Relating Watershed Physical Characteristics to Instantaneous Unit Hydrograph Parameters for Rainfall-Runoff Modeling in Central Texas

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  - Lamar University
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  - Texas Department of Transportation
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- Personnel:
  - Professional: David Thompson (TTU); Xing Fang (Lamar); William Asquith (USGS); Meghan Roussel (USGS); George Herrmann (TxDOT); Jamie Morales (TxDOT).
  - UH Students: Xin He; Samuel Orozco; Ioana Lazarescu; Krishna Jonalagadda; Matt Smith, Robert Pinder, Sara Johnson, Edsel Townsend.

Outline

- Background and Significance
- Study Area
- Data Base
- Methodology:
  - Regional Unit Hydrographs by Regression
  - Regional Unit Hydrographs by Time-area-method
- Results
- Conclusions

Background and Significance

- Hydraulics and Transportation Goals
  - Maintain service up to *n*-year event.
  - Survive extreme events.
  - Reasonable economics.

Maintain Service

~ 4% chance (25 year) discharge

Survive Extreme Events

~ 1% chance (100 year) discharge minimal damage.

Reasonable Economics

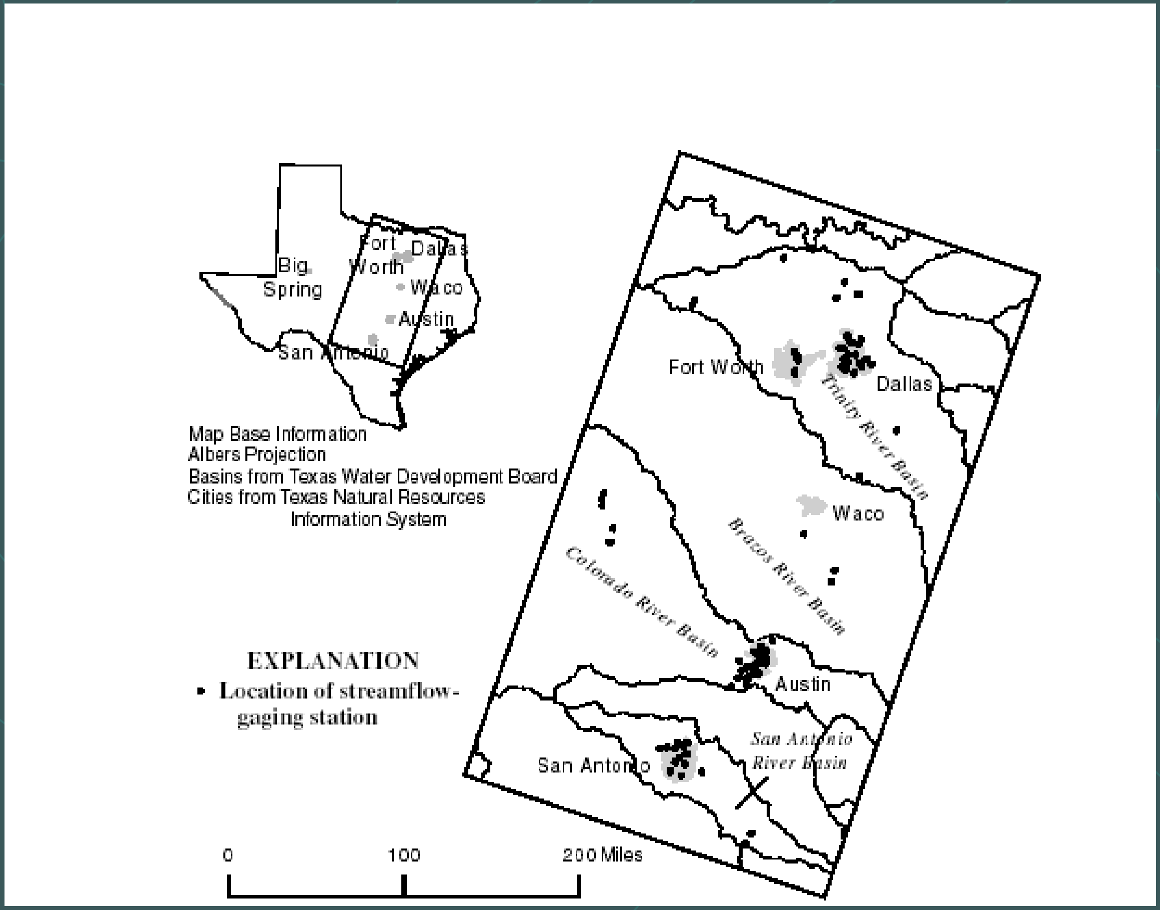
Costs need to be compared against risk of failure and traffic load

Research Scope

- Evaluate/develop regionalized unit hydrograph methods for Texas watersheds in the 200-acre to 10 square mile range.
- Application is watersheds with limited/no gage data for use by the Texas Department of Transportation.
- Currently the department uses the NRCS unit hydrograph as implemented in HEC-HMS.

Study Area

- 90 watersheds



Database(s)

- Precipitation
  - Texas, Louisiana, Oklahoma, New Mexico
- Paired rainfall-runoff (1600 events)
  - 1600 events
  - 90 watersheds in Texas
- Watershed characteristics
  - 90 watersheds in Texas

Texas Hyteograph(s)

- Link to Will's Presentation

Basin Characteristics

- Descriptive (Land use, % impervious, etc.)
  - Compiled by U.S.G.S. using GIS
- Physical
  - Compiled manually by University of Houston
  - Compiled by the U.S.G.S. using GIS.
    - The two approaches produced practically identical results for the common characteristics
    - All correlations are based on the U.S.G.S. physical characteristics.
- Of the 90+ watersheds
  - 58 are smaller than 10 square miles in drainage area
  - 72 are smaller than 20 square miles in drainage area

Basin Characteristics

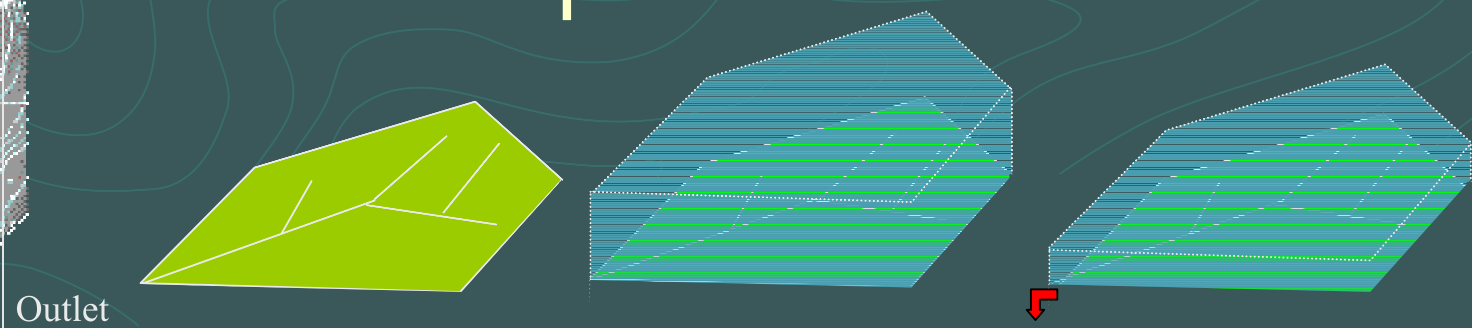
- Explanatory Variables:

Module	Basin	SubBasin	Station_ID	Total drainage area (mi2)	Basin length (mi)	Basin perimeter (mi)	Average basin slope (ft/mi)	Basin relief (ft)	Minimum basin elevation (ft)	Maximum basin elevation (ft)	Average basin elevation (ft)	Headwater elevation (ft);	Pourpoint (outlet) elevation (ft)	Effective basin width (mi)	Basin shape factor	Elongation ratio	Rotundity of basin	Compactness ratio	Relative relief (ft/mi)	Basin factor (MCL^2/A)	Main channel length (mi)	Main channel slope (ft/mi)	Main channel sinuosity ratio	Slope ratio of main channel slope to basin slope	Alternate Main channel slope (ft/mi)
Austin	BartonCreek	none	08155200	89.6	18.2	67.7	372.3	752.2	750	1503	1109	1479	750	4.9	3.70	0.59	2.91	2.0	11.1	9.06	28.5	19.1	1.56	0.05	25.6
Austin	BartonCreek	none	08155300	116.6	26.4	91.2	416.8	983.0	520	1503	1039	1479	520	4.4	5.98	0.46	4.70	2.4	10.8	17.42	45.1	15.3	1.71	0.04	21.3
Austin	BearCreek	none	08158810	12.3	5.0	19.7	318.8	374.1	868	1242	1053	1236	868	2.5	2.00	0.80	1.57	1.6	19.0	3.21	6.3	49.1	1.27	0.15	58.5
Austin	BearCreek	none	08158820	24.5	10.5	37.1	310.5	590.6	651	1242	980	1236	651	2.3	4.52	0.53	3.55	2.1	15.9	9.00	14.8	28.5	1.41	0.09	39.4
Austin	BearCreek	none	08158825	21.0	8.8	29.1	221.0	443.6	690	1134	891	1130	690	2.4	3.66	0.59	2.87	1.8	15.3	7.47	12.5	27.4	1.43	0.12	35.1
Austin	BoggyCreek	none	08158050	12.6	6.0	20.8	171.5	309.8	429	739	567	737	429	2.1	2.86	0.67	2.24	1.6	14.9	4.29	7.4	39.3	1.23	0.23	41.8
Austin	BoggySouthCreek	none	08158880	3.6	3.8	12.5	200.2	265.7	606	871	713	868	606	0.9	4.08	0.56	3.20	1.9	21.2	5.43	4.4	43.2	1.15	0.22	59.5
Austin	BullCreek	none	08154700	22.8	8.5	31.6	591.5	568.3	540	1108	869	1107	540	2.7	3.15	0.64	2.47	1.9	18.0	4.43	10.0	36.3	1.19	0.06	56.5
Austin	LittleWalnutCreek	none	08158380	5.3	3.4	13.0	125.5	155.8	645	801	734	793	645	1.5	2.24	0.75	1.76	1.6	12.0	3.06	4.0	32.2	1.17	0.26	36.9
Austin	OnionCreek	none	08158700	123.7	20.8	78.8	330.6	794.6	880	1674	1223	1673	880	6.0	3.48	0.60	2.73	2.0	10.1	8.95	33.3	16.3	1.60	0.05	23.8
Austin	OnionCreek	none	08158800	167.3	31.0	106.1	301.8	1013.7	661	1674	1138	1673	661	5.4	5.75	0.47	4.51	2.3	9.6	14.32	48.9	13.9	1.58	0.05	20.7
Austin	ShoalCreek	none	08156650	2.7	2.1	10.2	160.1	183.2	710	893	792	892	710	1.3	1.64	0.88	1.29	1.7	18.0	3.32	3.0	48.0	1.42	0.30	60.7
Austin	ShoalCreek	none	08156700	6.3	3.8	15.2	165.4	242.0	671	913	778	892	671	1.7	2.22	0.76	1.74	1.7	15.9	3.23	4.5	34.0	1.21	0.21	48.8
Austin	ShoalCreek	none	08156750	6.8	4.2	16.6	170.4	257.9	655	913	774	892	655	1.6	2.60	0.70	2.04	1.8	15.5	3.85	5.1	30.2	1.22	0.18	46.2
Austin	ShoalCreek	none	08156800	12.7	8.8	29.3	178.7	438.7	474	913	716	892	474	1.4	6.07	0.46	4.76	2.3	15.0	8.79	10.6	30.5	1.20	0.17	39.5
Austin	SlaughterCreek	none	08158840	8.8	4.8	17.9	286.6	313.8	880	1194	1028	1192	880	1.8	2.65	0.69	2.08	1.7	17.6	2.81	5.0	48.7	1.03	0.17	62.9
Austin	SlaughterCreek	none	08158860	23.2	10.6	34.2	211.3	534.2	660	1194	911	1192	660	2.2	4.80	0.51	3.77	2.0	15.6	7.05	12.8	32.0	1.21	0.15	41.6
Austin	WallerCreek	none	08157000	2.2	3.8	10.1	125.2	212.6	560	773	670	773	560	0.6	6.54	0.44	5.14	1.9	21.0	7.67	4.1	47.2	1.08	0.38	51.7
Austin	WallerCreek	none	08157500	4.2	4.7	14.8	145.3	256.9	516	773	641	773	516	0.9	5.37	0.49	4.22	2.0	17.4	6.39	5.2	45.6	1.09	0.31	49.8
Austin	WalnutCreek	none	08158100	12.7	3.7	23.9	156.2	292.9	675	968	824	948	675	3.4	1.10	1.08	0.87	1.9	12.2	2.52	5.7	47.1	1.51	0.30	48.2
Austin	WalnutCreek	none	08158200	26.4	8.0	32.9	193.0	401.7	566	968	776	948	566	3.3	2.42	0.73	1.90	1.8	12.2	4.51	10.9	30.1	1.36	0.16	35.0
Austin	WalnutCreek	none	08158400	5.7	4.0	14.2	129.6	167.1	634	801	730	793	634	1.4	2.87	0.67	2.25	1.7	11.8	3.51	4.5	32.2	1.11	0.25	35.5
Austin	WalnutCreek	none	08158500	12.1	7.2	22.2	184.0	315.1	486	801	687	793	486	1.7	4.32	0.54	3.39	1.8	14.2	6.08	8.6	33.8	1.19	0.18	35.7
Austin	WalnutCreek	none	08158600	53.6	14.4	53.7	215.5	528.9	439	968	702	948	439	3.7	3.87	0.57	3.04	2.1	9.9	7.08	19.5	20.5	1.35	0.10	26.1
Austin	WestBouldinCreek	none	08155550	2.7	3.0	10.2	235.4	243.2	461	704	616	704	461	0.9	3.32	0.62	2.61	1.8	23.9	5.02	3.7	69.9	1.23	0.30	66.4
Austin	WilbargerCreek	none	08159150	4.5	2.9	12.1	107.2	169.9	673	843	755	834	673	1.5	1.93	0.81	1.51	1.6	14.1	3.13	3.7	42.4	1.28	0.40	43.1
Austin	WilliamsonCreek	none	08158920	6.3	4.4	14.8	336.3	315.4	801	1116	959	1109	801	1.4	3.02	0.65	2.37	1.7	21.3	3.93	5.0	51.3	1.14	0.15	61.9
Austin	WilliamsonCreek	none	08158930	18.7	9.5	30.3	217.0	492.8	623	1116	839	1109	623	2.0	4.81	0.51	3.78	2.0	16.2	5.78	10.4	37.5	1.10	0.17	46.7
Austin	WilliamsonCreek	none	08158970	27.4	13.8	42.0	207.4	607.4	509	1116	776	1109	509	2.0	6.96	0.43	5.46	2.3	14.5	11.32	17.6	27.1	1.28	0.13	34.1
Dallas	AshCreek	none	08057320	7.2	5.4	16.6	116.3	174.9	430	605	525	590	430	1.3	4.12	0.56	3.24	1.8	10.5	4.09	5.4	34.4	1.00	0.30	29.5

Unit Hydrograph Analysis

- The instantaneous unit hydrograph (IUH) is a direct runoff hydrograph (DRH) resulting from a unit depth of an effective precipitation hyetograph (EPH) applied uniformly over a watershed.
- A major advantage of an IUH over a unit hydrograph is that the IUH does not require the effective precipitation hyetograph to have a specific duration

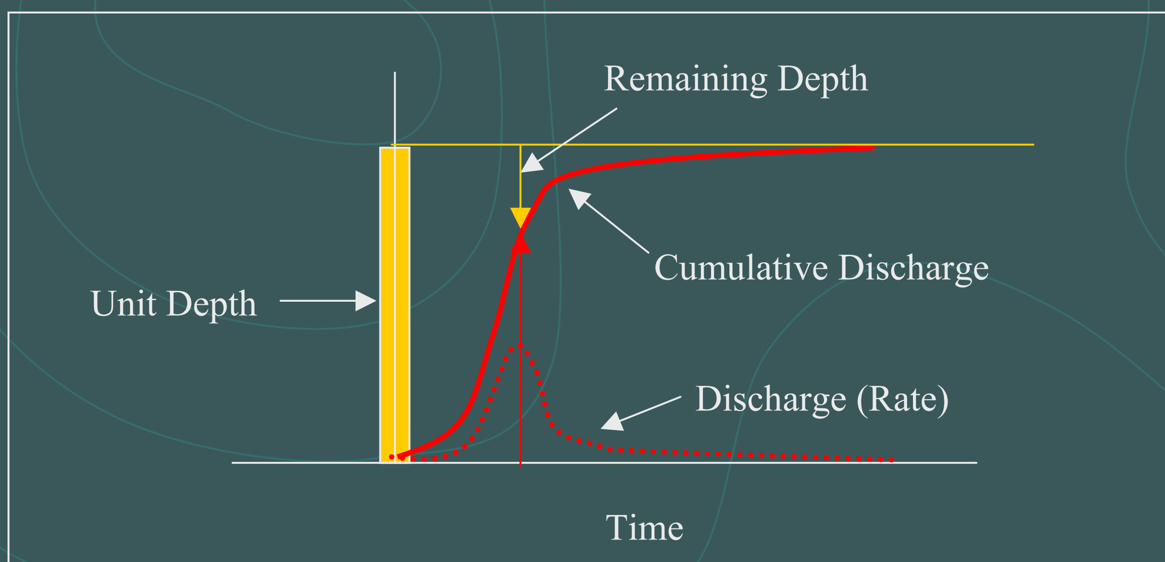
IUH Concept



Unit Depth at Time < 0;
Discharge at Time < 0

Unit Depth at Time = 0;
Discharge at Time = 0

Remaining Depth at Time > 0;
Discharge at Time > 0



Instantaneous Unit Hydrographs

- The direct runoff hydrograph is computed as the convolution of the effective precipitation hyetograph and the IUH kernel function.

$$Q(t) = \int_0^t i(\tau)u(t-\tau)d\tau$$

[Eqn. 1]

i(t) is the EPH (precipitation rate as a function of time)

u(t) is the IUH (unit response rate as a function of time)

Q(t) is the DRH (direct runoff rate as a function of time).

