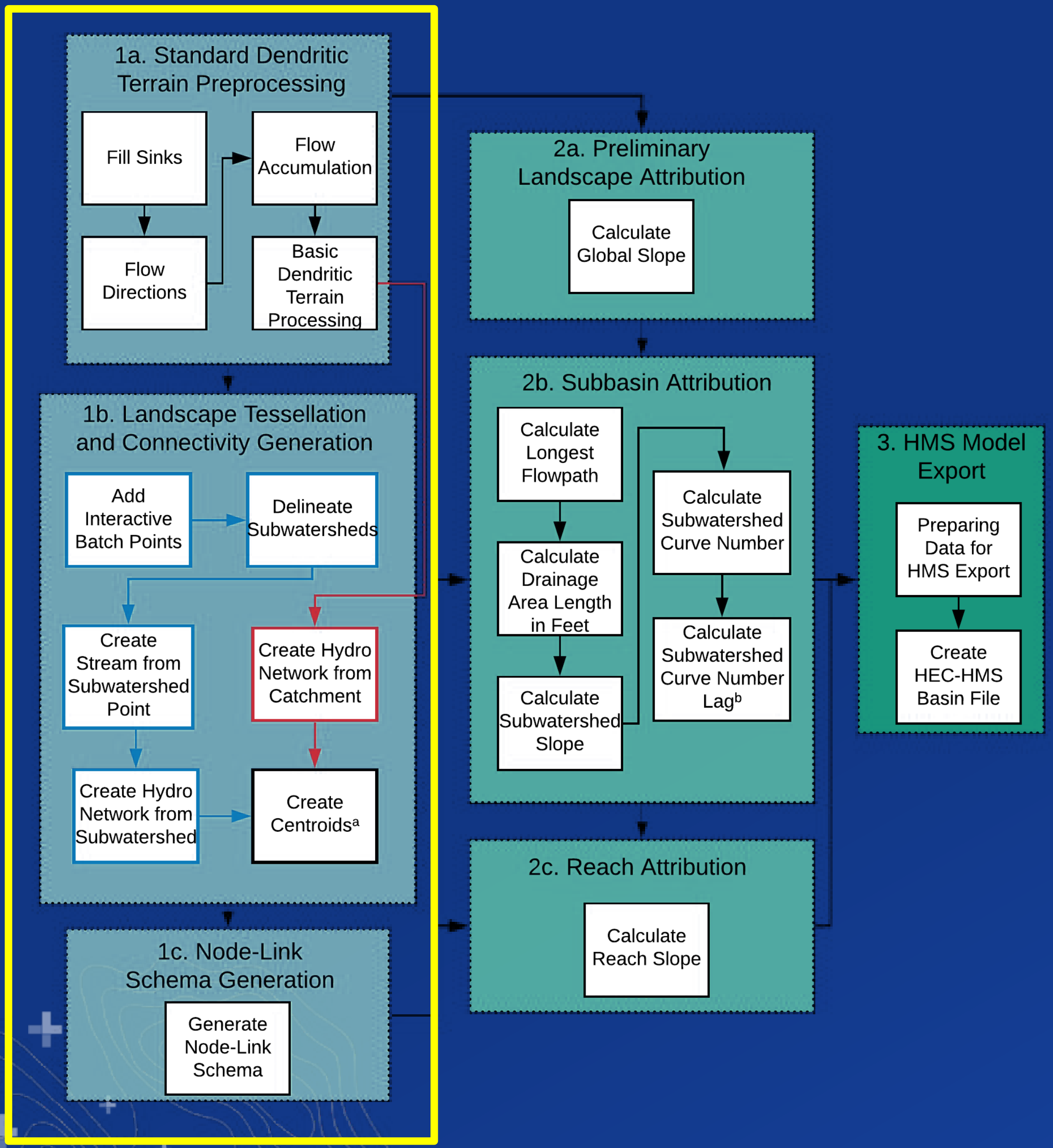
Geo Capabilities in HEC-HMS and HEC-RAS

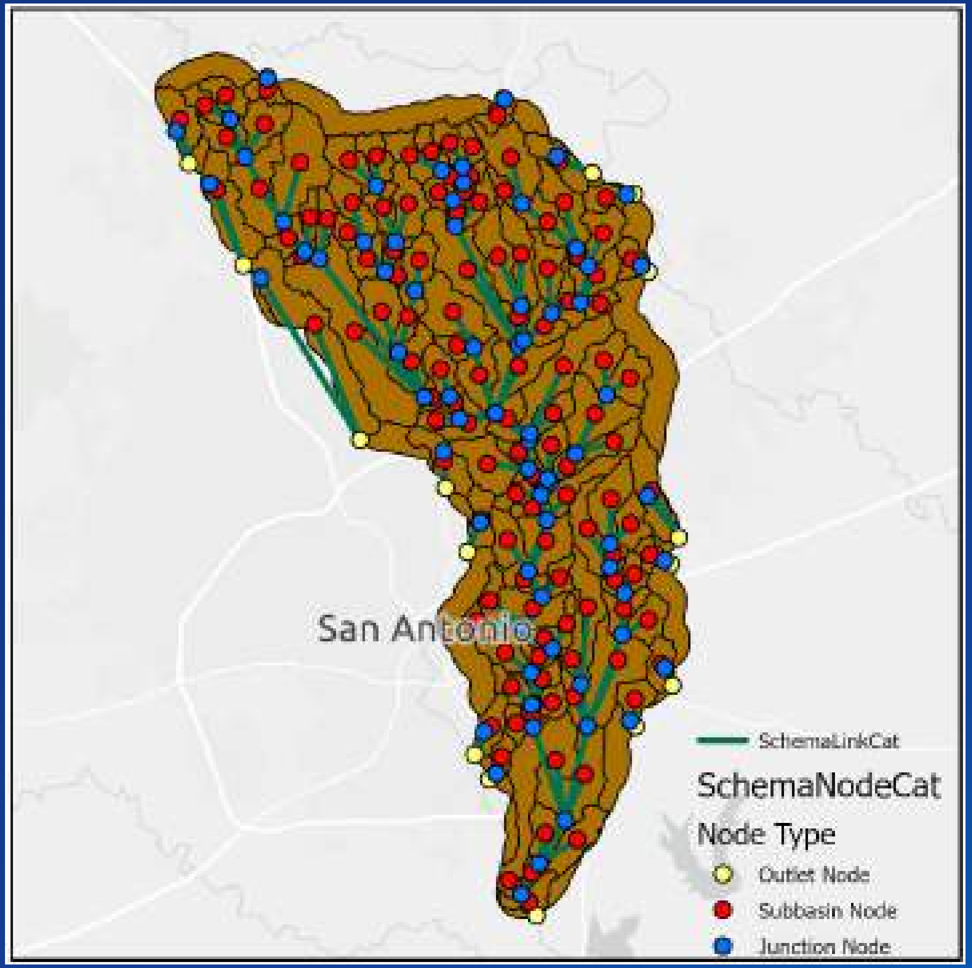


- HEC adding capabilities to use spatial data in their native products
- Integrated into HEC apps
  - HEC-HMS (since v4.4, 2020)
    - Similar to terrain preprocessing capabilities from HEC-GeoHMS
    - GIS menu
  - HEC-RAS – RAS Mapper
    - Extensive additions for 2D modeling support

