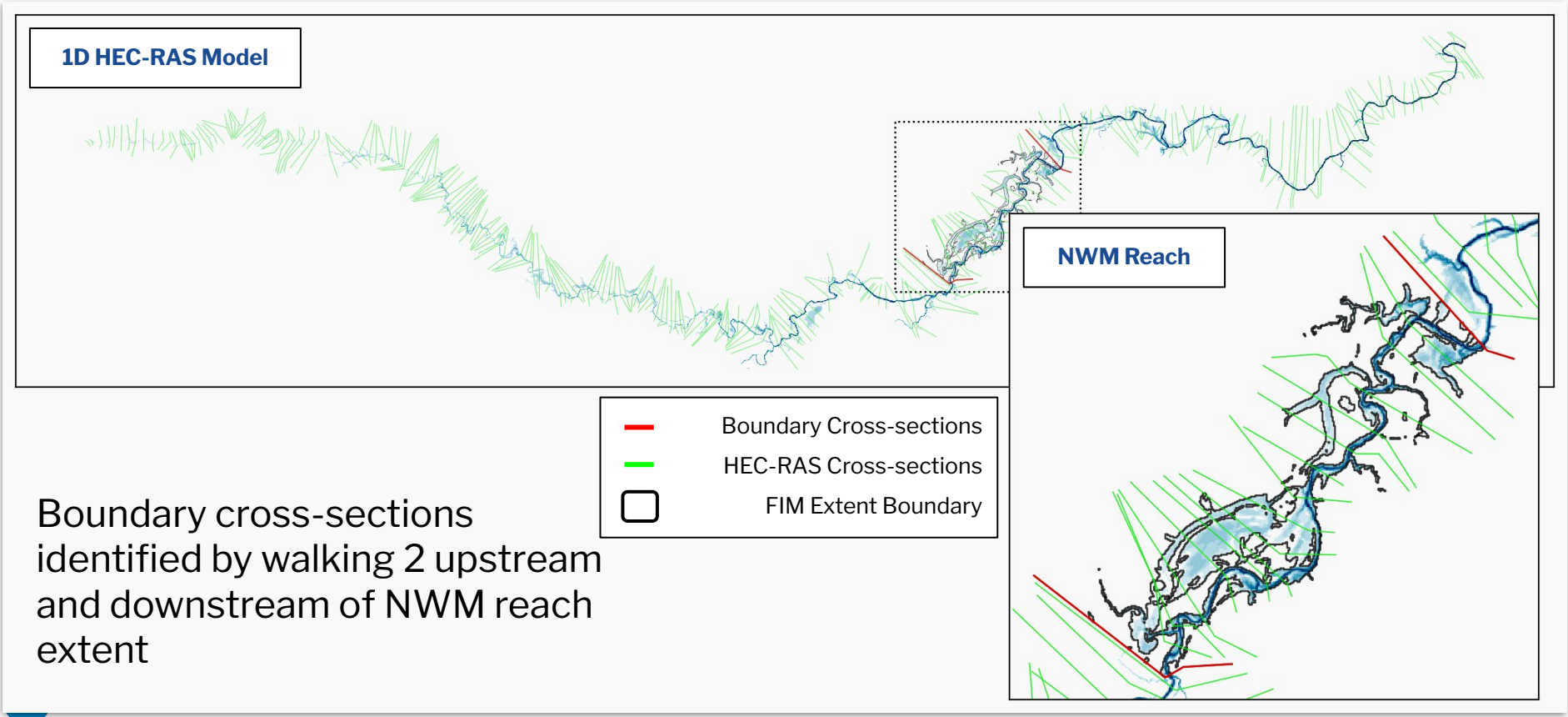

OWP
OFFICE OF
WATER
PREDICTION
FLOG Meeting
Geo-Intelligence Division FIM Development
Updates
November 8th, 2024
NOAA
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE

RAS2FIM v2



Boundary cross-sections identified by walking 2 upstream and downstream of NWM reach extent

RAS2FIM v2 Concept

1. Running original HEC-RAS models instead of creating child HEC-RAS models

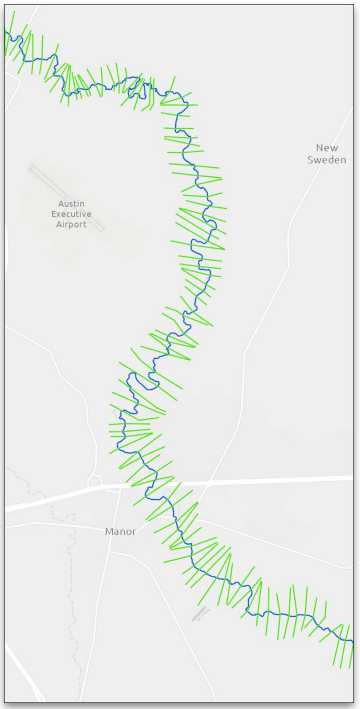
Source HEC-RAS model

Continuous FIM libraries for entire model

FIM libraries split by NWM segment

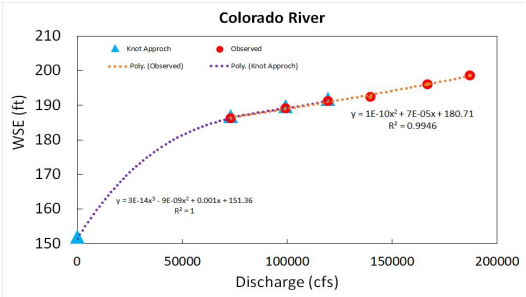
RAS2FIM v2 Boundary Conditions

2. Following parent models boundary conditions

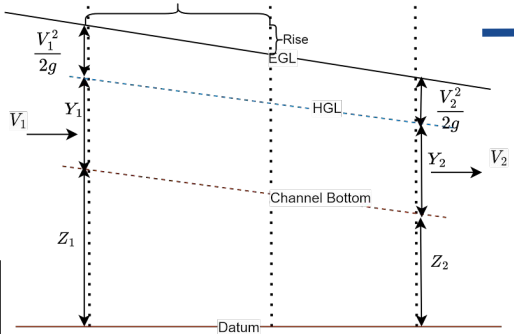


Source HEC-RAS model

Known Water Surface Elv.



Known Energy Gradeline

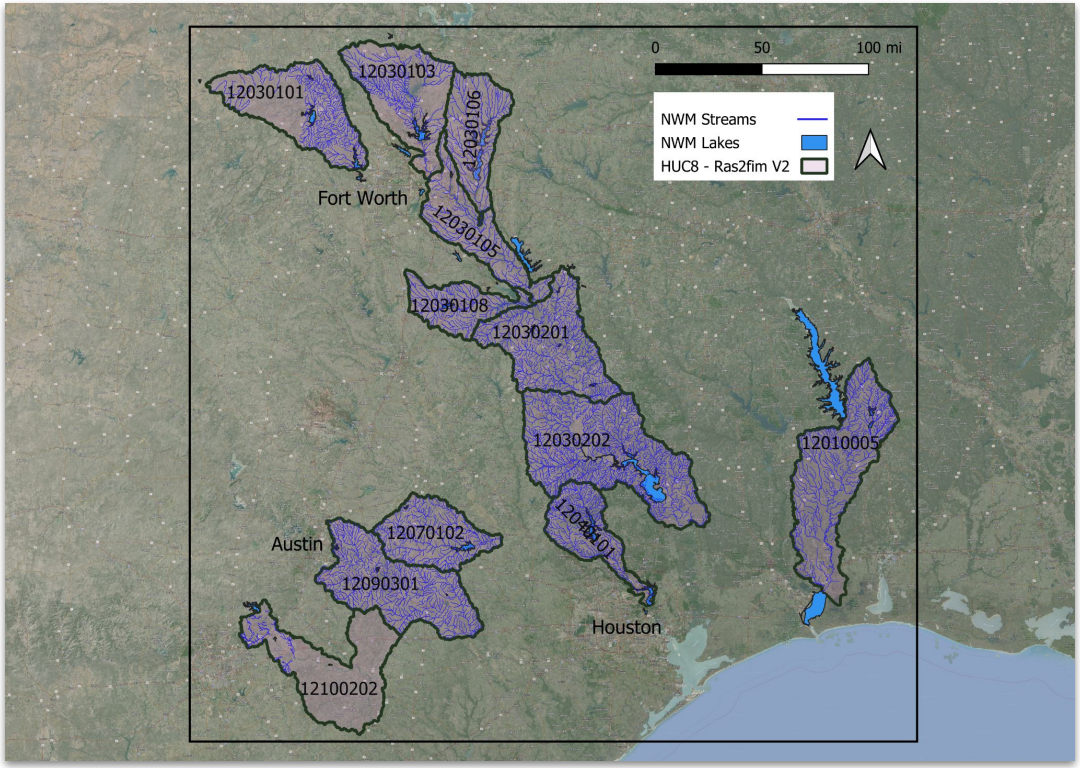


$$Z_2 + Y_2 + \frac{V_2^2}{2g} = Z_1 + Y_1 + \frac{V_1^2}{2g} + h_c$$

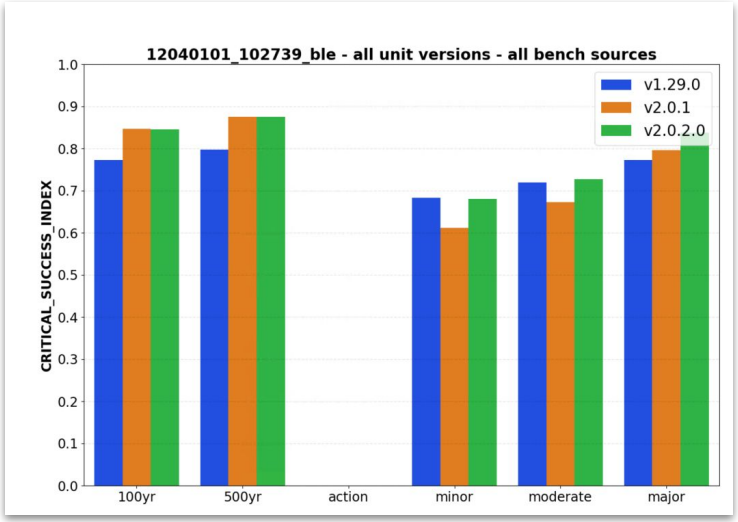
Boundary conditions (BC)

Continuous FIM libraries for entire model

RAS2FIM v2.x

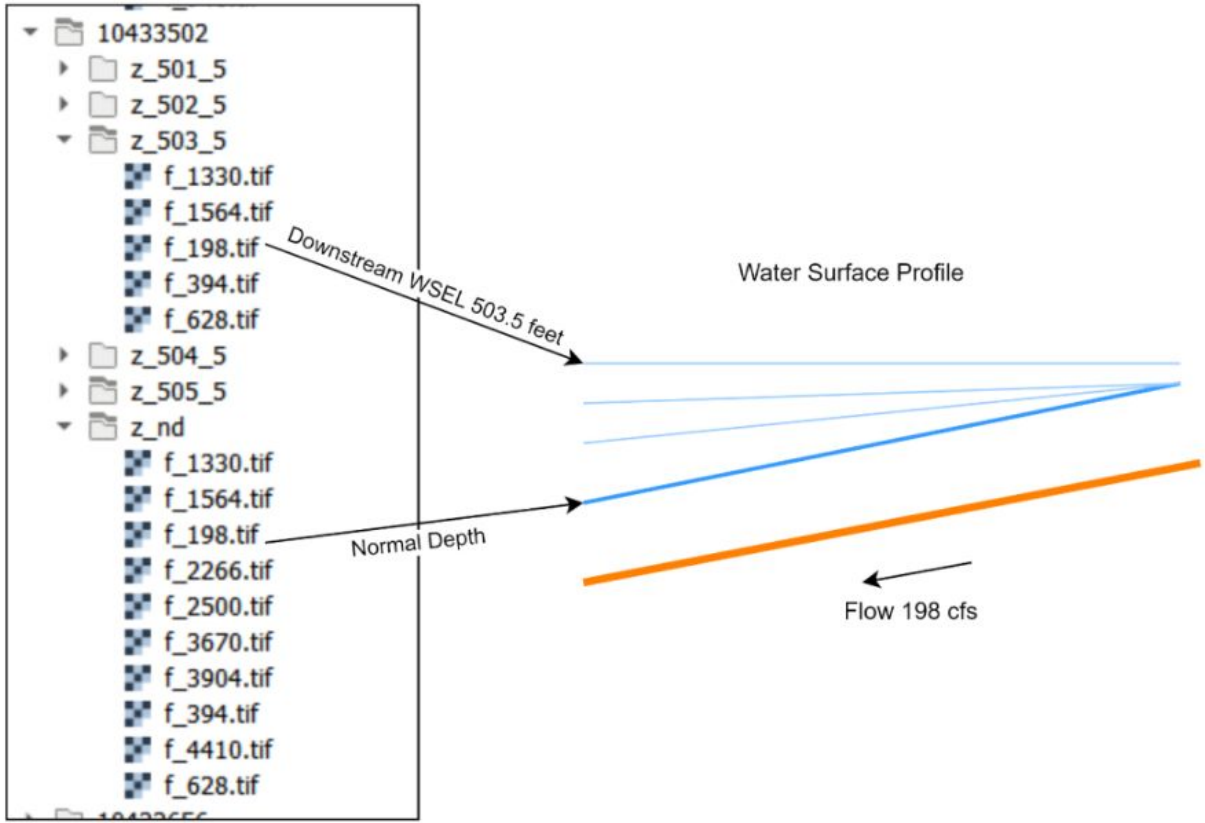


RAS2FIM v2 Domain

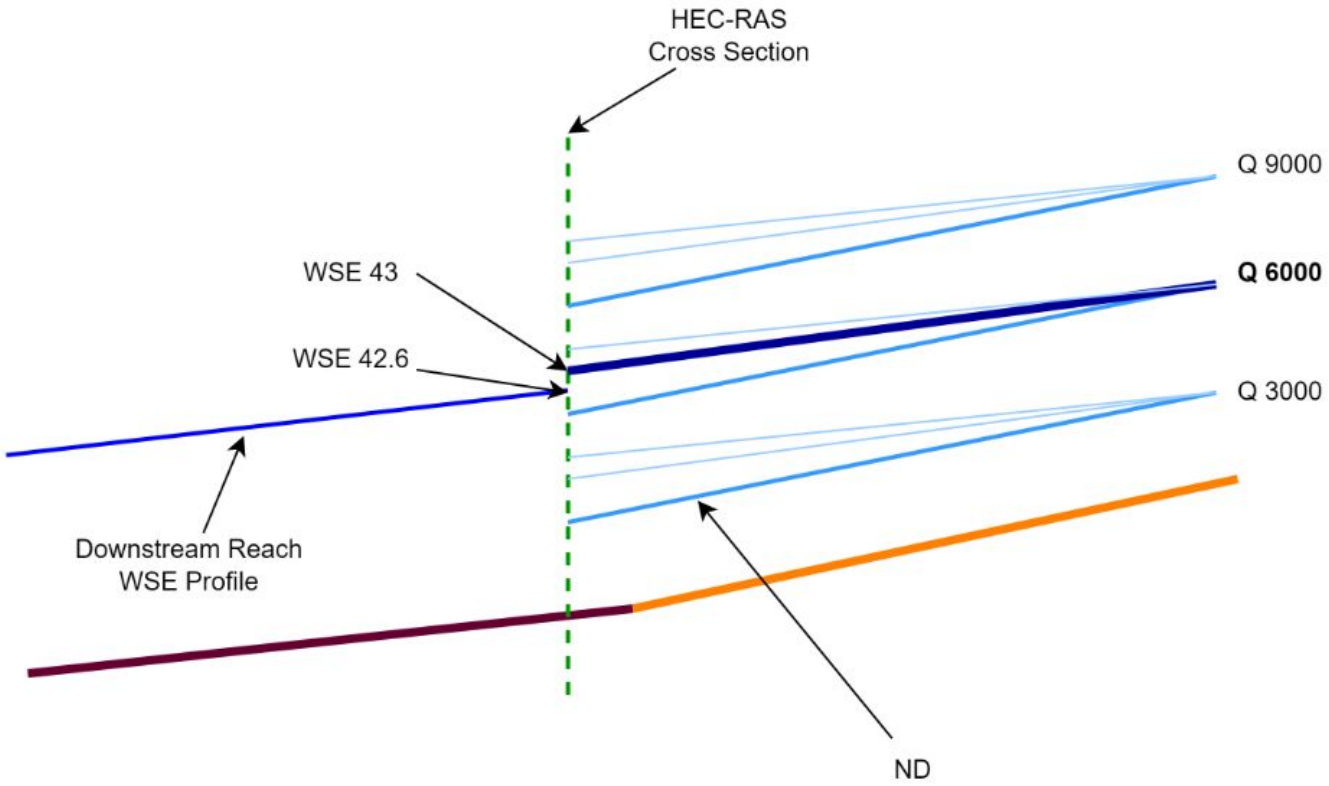


RAS2FIM v2 Evaluation

Ripple 1D


10433502
z_501_5
z_502_5
z_503_5
f_1330.tif
f_1564.tif
f_198.tif
f_394.tif
f_628.tif
z_504_5
z_505_5
z_nd
f_1330.tif
f_1564.tif
f_198.tif
f_2266.tif
f_2500.tif
f_3670.tif
f_3904.tif
f_394.tif
f_4410.tif
f_628.tif
Downstream WSEL 503.5 feet
Normal Depth
Water Surface Profile
Flow 198 cfs

Ripple 1D Backwater



Ripple STAC

Texas HUC 12040101 BLE Models

API | Source | Share

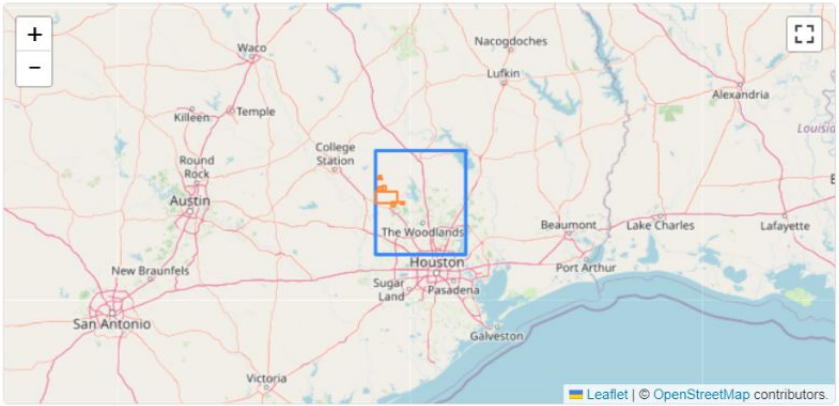
in stac-fastapi

Up | Browse | Search

Description

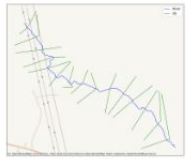
Test collection for Ripple using Texas BLE data accessed via https://webapps.usgs.gov/infrm/estbfe/

License	proprietary
Temporal Extent	2024-06-27 18:59:10 UTC – 21:29:59 UTC



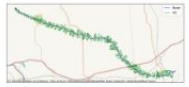
Items

« First | ‹ Previous | Next › | Show Filters



BUMS CREEK

2024-06-27 21:27:46 UTC



Metadata

General

ANDY CARTER, PE
Senior Engineering Scientist, The University of Texas at Austin

Flood Organizing Group
Flood Inundation Mapping
(FLOG/FIM)