Model Hydrographs

- Modeled the conversion of precipitation to runoff as a hybrid of a translation hydrograph, and a series (cascade) of storage elements.

$$Q(t)_m = \int_0^t \{i(t)\} A \frac{2}{\bar{t}} \frac{1}{\Gamma(N)} \left(\frac{(t-\tau)^{2N-1}}{\bar{t}^{2N-1}} \right) \exp(-\left(\frac{(t-\tau)}{\bar{t}} \right)^2) d\tau$$

$$\{i(t)\} \quad = 0 \quad if \int_0^t p(\tau) d\tau \le I_a$$

$$\{i(t)\} = C_r p(t) \, if \int_0^t p(\tau) d\tau > I_a$$

Finding Model Parameters

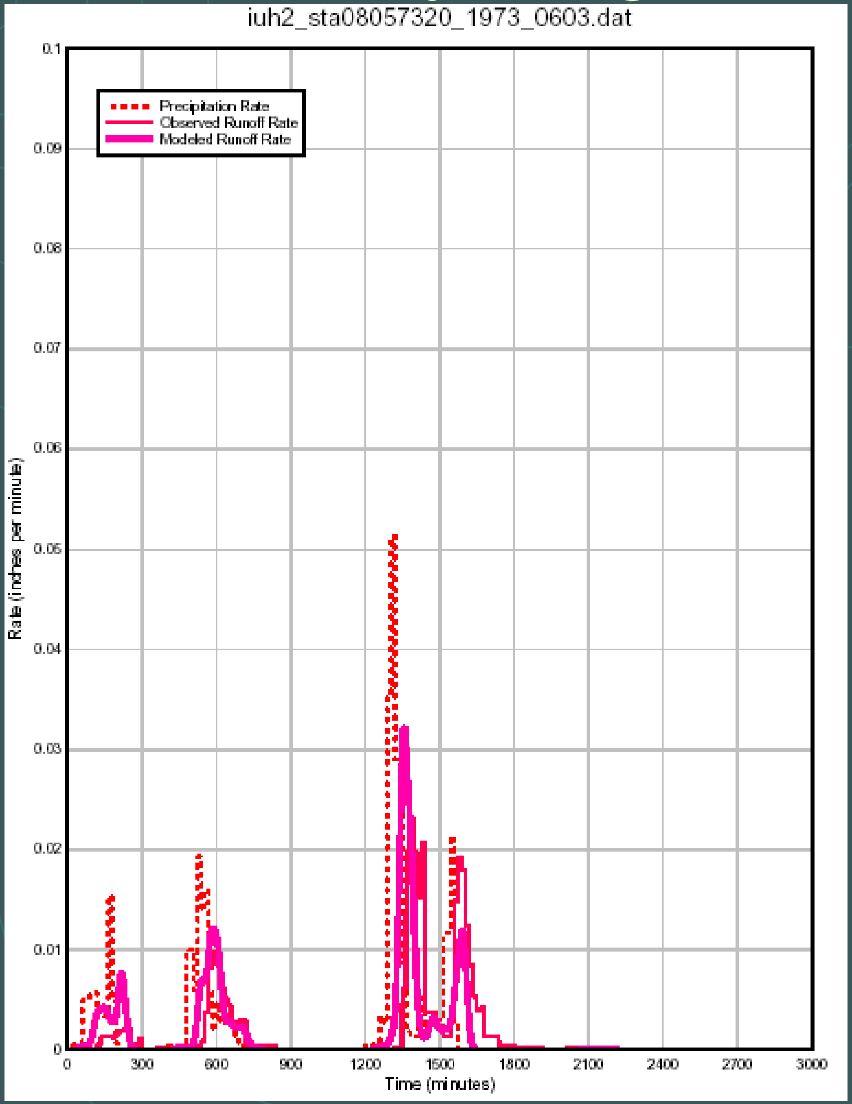
- Calculate DRH from the effective rainfall signal (Equation 2) and adjust values until some merit function is minimized.

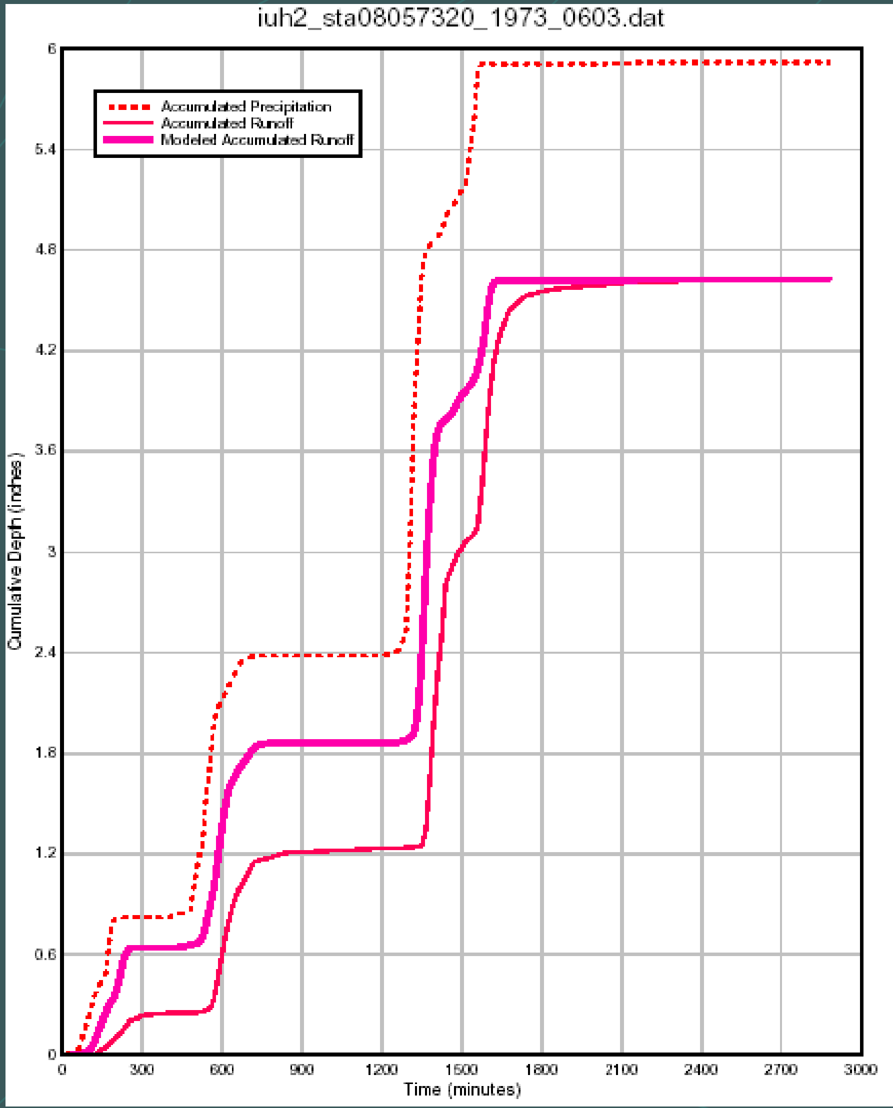
$$SSE = \sum_{i=1}^{NOBS} (Q_s - Q_o)_i^2$$

$$Q_p MAD = \left| Q_s(t_{peak}) - Q_o(t_{peak}) \right|$$

- A modified direct-search technique (Hooke and Jeeves, 1961). (Essentially a grid-search –many simulations)
- Used a cluster computer to perform the computations

“Fitted” Hydrographs





Regional Regression Equations

- Regionalization:
  - Regression Models using Watershed Characteristics
    - Use power-law model values of distribution and loss model parameters.
    - Least squares fit to median values for each watershed.

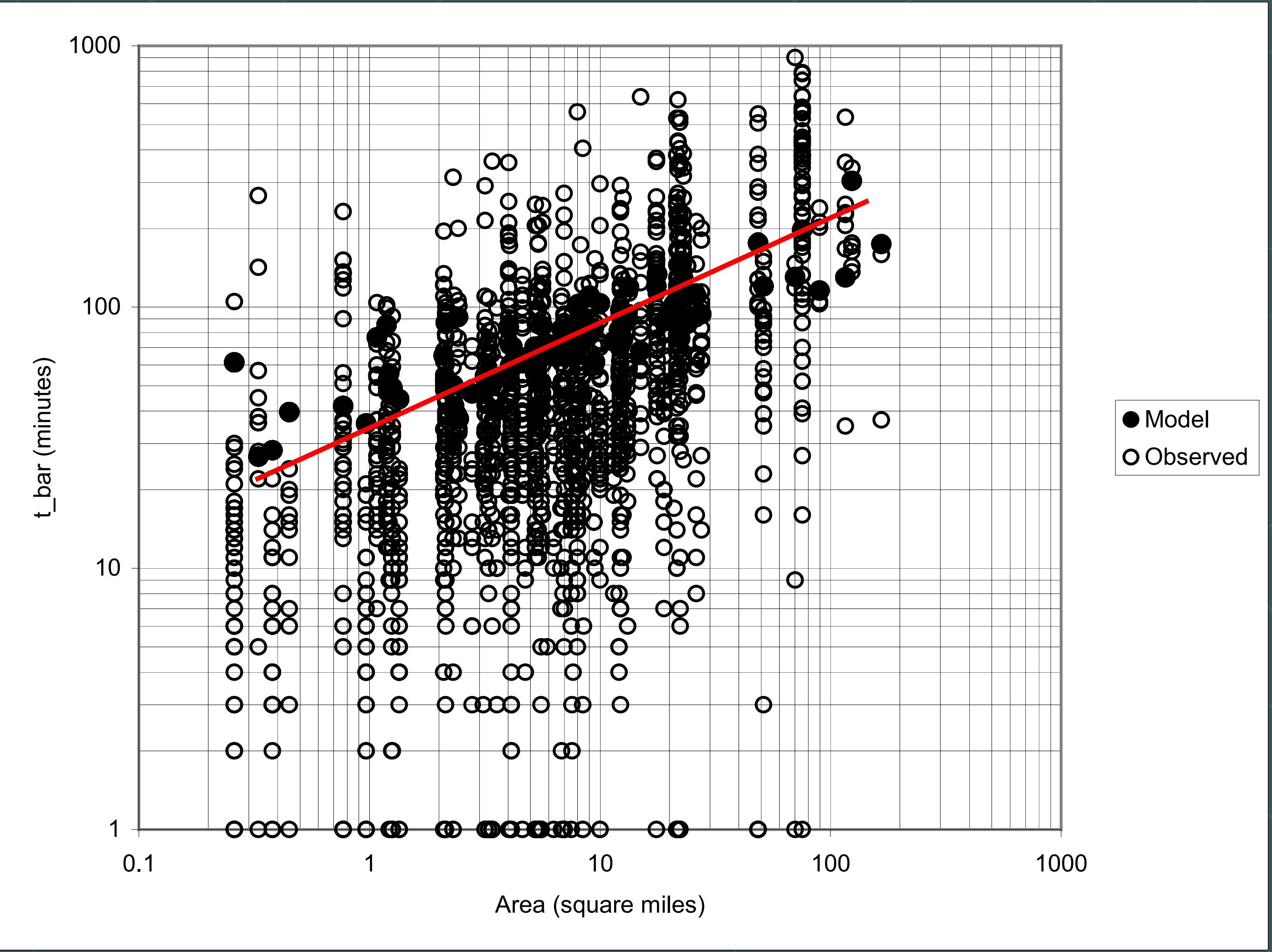
$$I_a = 0$$

$$C_r = 0.137 A^{-0.109} S^{-0..206}$$

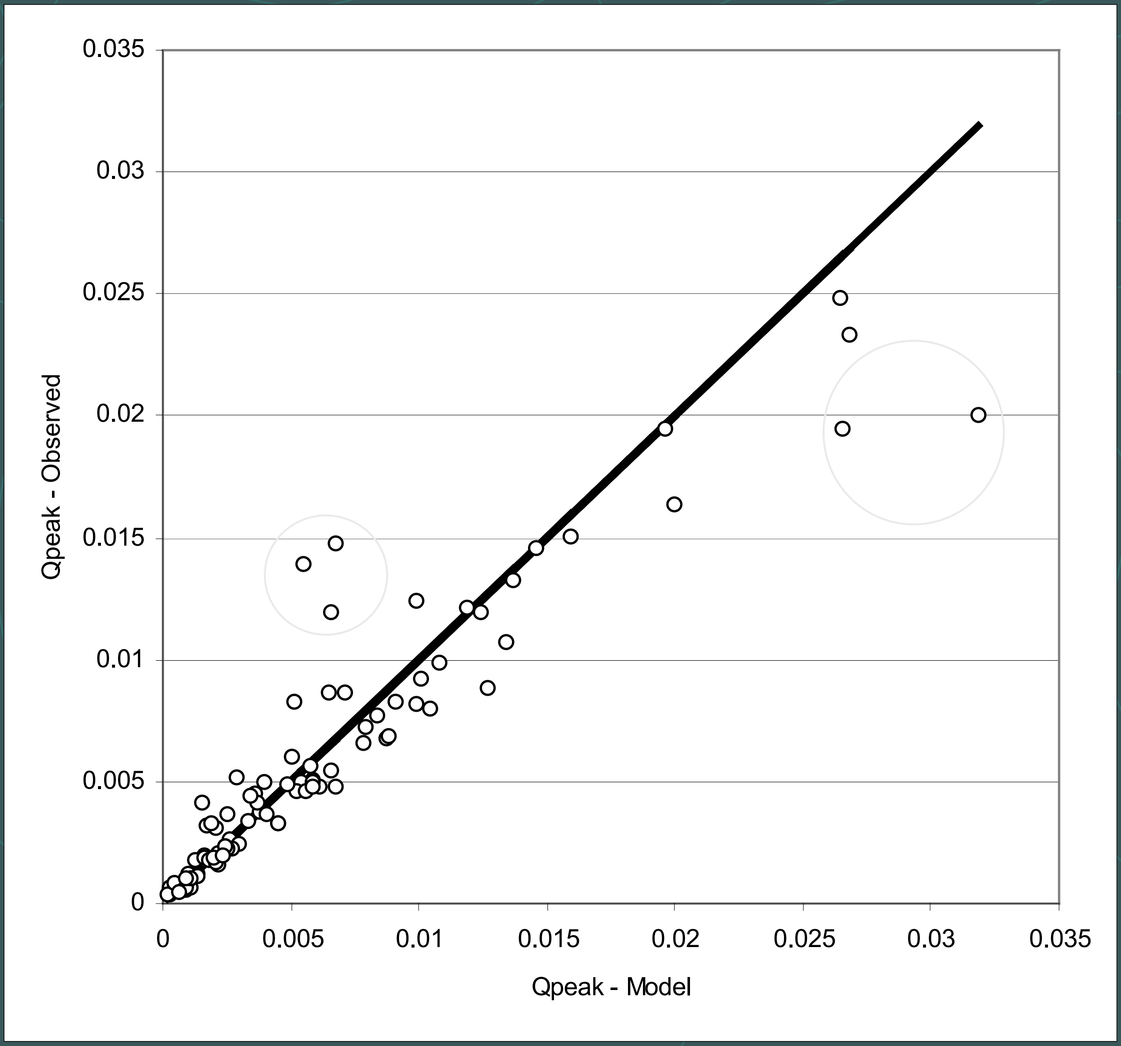
$$\bar{t} = 138\left(\frac{A}{P}\right)^{0.334} S^{-0.500}$$