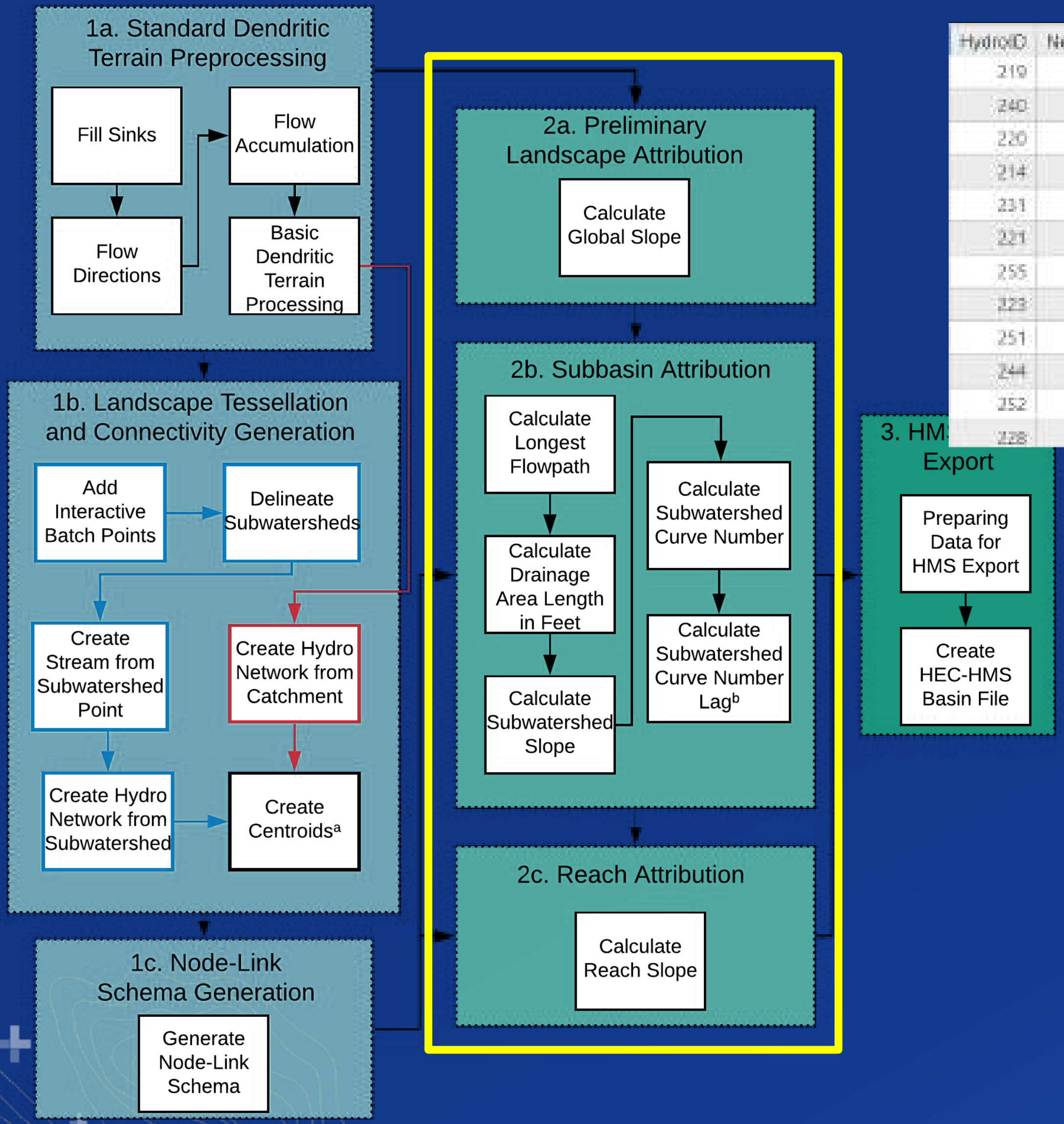
HEC-HMS Support in Arc Hydro for Pro

From Watershed Characterization to Simulating Hydrologic Processes





From Watershed Characterization to Simulating Hydrologic Processes



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240	254	<Null>	662	31916.303013	2.210784	83.149134	3.082124	CNLag
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214	221	<Null>	624	26561.744572	2.238976	81.747475	2.770292	CNLag
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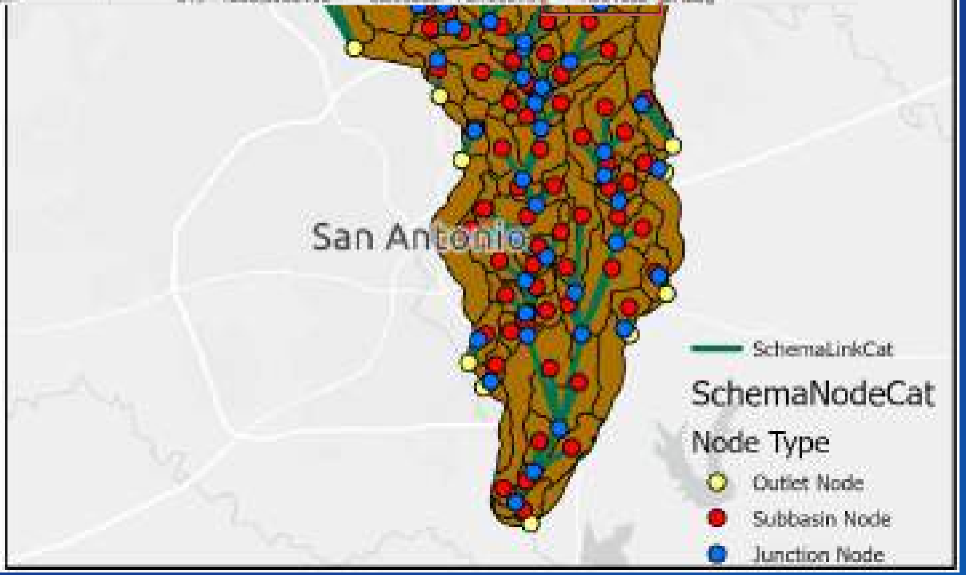
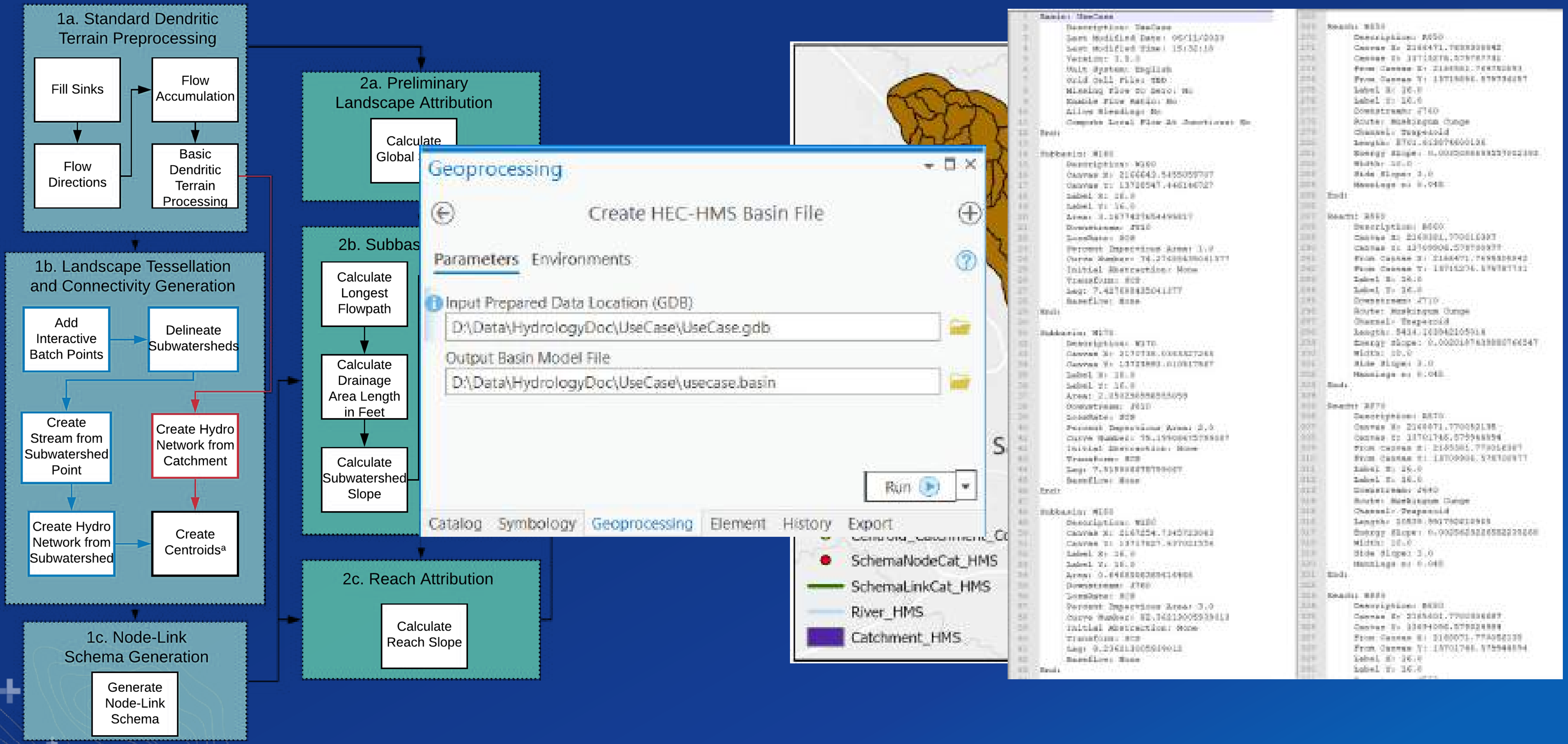
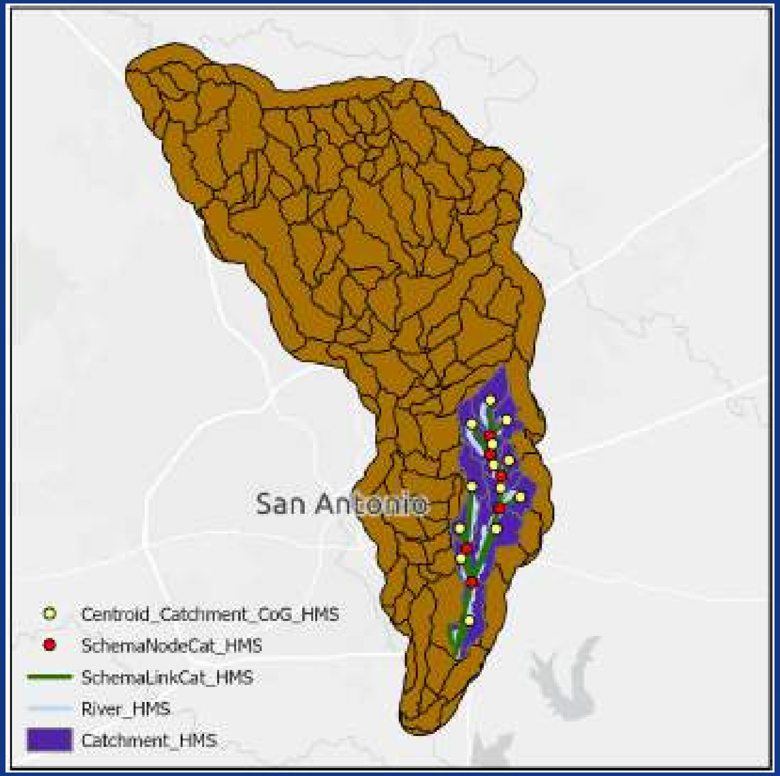
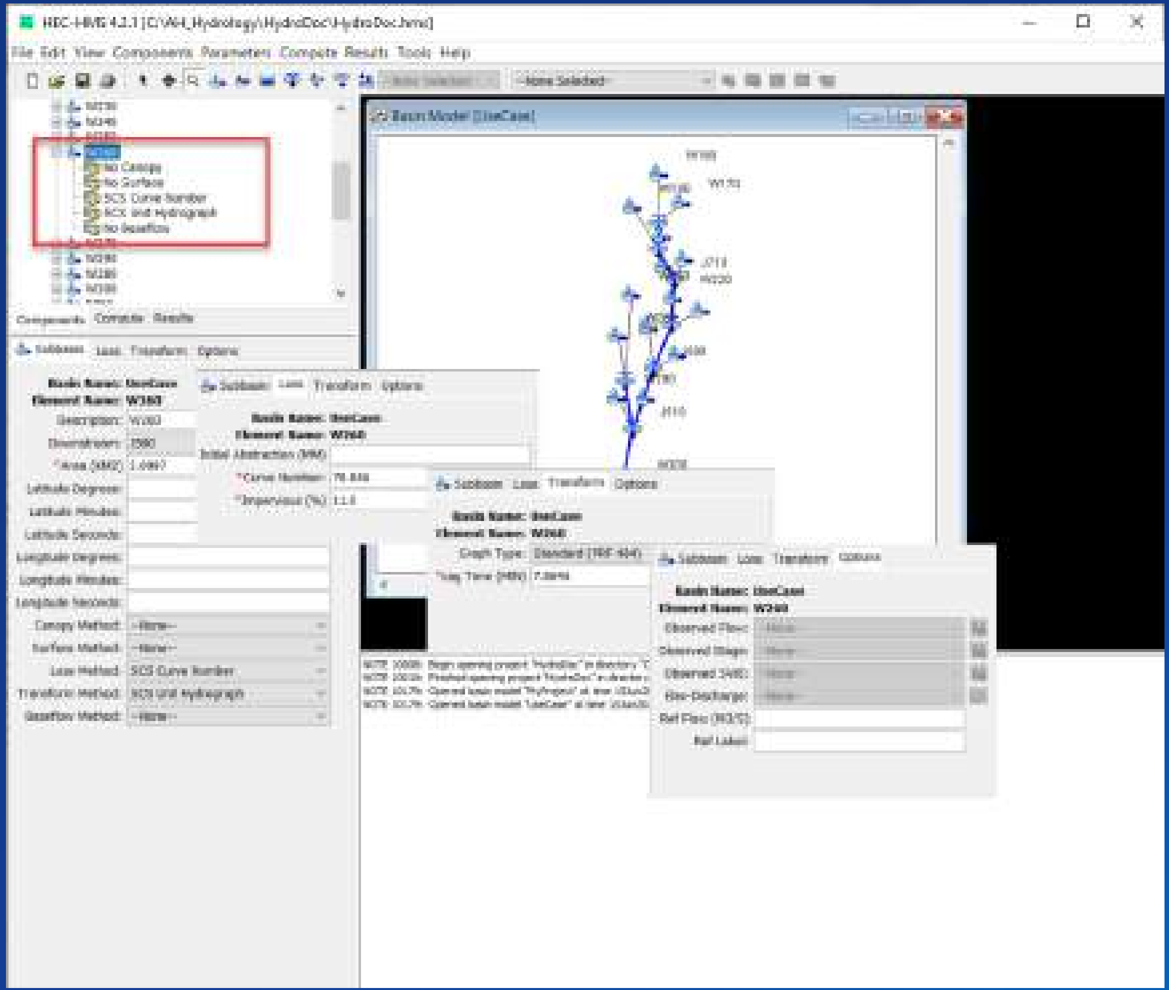