RAS2FIM-2D

Updated
2024.11.08

Flood Mapping Suite

2019-2021

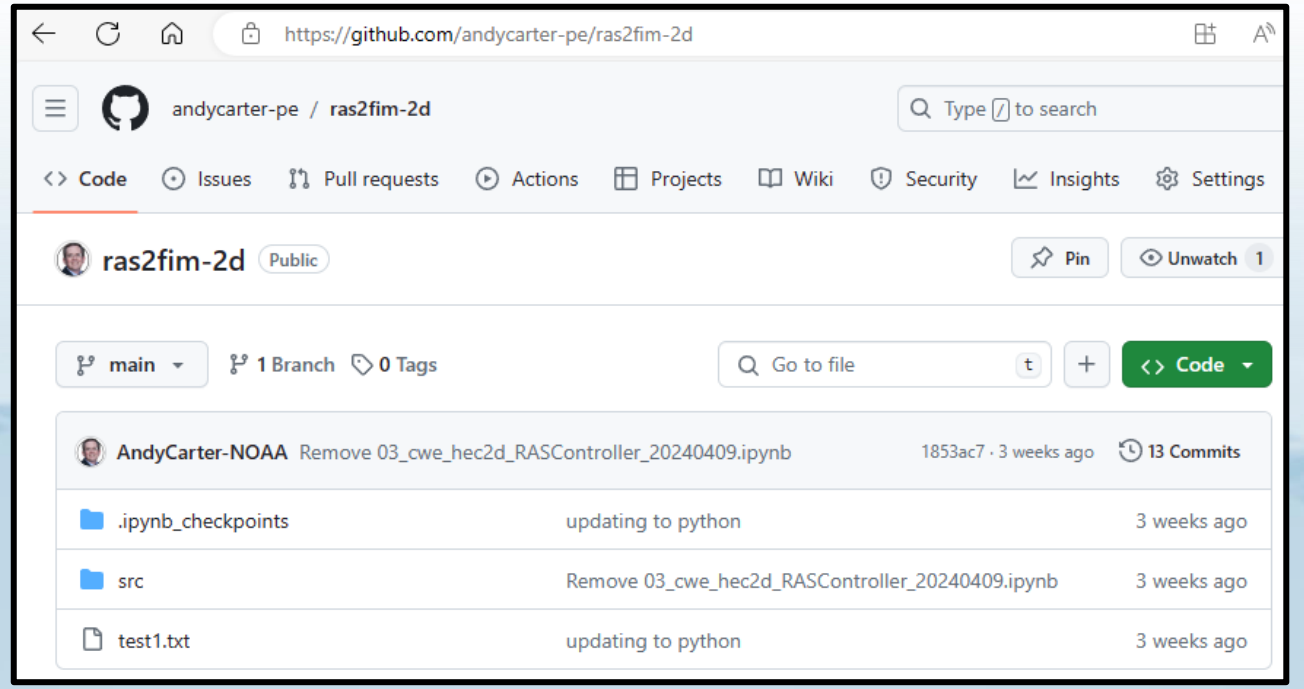
2022-2023

2023-2024+

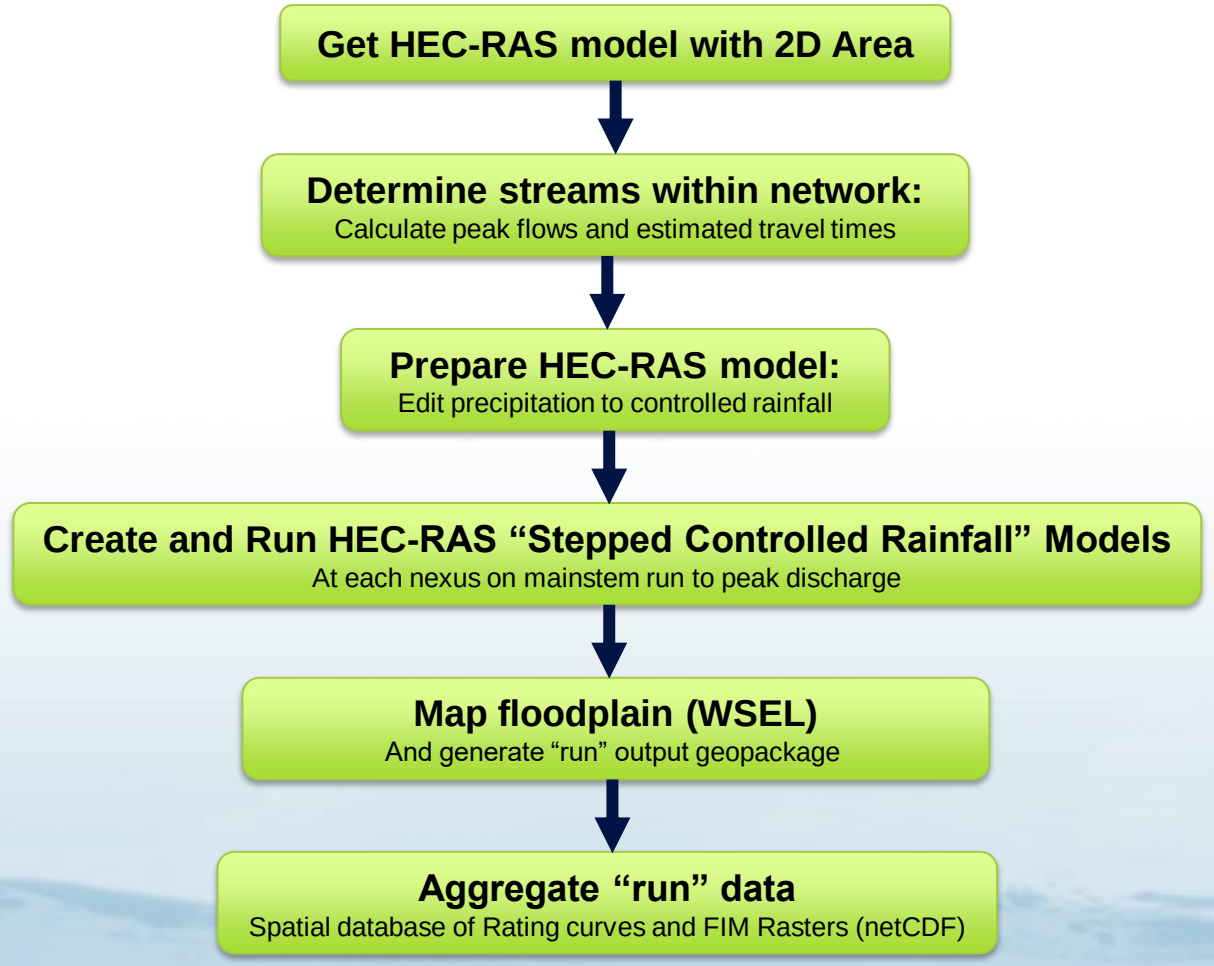
What is RAS2FIM-2D

GOAL: Utilize HEC-RAS 2-dimensional computational grid meshes to develop flood inundation products and corresponding synthetic rating curves for use in the National Water Prediction Service (NWPS)

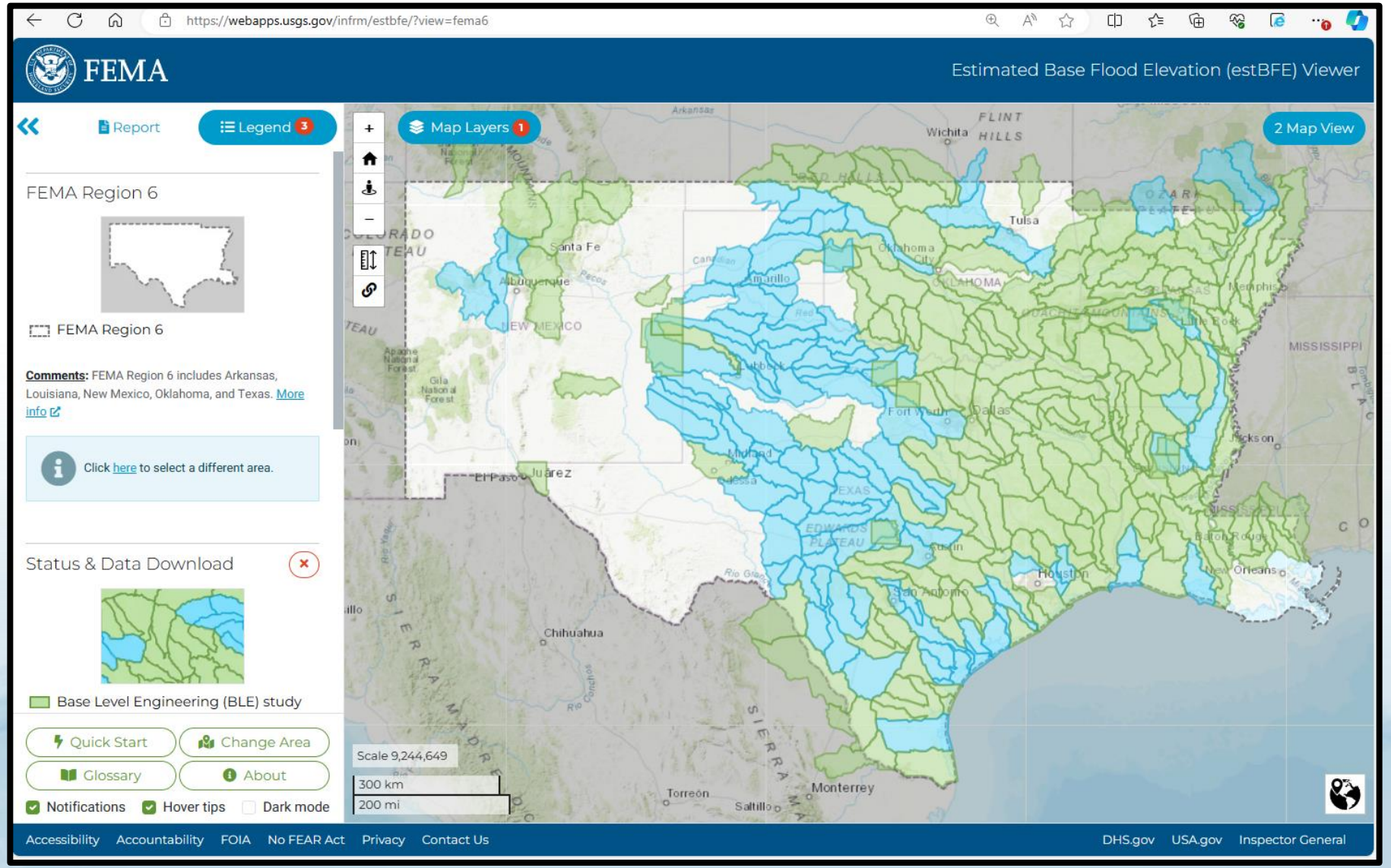
Pair these data with the National Water Model for real-time flood warning and prediction.



Workflow


Get HEC-RAS model with 2D Area
Determine streams within network:
Calculate peak flows and estimated travel times
Prepare HEC-RAS model:
Edit precipitation to controlled rainfall
Create and Run HEC-RAS “Stepped Controlled Rainfall” Models
At each nexus on mainstem run to peak discharge
Map floodplain (WSEL)
And generate “run” output geopackage
Aggregate “run” data
Spatial database of Rating curves and FIM Rasters (netCDF)

RAS2FIM-2D – $$ Millions $$ in Modeling



Needed Inputs

Global Inputs:

(1) NOAA's NextGEN Hydrofrabic (geopackage)

(2) Method for determining peak discharge as function of drainage area

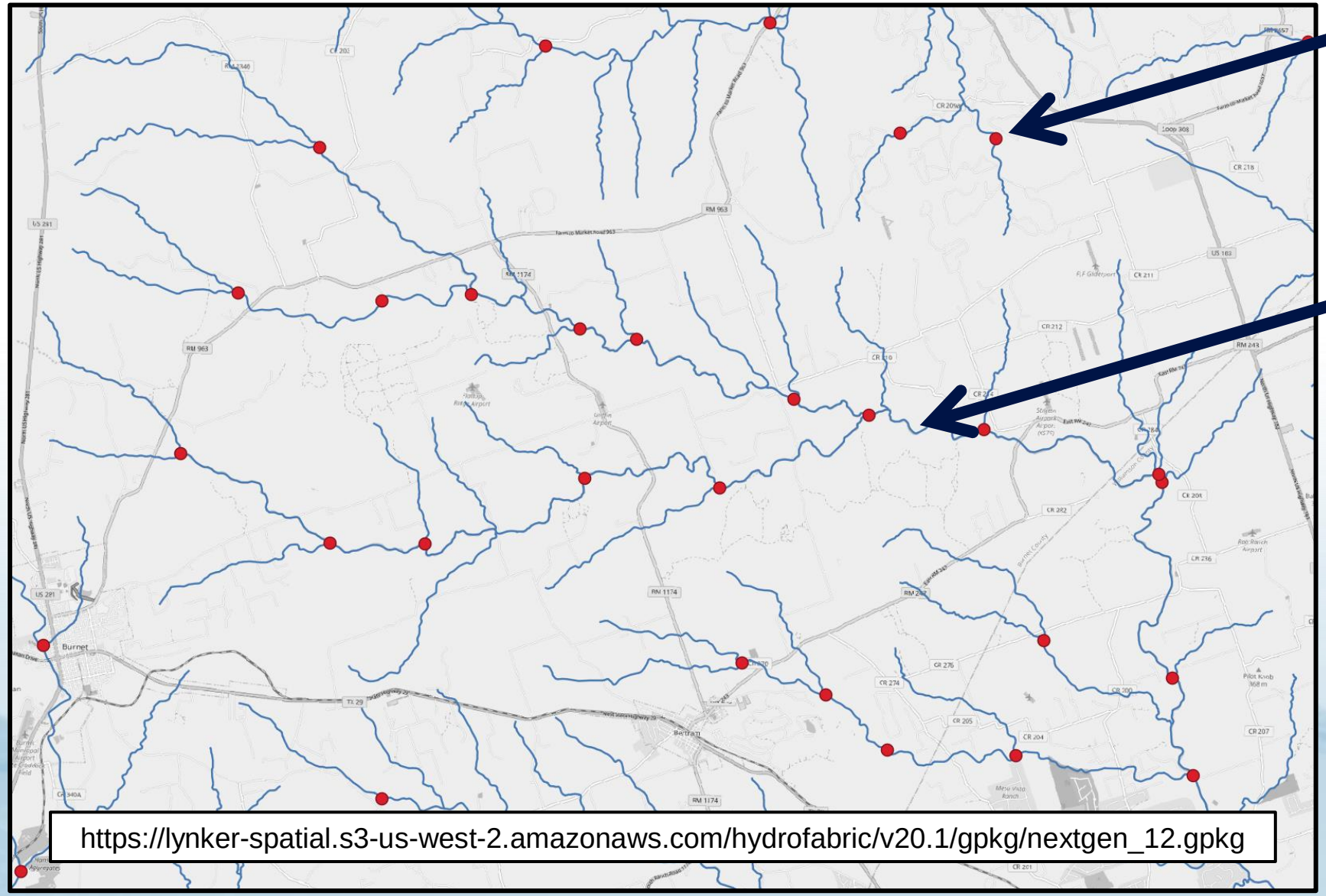
Model Specific Inputs:

(3) HEC-RAS plan HDF with a 2D computational area

(4) HEC-RAS files used to "spawn" a run
- geometry file
- unsteady flow file (including uXX.hdf for precip)
- unsteady plan file

(5) Terrain used to create HEC-RAS computational grid mesh

NextGEN Hydrofabric – Global Input (1)



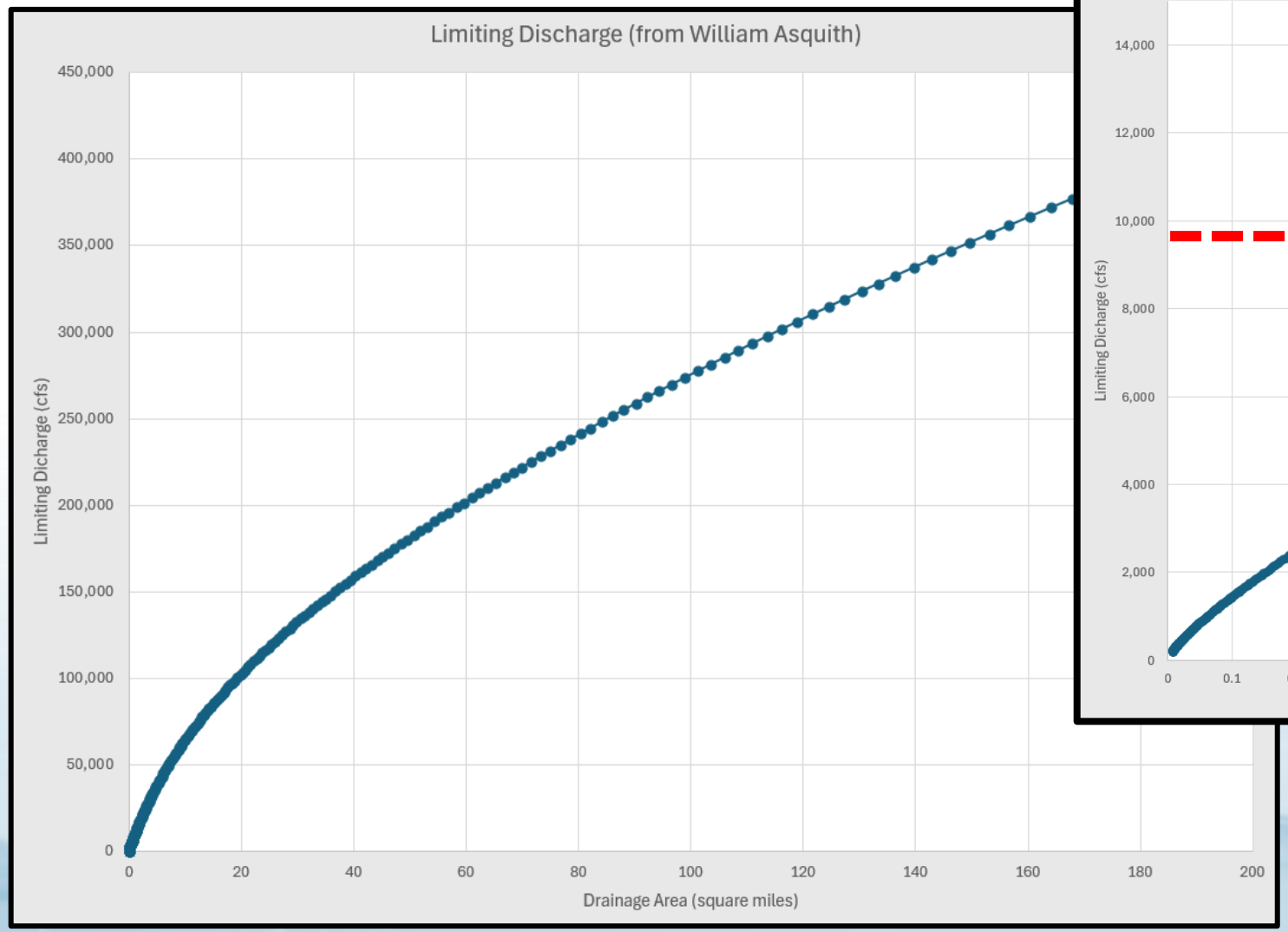
Nexus Points

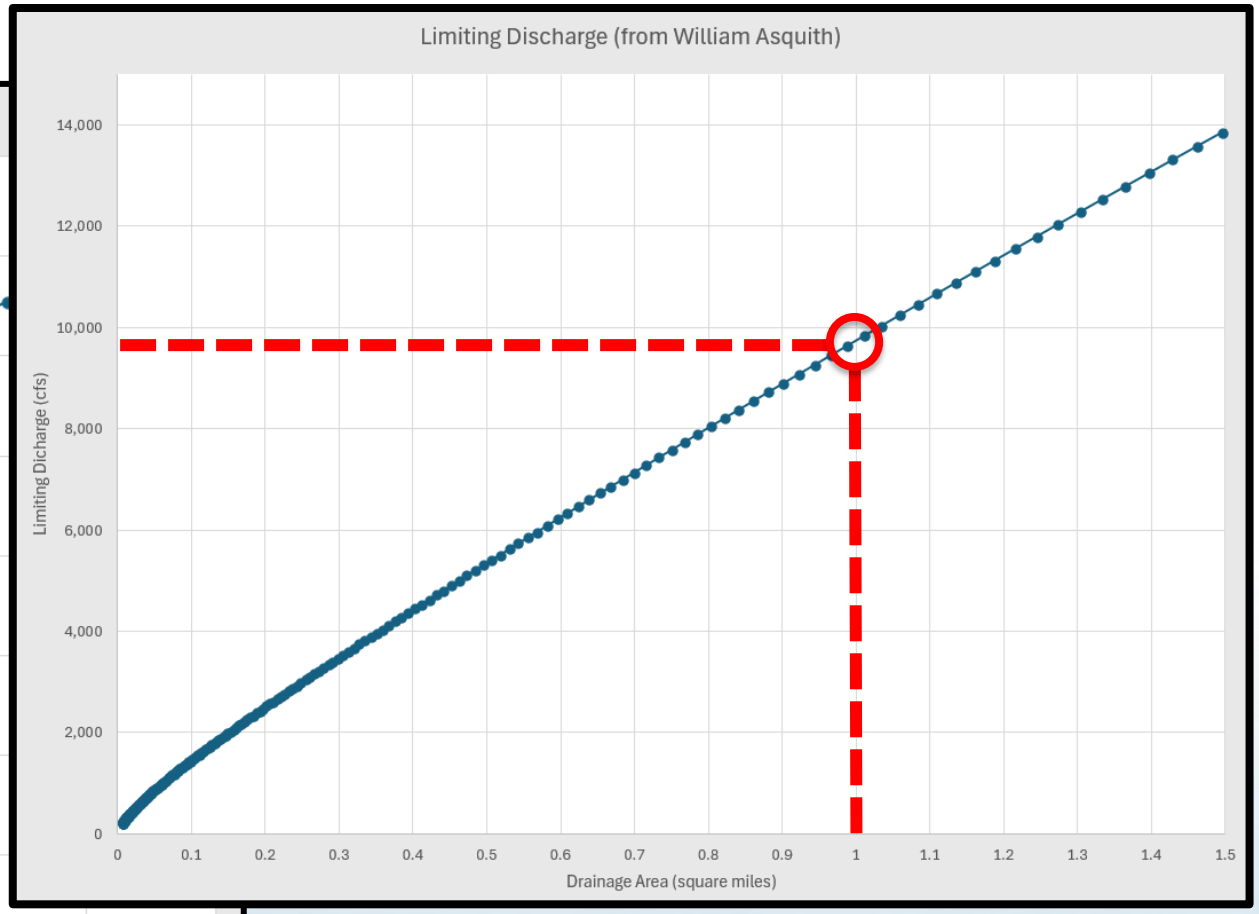
nextgen_12 — nexus	
id	nex-2410832
(Derived)	
(Actions)	
fid	6733
id	nex-2410832
toid	wb-2410832
hl_id	NULL
hl_uri	NA
type	nexus