$$N = 2.43 P^{0.102} S^{0.064}$$

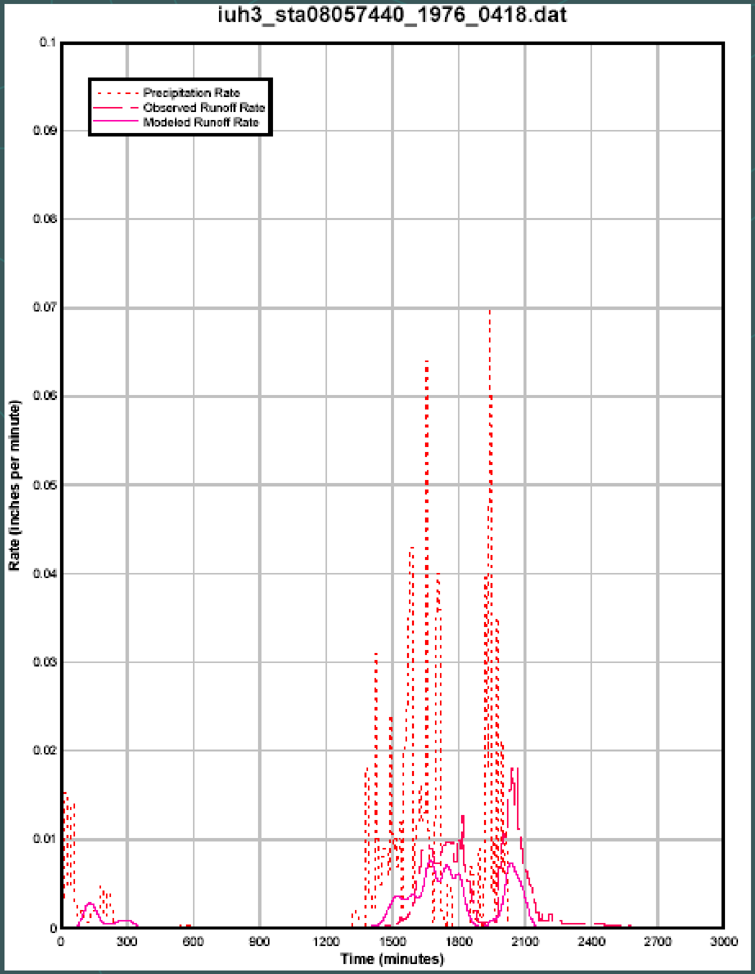
Regional Regression Equations

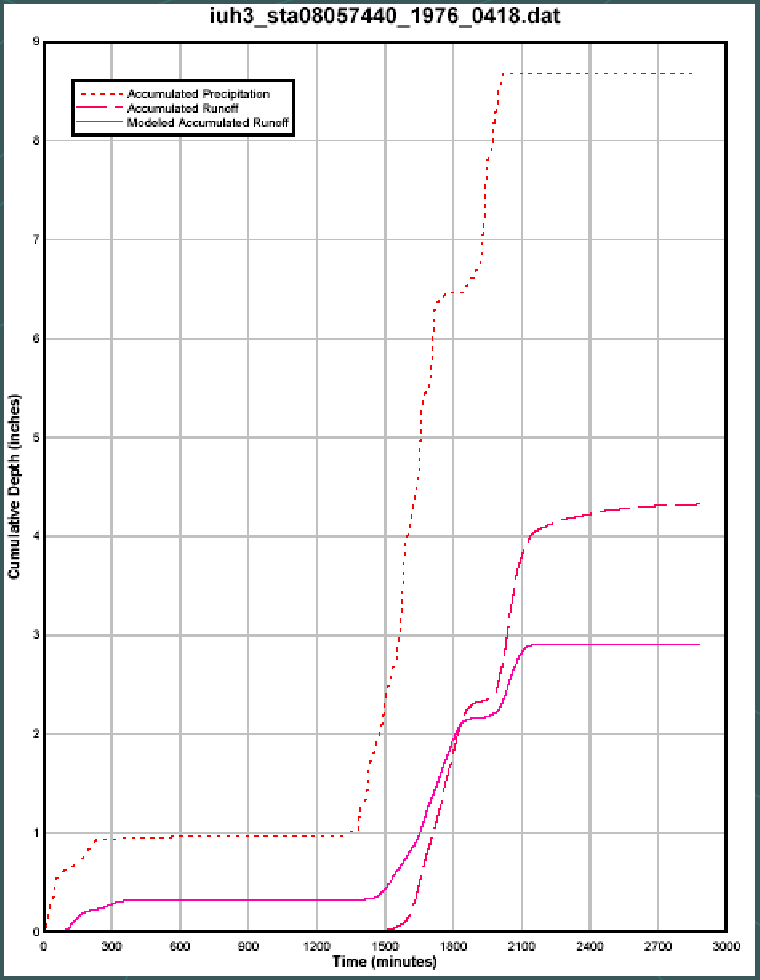


Regional Regression Equations



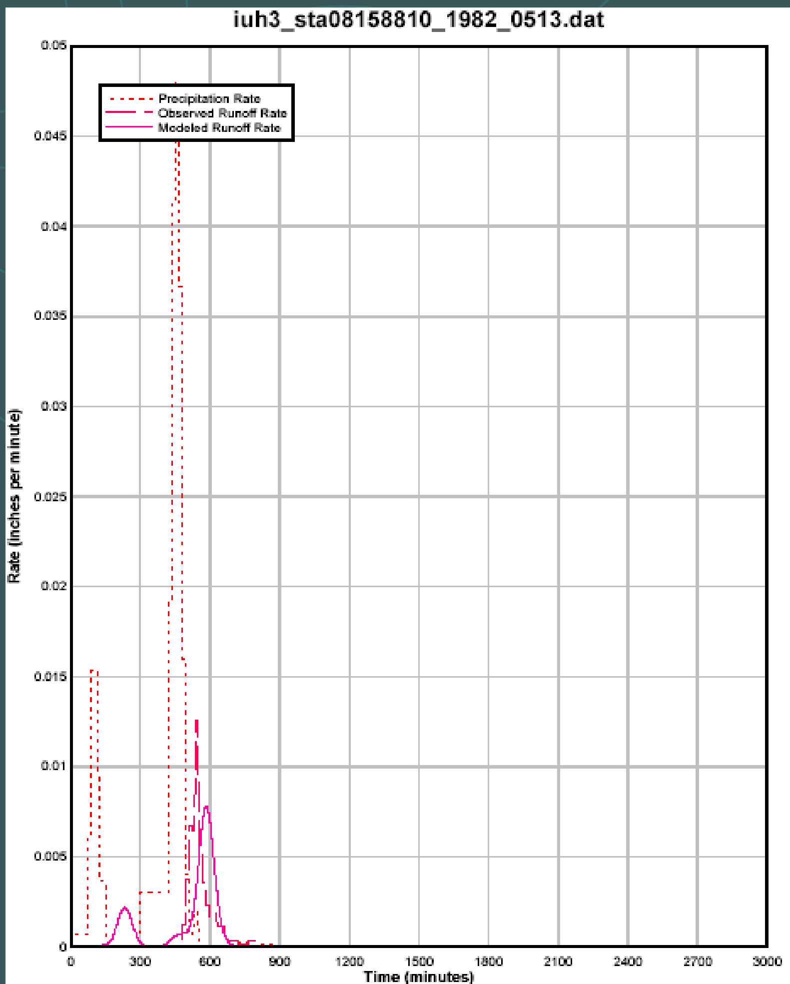
Performance Testing

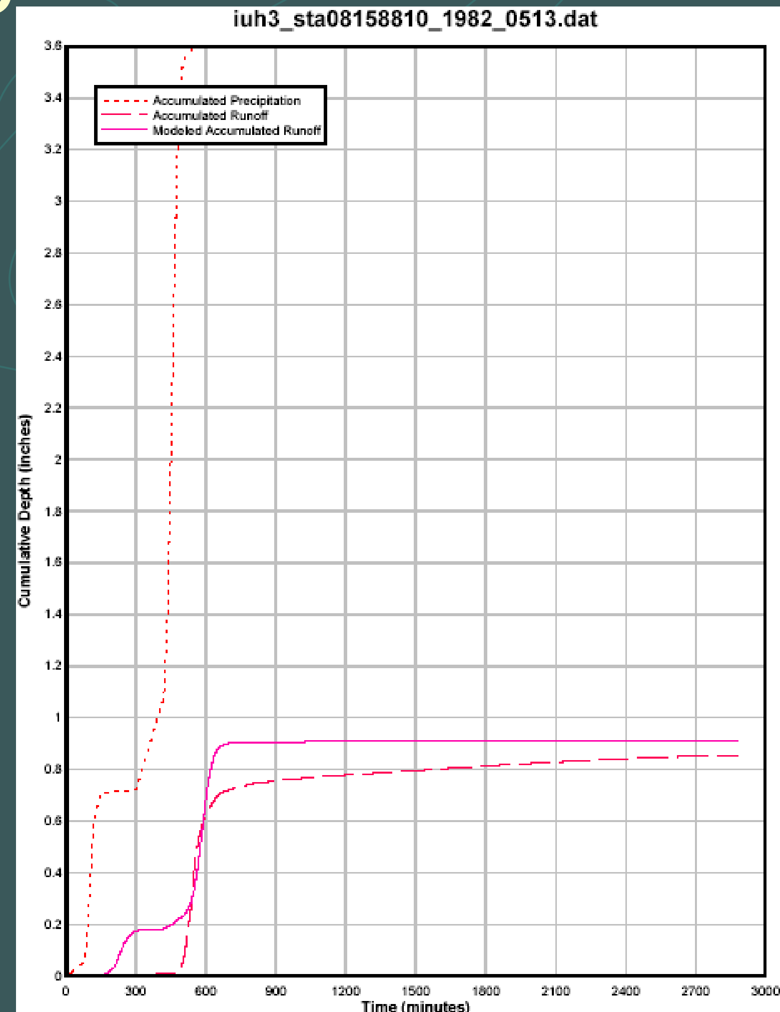




~2 sq.mi.

Performance Testing





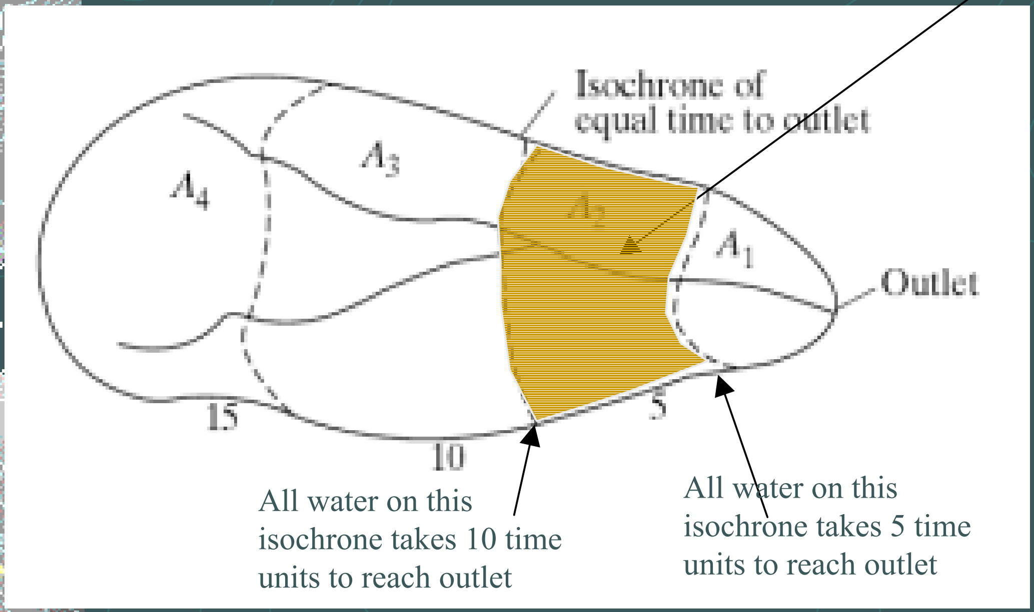
~12 sq.mi.

Finding Model Parameters

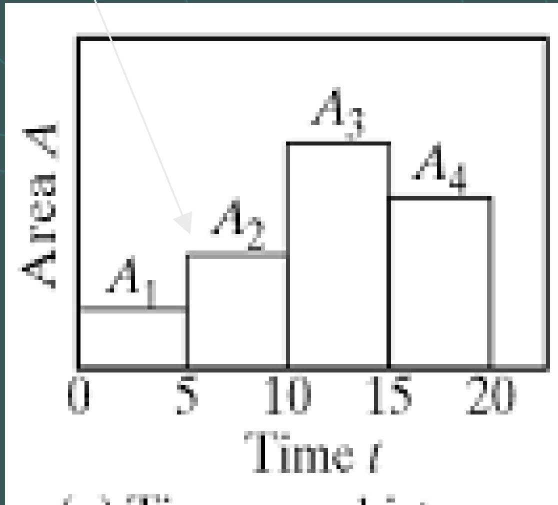
- Time-area-analysis.
  - Relates travel time to different areas in the watershed.
  - Also called Contributing Area Method.
- Procedure:
  - Create a histogram of contributing area versus time.
  - Apply precipitation hyetograph, and use the histogram as the kernel function in the convolution integral.
  - Result of convolution is a direct runoff hydrograph.

Contributing Area Histogram

Area between
travel time intervals



Watershed Map

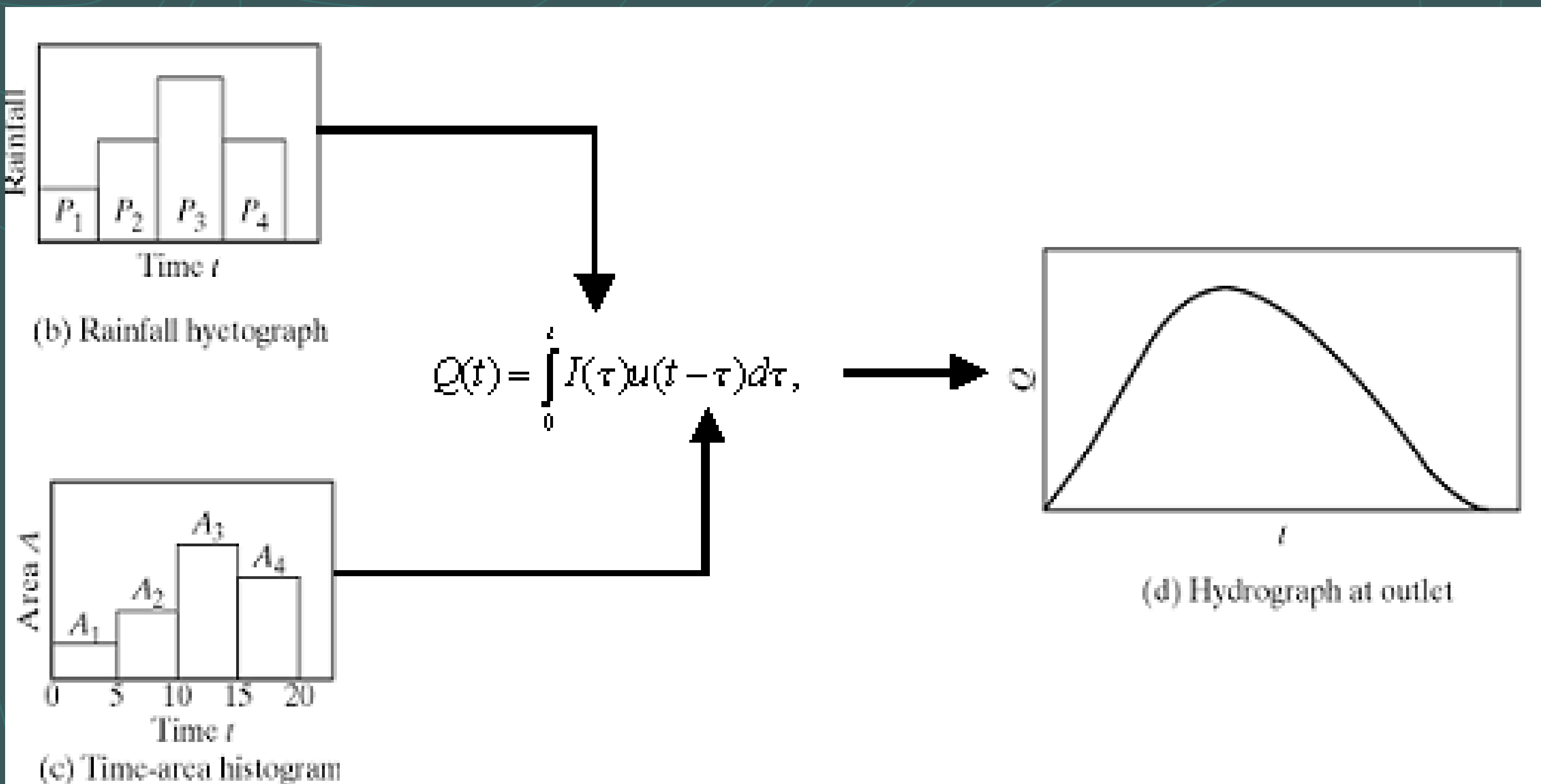


(c) Time-area histogram

Plot is the time-area histogram

Synthetic Unit Graph

- Convolve the Precipitation and Time-Area Histogram

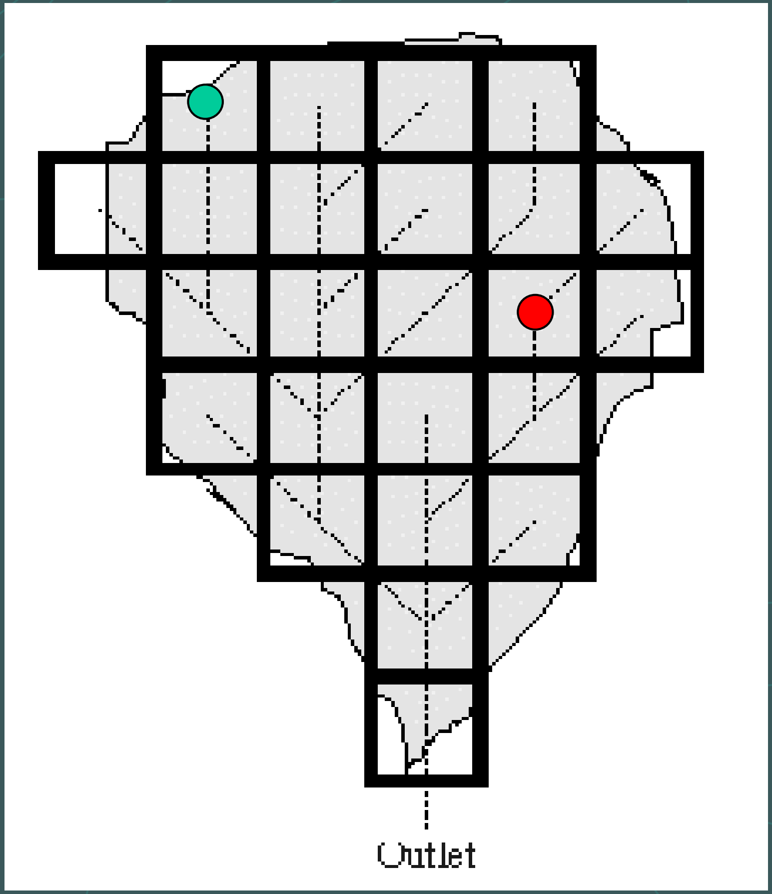


Determining the Time-Area Diagram

- One needs to have a good idea of the path (trajectory) a water particle will follow.
- One needs to know how fast (velocity) the particle will move at different points along that path.