From Watershed Characterization to Simulating Hydrologic Processes

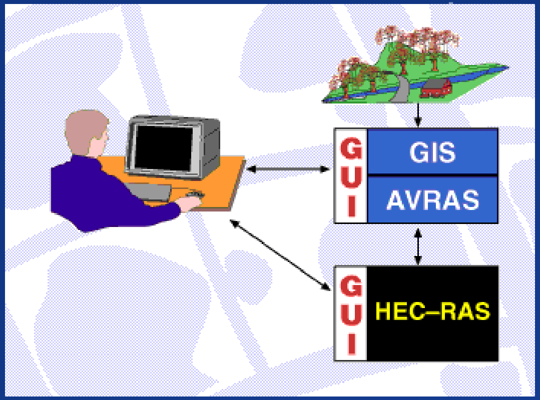


From Watershed Characterization to Simulating Hydrologic Processes





System/Integration Architecture

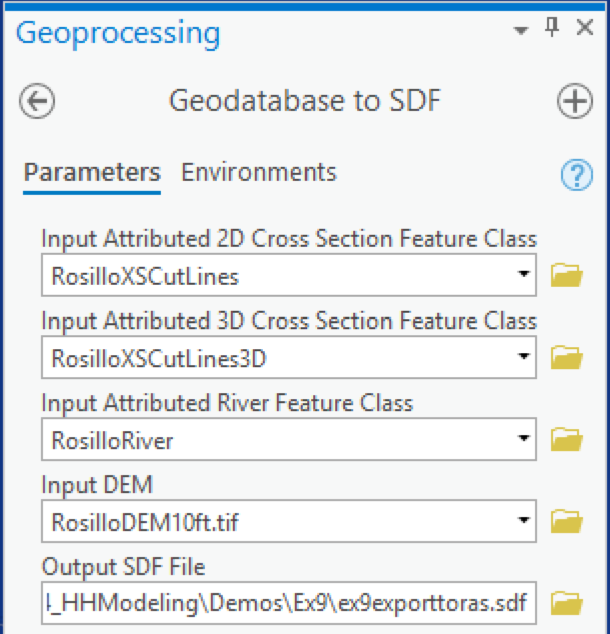


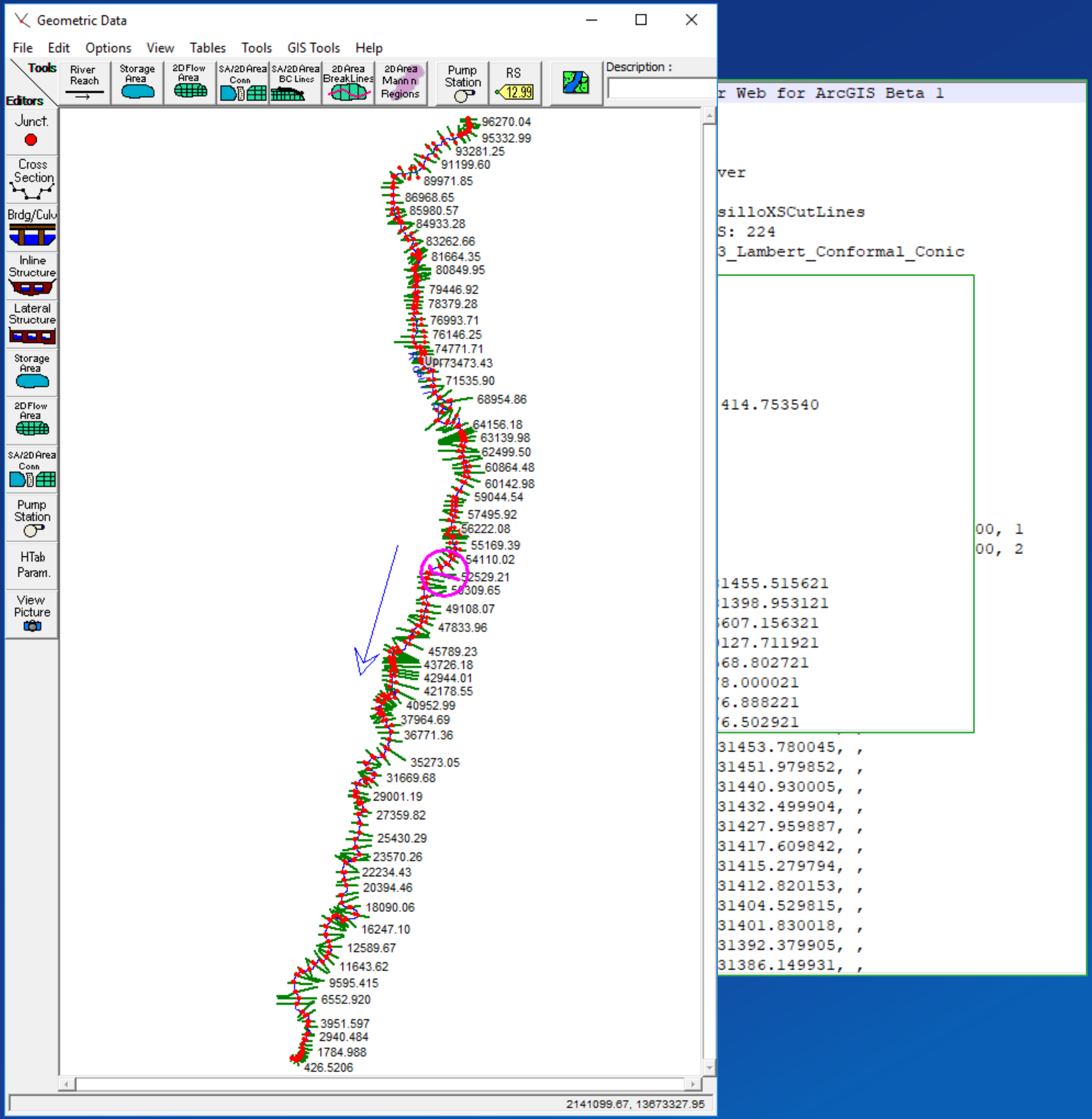
- Loose coupling.
- Only one specific HMS tool, the rest are standard Arc Hydro tools.
  - Python export code (to ASCII file). This is different from HEC-GeoHMS that used XML and XSLT export methodology.
- You can use the same tools to support any other node-link hydrologic model.
  - Modify python code to export to a different model-specific output format.
- Fully compliant with geoprocessing infrastructure so you can build automation around your specific modeling workflows (Model Builder, Python, Notebooks).

HEC-RAS Support in Arc Hydro for Pro

HEC-RAS Preprocessing

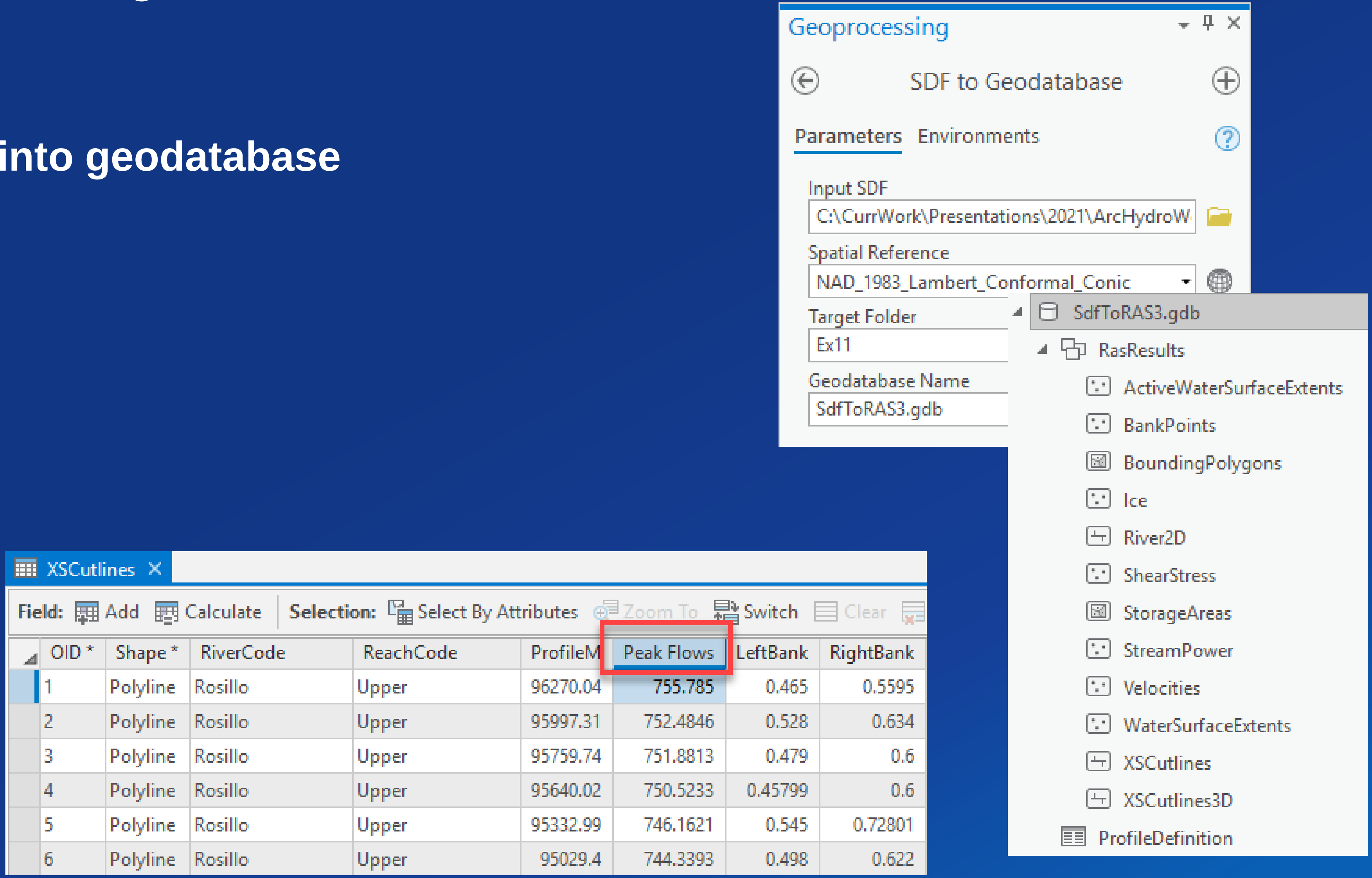
- **Export from geodatabase into sdf file**





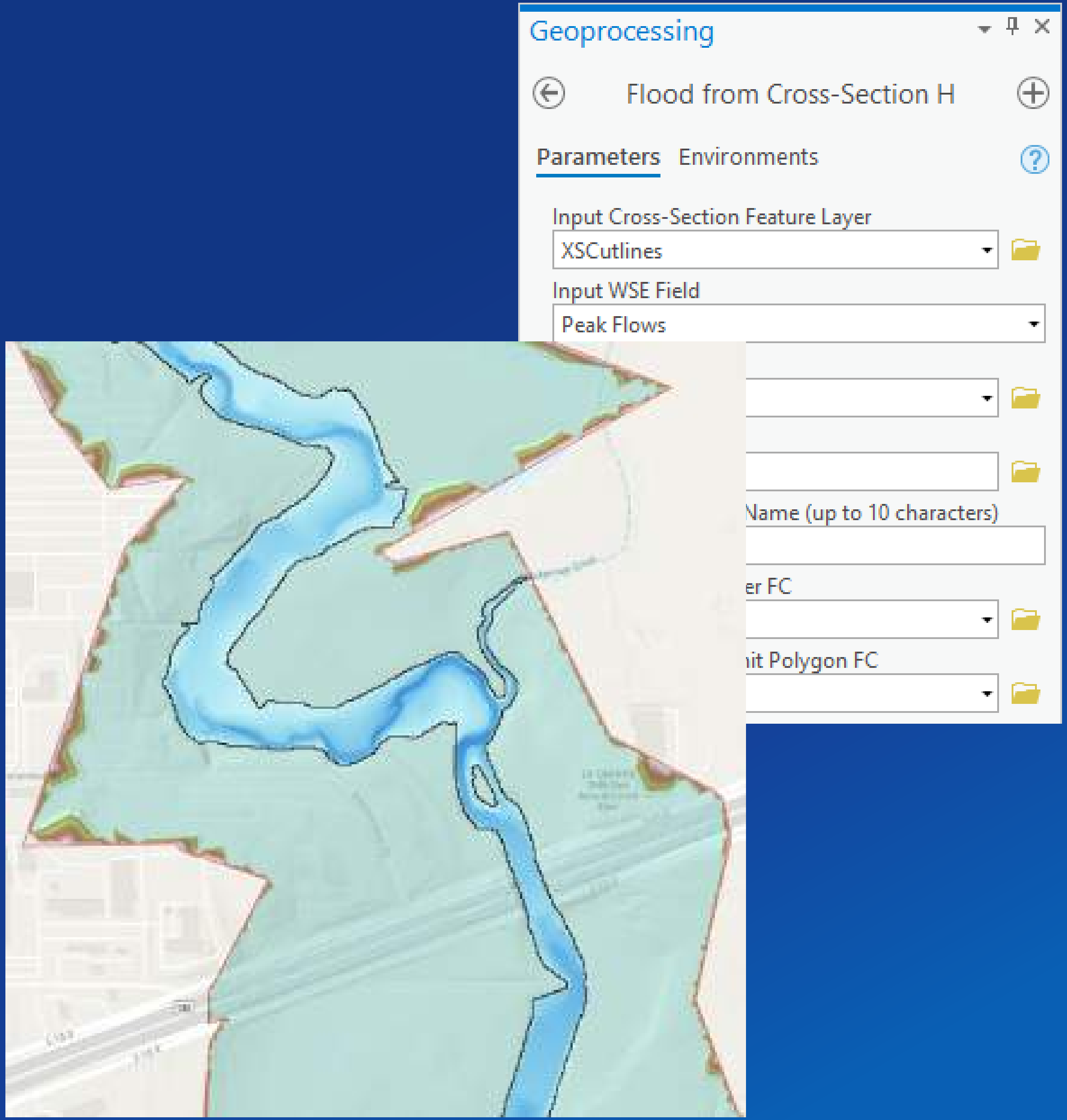
HEC-RAS Postprocessing

- Import from sdf file into geodatabase
  - XSCutlines
    - With WSE fields
  - River2D
  - BoundingPolygons
  - …

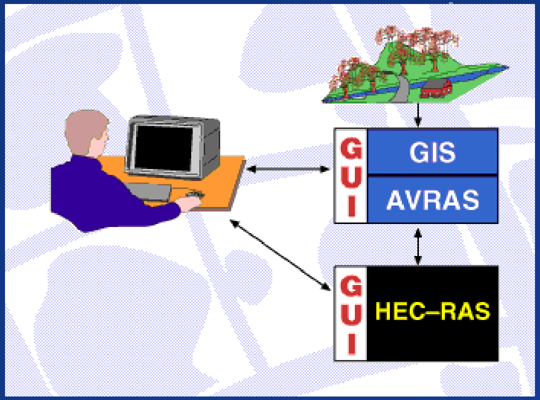


HEC-RAS Postprocessing

- Floodplain delineation from cross-sections
  - Using DEM as terrain
  - Limit floodplain to directly connected areas
  - Limit floodplain to limiting polygon
- Results:
  - Geodatabase:
    - Flood polygon extents
  - Surfaces:
    - Depth
    - Water surface elevation



System/Integration Architecture



- Loose coupling.
- Two specific RAS tools, the rest are standard Arc Hydro tools.
  - Python export code (to ASCII file). This is different from HEC-GeoRAS that used XML and XSLT export methodology.
- You can use the same tools to support any other 1D hydraulic model.
  - Modify python code to export to a different model-specific output format.
- Fully compliant with geoprocessing infrastructure so you can build automation around your specific modeling workflows (Model Builder, Python, Notebooks).
- Adding few more functions on pre and post-processing.