Flowpath Lines

nextgen_12 — flowpaths	
id	wb-2410255
(Derived)	
(Actions)	
fid	3716
id	wb-2410255
toid	nex-2410256
mainstem	1884413
order	3
hydroseq	23880
lengthkm	4.242298643243516
areasqkm	12.44339918009997
tot_drainage_areasqkm	298.6425001529997
has_divide	true
divide_id	cat-2410255

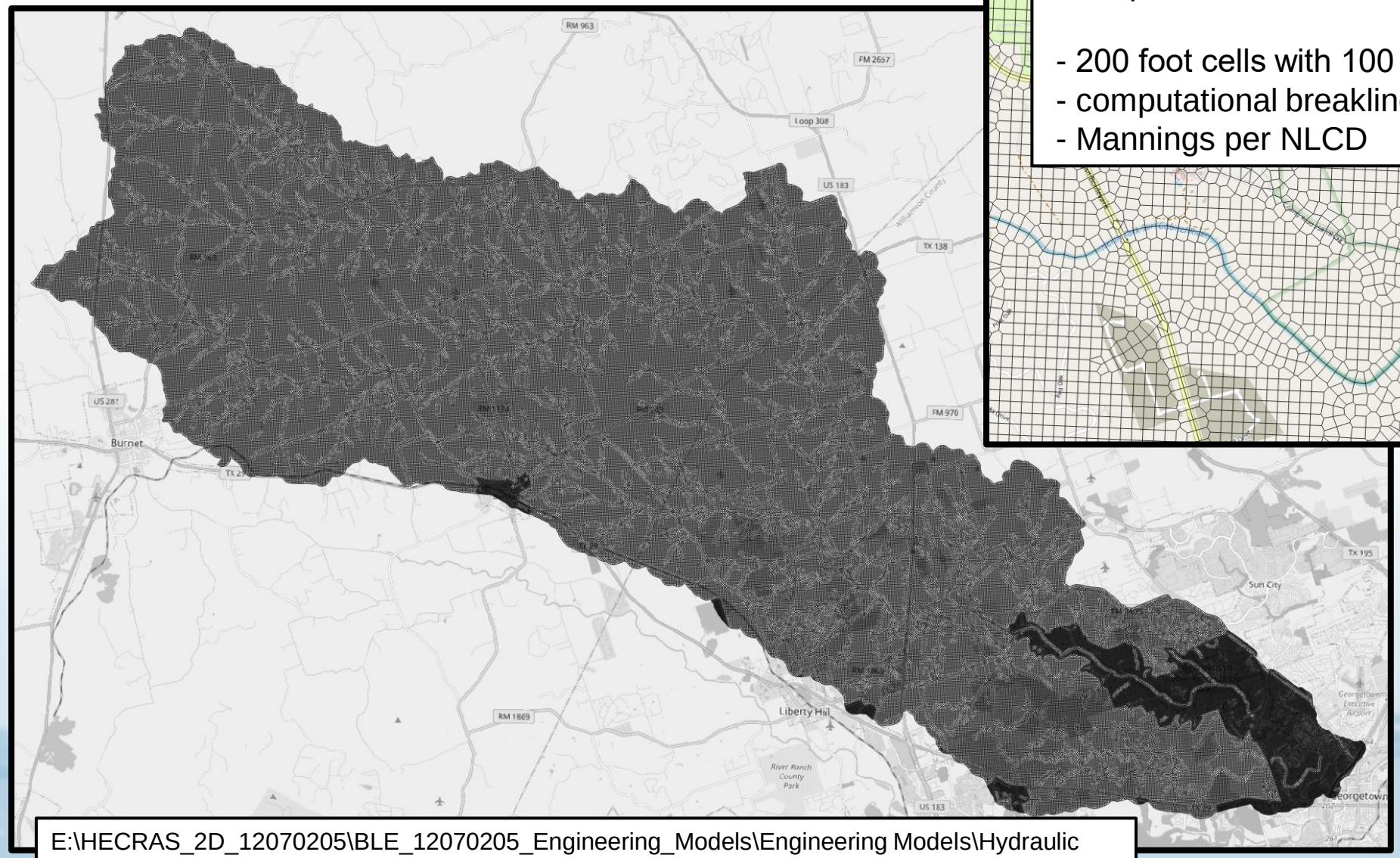
Limiting Discharge – Global Input (2)





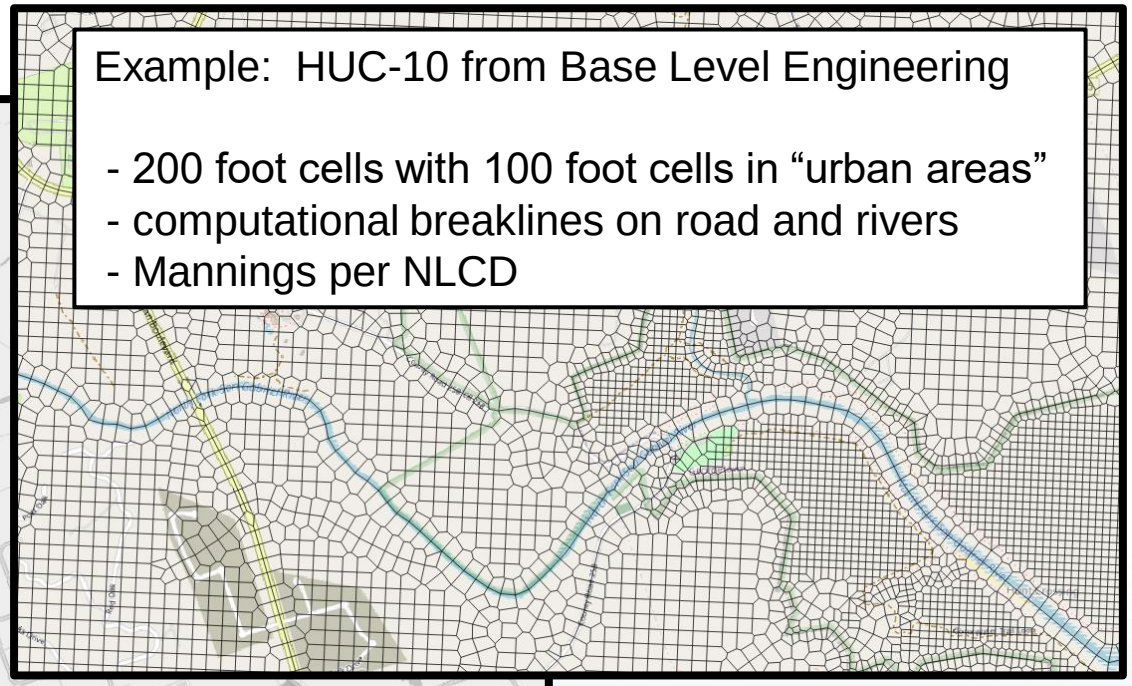
Limiting Discharge (from William Asquith)
https://www.caee.utexas.edu/prof/maidment/StreamflowII/Data/LimitingDischarge.csv

HEC-RAS Plan (HDF)– Local Input (3)



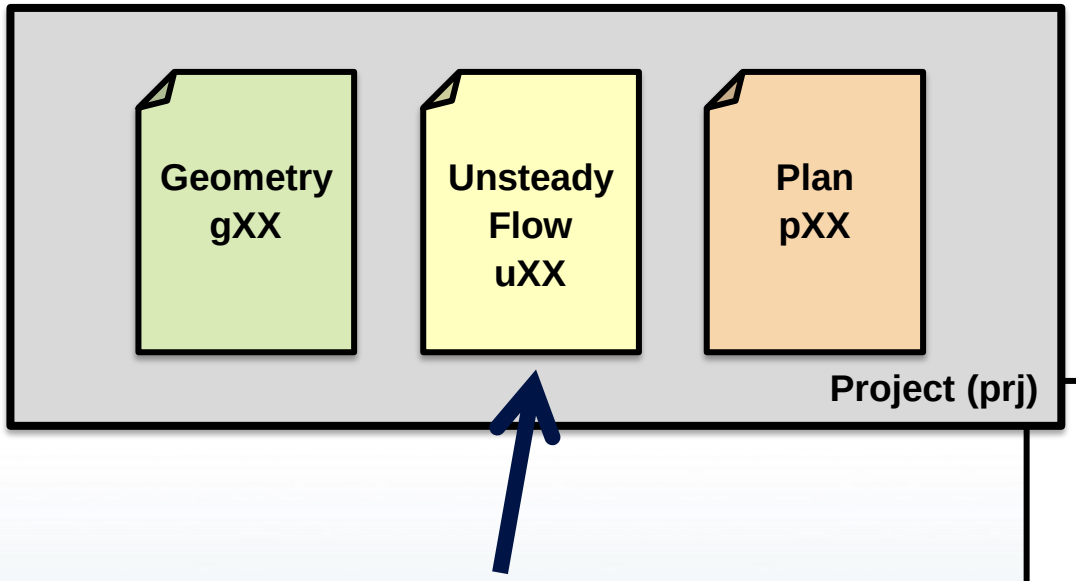
Example: HUC-10 from Base Level Engineering

- 200 foot cells with 100 foot cells in “urban areas”
- computational breaklines on road and rivers
- Mannings per NLCD

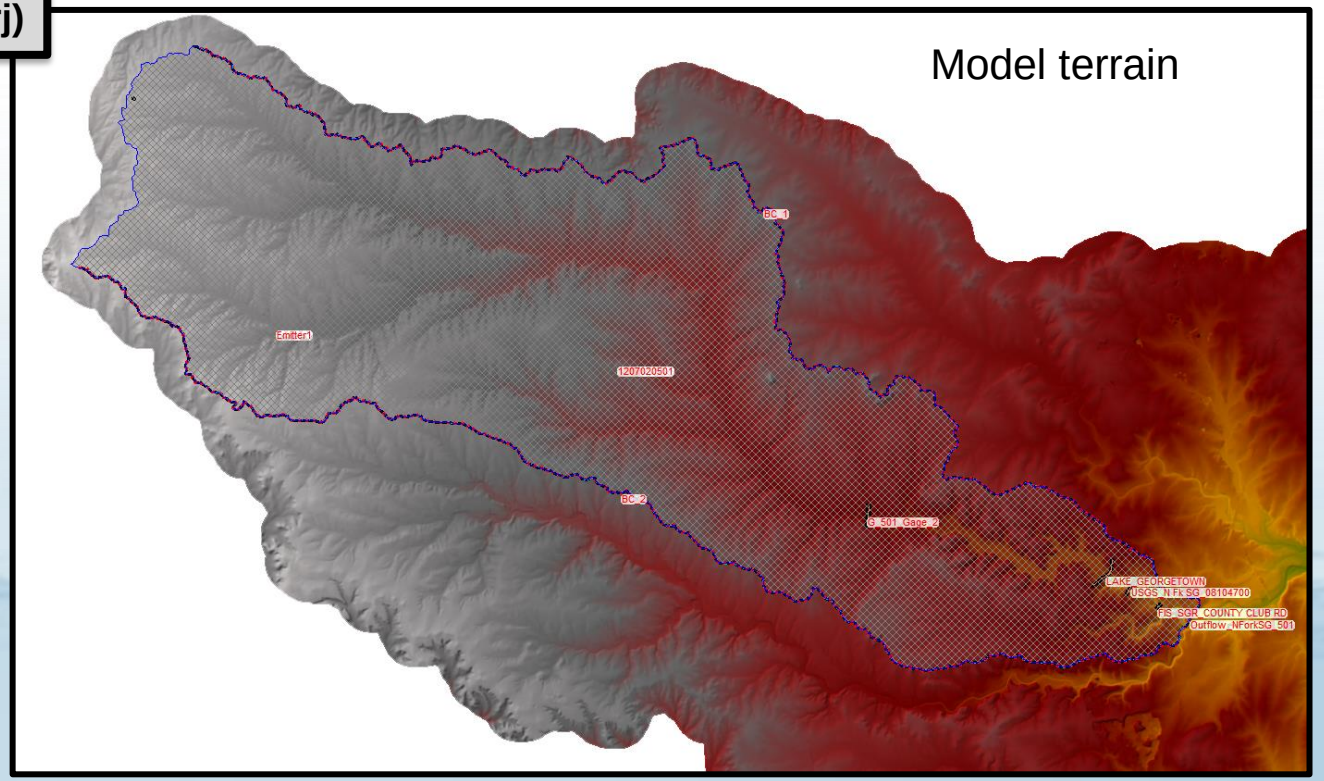


E:\HECRAS_2D_12070205\BLE_12070205_Engineering_Models\Engineering Models\Hydraulic Models\RAS_Submittal\LBSG_501\Input\BLE_LBSG_501.p02.hdf

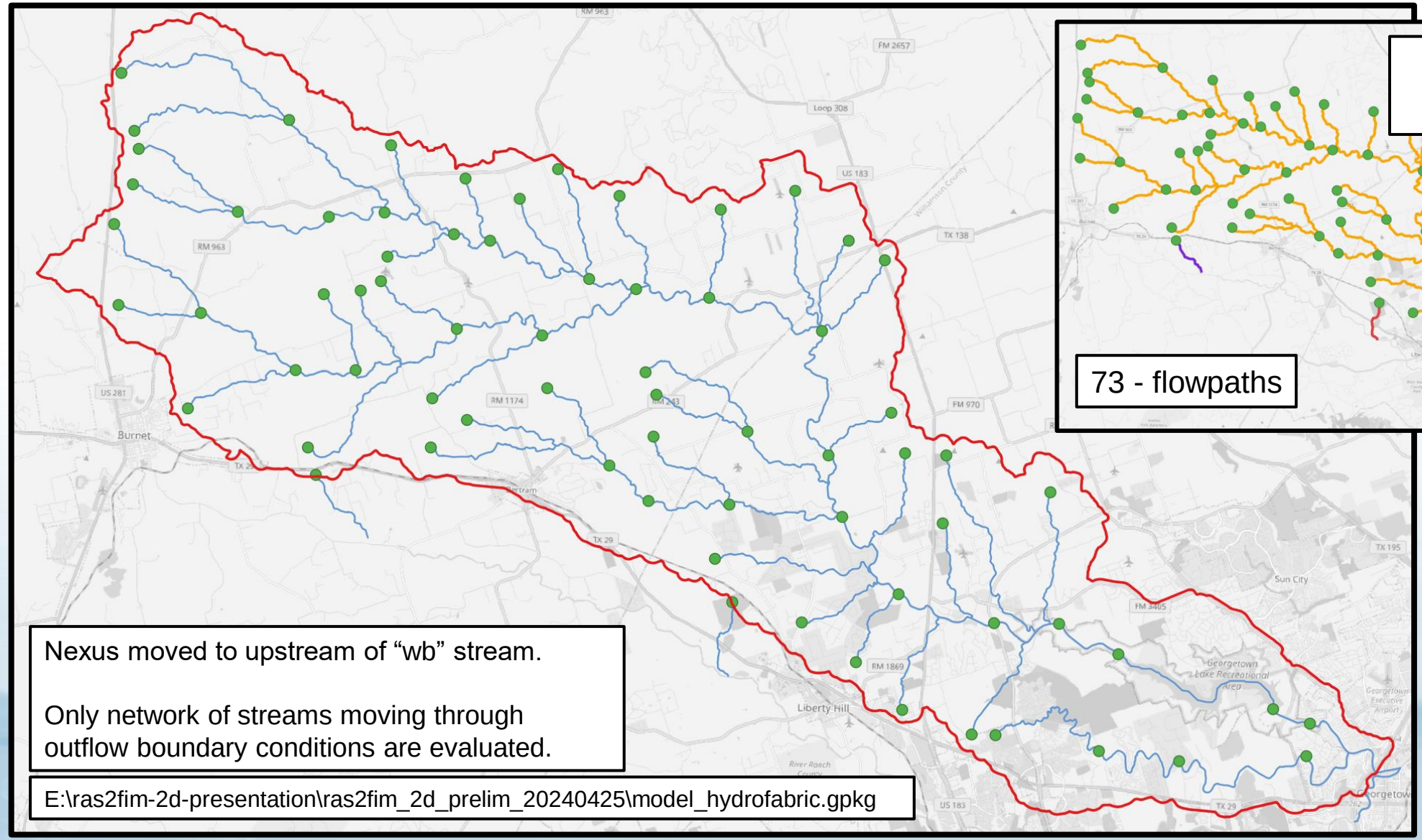
HEC-RAS Model - Local Inputs (4) & (5)



Augment the “Precipitation” boundary condition. Remove any other “Inflows”



RAS2FIM-2D Steps - Determine NextGEN streams in 2D area



3 network groupings… does this network flow out of a boundary condition?

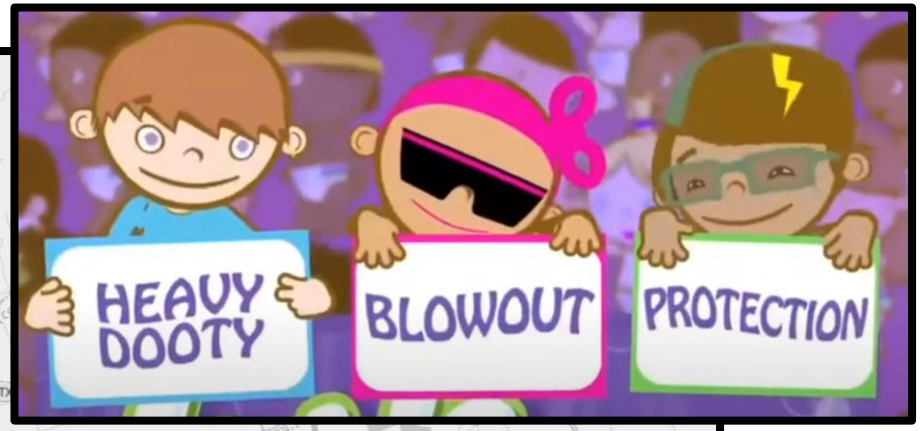
73 - flowpaths

Nexus moved to upstream of “wb” stream.

Only network of streams moving through outflow boundary conditions are evaluated.

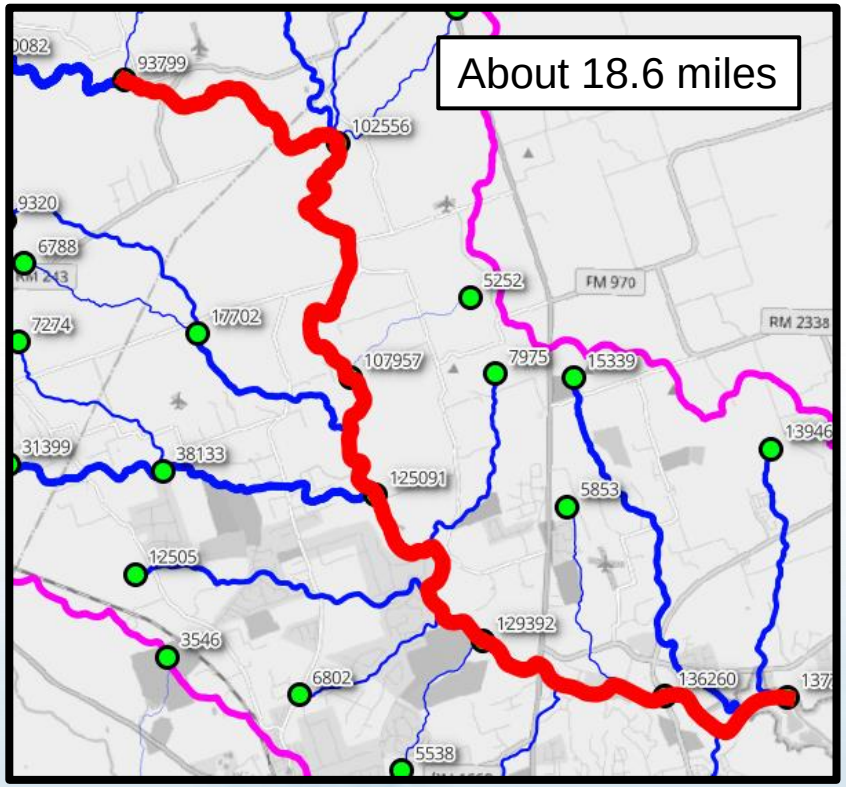
E:\ras2fim-2d-presentation\ras2fim_2d_prelim_20240425\model_hydrofabric.gpkg

RAS2FIM-2D Steps - flowpaths (evaluation limits)



id	wb-2410256
within_2darea	true
mainstem	1884413
tot_drainage_areasqkm	319.2102001529997
order	3
q_limiting	312662
q_upper_limit	93799
q_lower_limit	90082
id_end_node	wb-2410261
travel_time_hr	10.68

RAS2FIM-2D – How much flow? How Long?