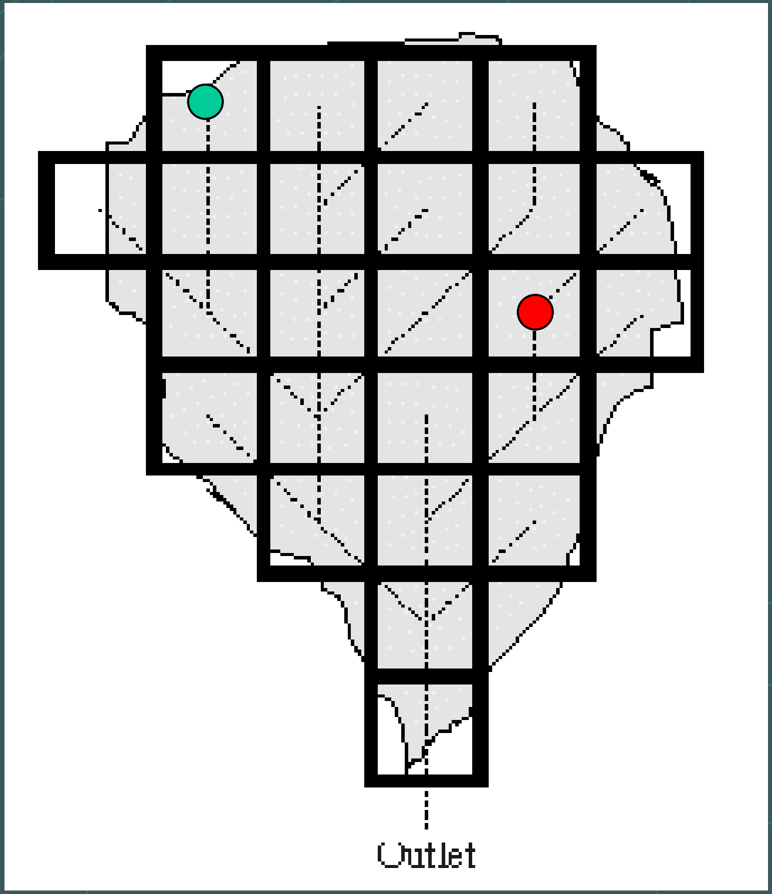
Determining the Time-Area Diagram

- Instead of focusing on large distances and areas, we divide the watershed into small areas and distances.
- Notice the fundamental difference in the subdivision as compared to the classical isochrone division.



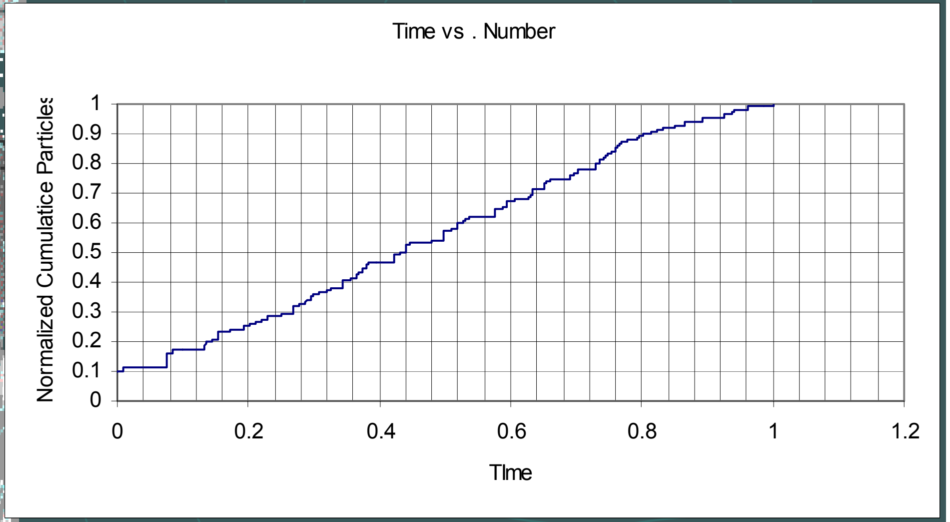
Determining the Time-Area Diagram

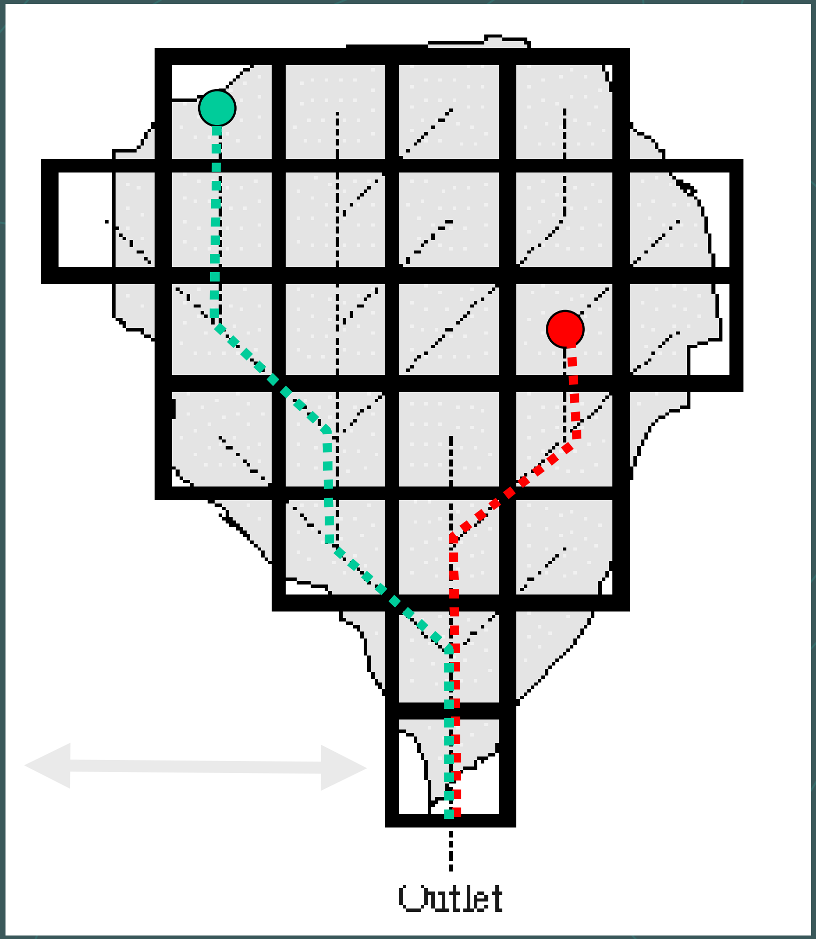
- Place "particles" in each subdivision.
- Specify particle kinematics (how the particles will move).
- Allow the particles to move following the kinematics equations.



Determining the Time-Area Diagram

- Track particles over time.
  - Recover path lines (if we are interested)
- Accumulate arrival times at the outlet.
  - Time series of cumulative arrivals (normalize by total particle arrivals)





Particle Kinematics

- Trajectory equations:

$$\frac{dx_p}{dt} = u_p(x_p(t), y_p(t), t)$$
$$\frac{dy_p}{dt} = v_p(x_p(t), y_p(t), t)$$

- Euler-difference form (how we actually calculate):

$$x_p(t+\Delta t) = x_p(t) + u_p(x_p(t), y_p(t), t)\Delta t$$
$$y_p(t+\Delta t) = y_p(t) + v_p(x_p(t), y_p(t), t)\Delta t$$

Velocity Models

- Like other methods, the difficulty in specifying velocity field.
  - Flow Potential: Velocity is proportional to some potential.
  - Newtonian mechanics: Momentum equation for each particle.
- Models (pathline coordinates)
  - Linear

$$u(\xi) = k * \left.\frac{dz}{d\xi}\right|_{(\xi)}$$

Quadratic

$$u(\xi) \cdot |u(\xi)| = k^2 * \left.\frac{dz}{d\xi}\right|_{(\xi)}$$

  - Newtonian (concept)

$$m\frac{du_p}{dt} = -mg * \frac{dz}{dx} - mk^2 u(x,y) \bullet |u(x,y)| - d_f\left(\frac{dp}{dx}\right)$$

Unit Velocity Coefficient

- The "*k*" term represents velocity magnitude at unit slope (1:1) and this term should be different with surface type, etc.
- In the quadratic model, we choose a Manning's type structure for *k*.

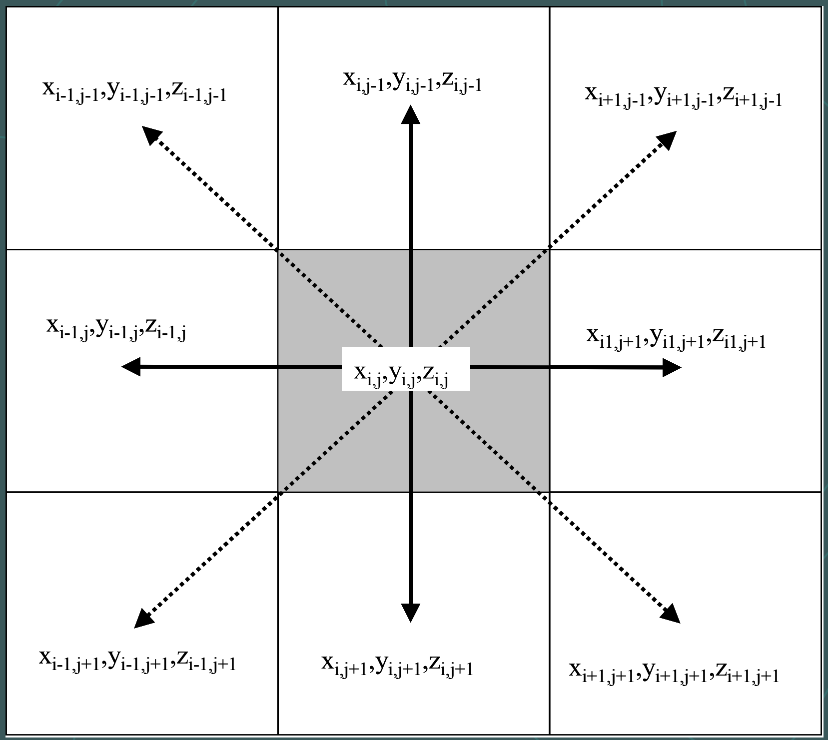
$$k^2 = \left(\frac{1.5}{n} d^{\frac{2}{3}}\right)^2$$

$$u(\xi) = \frac{1.5}{n} d^{\frac{2}{3}} \left(\left.\frac{dz}{d\xi}\right|_{(\xi)}\right)^{\frac{1}{2}}$$

- Key point is that the localized watershed slope conveys the drainage information.

Direction and Slope

- 8-cell pour-point-model.
  - 8 elevation differences.
  - Largest “downhill” difference is local direction.
  - Slope is ratio of difference in elevation and distance to adjacent cell center in local direction.
  - Velocity from path-line equation.



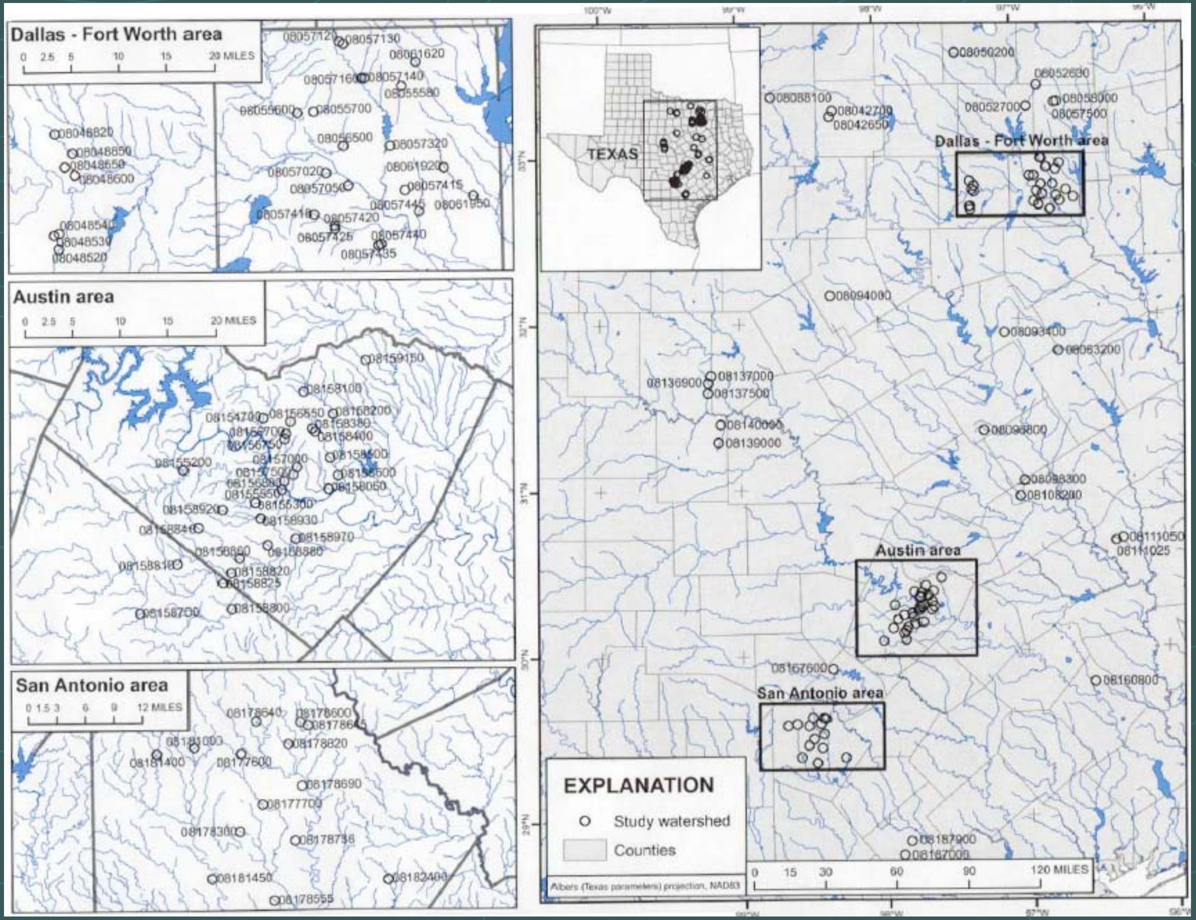
Watershed Elevation Maps

- Require information about the spatial distribution of watershed elevation.
  - Manually from USGS topographical (paper) maps
  - engineering survey
  - USGS digital elevation maps.
- The representation is a grid whose horizontal and vertical positions represent locations on the surface of the Earth, and whose values represent elevation above some datum.
- The numerical experiments presented below are all based on USGS 30-meter DEM maps downloaded from the Internet.