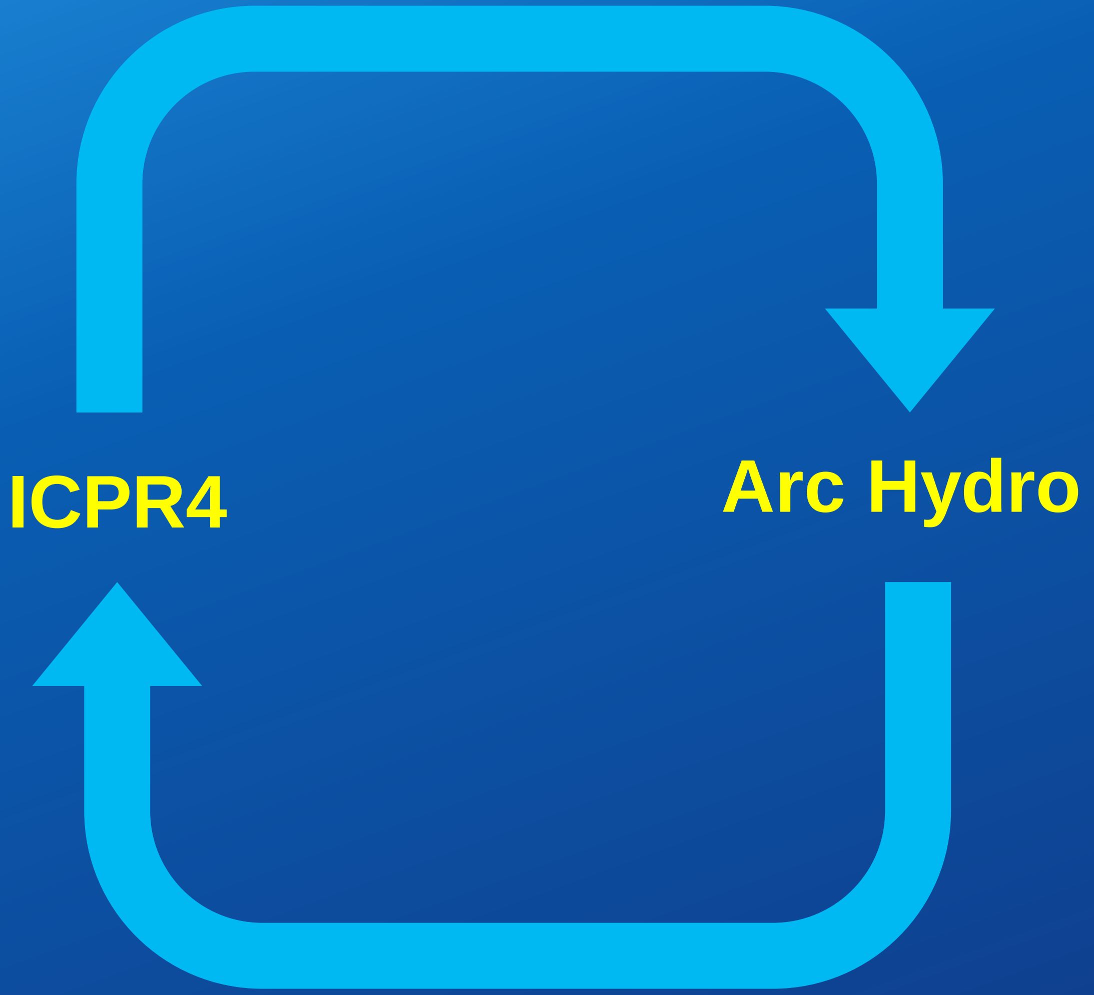
Polling question

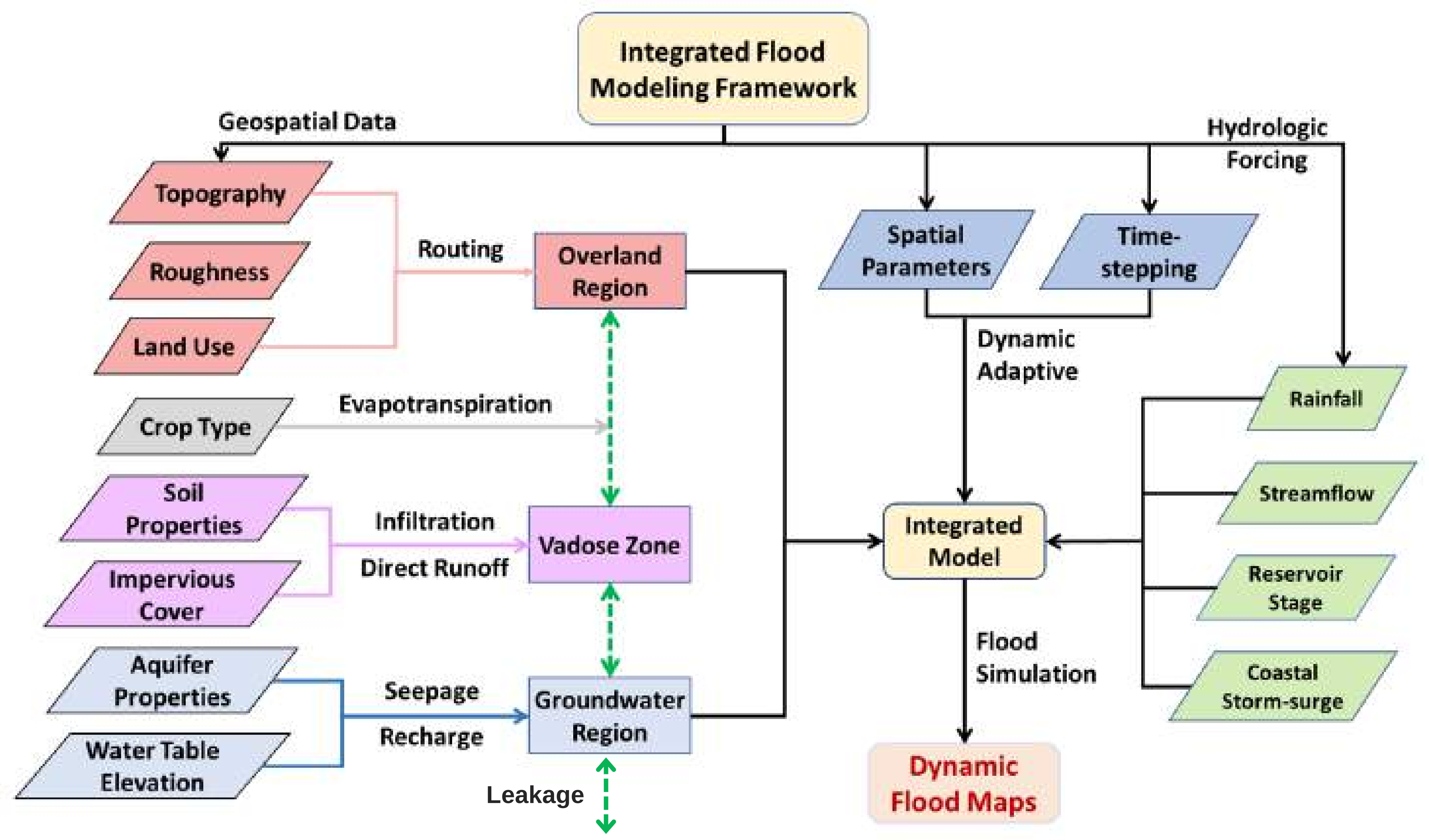
- Is integrated hydrologic and hydraulic modeling important for your work?
  - Yes
  - No
- Are you familiar with ICPR 4? (Interconnected Channel and Pond Routing Model)
  - Yes, I’ve used it
  - Yes, I’ve heard about it
  - No, I’m not familiar with ICPR 4
- Do you use real-time flow forecasting?
  - Yes
  - No
  - I know about flow forecasting but haven’t used it