Maximum Flow:
~ 123 square miles... on “wb-2410256”

Estimated Peak Flow:
Asquith limiting discharge is 312,662 cfs…
so 30% is **93,799 cfs**

id	wb-2410256
within_2darea	true
mainstem	1884413
tot_drainage_areasqkm	319.2102001529997
order	3
q_limiting	312662
q_upper_limit	93799
q_lower_limit	90082
id_end_node	wb-2410261
travel_time_hr	10.68

Minimum Flow … say **500 cfs**

How long for water to flow from “emitter” to outlet of mainstem?

$$T = \frac{Ln}{R_h^{2/3} S^{1/2}}$$

1

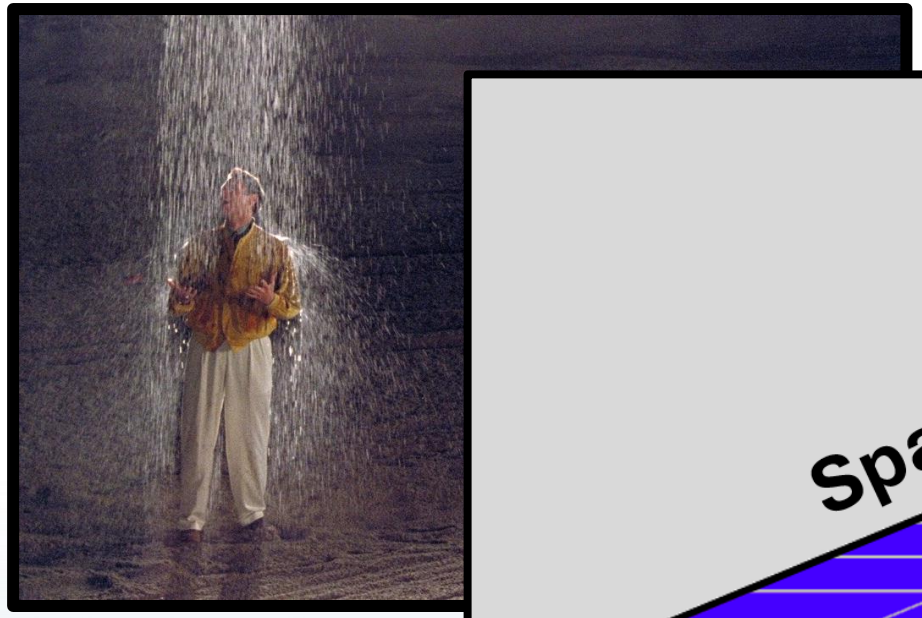
Estimated Low Flow velocity ~ 2.6 fps

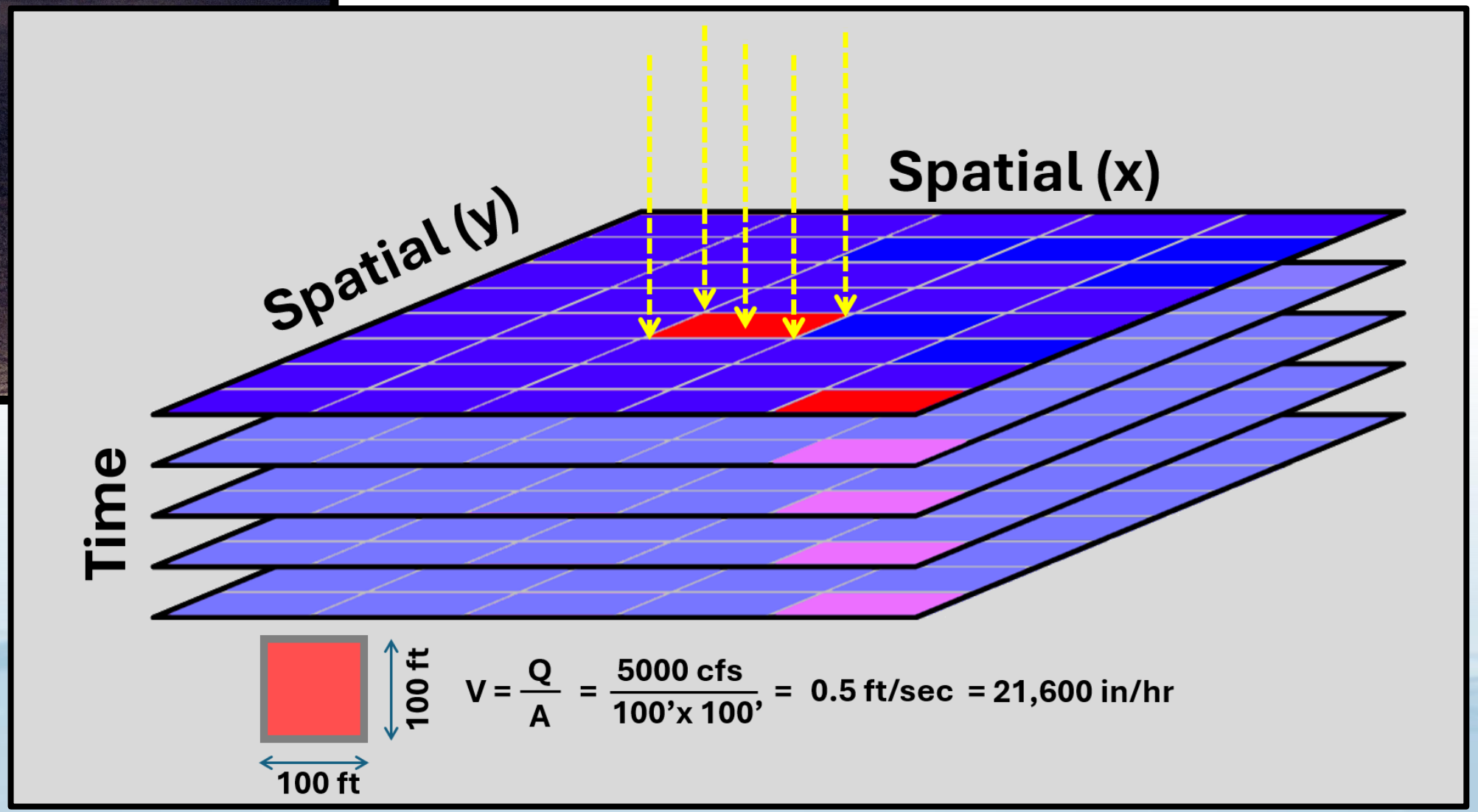
Introducing controlled flow

Internal Boundary Condition

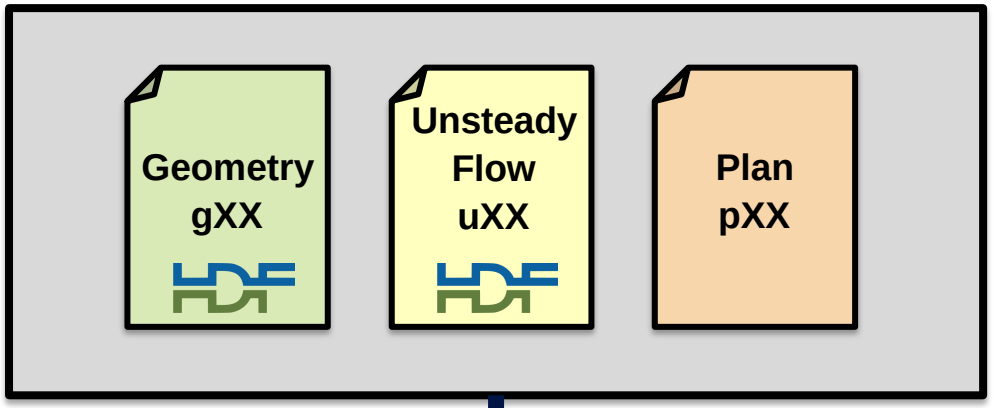
Controlled Precipitation

Controlled Precipitation





RAS2FIM-2D – Running the Model



HEC-RAS Windows API to create **cXX** and **bXX** for the run (in blocking mode)

bXX (text file tied to plan)?

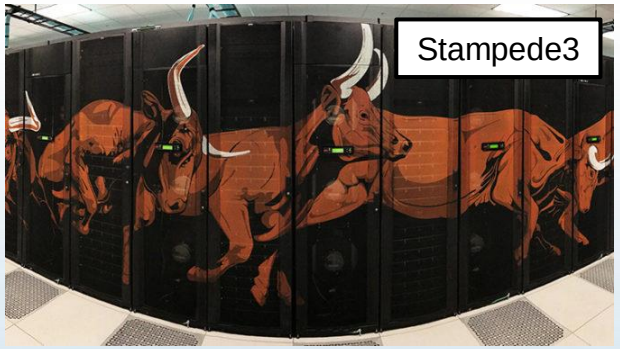
cXX (binary file tied to geometry)?

Run this configuration on Linux version of HEC-RAS (v6.5)

HEC-RAS Plan HDF5 file

Working Plan Name:

1884413_wb-2410249_wb-2410261_30-hr_500-cfs_to_3000-cfs_step_600-cfs_plan

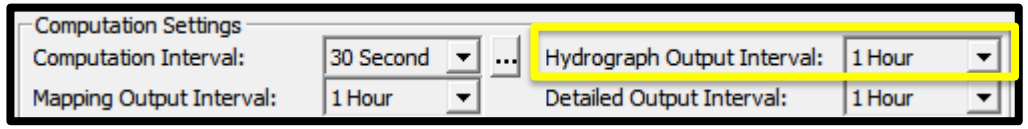


RAS2FIM-2D – Wet Cells

Working Plan Name:

1884413_wb-2410249_wb-2410261_30-hr_500-cfs_to_3000-cfs_step_600-cfs_plan

HEC-RAS Plan HDF5 file



E:\HECRAS_2D_12070205\base_model_20240414_copy\BLE_LBSG_501.p23.hdf

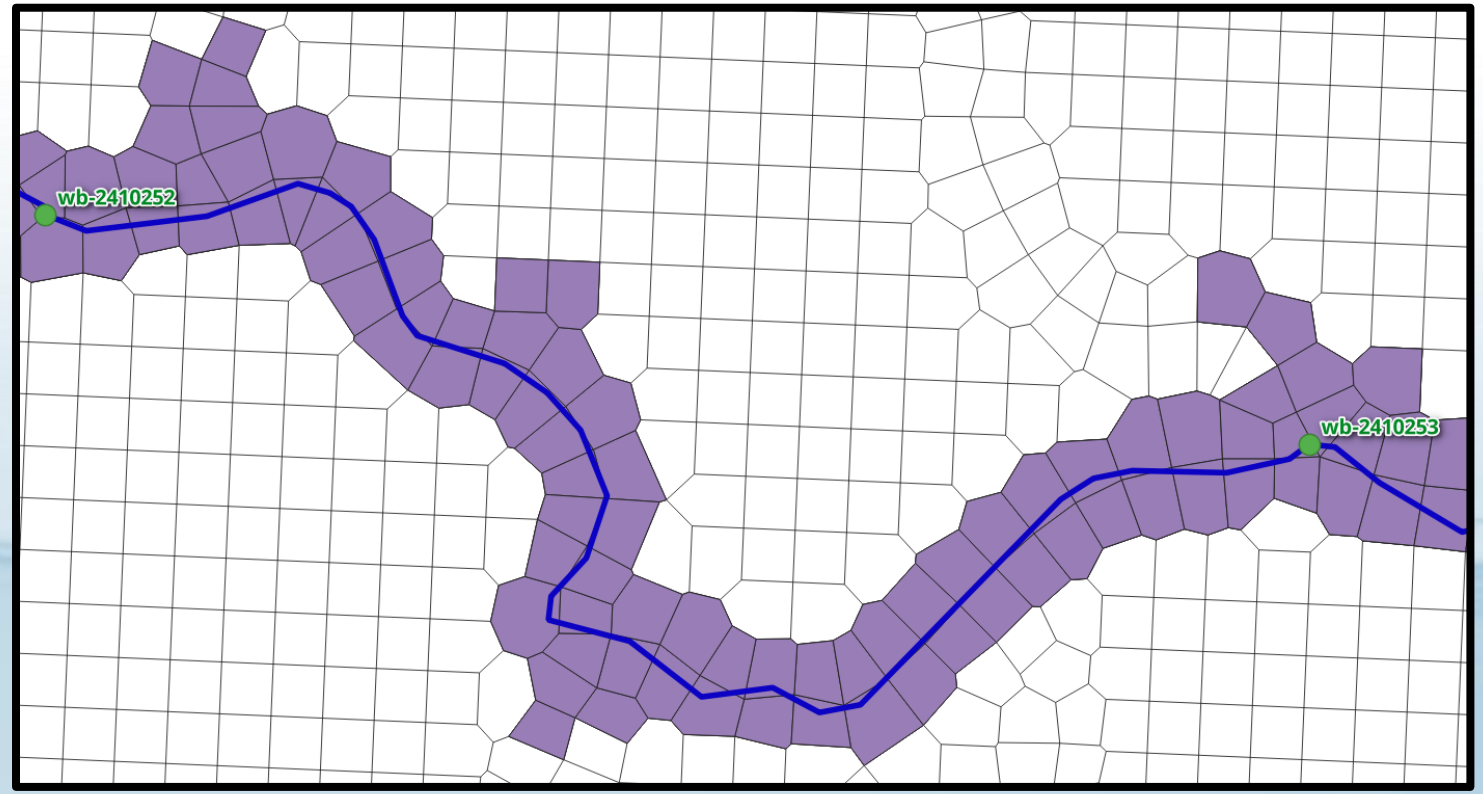
/Results/Unsteady/Output/Output Blocks/Base Output/Unsteady Time Series/2D Flow Areas/1207020501/Water Surface

180 hours x 220,317 cells (39.6 million values)

/Geometry/2D Flow Areas/1207020501/Cells Minimum Elevation

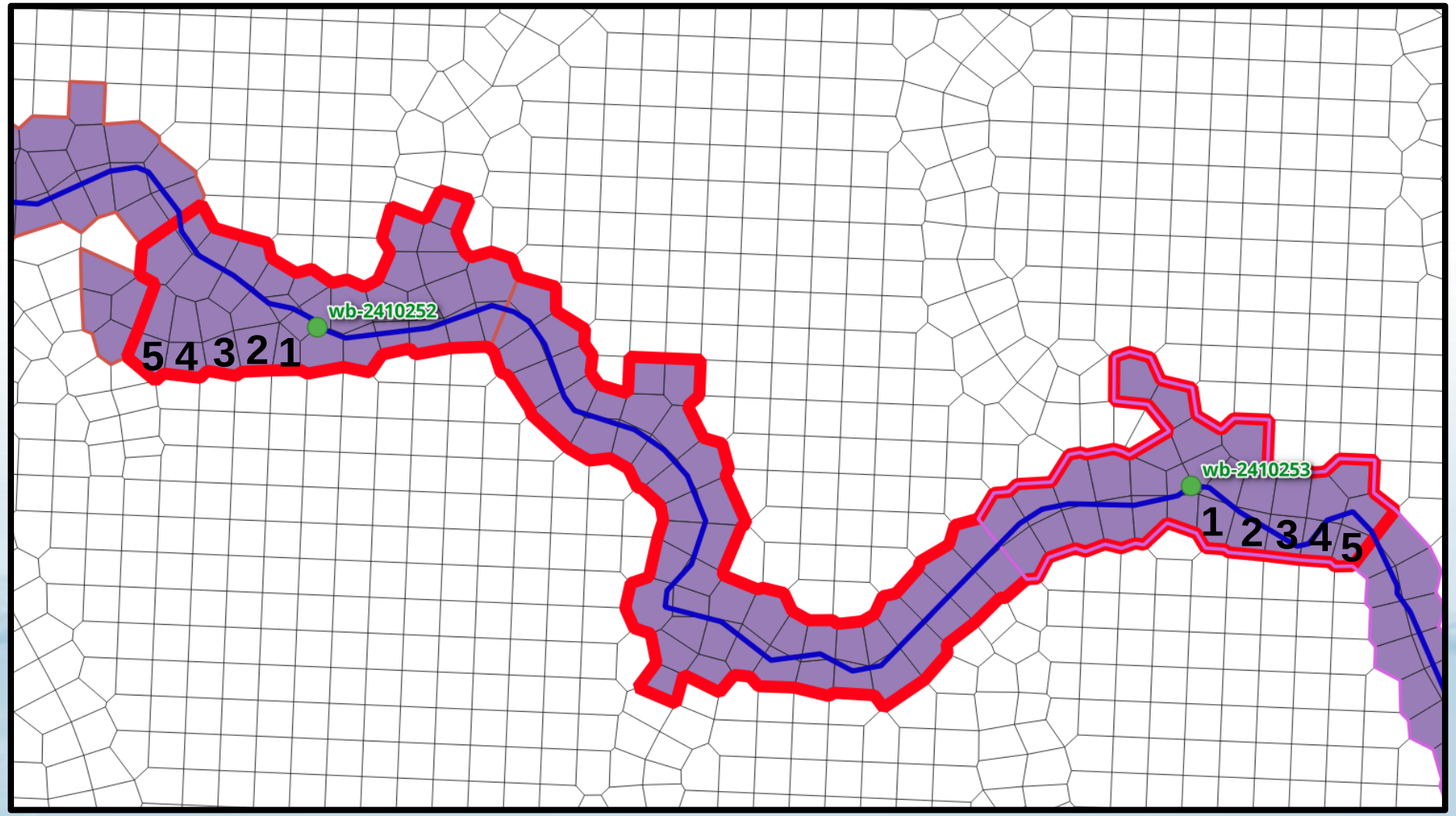
220,317 cells

If WSEL > Minimum elevation … cell in grid mesh is "wet"

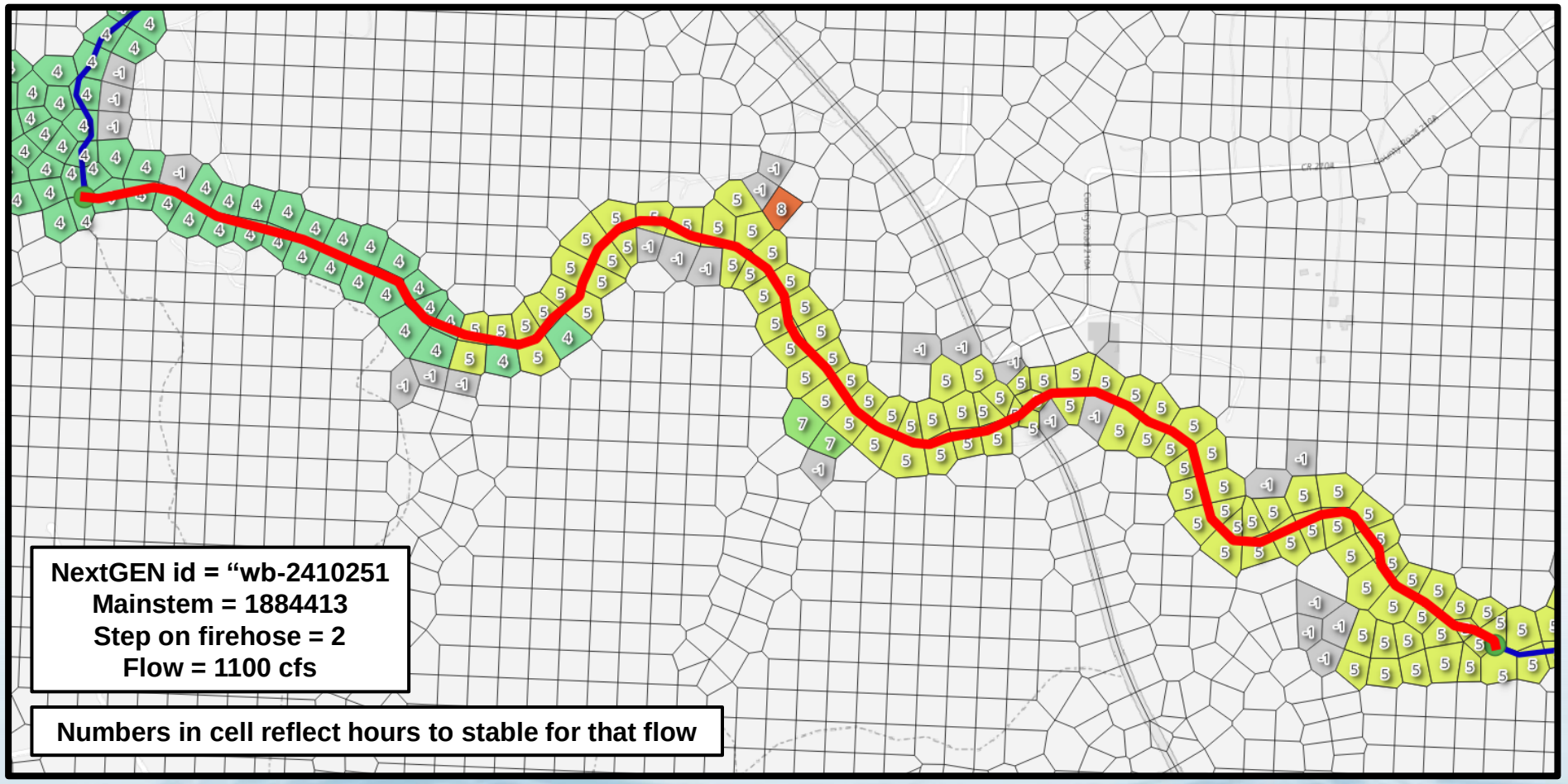


RAS2FIM-2D – Grouping Wet Cells

For each “wet” cell in a mainstem run, determine the nearest ‘flowpath’. Buffer these groupings {5} cells