Study Area

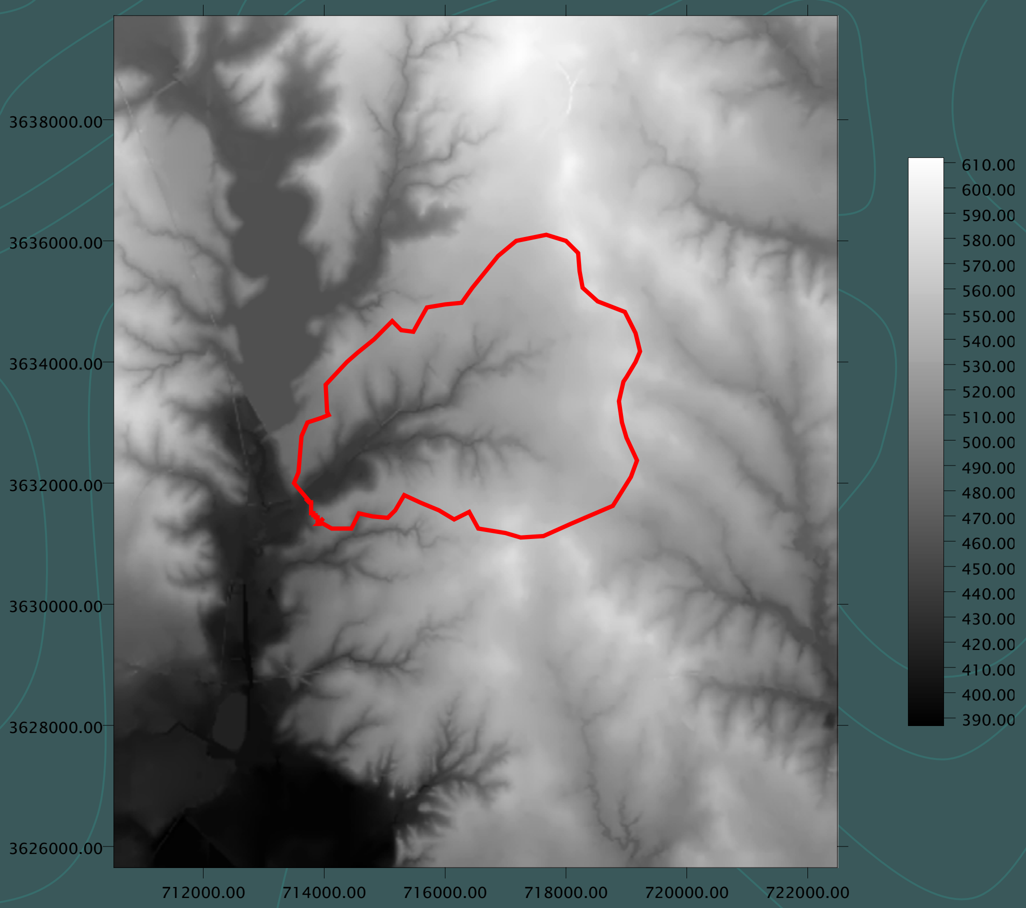
Same as before.

- Digital Elevation Maps
- Digital Raster Graphics



Preparing the Model

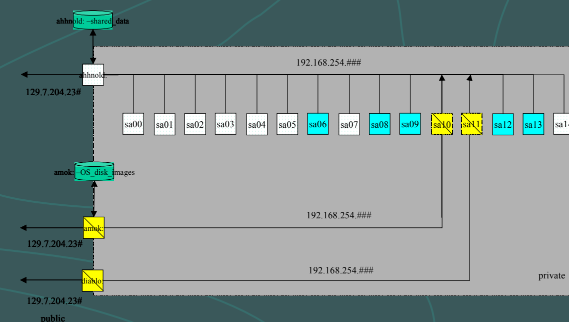
- Locate the watershed.
- Manually or automatically delineate the watershed boundary.
- Prepare a DEM for the area
- Locate the watershed on the DEM, and extract the elevations.
- This elevation array is input the a particle tracking code.



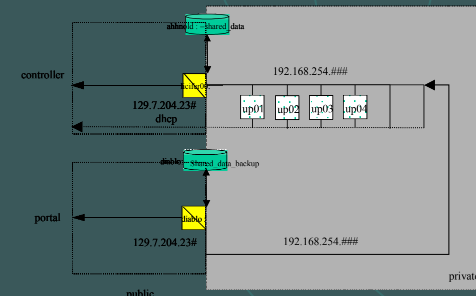
Ash Creek Sta08057320

Tracking the Particles

- Large computational burden – each particle must be followed from beginning to outlet and displacements and elapsed time recorded.
- Paths are independent in potential based models (one particle at a time).
- Paths are interdependent in Newtonian model (all particles at once).



NASDC Cluster (16 CPUs)



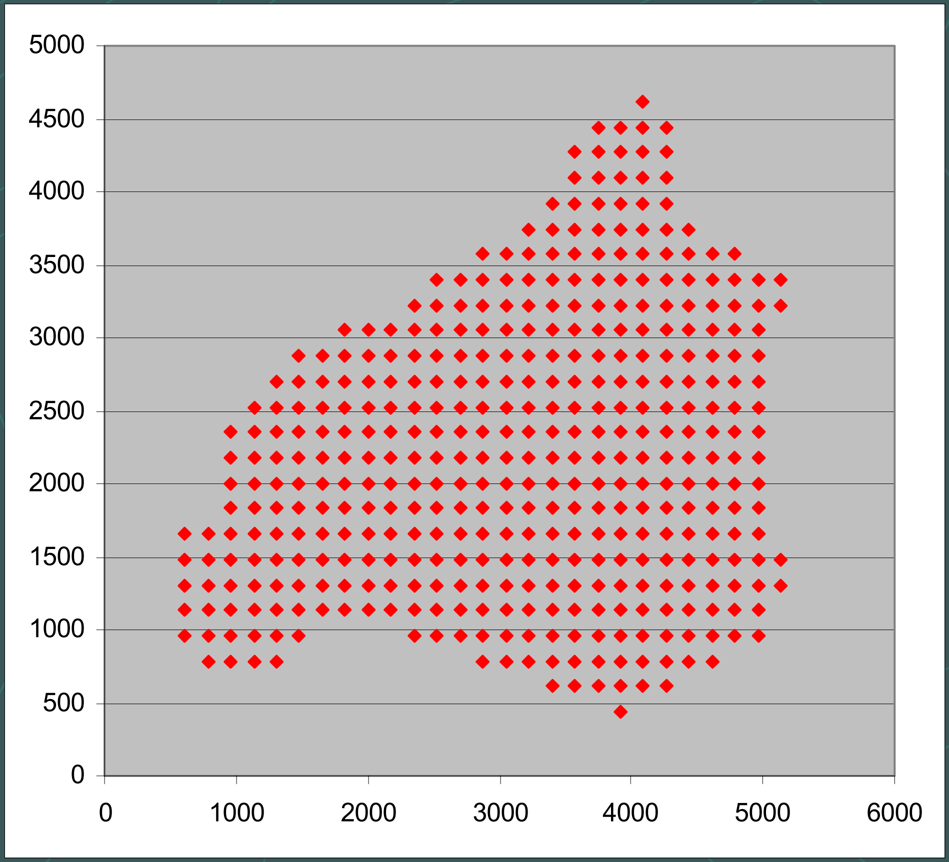
S2PC Cluster (8 CPUs)

Share an NFS mount over public internet to have 24 CPUs all operating on the same data.

NASDC/S2PC cluster

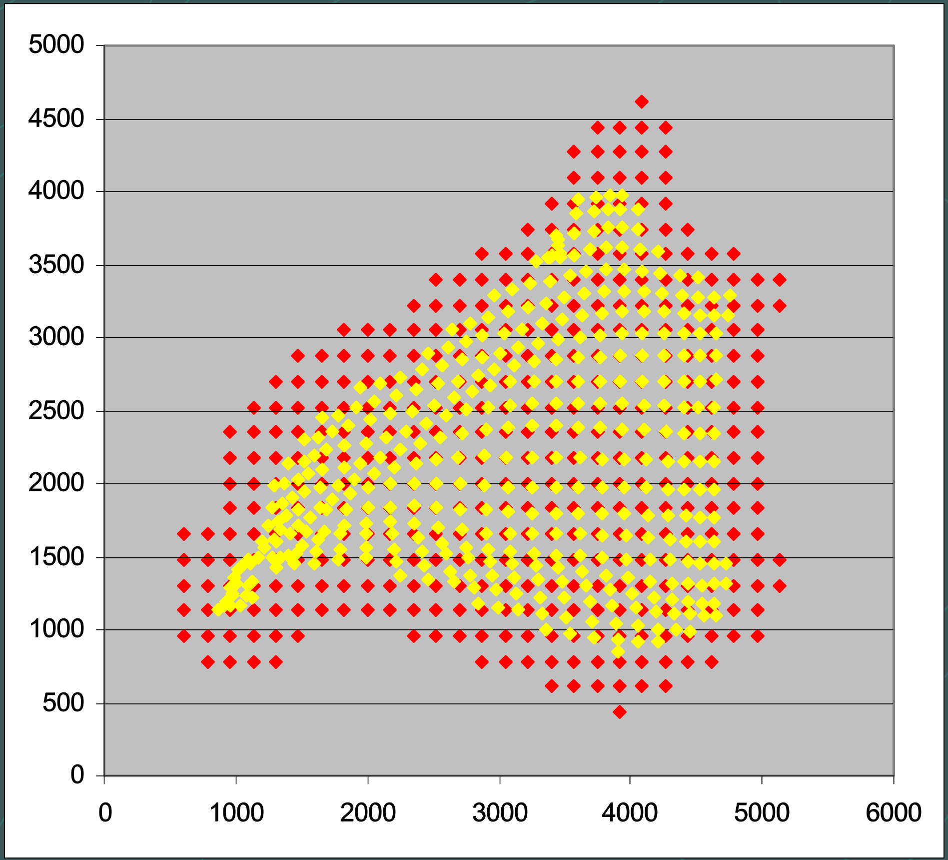
Numerical Experiments

- Initial Particle Array for Ash Creek
- Particles are placed uniformly over watershed.
- Coarse grid
  - 150 meter resolution



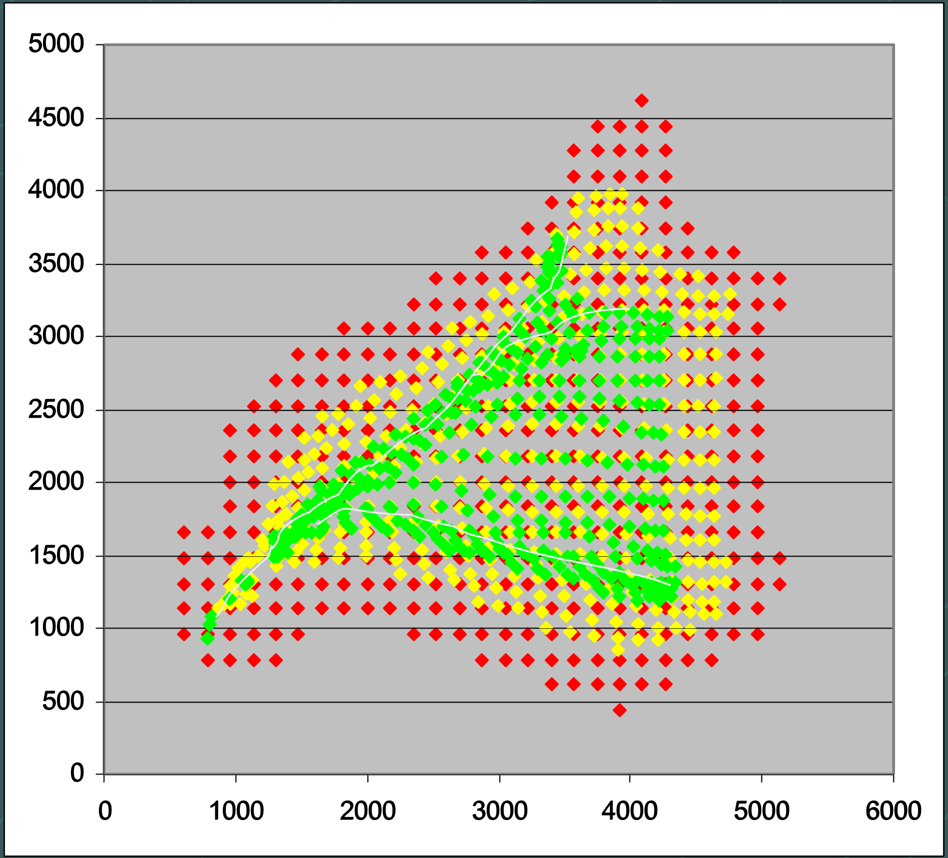
Running the Model

- Particle Array at 5 minutes simulation time (Yellow)
- Particles are concentrating towards lower elevations.



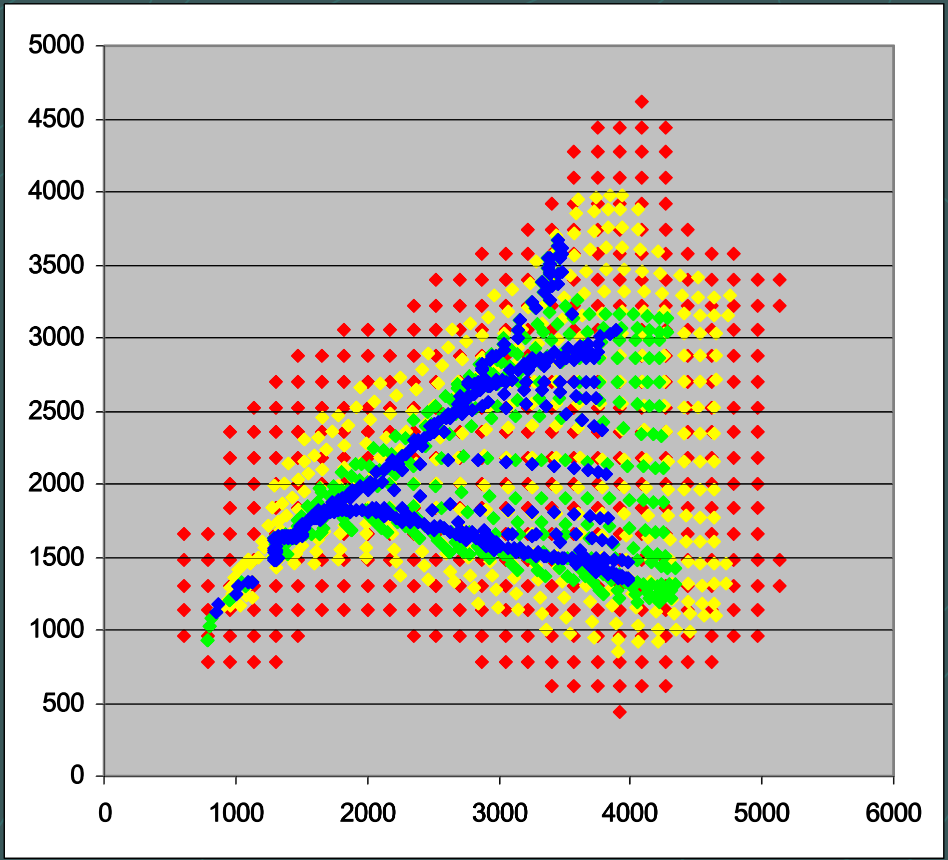
Running the Model

- Particle Array at 15 minutes simulation time (Green)
- Particles are concentrating toward lower elevations.
- Tributaries apparent.