Interconnected Channel & Pond Routing Model

ICPR4

Pete Singhofen & Warren McKinnie



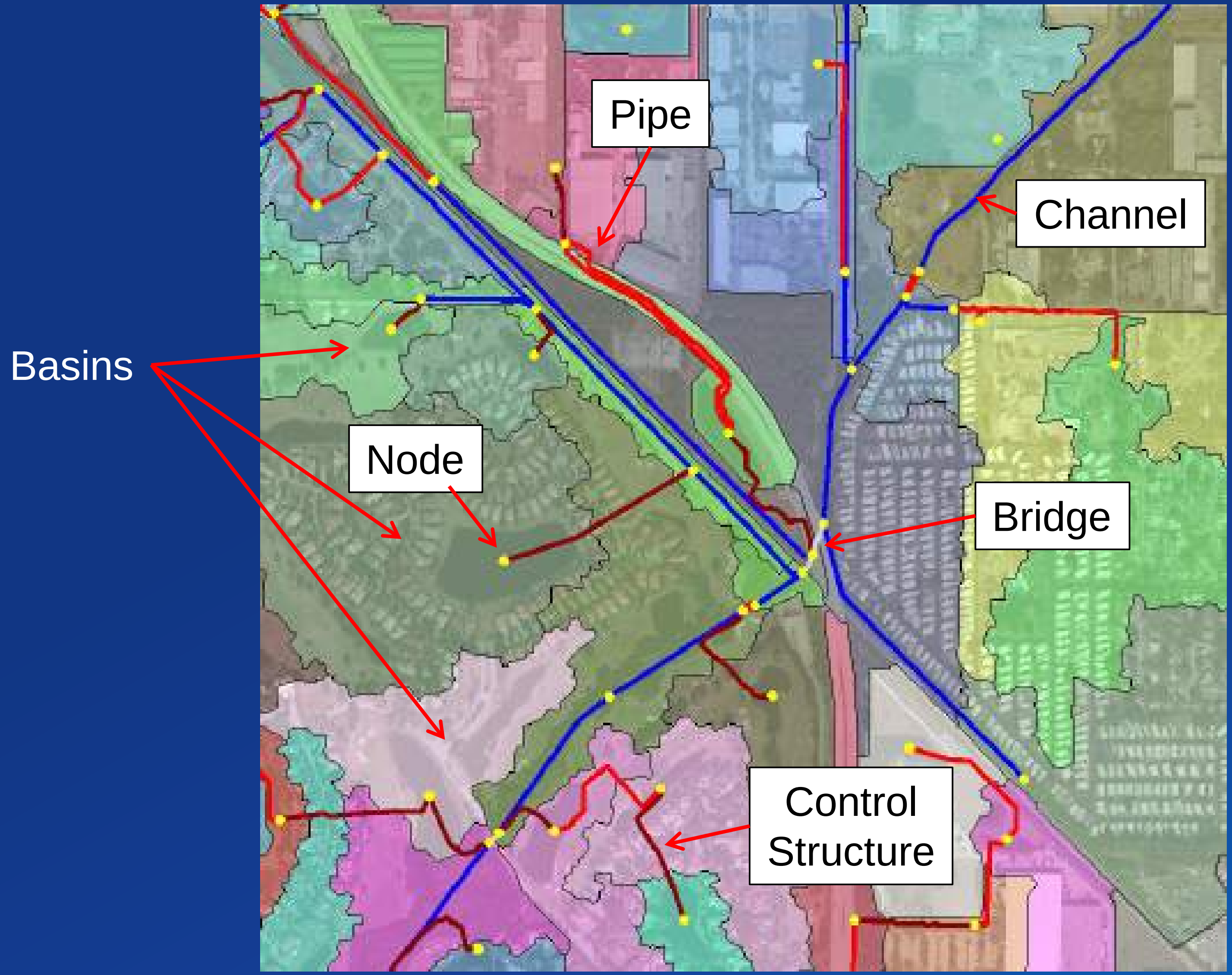


STREAMLINE TECHNOLOGIES

ICPR4 Building Blocks

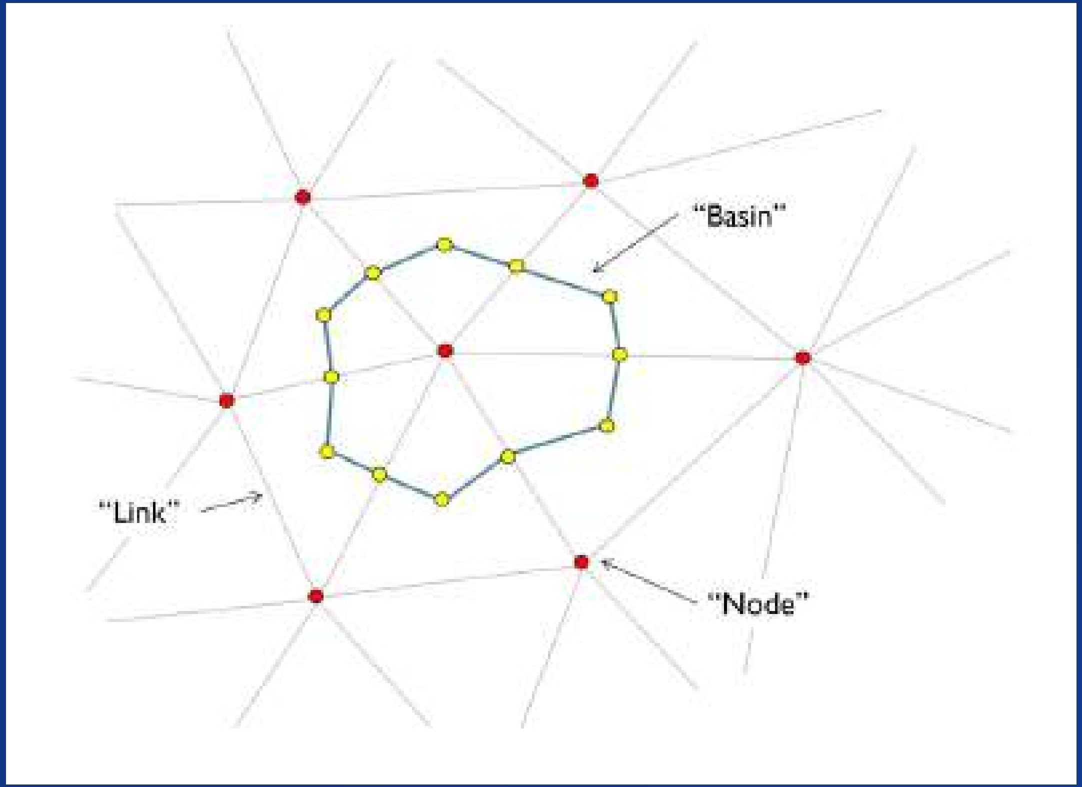
Nodes, Links, Basins

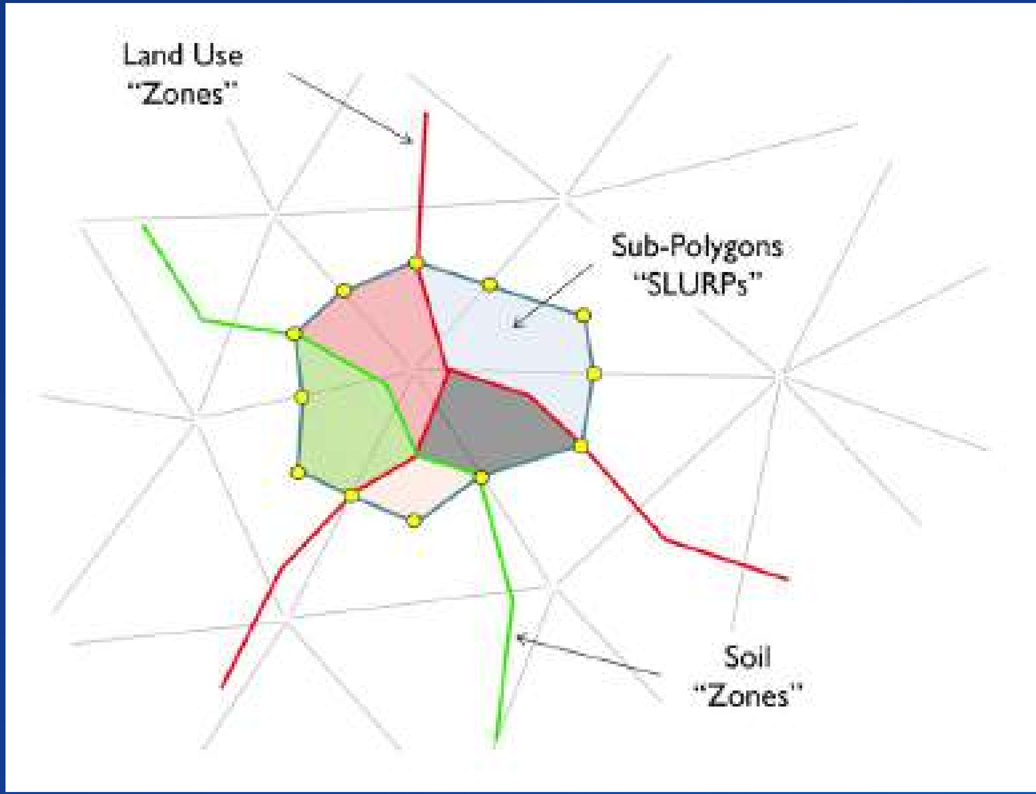
- Runoff hydrographs from “Basins” are delivered to “Nodes”
- Water surface elevations are calculated at “Nodes”
- Flows are calculated for “Links” based on WSEs at the connecting nodes



2D Overland Flow in ICPR4

Finite Volume Approach Based on Underlying Triangular Computational Mesh





2D Overland Flow in ICPR4

Important Characteristics of a 2D Surface Model

1. Reasonably Replicate Terrain
   a. Storage
   b. Ridges and Valleys
   c. Obstructions
2. Mechanisms to Interface with 1D Components
3. Boundary Condition Flexibility
   a. Stage
   b. External Flow

2D Graphical Elements

Exclusions...
Extrusions...
Breakpoints...
Breaklines...

← Terrain Characterization

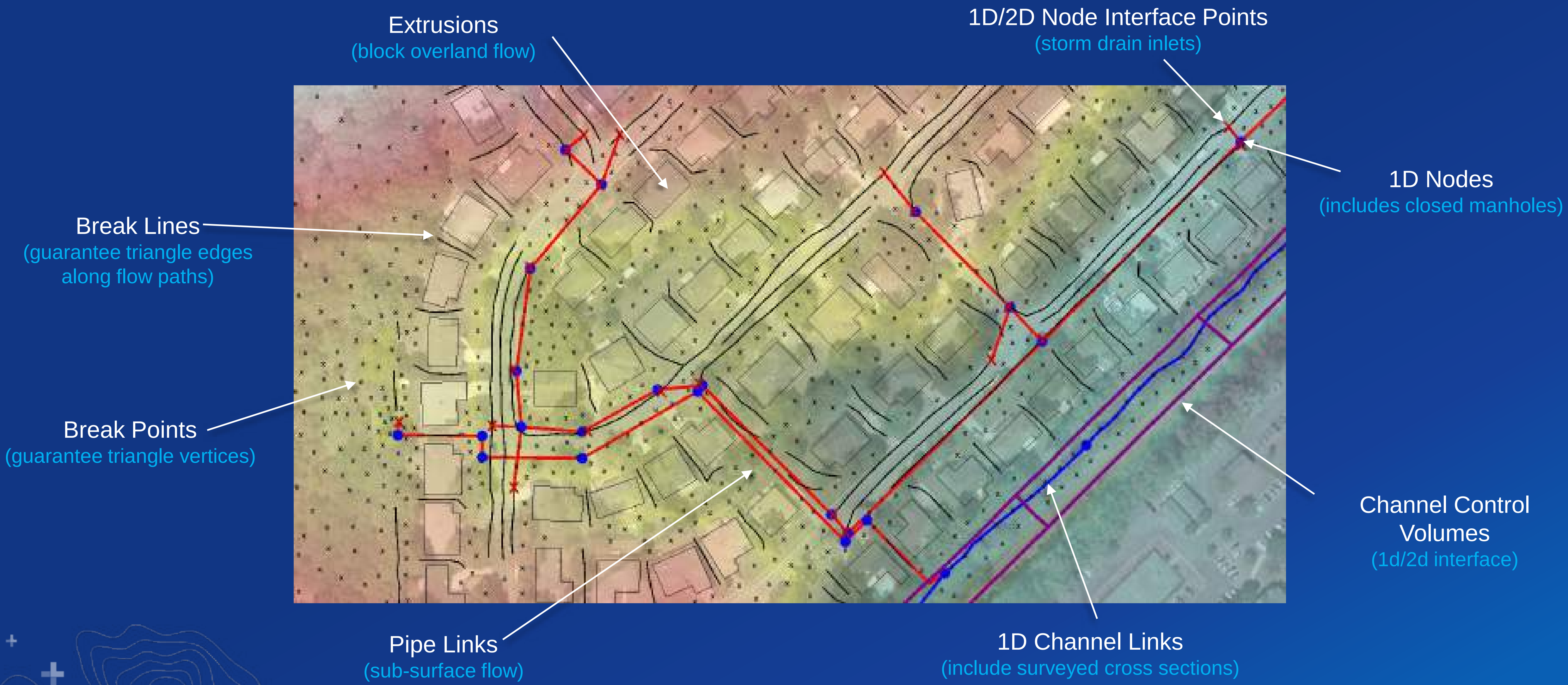
Pond Control Volumes...
Channel Control Volumes...
Channels...
Weirs...
1D Node Interfaces...
Mapped Basins...
Basin Interface Points...
Basin Interface Lines...

← Interface with 1D Elements

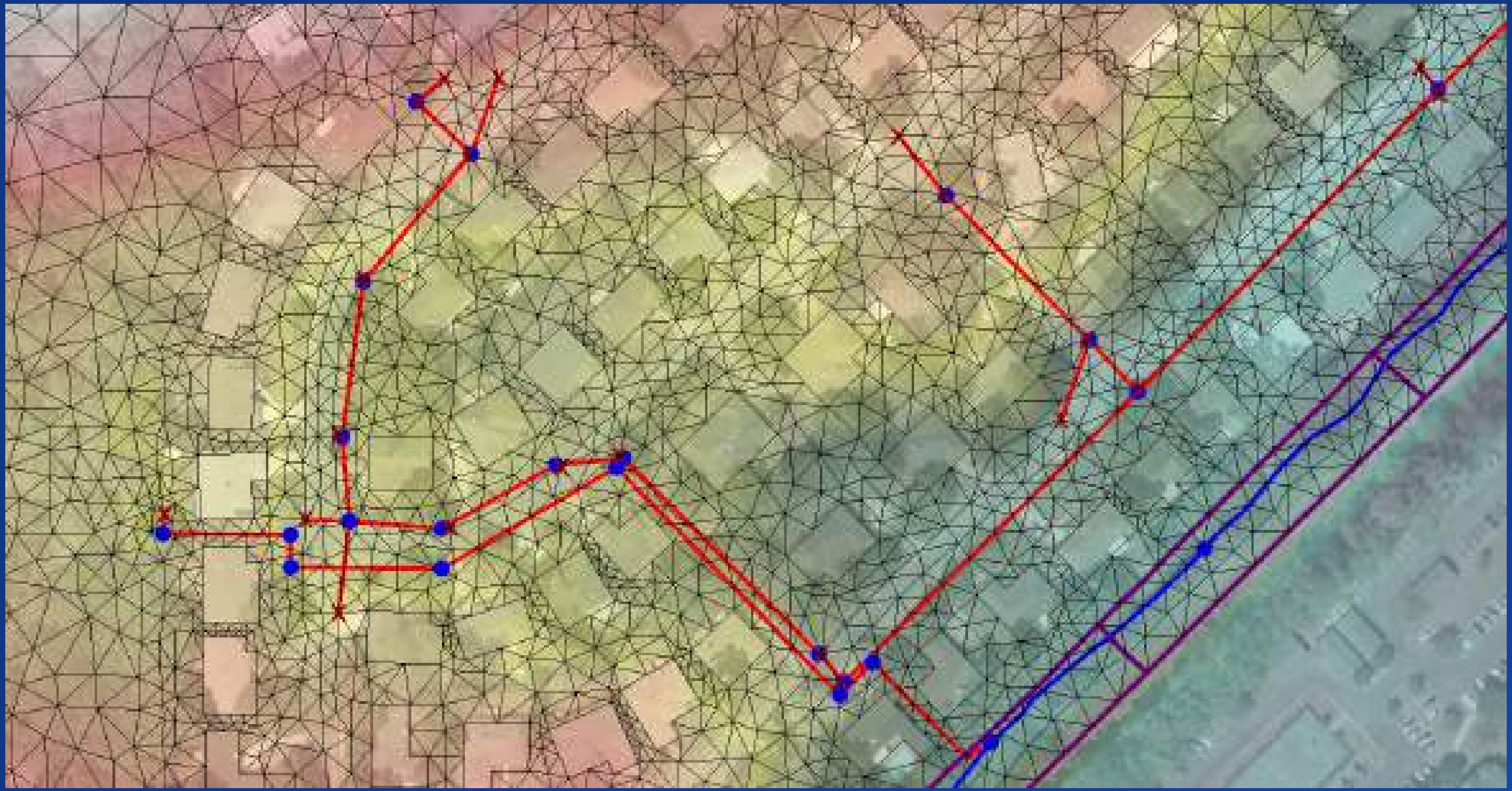
Boundary Stage Points...
Boundary Stage Lines...
External Hydrograph Points...
External Hydrograph Lines...