RAS2FIM-2D – Stream Analysis per flow in a “run”

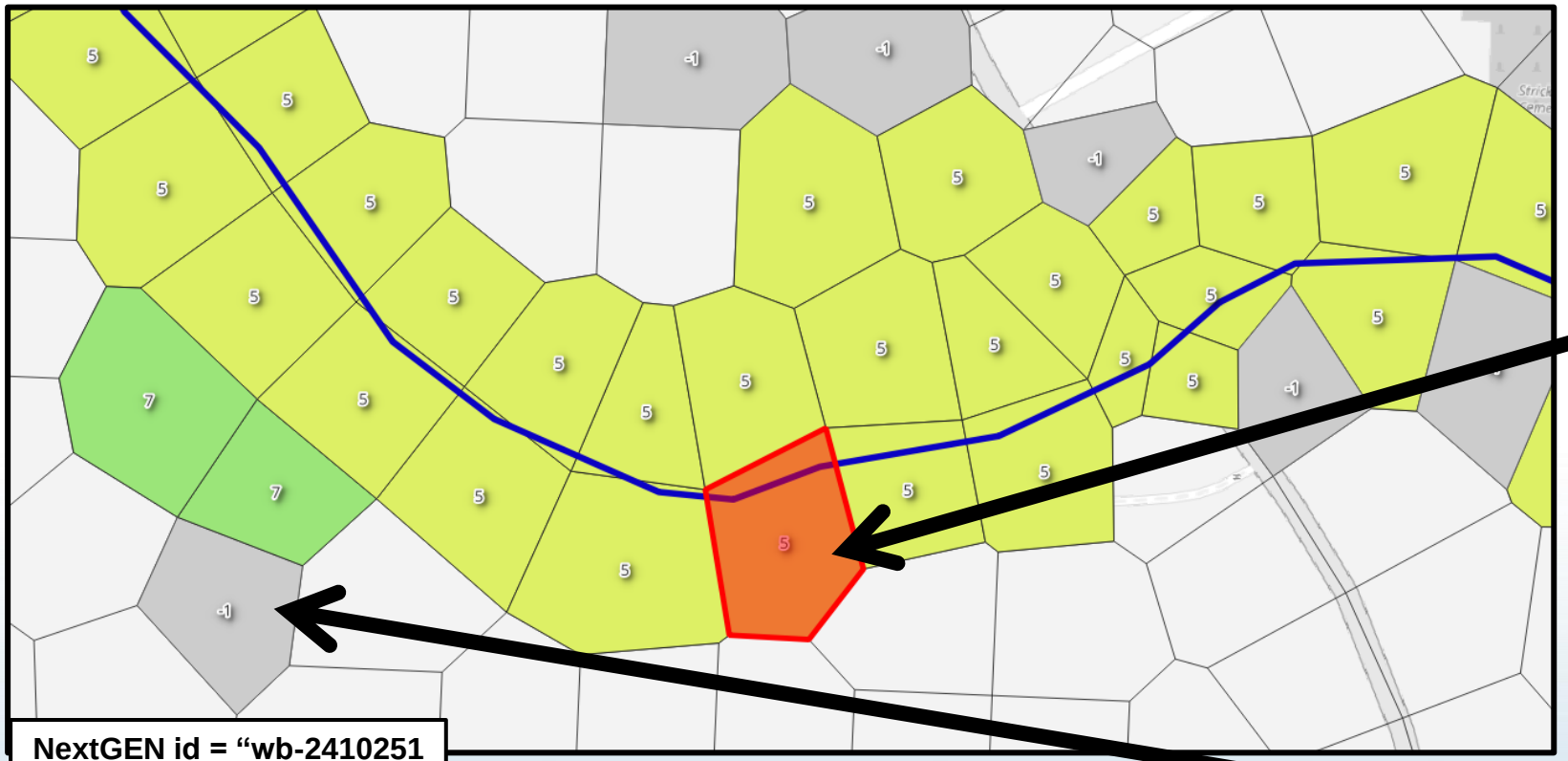


fid	1
id	wb-2410251
mainstem	1884413
order_	3
tot_drainage_areasqkm	105.37965092249951
length	11859.503063408156
dist_wet_1	11859.503063408152
dist_stable_1	11859.503063408152
stream_cl_hr_to_stable_1	7
dist_wet_2	11859.503063408152
dist_stable_2	11859.503063408152
stream_cl_hr_to_stable_2	5
dist_wet_3	11859.503063408152
dist_stable_3	11859.503063408152
stream_cl_hr_to_stable_3	5
dist_wet_4	11859.503063408152
dist_stable_4	11859.503063408152
stream_cl_hr_to_stable_4	4
dist_wet_5	11859.503063408152
dist_stable_5	11859.503063408152
stream_cl_hr_to_stable_5	4
dist_wet_6	11859.503063408152
dist_stable_6	11859.503063408152
stream_cl_hr_to_stable_6	4
perct_wet_1	100
perct_stable_1	100
perct_wet_2	100
perct_stable_2	100
perct_wet_3	100
perct_stable_3	100
perct_wet_4	100
perct_stable_4	100
perct_wet_5	100
perct_stable_5	100
perct_wet_6	100
perct_stable_6	100
flow_1	500
flow_2	1100
flow_3	1700
flow_4	2300
flow_5	2900
flow_6	3000
run_name	1884413_wb-2410249_wb-

Working Plan Name:

1884413_wb-2410249_wb-2410261_30-hr_500-cfs_to_3000-cfs_step_600-cfs_plan

RAS2FIM-2D – Cell values per run



fid	1241
cell_idx	213011
nearest_flowpath	wb-2410251
hours_to_stable_1	6
hours_to_stable_2	5
hours_to_stable_3	4
hours_to_stable_4	4
hours_to_stable_5	4
hours_to_stable_6	3
wsel_max_1	1142.27001953125
wsel_max_2	1144.31005859375
wsel_max_3	1145.8499755859375
wsel_max_4	1147.1700439453125
wsel_max_5	1148.280029296875
wsel_max_6	1148.47998046875
flow_1	500
flow_2	1100
flow_3	1700
flow_4	2300
flow_5	2900
flow_6	3000
run_name	1884413_wb-2410249_v

NextGEN id = “wb-2410251
Mainstem = 1884413
Step on firehose = 2
Flow = 1100 cfs

fid	1235
cell_idx	205279
nearest_flowpath	wb-2410251
hours_to_stable_1	-1
hours_to_stable_2	-1
hours_to_stable_3	-1
hours_to_stable_4	-1
hours_to_stable_5	-1
hours_to_stable_6	5
wsel_max_1	NULL
wsel_max_2	NULL
wsel_max_3	NULL
wsel_max_4	NULL
wsel_max_5	NULL
wsel_max_6	1150.3399658203125
flow_1	500
flow_2	1100
flow_3	1700
flow_4	2300
flow_5	2900
flow_6	3000
run_name	1884413_wb-2410249_w

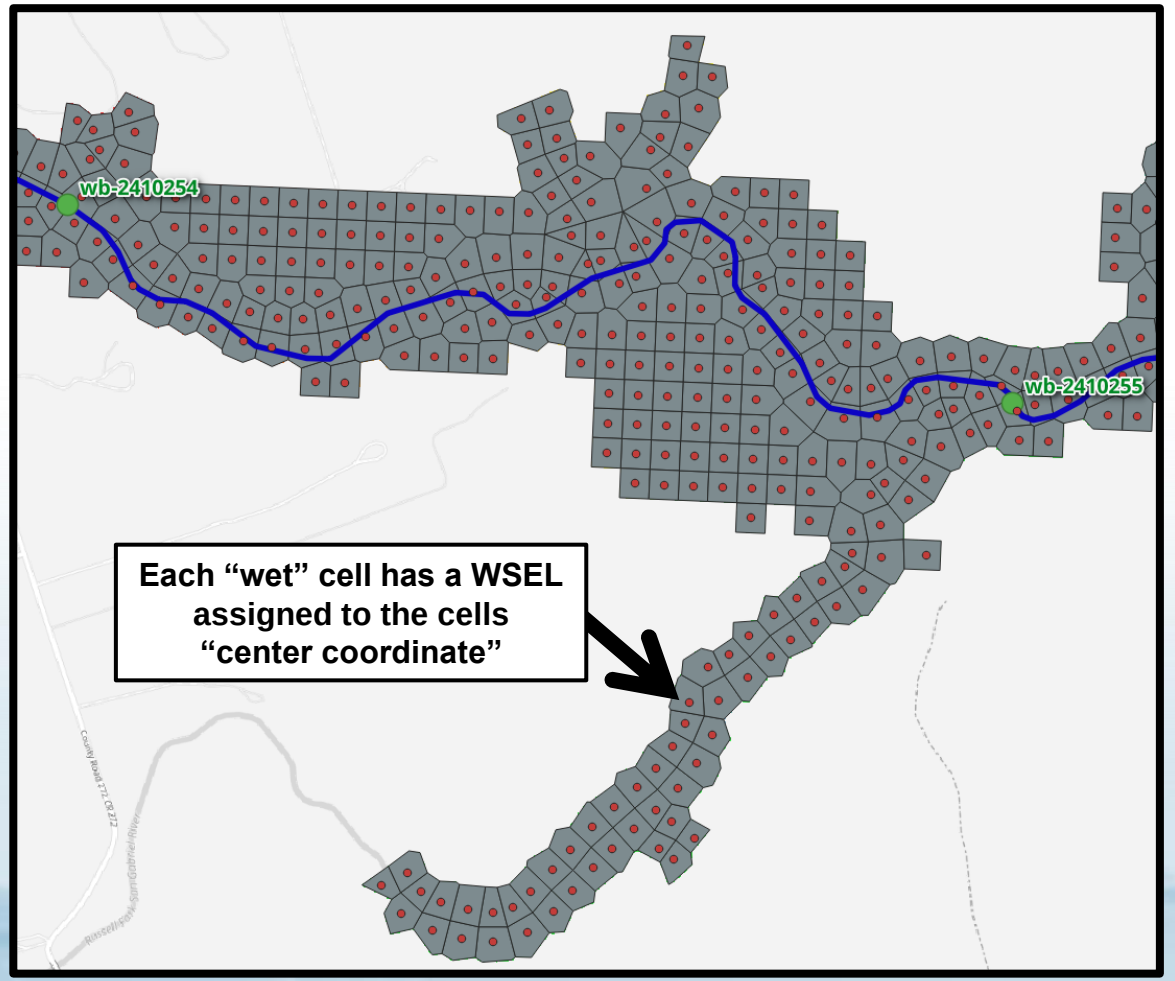
Numbers in cell reflect hours to stable for that flow

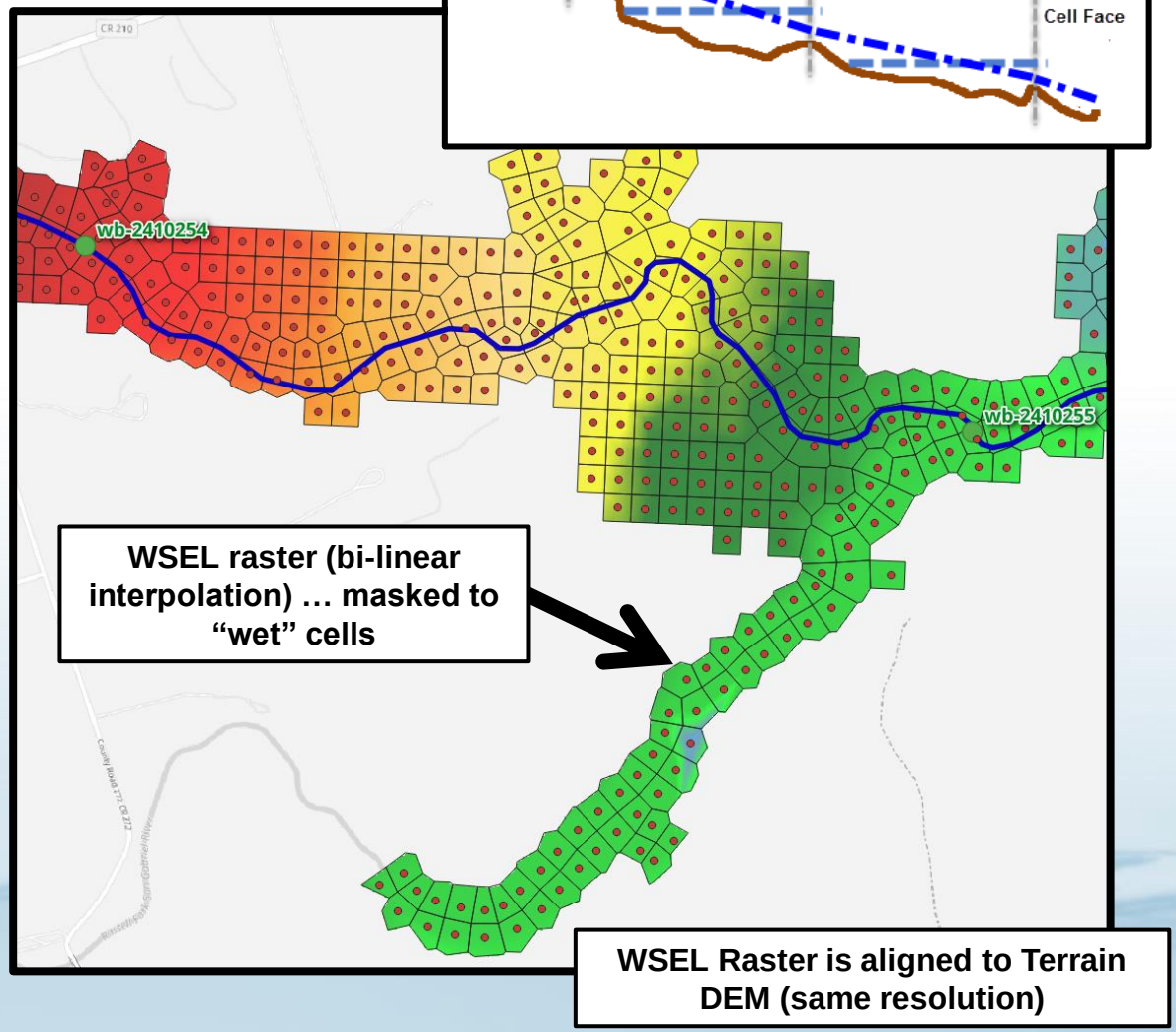
Working Plan Name:

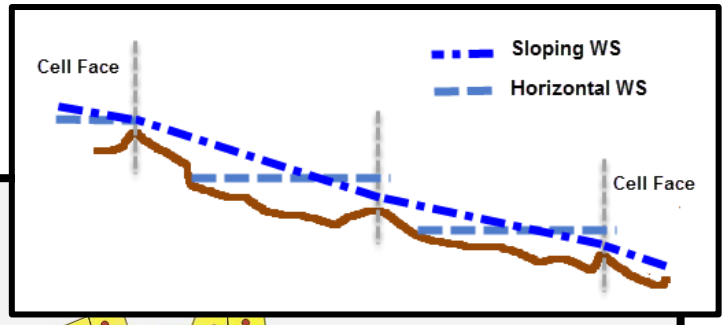
1884413_wb-2410249_wb-2410261_30-hr_500-cfs_to_3000-cfs_step_600-cfs_plan