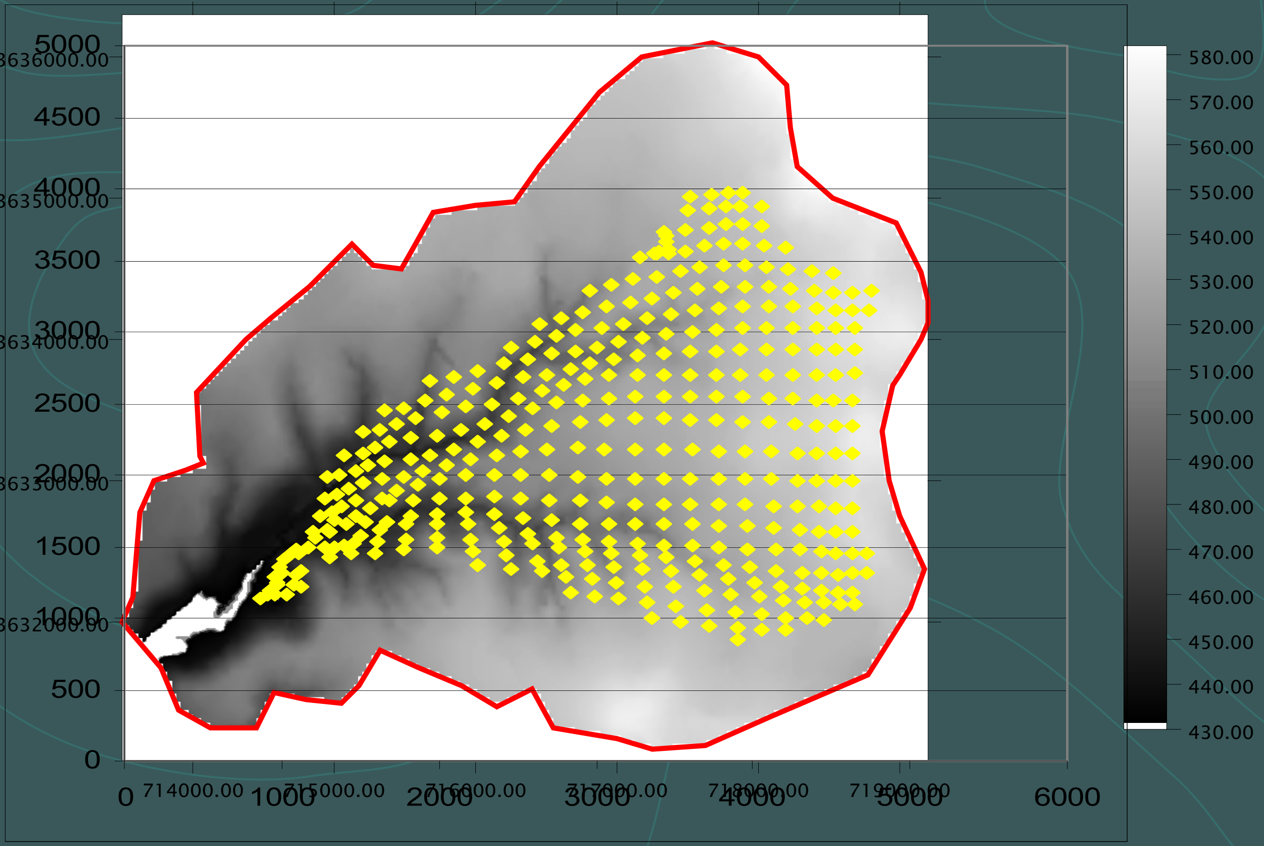
Running the Model

- Particle Array at 30 minutes simulation time (Blue)
- Particles are concentrating toward lower elevations.
- Tributaries more apparent.



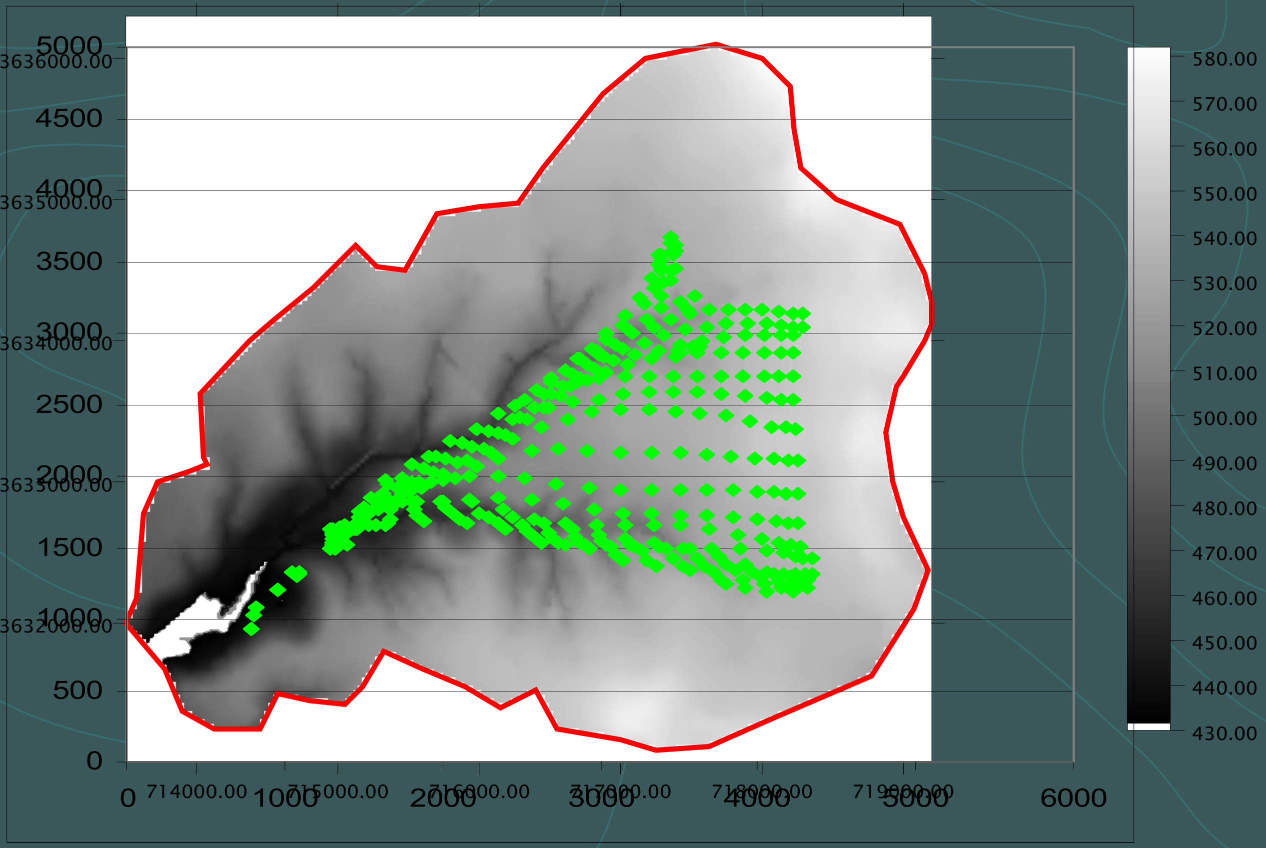
Running the Model

- 5 minutes (Maps are at different resolutions)



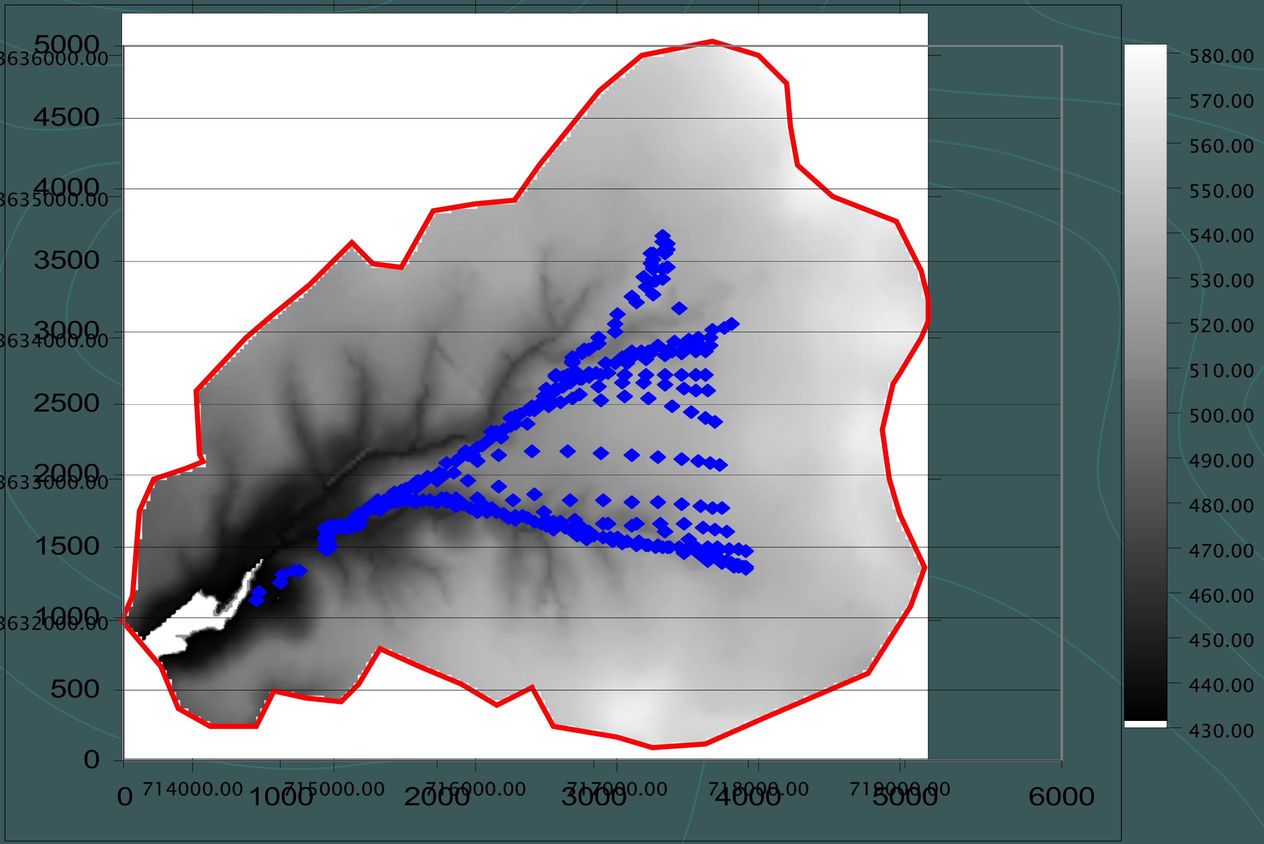
Running the Model

- 15 minutes

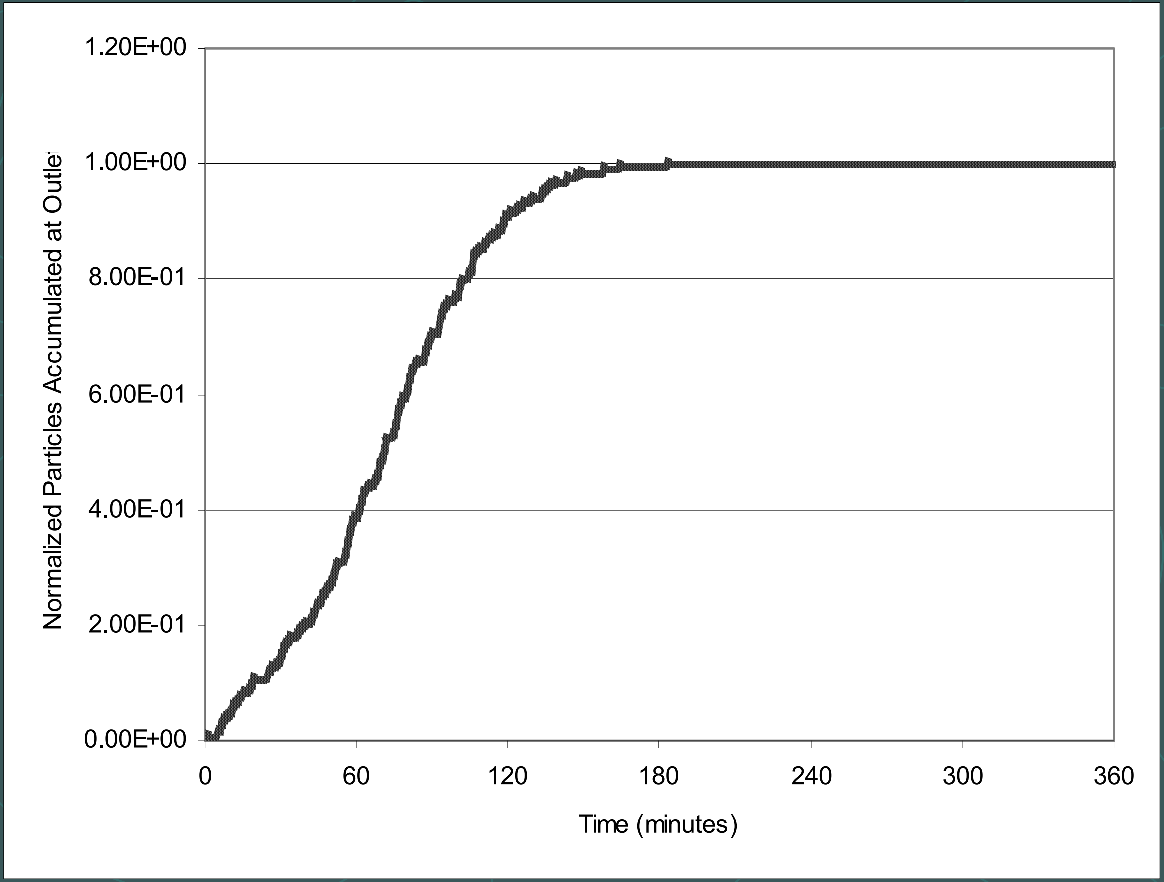


Running the Model

- 30 minutes

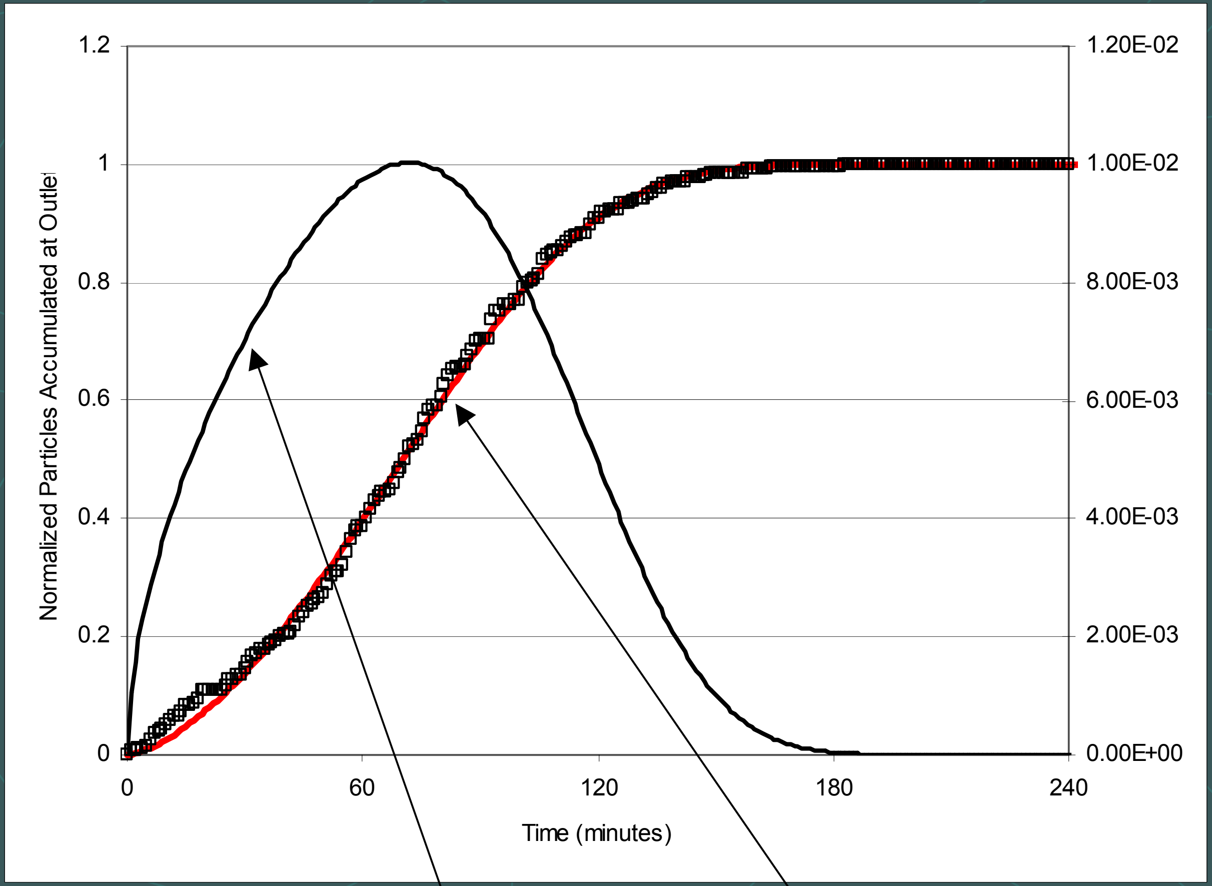


Empirical Cumulative IUH



- Conceptually this is a time-area histogram.