← Boundary Conditions

2D Overland Flow in ICPR4

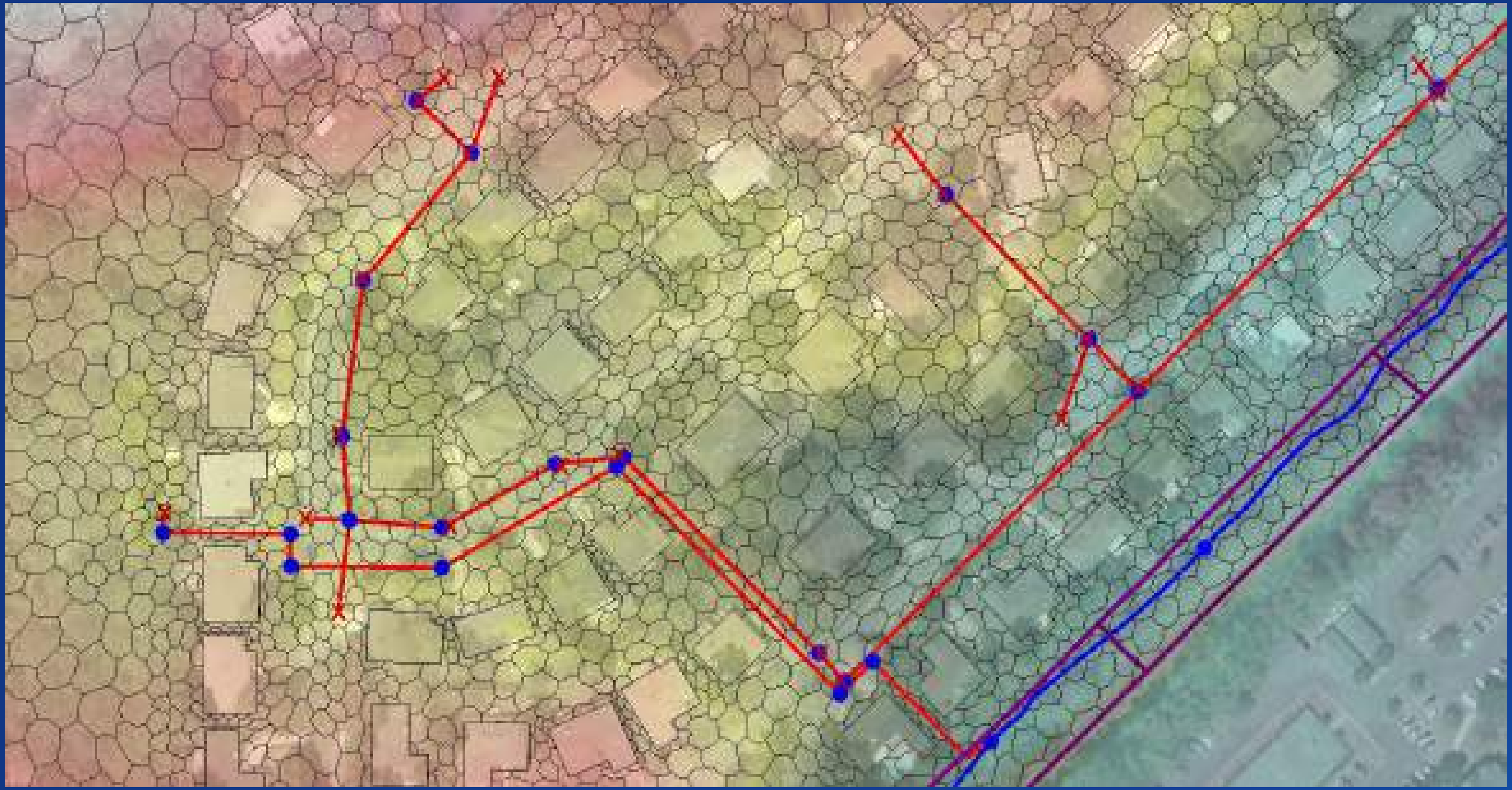


2D Overland Flow in ICPR4



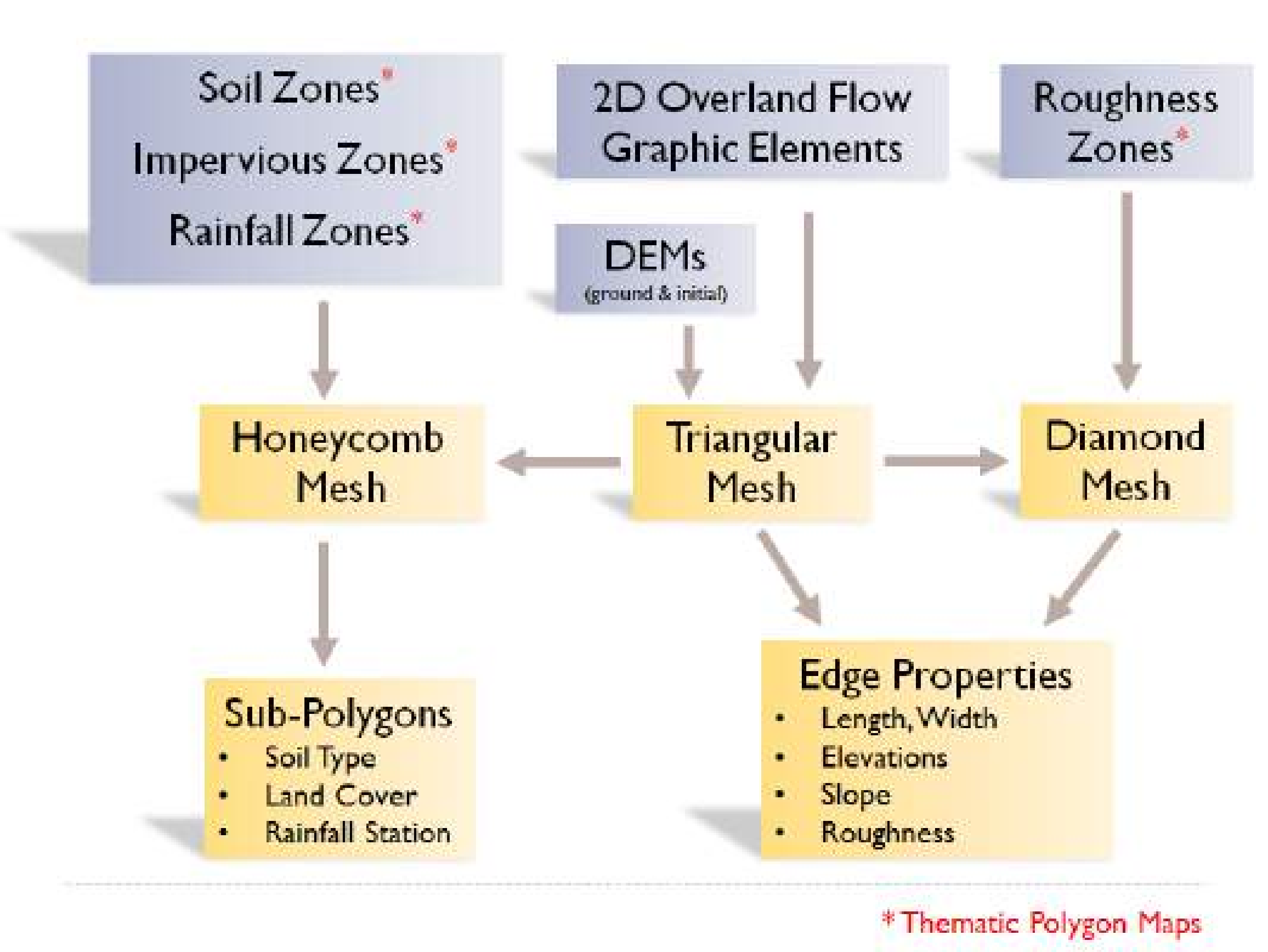
Triangular Mesh Generation

2D Overland Flow in ICPR4



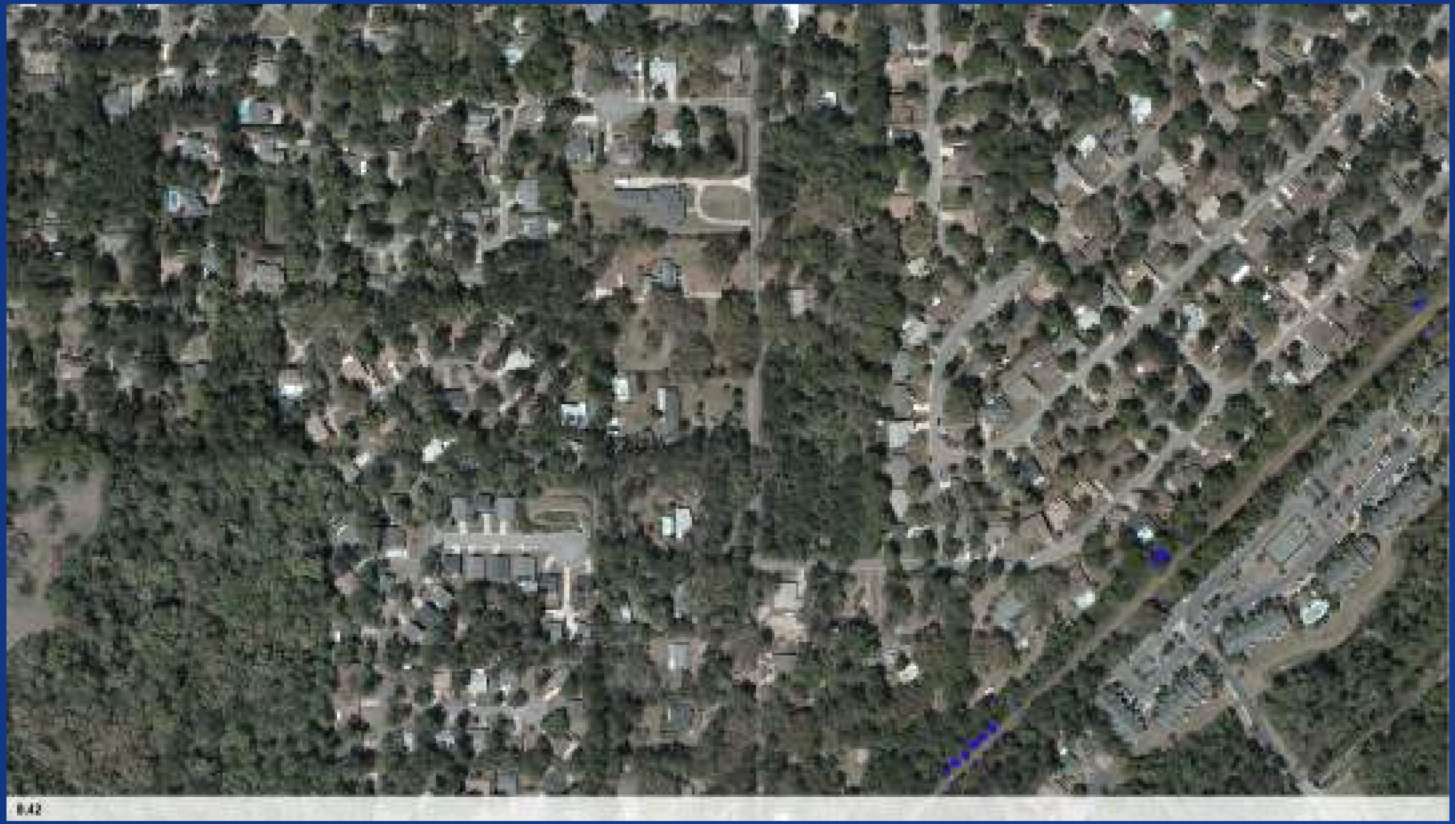
Honeycomb Mesh Generation

2D Overland Flow in ICPR4



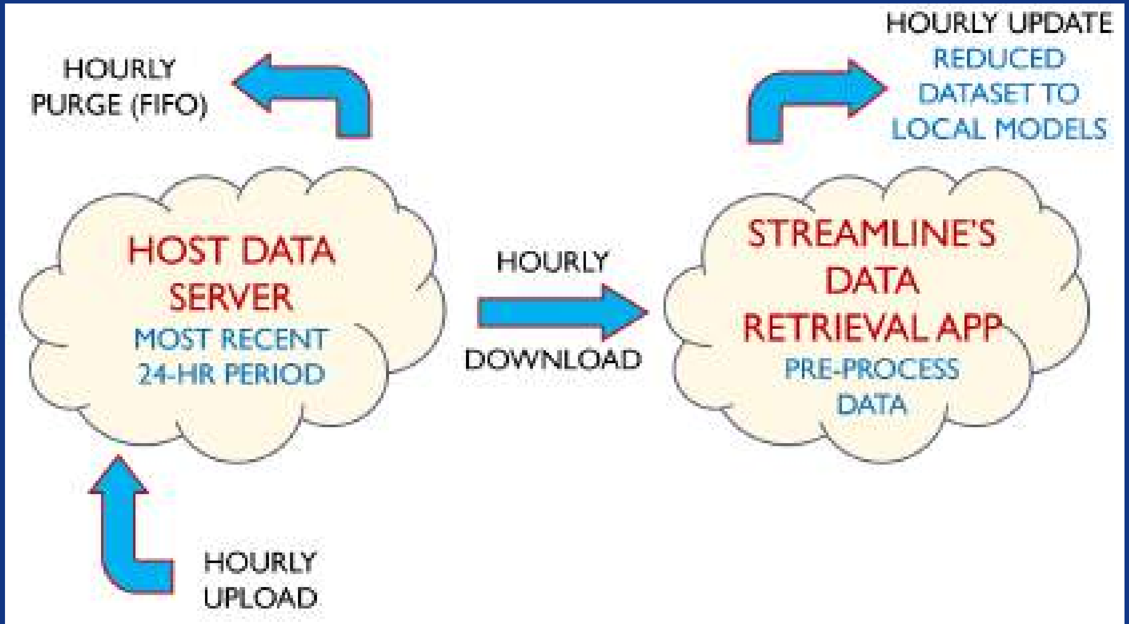
Mesh Parameterization Process

2D Overland Flow in ICPR4



100-yr 24-hr Storm
Flood Depths > 3”

Real-Time Flood Forecasting with ICPR4



National Water Model (NWM)
Gridded Forcing Data Products (Rain/ET))

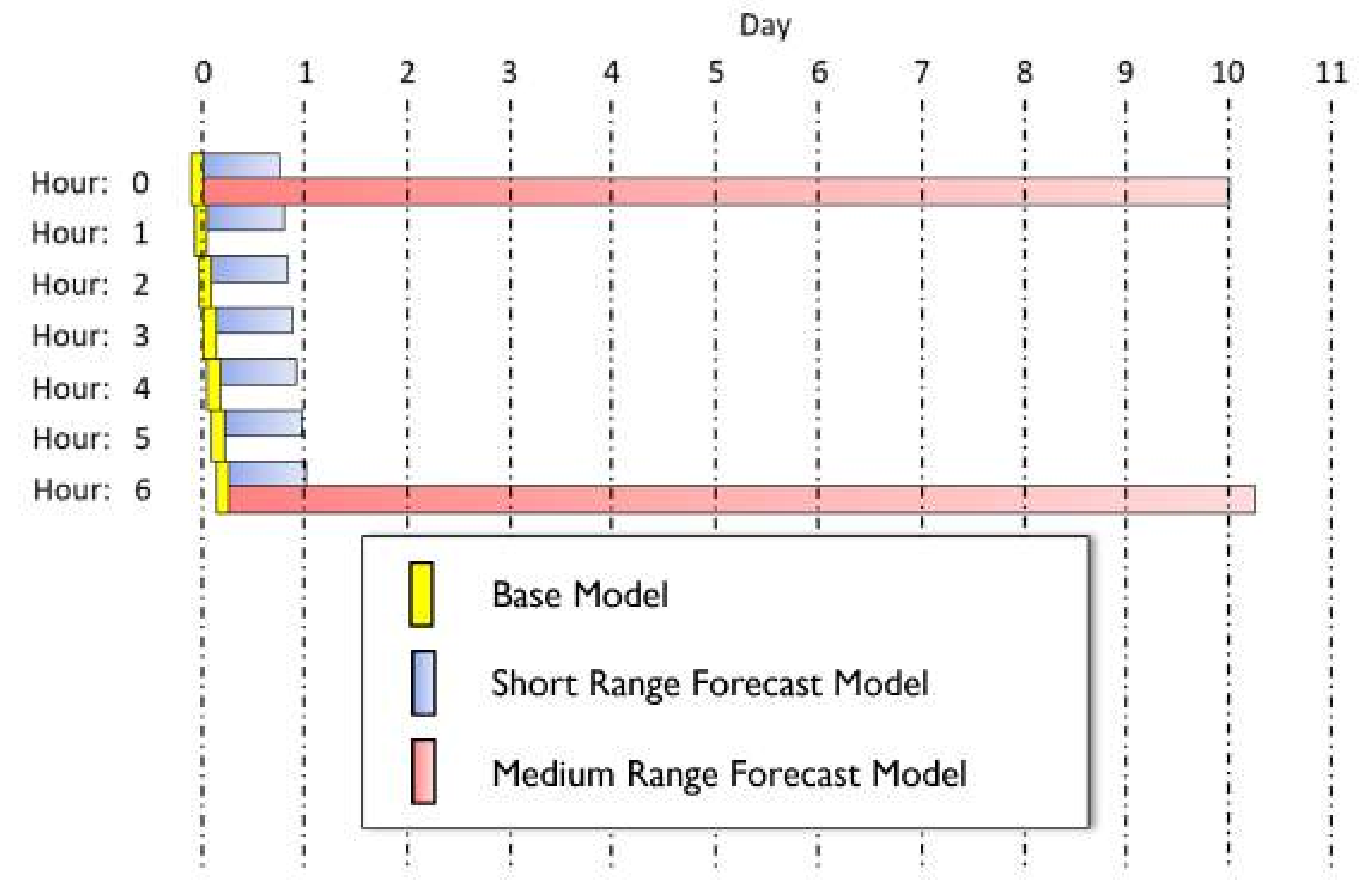
Near Real-Time
- Present Time Minus 1&2 Hours (Radar Only)