RAS2FIM-2D – Raster Engine

In Plan HDF:
/Geometry/2D Flow Areas/1207020501/Cells Center Coordinate



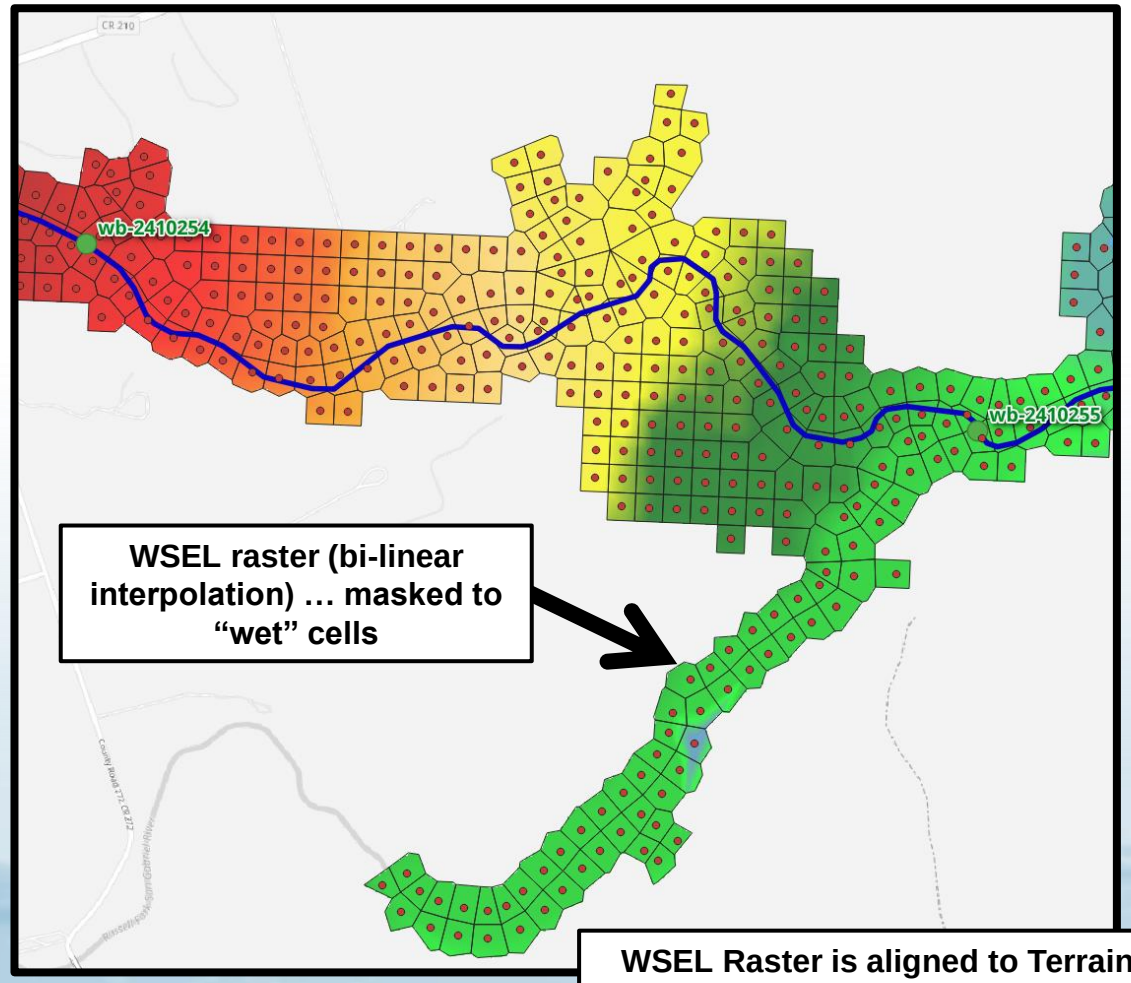


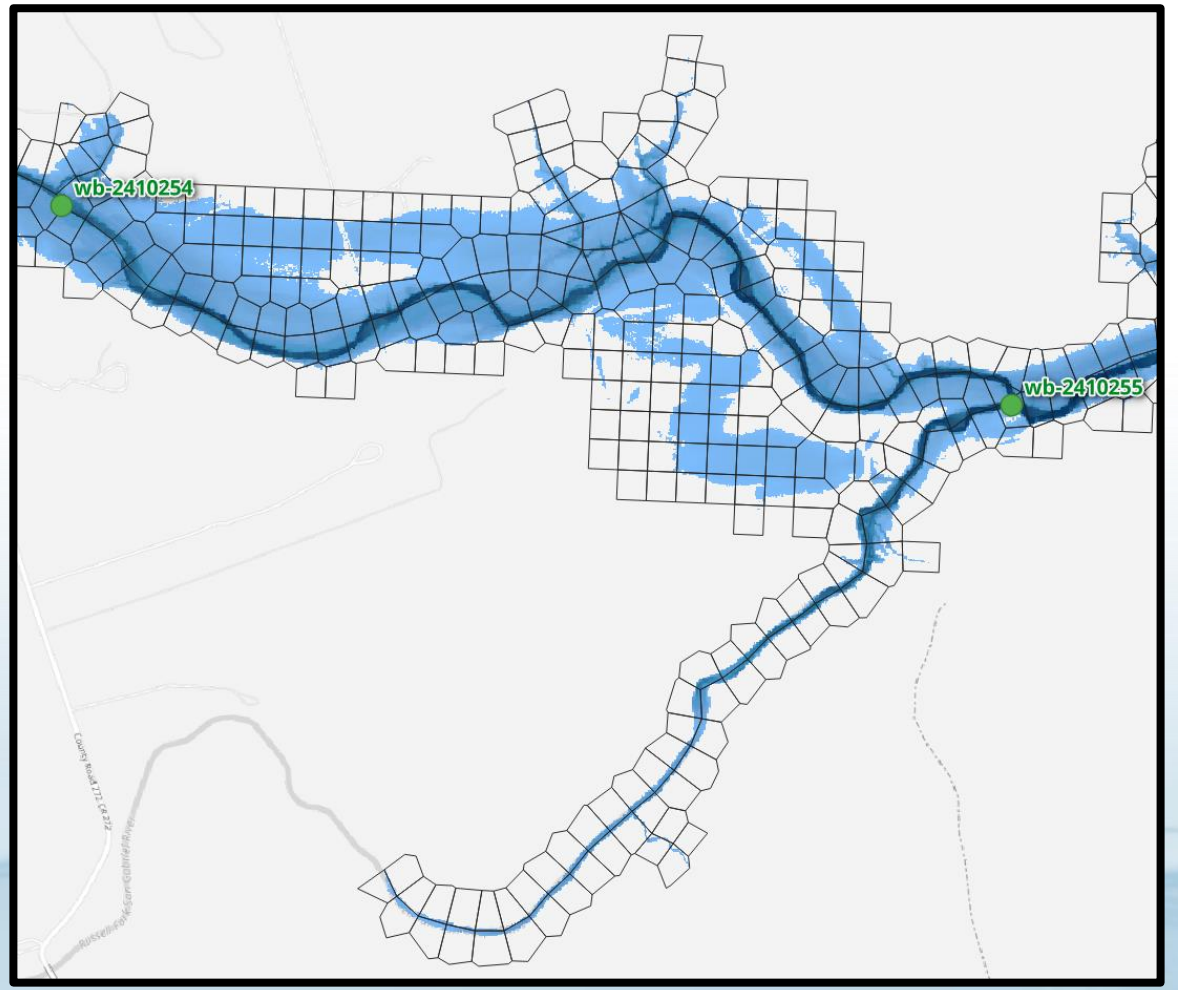


Working Plan Name:
1884413_wb-2410249_wb-2410261_29-hr_14100-cfs_plan

RAS2FIM-2D – Depth and WSEL Rasters

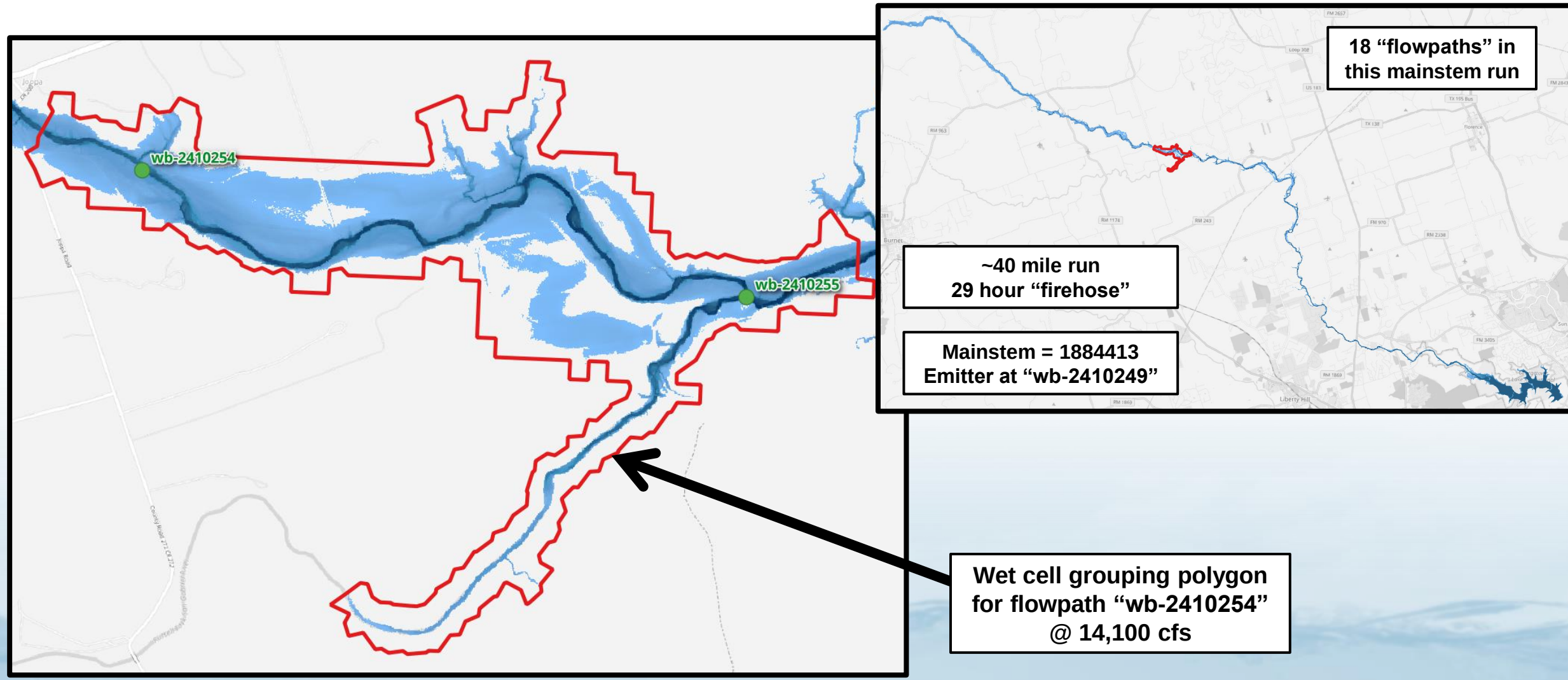
“High Resolution Subgrid Model”





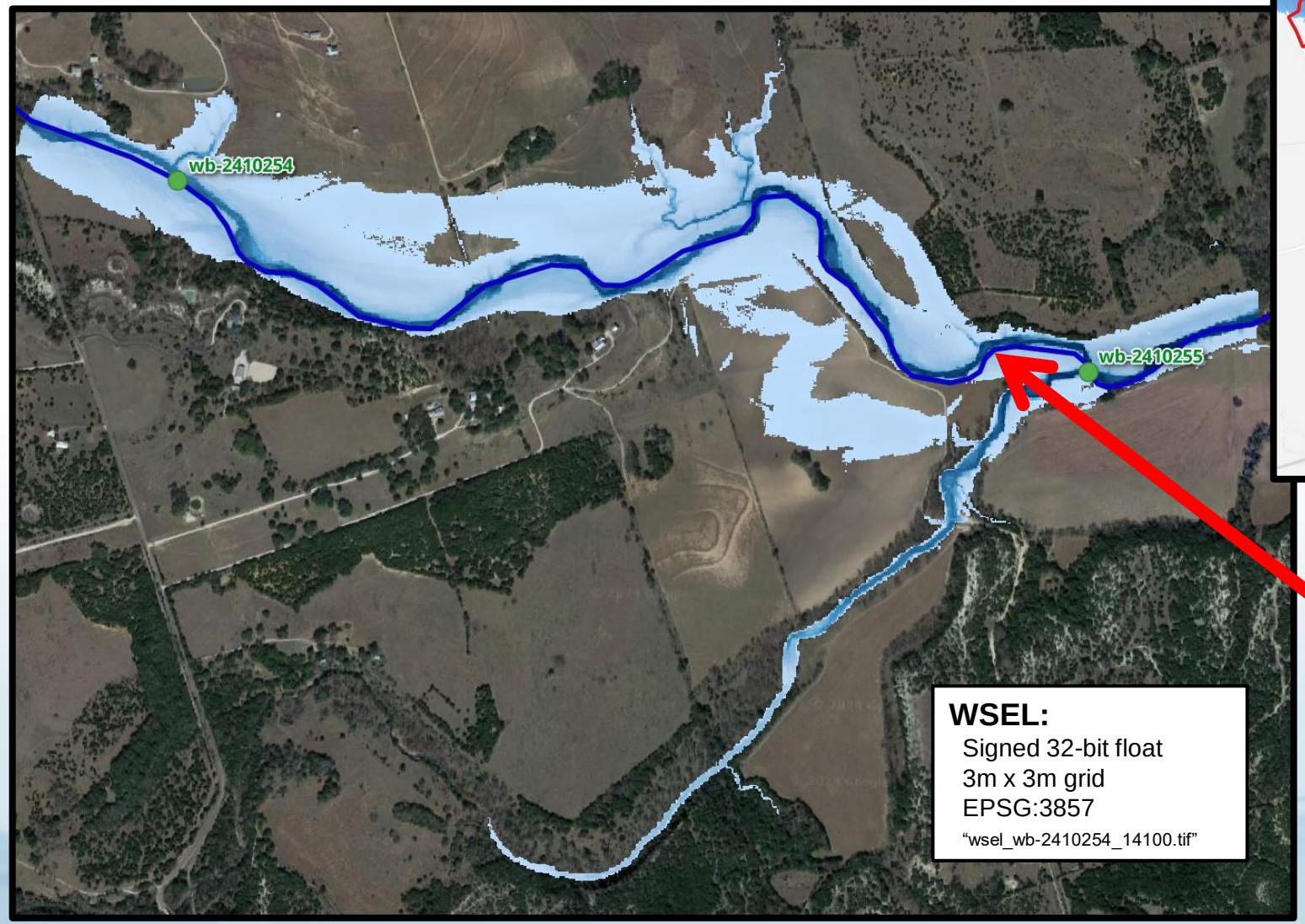
Working Plan Name:
1884413_wb-2410249_wb-2410261_29-hr_14100-cfs_plan

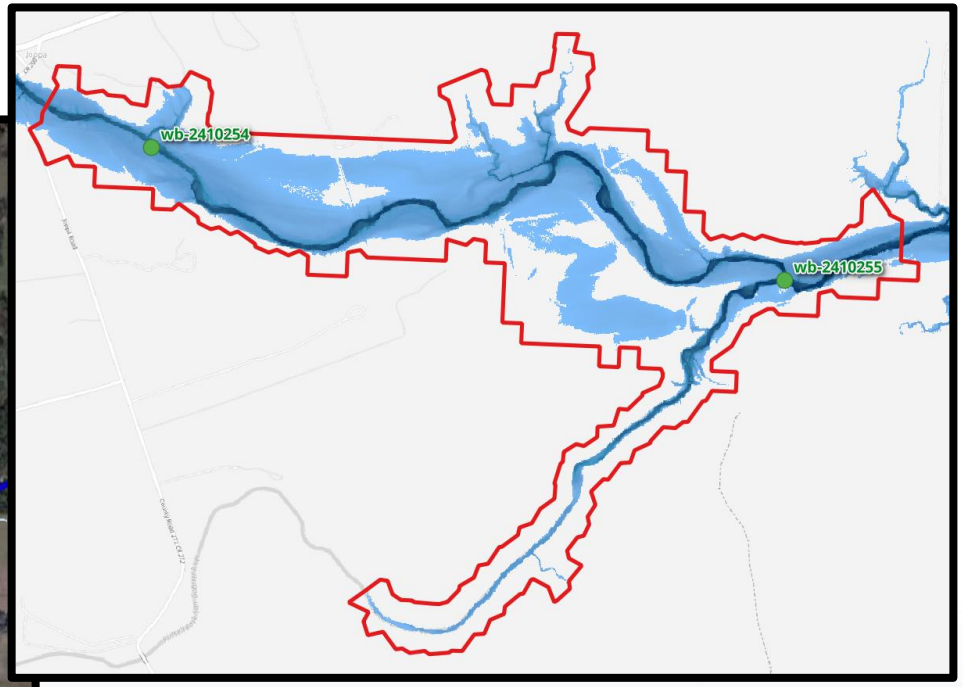
RAS2FIM-2D – Depth and WSEL Rasters



Working Plan Name:
1884413_wb-2410249_wb-2410261_29-hr_14100-cfs_plan

RAS2FIM-2D – WSEL Rasters





WSEL:
Signed 32-bit float
3m x 3m grid
EPSG:3857
"wsel_wb-2410254_14100.tif"

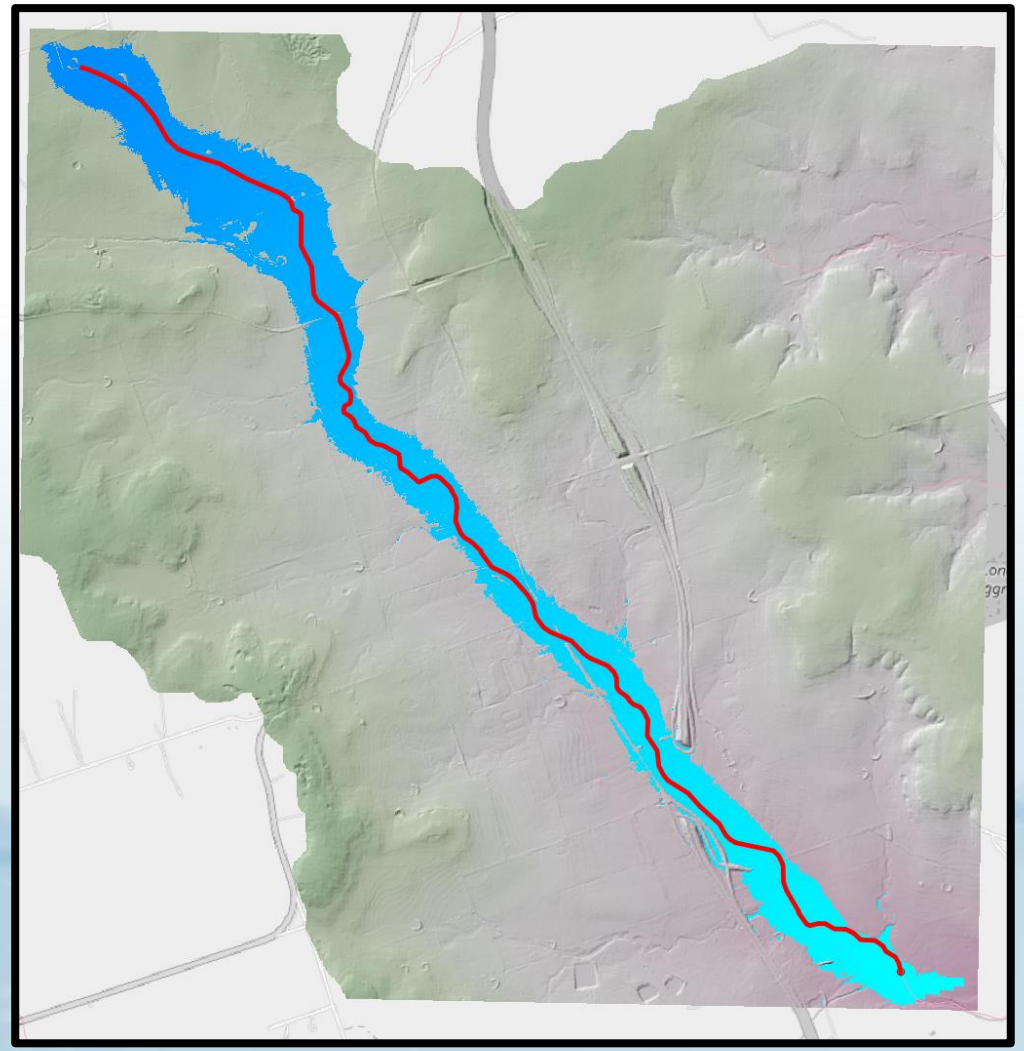
Example Pixel:
WSEL = 1,046.5 ft

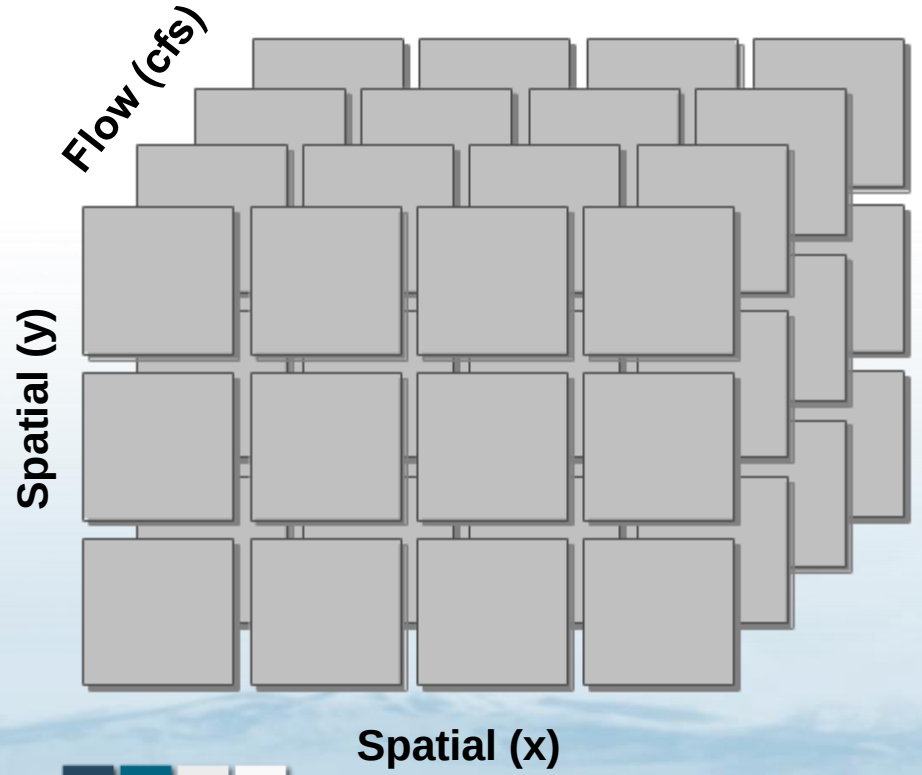
For Q = 14,100 cfs

Working Plan Name:
1884413_wb-2410249_wb-2410261_29-hr_14100-cfs_plan

Output

From multiple runs with multiple “stable” flows … a stack of WSEL can be created for a given stream reach …