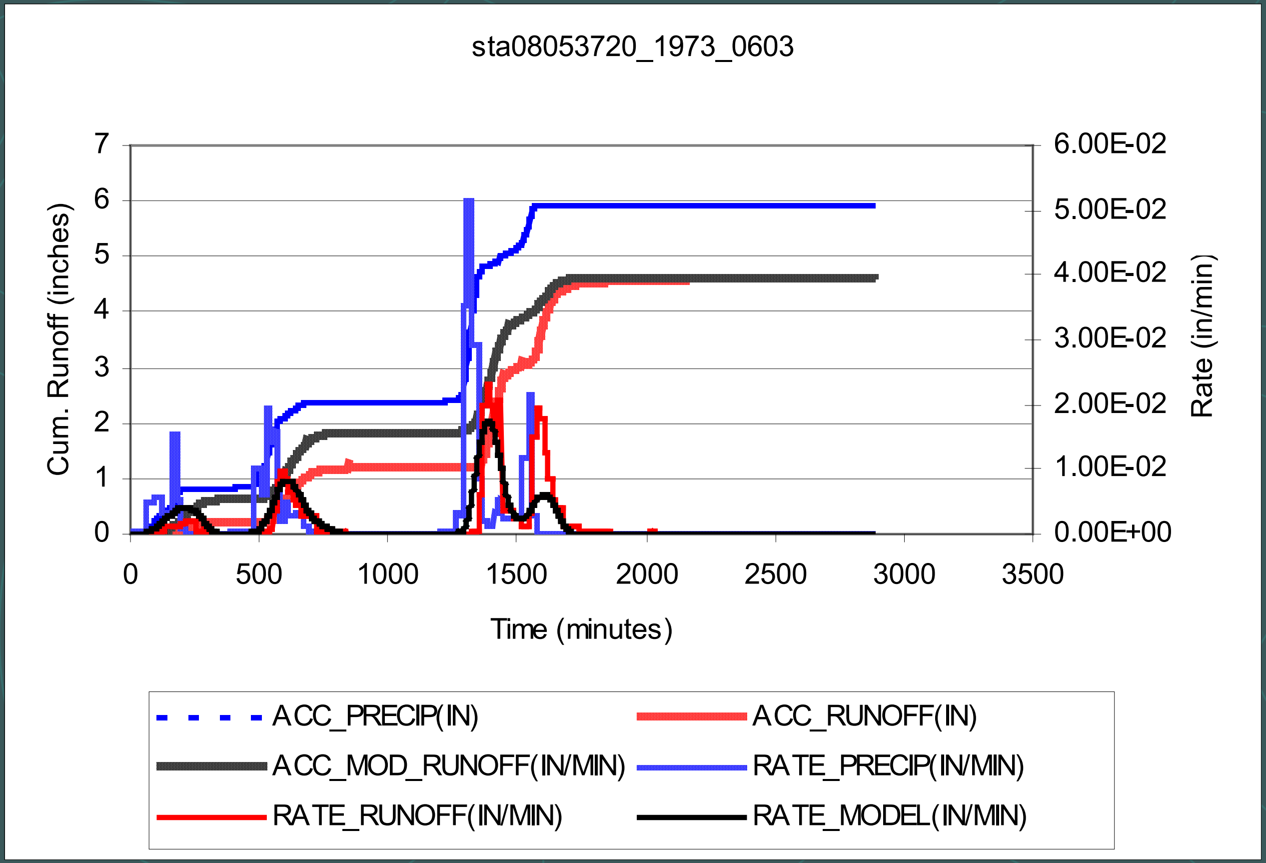
Curvilinear IUH



$$q(t) = 2z_0\left(\frac{t^{2N-1}}{\bar{t}^{2N-1}}\right)\exp(-\left(\frac{t}{\bar{t}}\right)^2); \quad Q(t) = \int_0^t q(\tau)d\tau$$

- Fit an IUH function to the Empirical IUH

SUH Performance

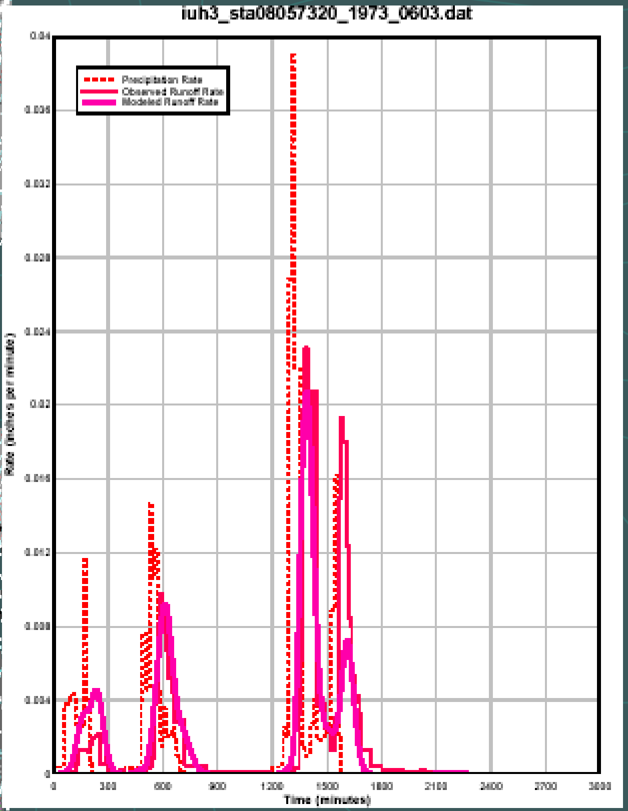


- Recover parameter values for the curvilinear IUH and use this as the SUH for modeling runoff using actual precipitation

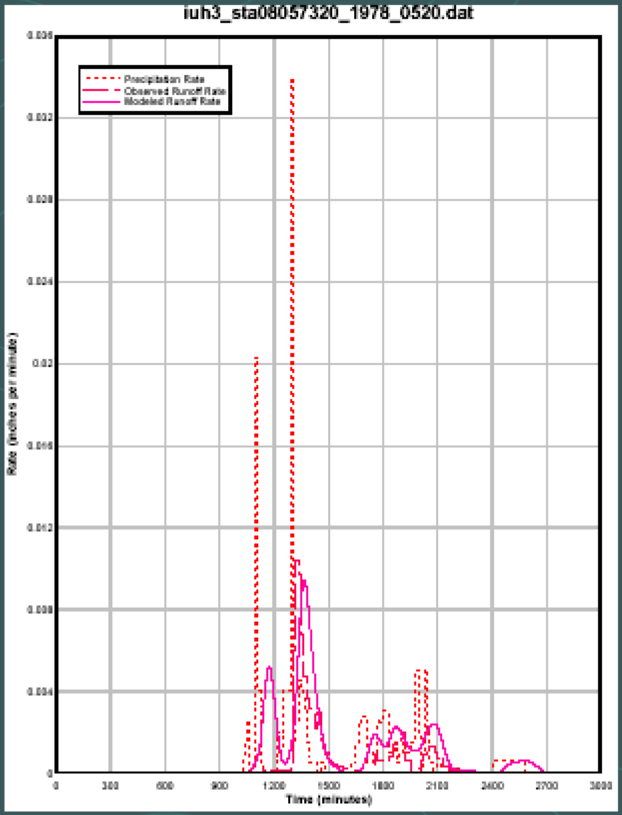
Sample Results

- Entire database has been modeled once using k =0.04 d=0.2.
  - These numerical values are from a trial-and-error calibration to a single storm on the Ash Creek watershed.
- Entire set of storms (1600+) is recreated on the 90 watersheds using the runoff coefficients from the statistical analysis.

Ash Creek



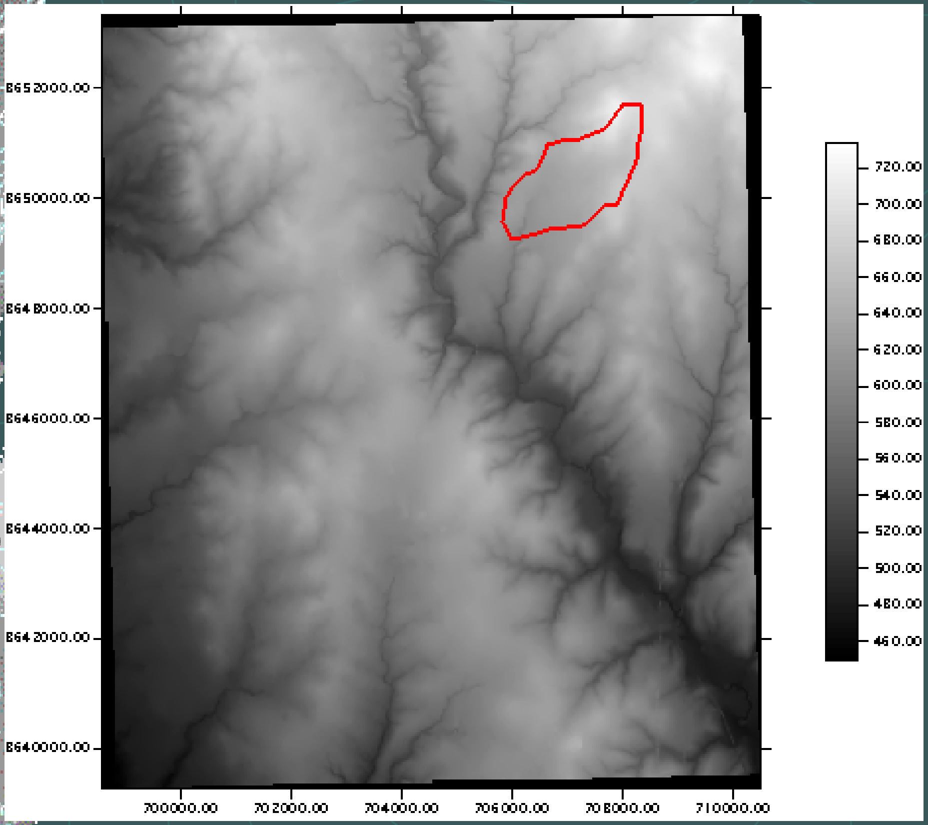
Storm 1



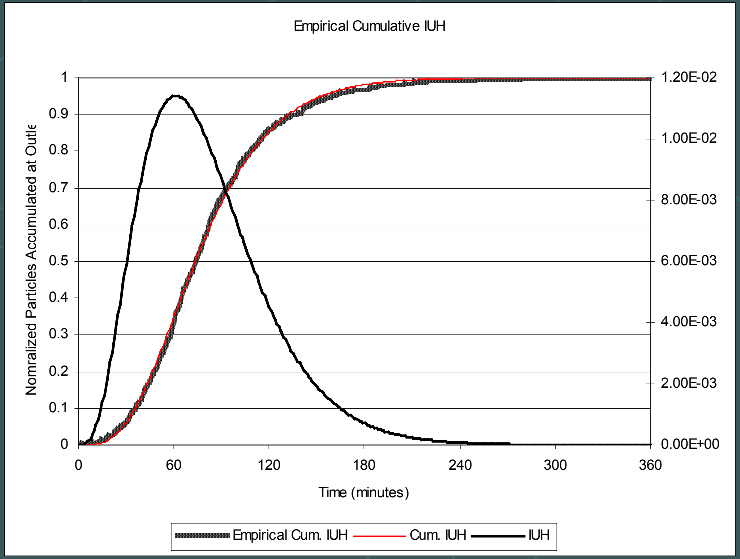
Storm 2

- Dallas Module, 6.92 square miles

Rush Branch



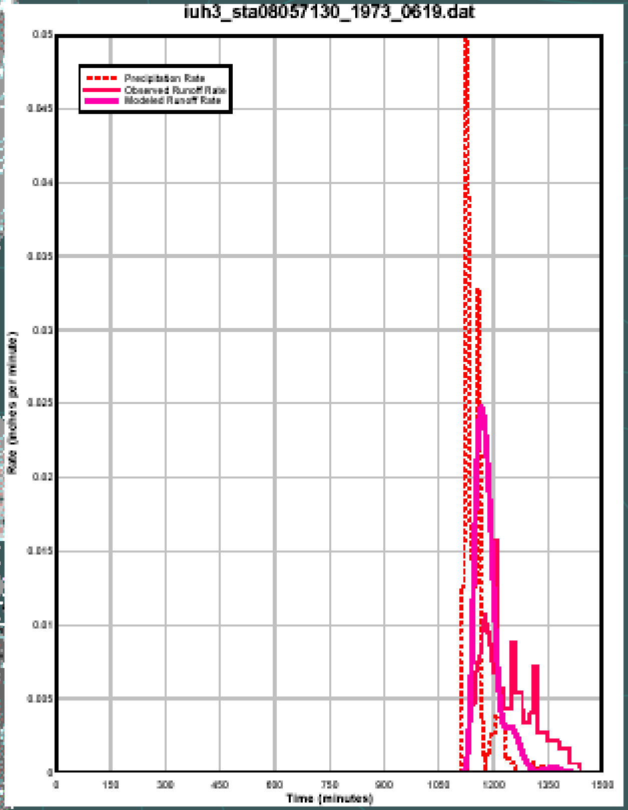
DEM rendering



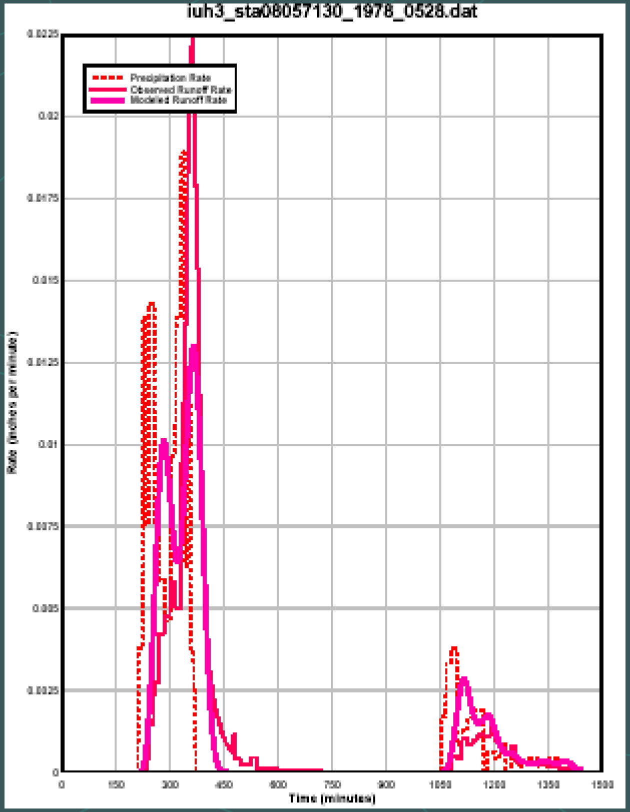
IUH from PT model

- Dallas Module, 1.22 square miles.

Rush Branch



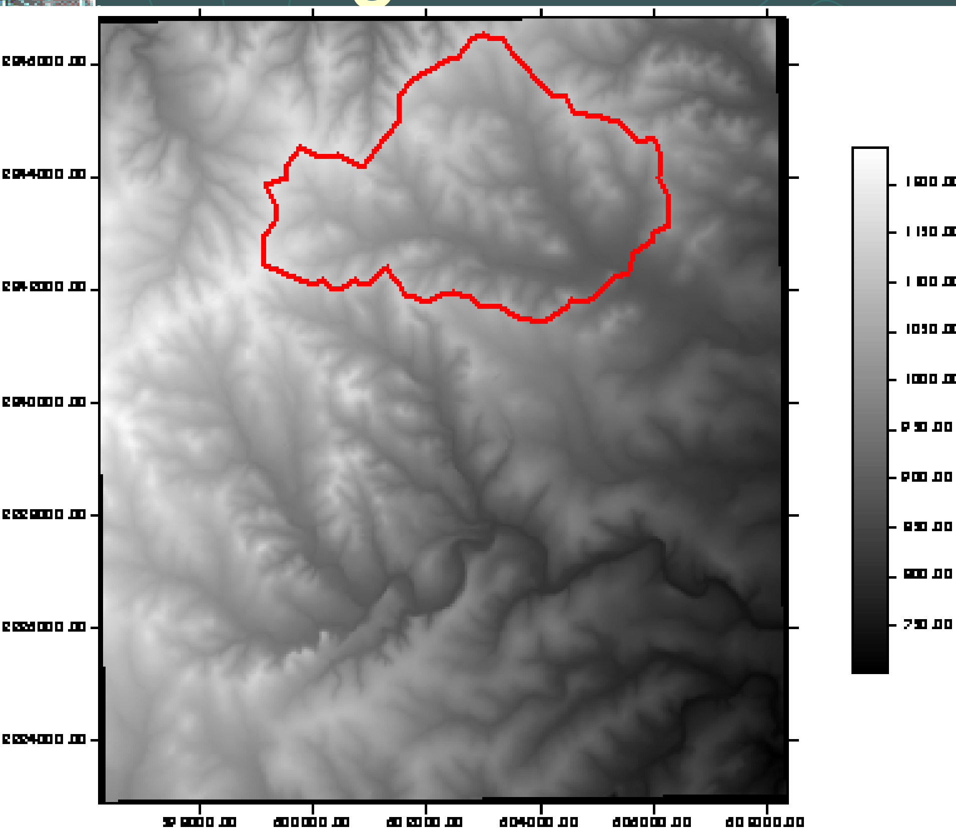
Storm 1



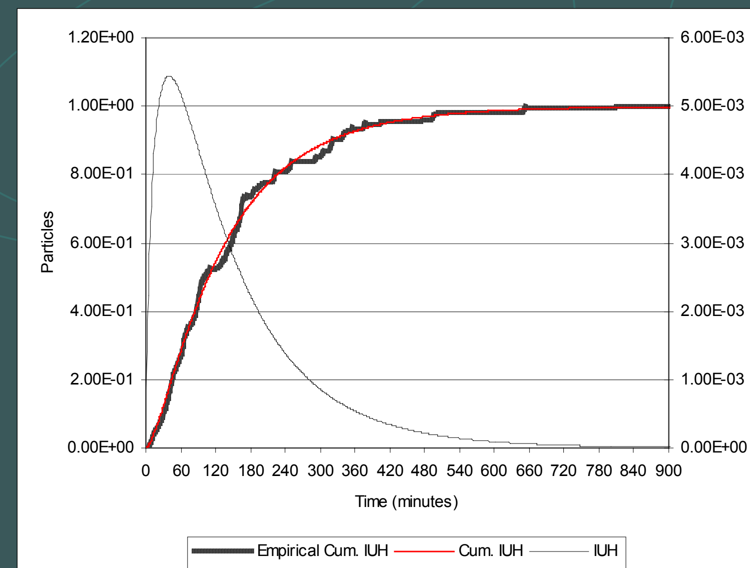
Storm 2

- Dallas Module, 1.22 square miles.