- Present Time Minus 3 Hours (Gage Adjusted)

Short Range Forecast
- Forecast Duration: 18 hours in 1-hour Increments
- Forecast Frequency: Every hour

Medium Range Forecast
- Forecast Duration: 10 days in 1-hour Increments
- Forecast Frequency: Every 6 hours

STREAMLINE TECHNOLOGIES

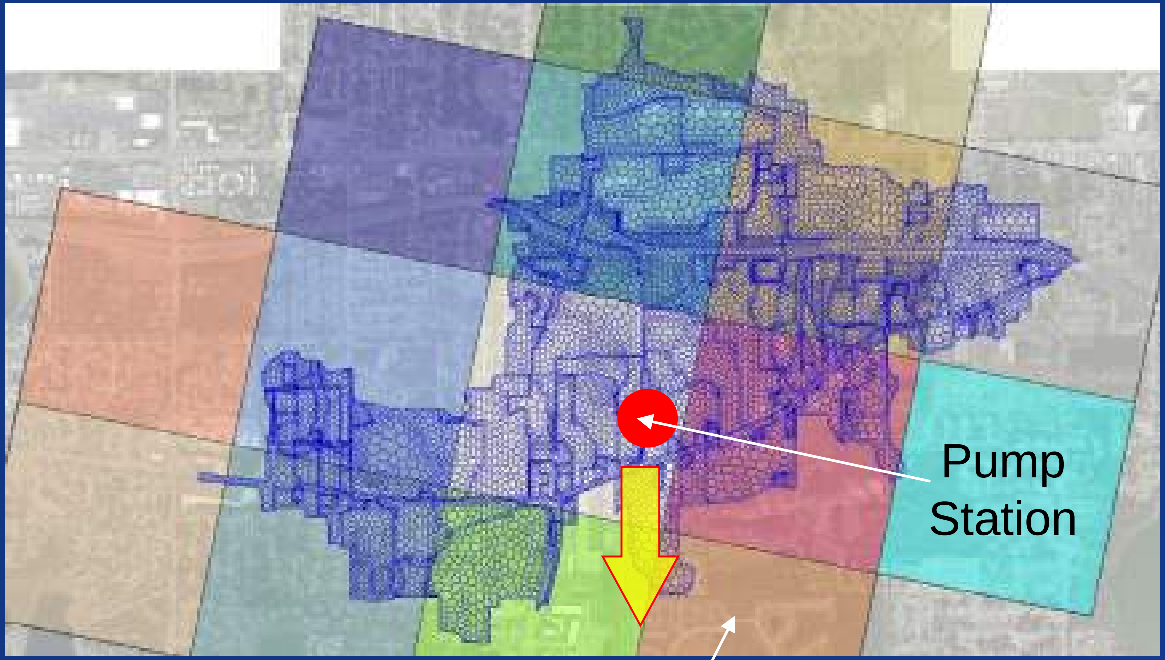
Real-Time Flood Forecasting with ICPR4



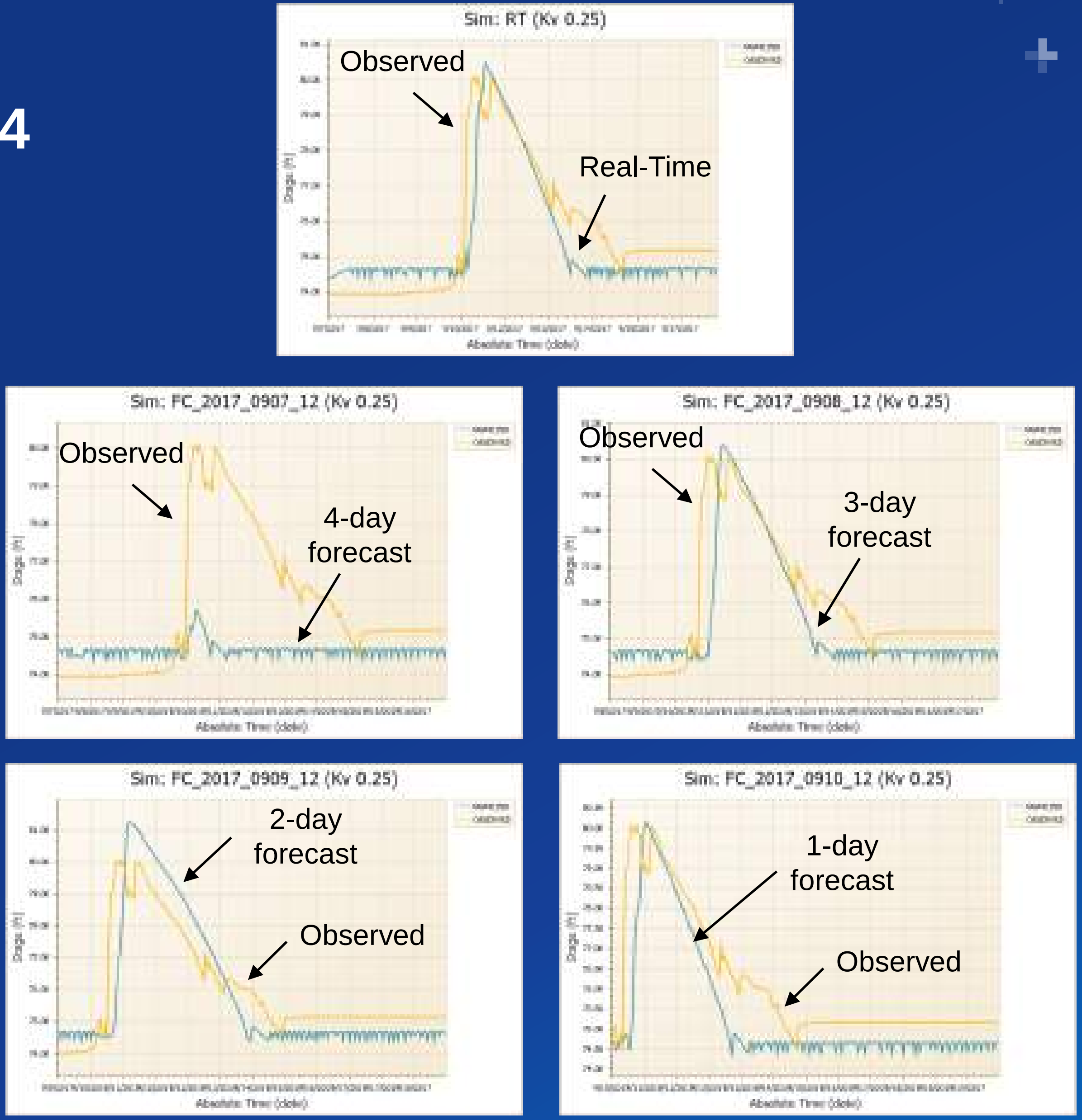
- Base model runs continuously in near real-time
- Base model maintains current surface water and groundwater levels and soil moisture conditions
- Forecasts are spawned from base model using it for initial conditions