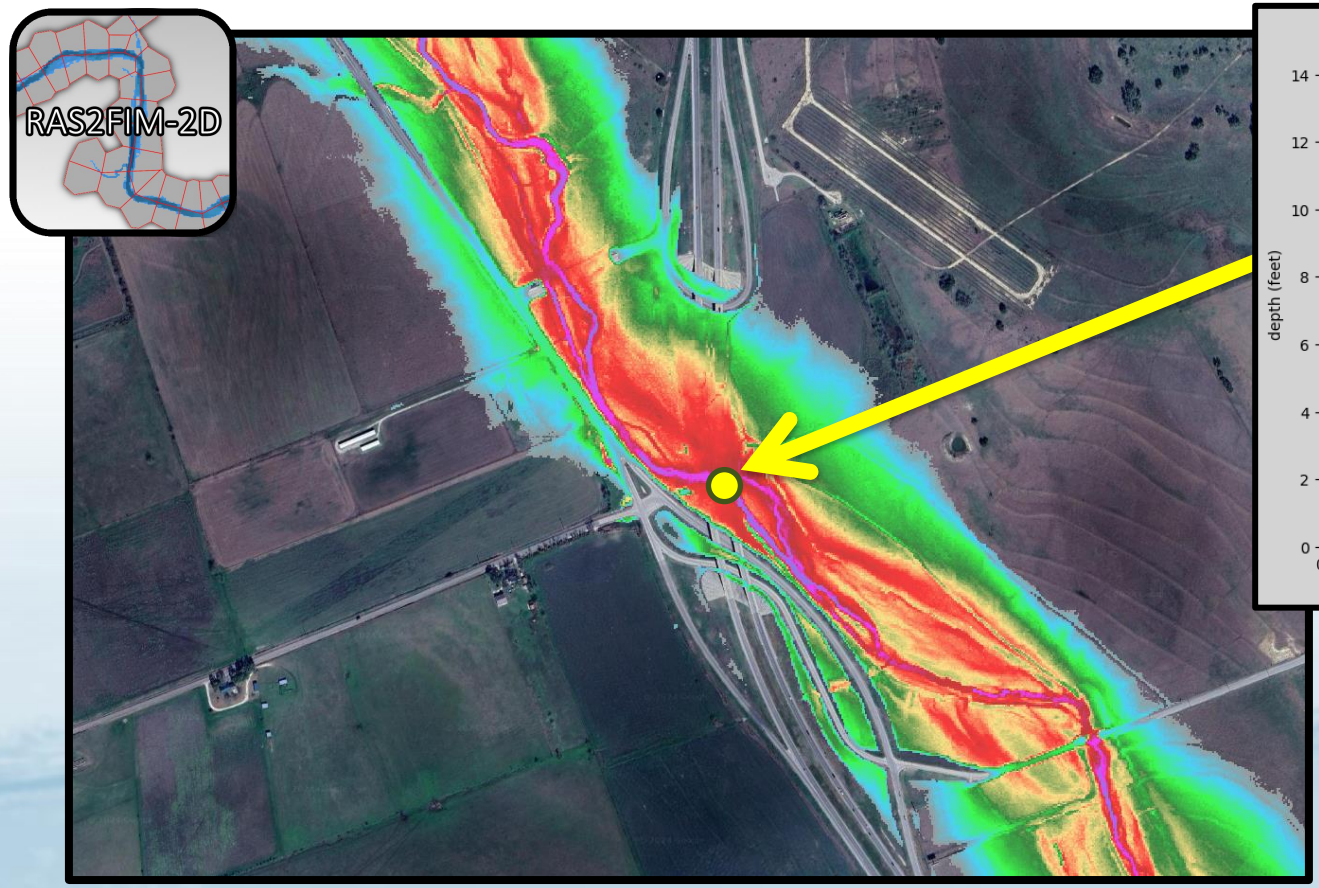


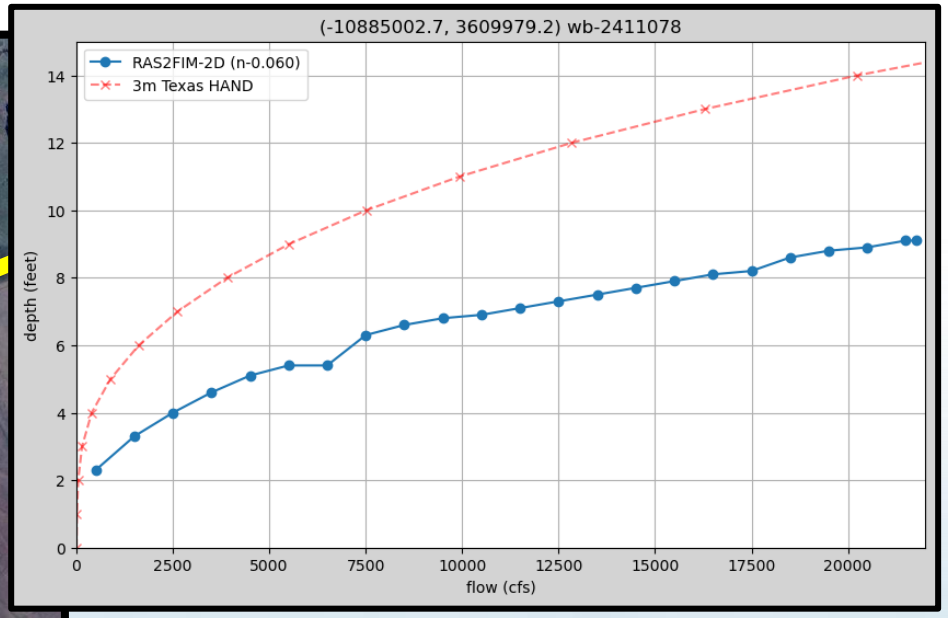
netCDF

Carry WSEL and Terrain (pixel aligned) indexed to flow

Output

From multiple runs with multiple “stable” flows … a stack of WSEL can be created for a given stream reach …

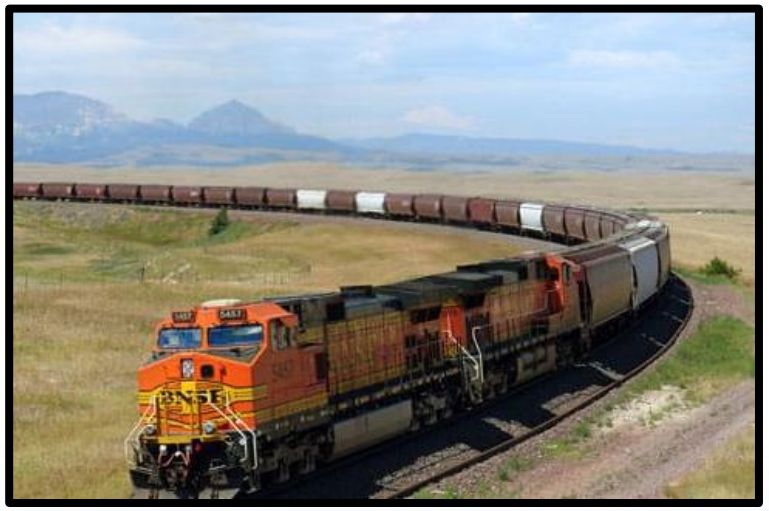




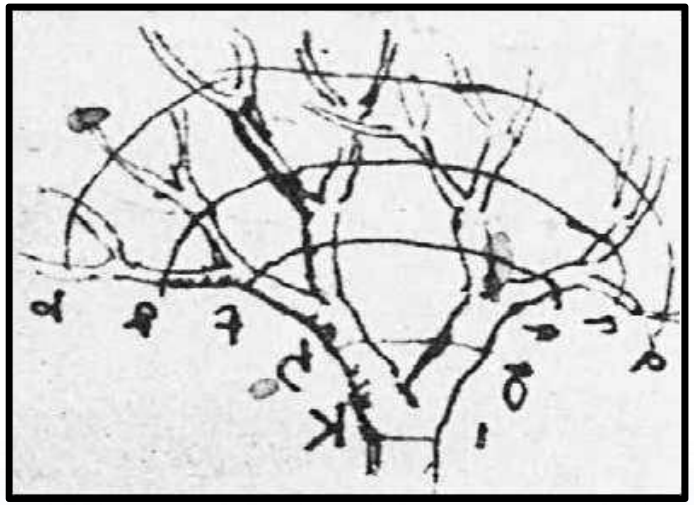
netCDF

HEC-RAS 2D models used to provide updated synthetic rating curves and flood inundation rasters for better flood forecasting

Conveyance vs Contributing (how the stream flooding?)



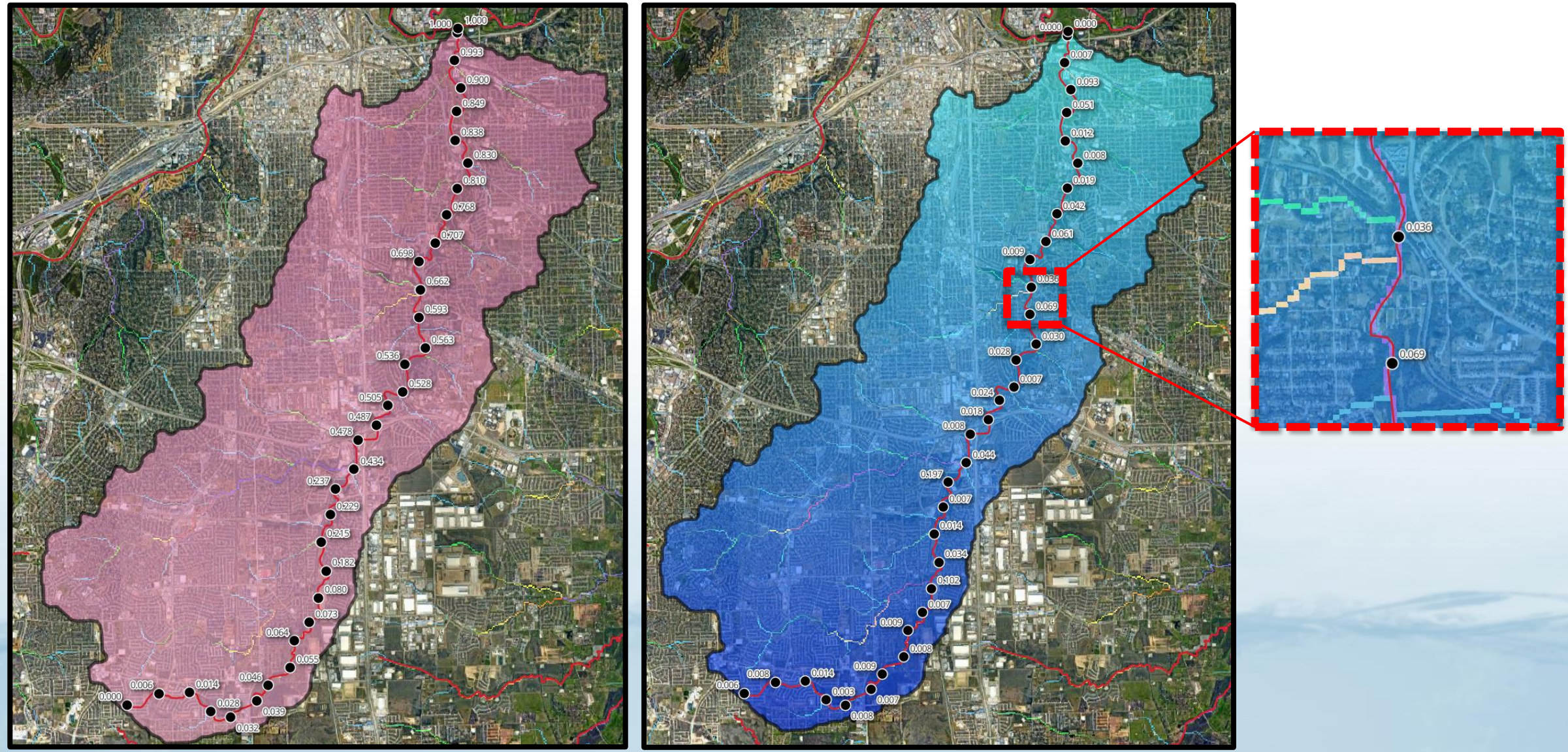
Current RAS2FIM-2D configuration assumes constant discharge from upstream limits to outlet



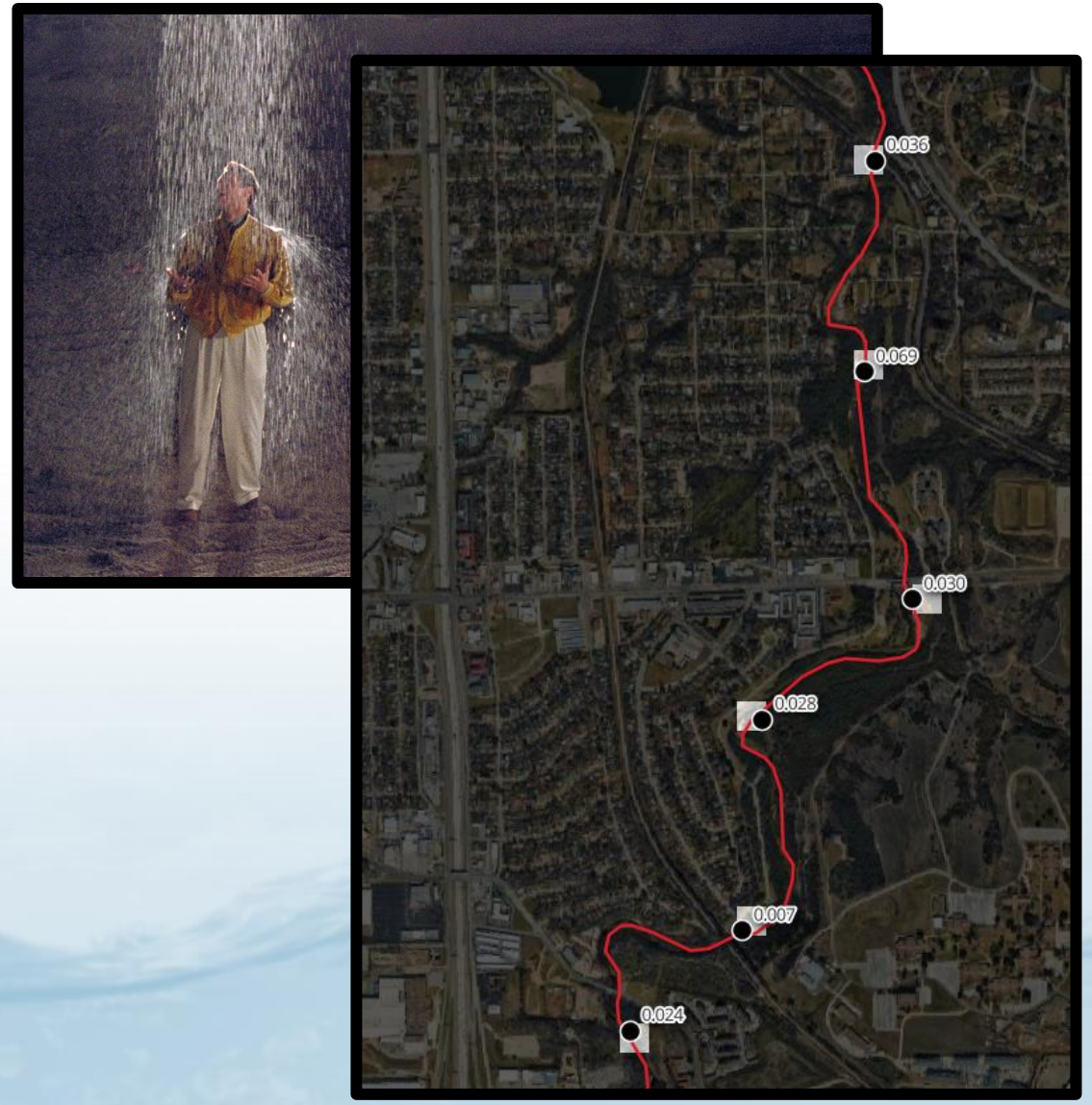
Direct excess precipitation might offer a different flooding response, in both headwater basins and “local flooding” basins

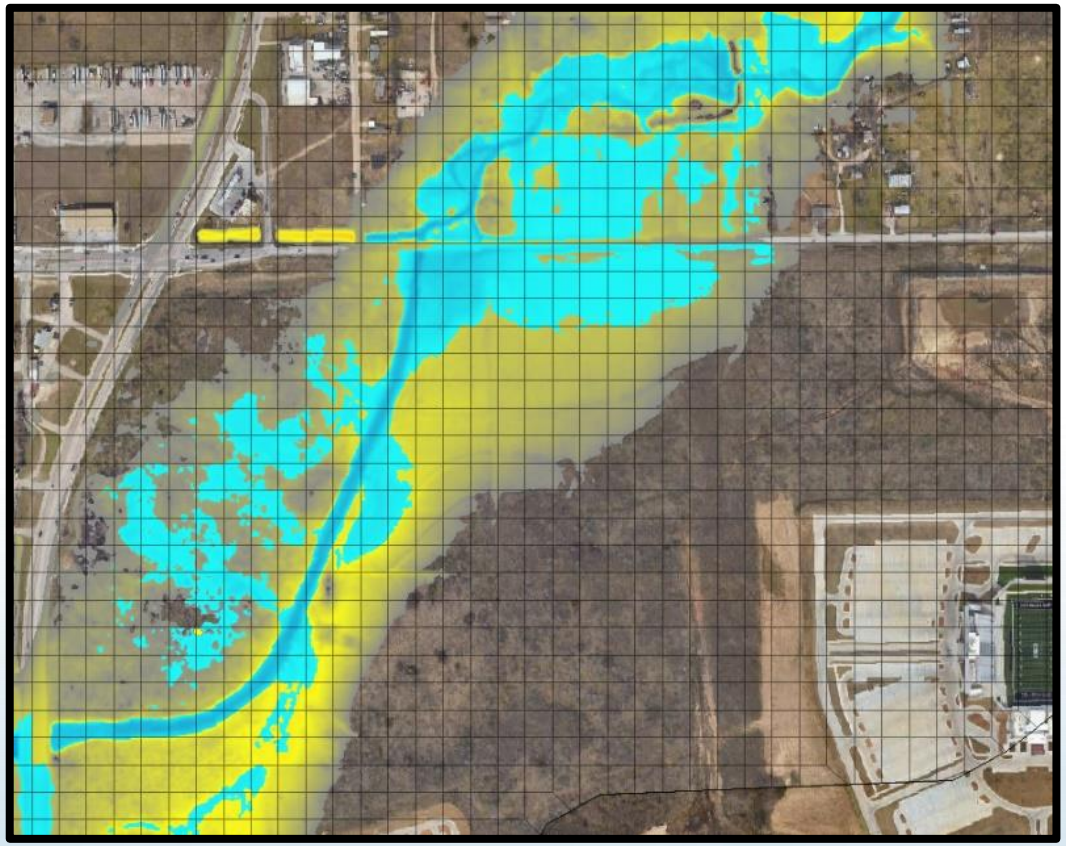
Proposing two different flood inundation operational real-time flooding products

Area adjusted flows along a predicted reach



Area adjusted flows along a predicted reach





West Risinger Road (32.614°, -97.346°)

% Drainage Area to this point: 4.6%

…So … 10,000 cfs at the outlet = 460 cfs at this point

ANDY CARTER, PE
Senior Engineering Scientist, The University of Texas at Austin

Questions?

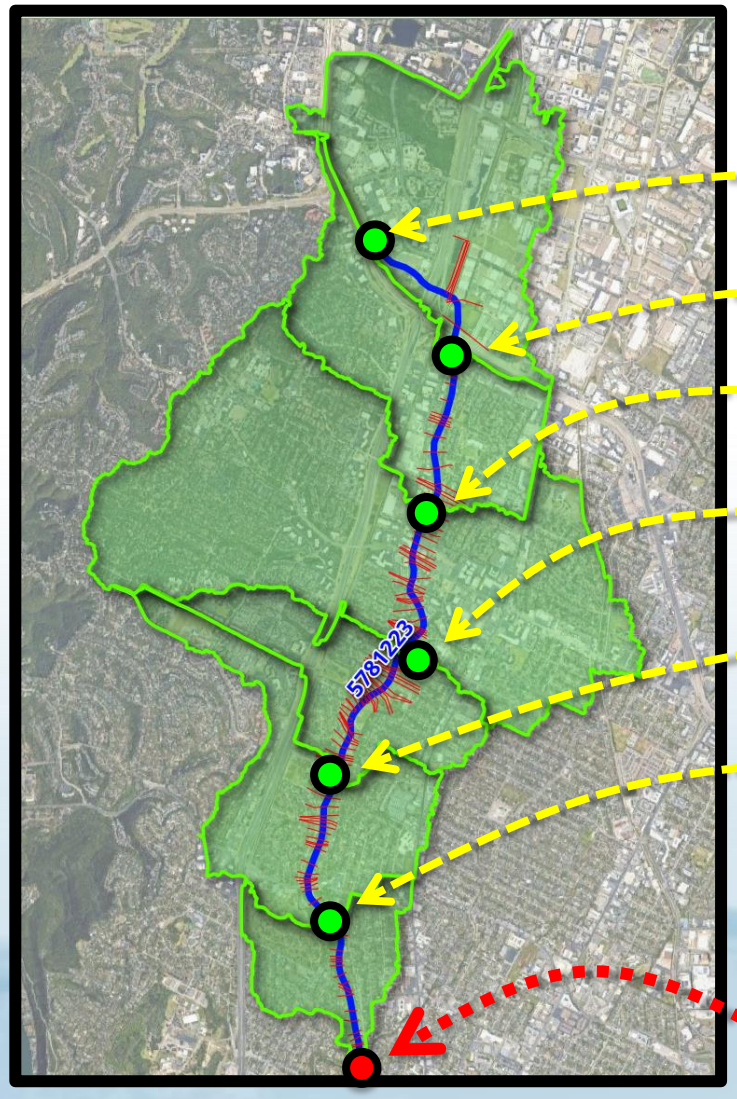
RAS2FIM-2D

Updated
2024.11.07

ANDY CARTER, PE
Senior Engineering Scientist, The University of Texas at Austin

Backup Slides

RAS2FIM - Overestimating Stream Order 1 Floodplains



	% of Total Flow to Emit
Drainage Area = 1.55 sq mi (1.55/8.27) = 19%	19%
Drainage Area = 2.67 sq mi (2.67/8.27) = 32%	13%
Drainage Area = 5.88 sq mi (5.88/8.27) = 71%	39%
Drainage Area = 6.67 sq mi (6.67/8.27) = 81%	10%
Drainage Area = 7.77 sq mi (7.77/8.27) = 94%	13%
Drainage Area = 8.27 sq mi (8.27/8.27) = 100%	6%
	Total = 100%

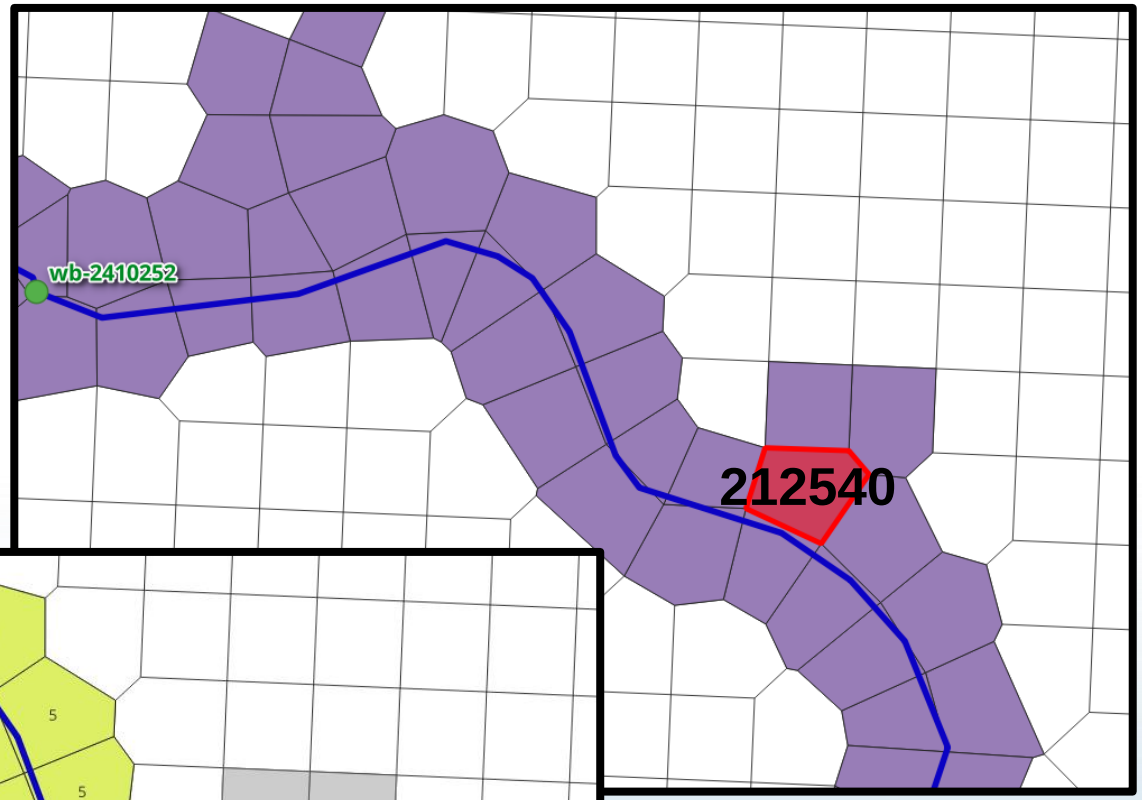
National Water Model flow forecast point

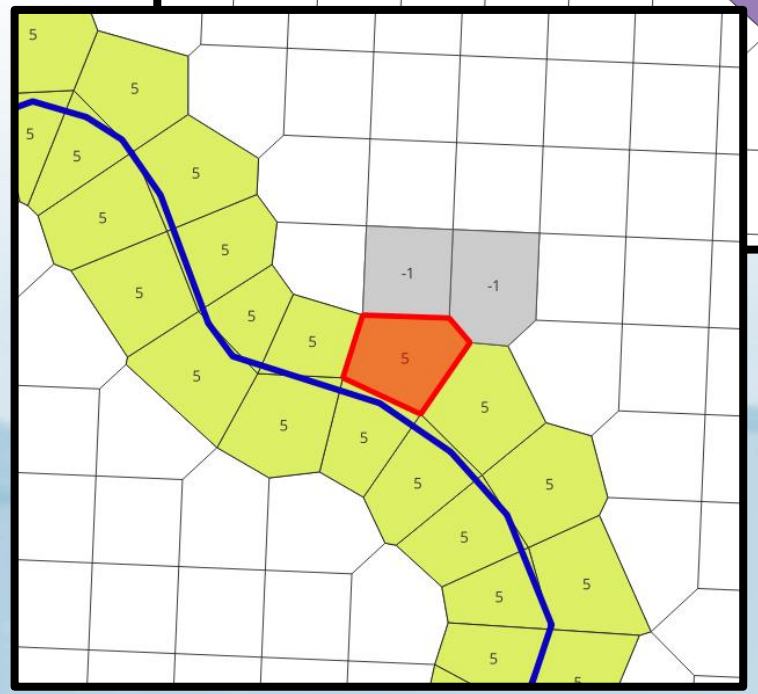
For headwater streams characterized by a Strahler stream order of 1, flood inundation mapping is traditionally generated using a constant flow down the entire reach.

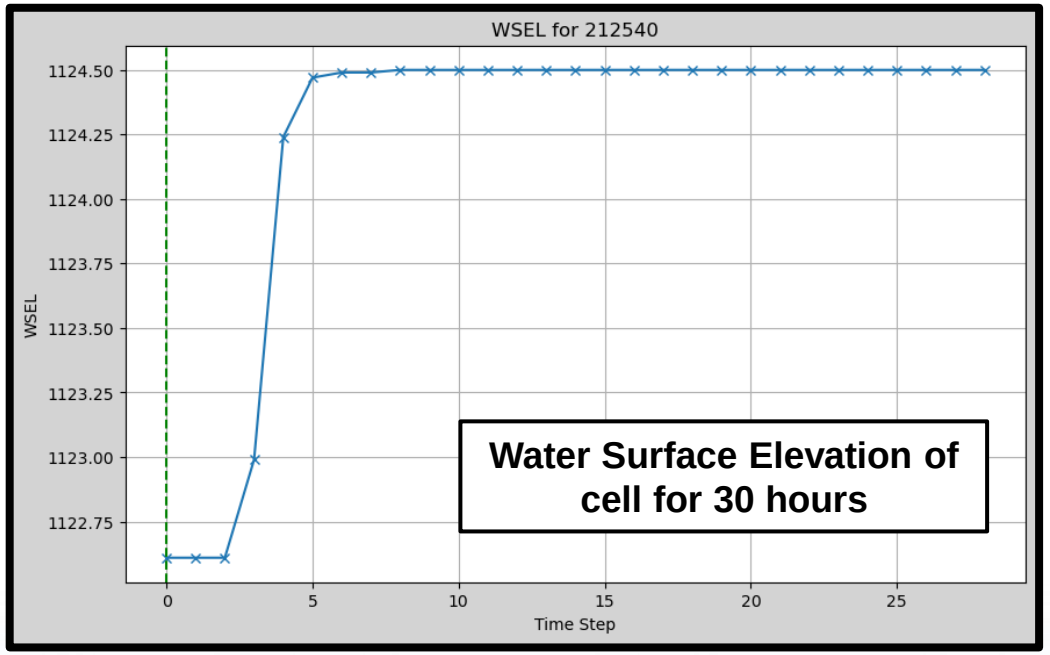
This approach tends to overestimate flooding at the upstream end.

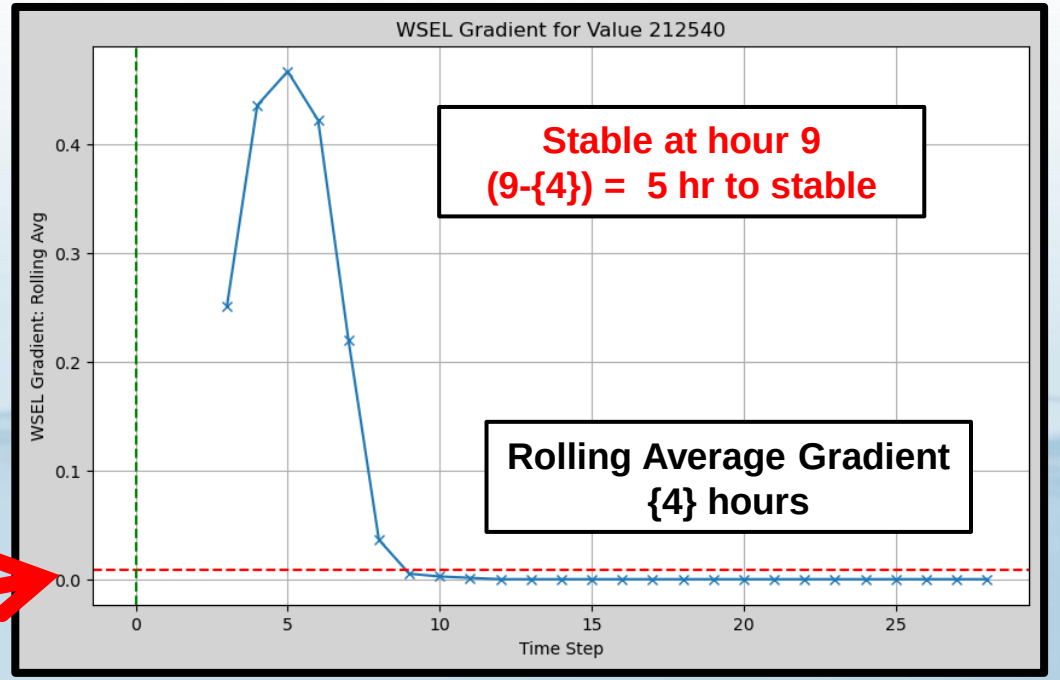
Using the 30m "Flow Accumulation Grid" for CONUS, determine multiple "Emitters" locations and ratio rates.

RAS2FIM-2D – Determine “Stable” cells



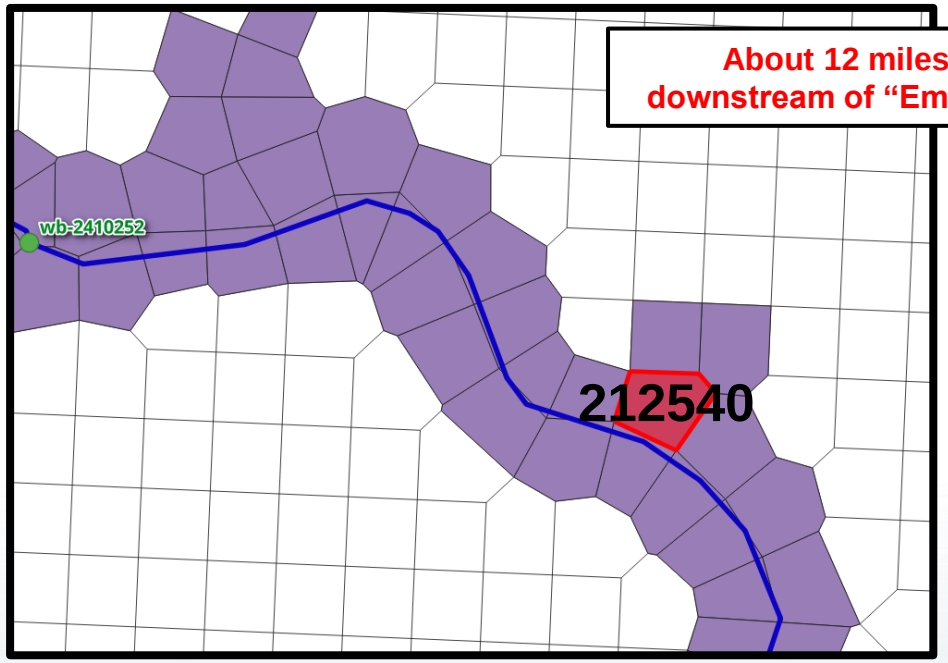






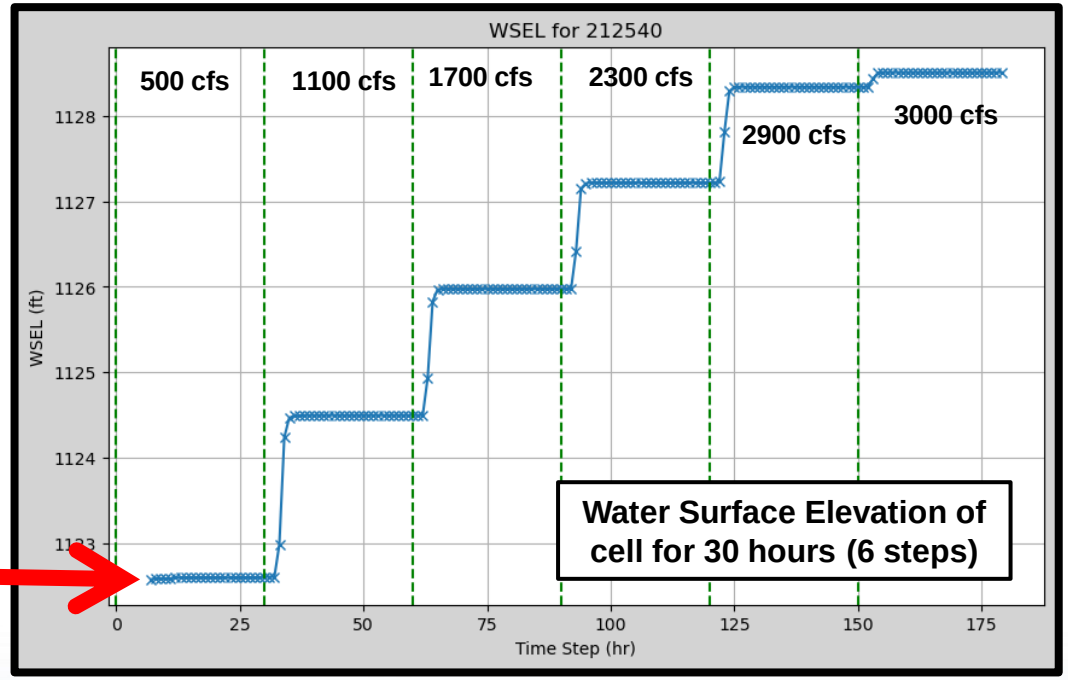
Minimum passable gradient = 0.009

RAS2FIM-2D – Stepped Flows



About 12 miles downstream of "Emitter"

First "wet" hour = 7



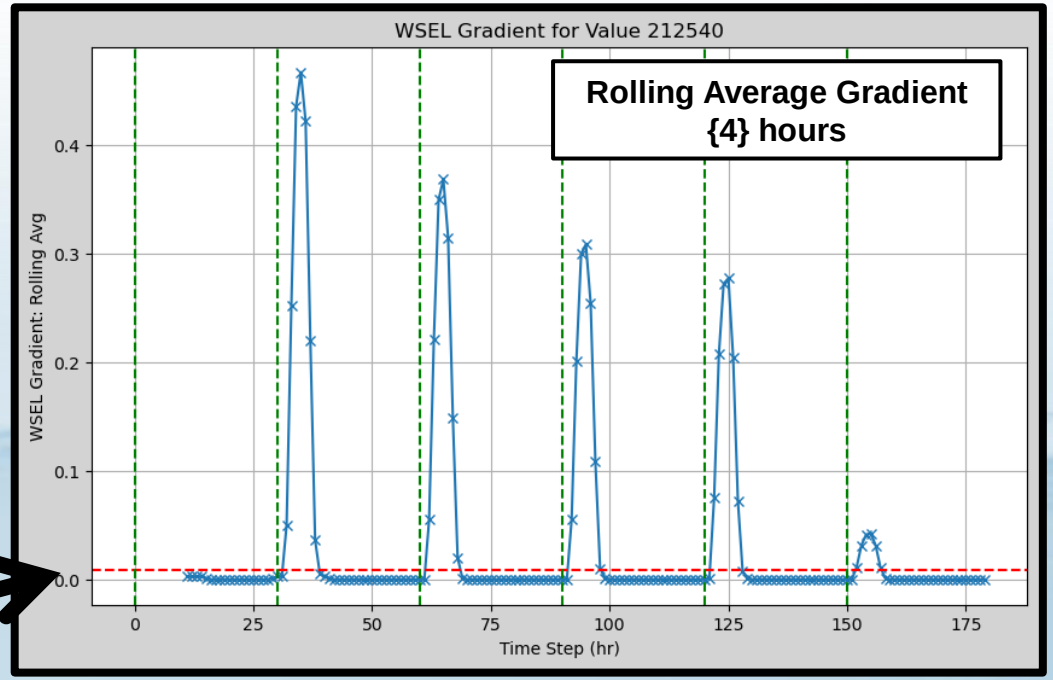
Working Plan Name:

1884413_wb-2410249_wb-2410261_30-hr_500-cfs_to_3000-cfs_step_600-cfs_plan

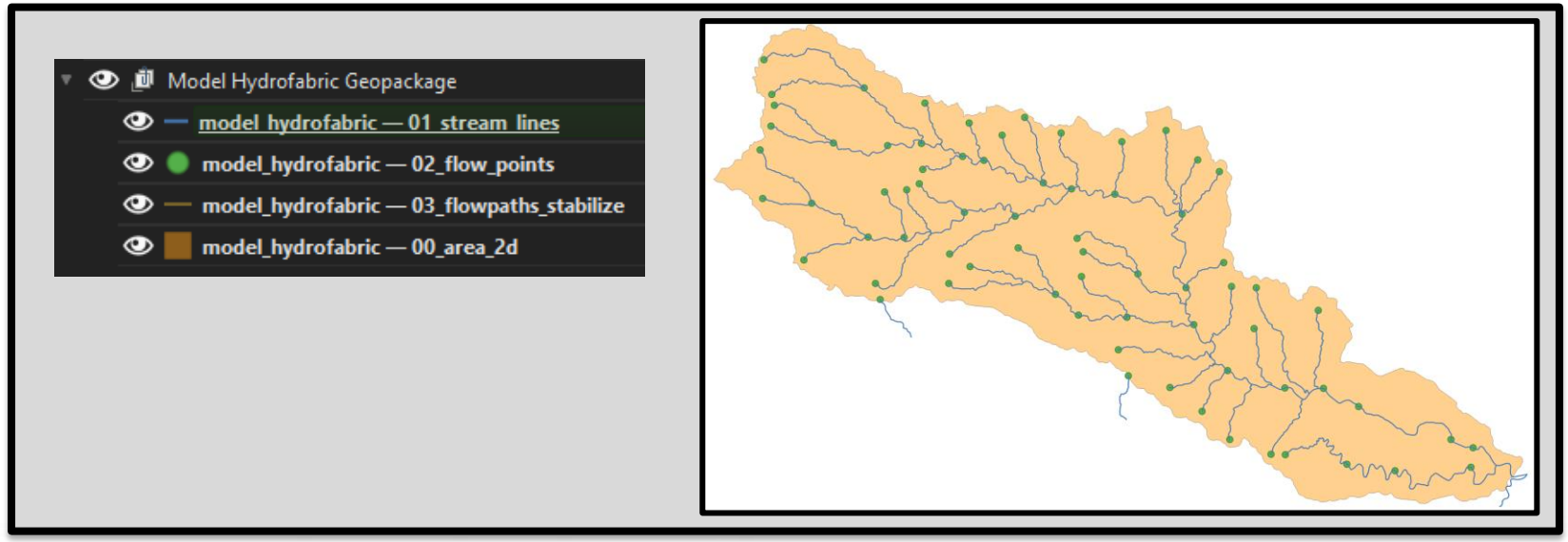
Flows: 500,1100,1700,2300,2900,3000 (cfs)

Computed Low Flow Travel Speed = ~2.5 ft/sec

Minimum passable gradient = 0.009



Output


Model Hydrofabric Geopackage
model_hydrofabric — 01_stream_lines
model_hydrofabric — 02_flow_points
model_hydrofabric — 03_flowpaths_stabilize
model_hydrofabric — 00_area_2d


Hydraulic Results Geopackage
hydraulic_results_1884413_wb-2410249_29-hr_14100-cfs — 03_streams_ln
hydraulic_results_1884413_wb-2410249_29-hr_14100-cfs — 04_floodplain_limits
hydraulic_results_1884413_wb-2410249_29-hr_14100-cfs — 02_cells_wsel_ar
hydraulic_results_1884413_wb-2410249_29-hr_14100-cfs — 01_flowpath_flooded_cells_ar
hydraulic_results_1884413_wb-2410249_29-hr_14100-cfs — 00_hec_info