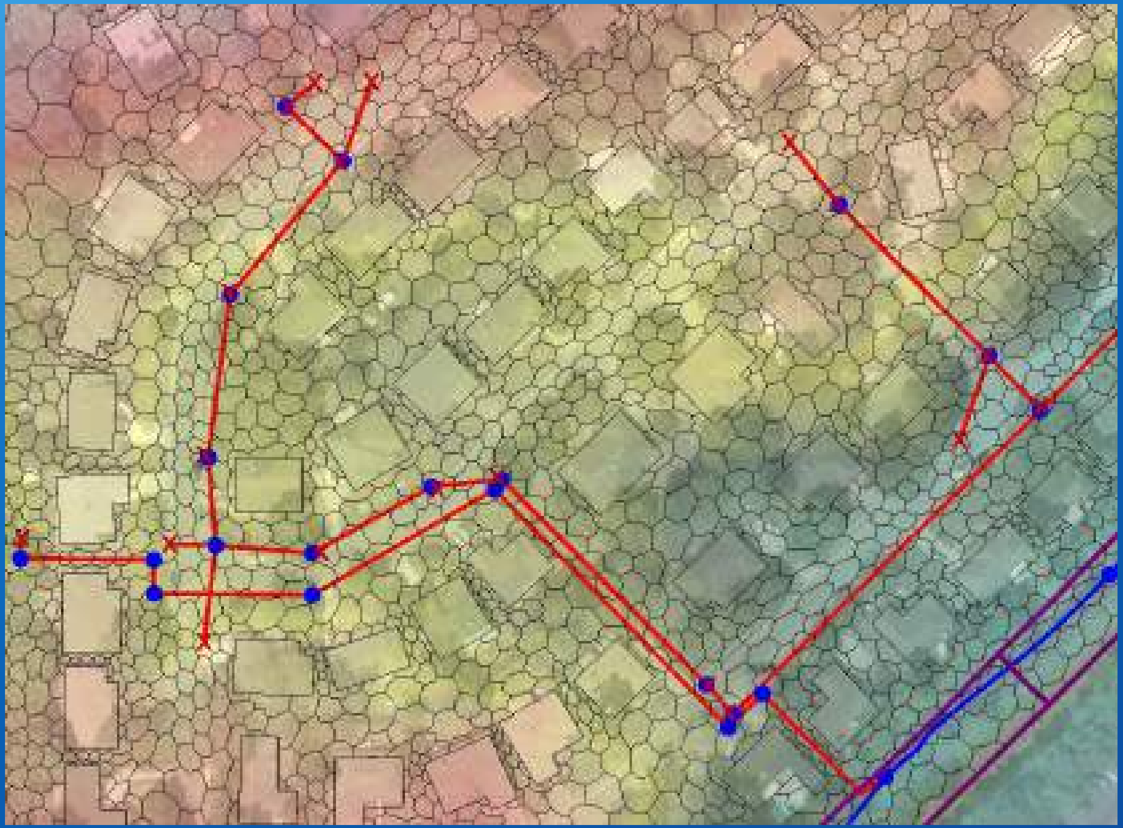
Real-Time Flood Forecasting with ICPR4

Hurricane Irma



NWM 1-km^2 Forcing Grid





GWIS/ICPR4 Demo

Final Thoughts

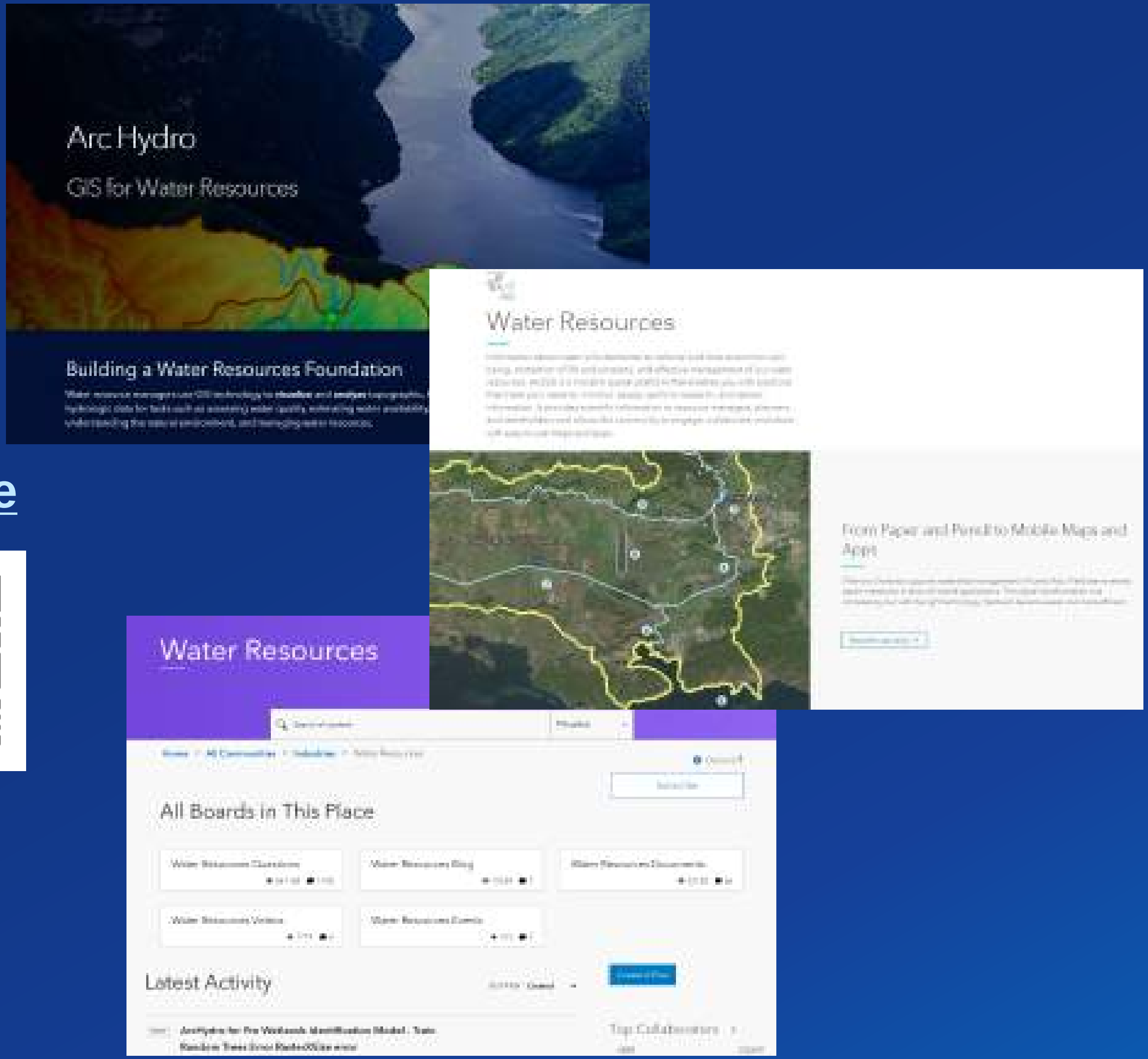
Final Thoughts

- Model integration is an active area of Arc Hydro development.
  - Let us know what you think, what you need.
- Get involved with Arc Hydro.
  - Use the Community pages to interact with each other and the Arc Hydro team.
    - More focused the better!
  - Or email us directly

Questions?

Getting involved

- [Arc Hydro Web Page]
- [Water Resources Industry Web Page]
- [Arc Hydro Community]
  - archydro@esri.com
  - ddjokic@esri.com

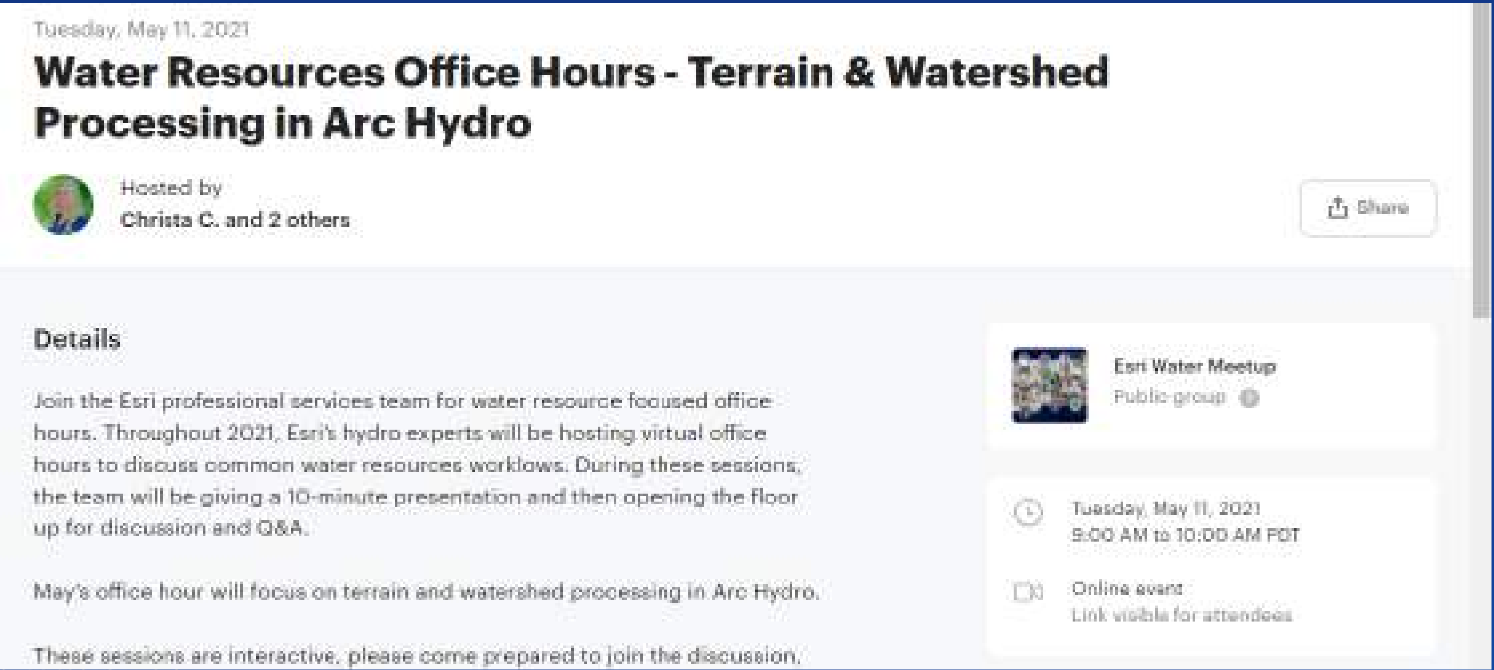


@EsriWater Esri Water Resources @EsriWater Esri Water Meetup Esri Water eNewsletter

In Closing

Announcing “Arc Hydro Office Hours”

- **May 11th, 9-10 PDT. “Terrain and watershed processing in Arc Hydro”**
  - https://www.meetup.com/Esri-Water-Meetup/events/277554666/



Arc Hydro in Action Webinar Series

- **All webinar recordings will be available on demand.**

THANK YOU!


Pete Singhofen
Gina O'Neil
Warren McKinnie
Anneliese Sytsma
Dana Lapides
Christa Campbell
Mariah Salazar
Christine Dartiguenave