Slaughter Creek



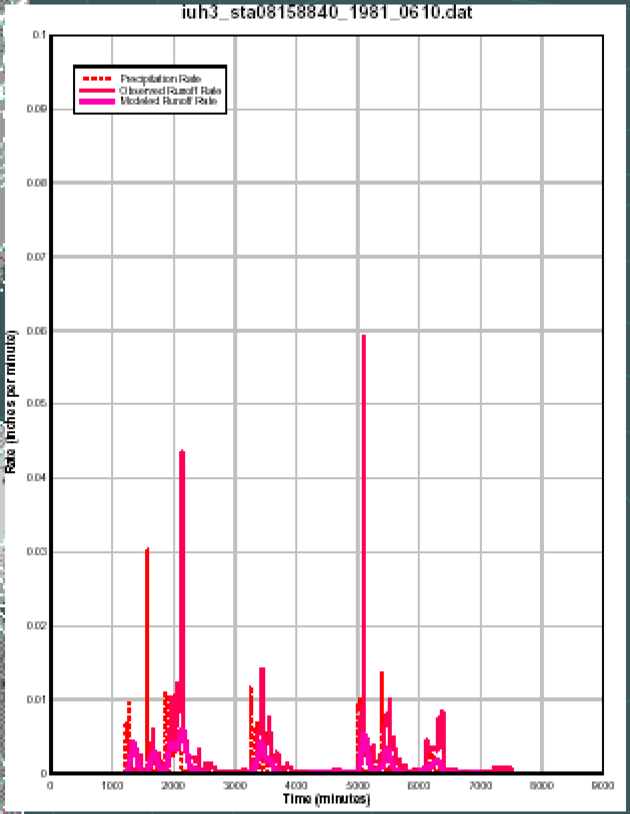
DEM Rendering



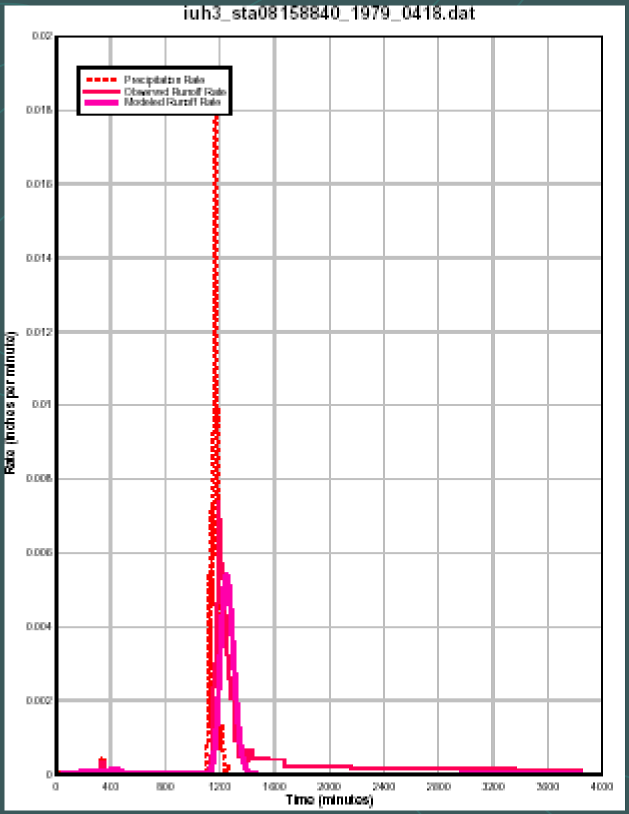
IUH from PT Model

- Austin Module, 8.24 square miles

Slaughter Creek



Storm 1



Storm 2

- Austin Module, 8.24 square miles

Austin Module

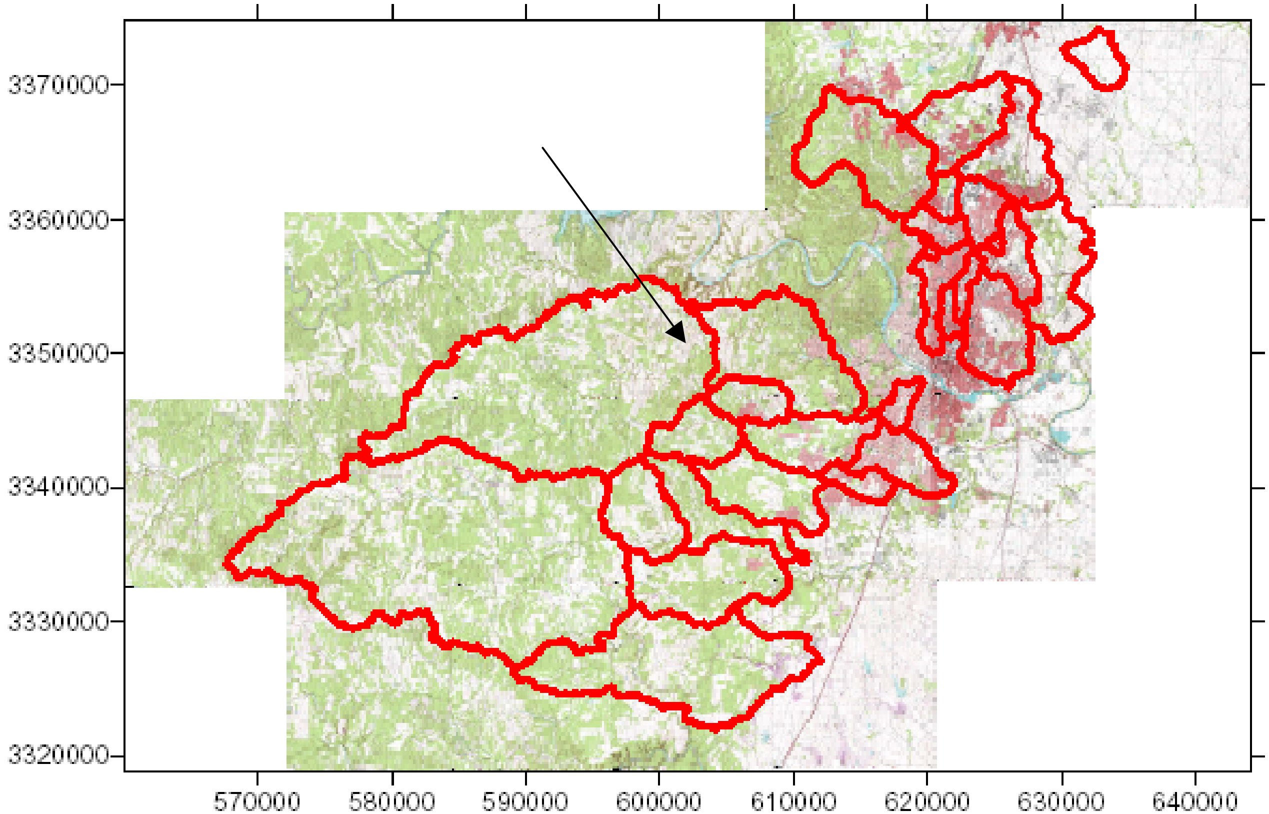


Figure 1. Map of the 29 study watersheds in the Austin module overlain in a mosaic of digital raster graphics (DRG) maps derived from U.S.G.S. 1:24000 series topographic quadrangle maps. Horizontal and vertical scales are meters Easting and Northing in UTM coordinates.

Austin Module

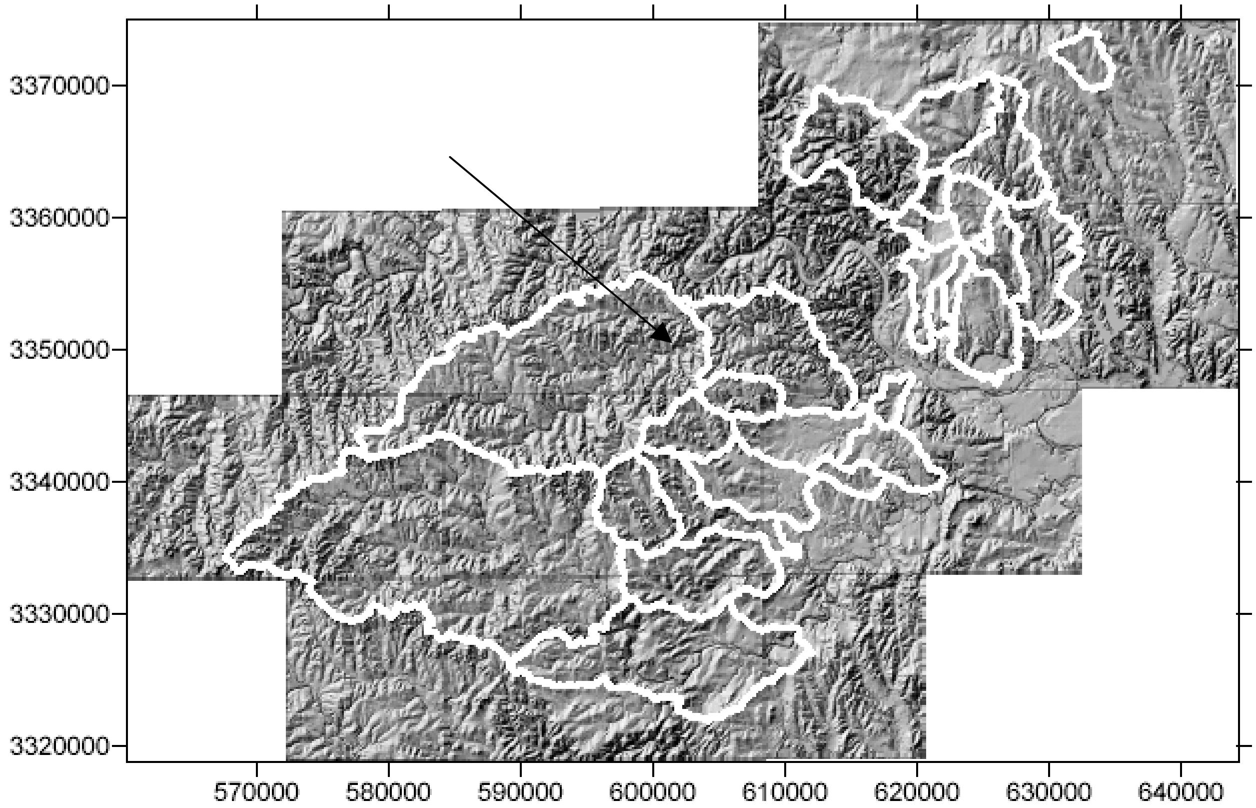
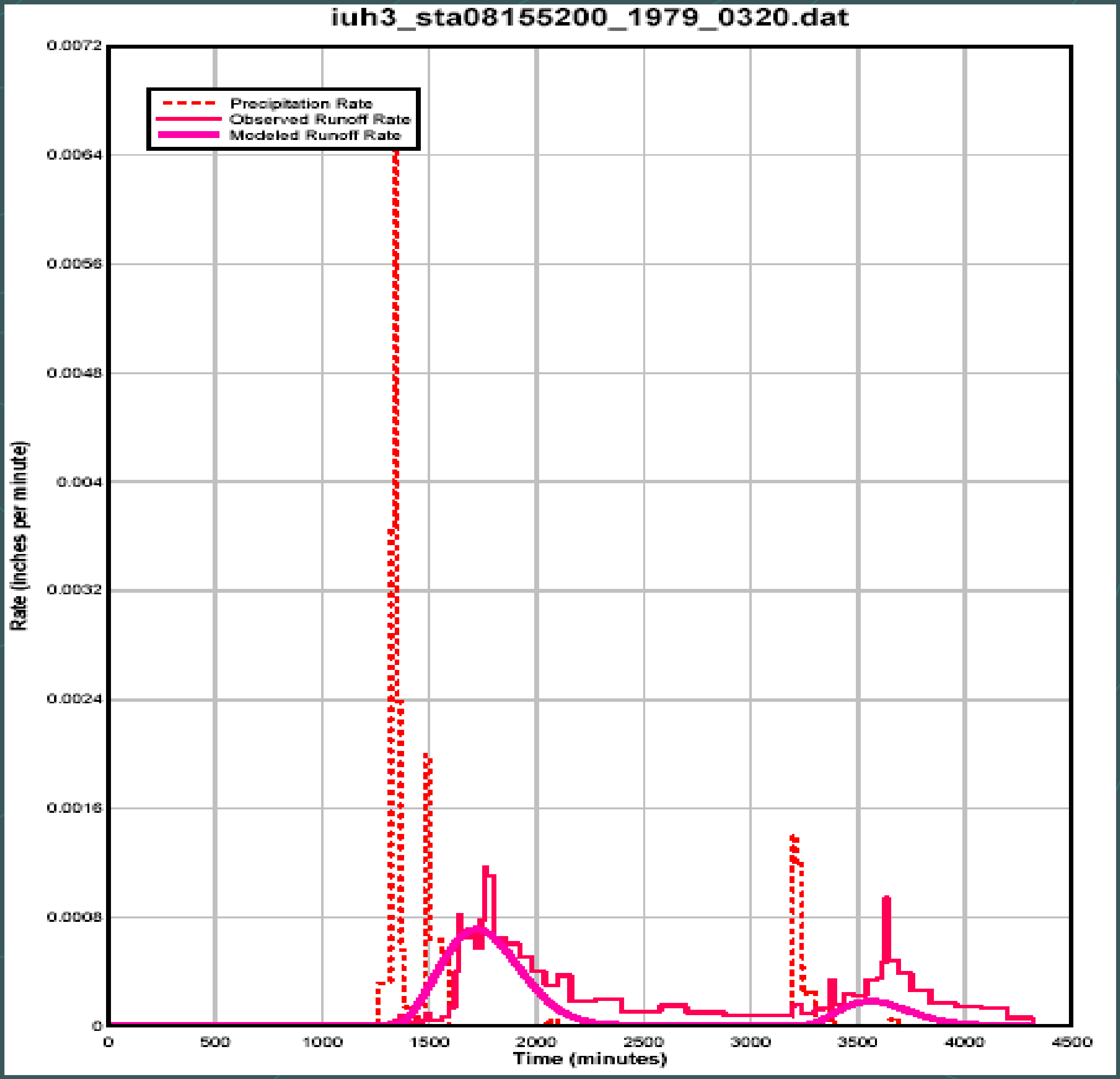


Figure 2. Map of the 29 study watersheds in the Austin module overlain on a shaded relief mosaic derived from U.S.G.S. 30-meter digital elevation maps (DEM). Horizontal and vertical scales are meters Easting and Northing in UTM coordinates.

Barton Creek

- Austin Module
  - ~ 89 sq.mi.



Dallas Module

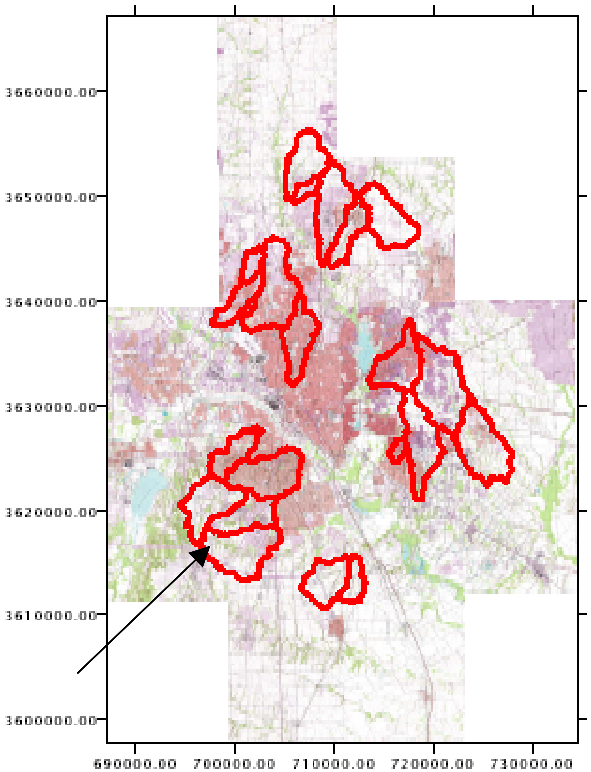


Figure 1. Map of the 21 study watersheds in the Dallas module overlain on a mosaic of digital raster graphics (DRG) maps derived from U.S.G.S 1:24000 series topographic quadrangle maps. Horizontal and vertical scales are meters Easting and Northing in UTM coordinates.

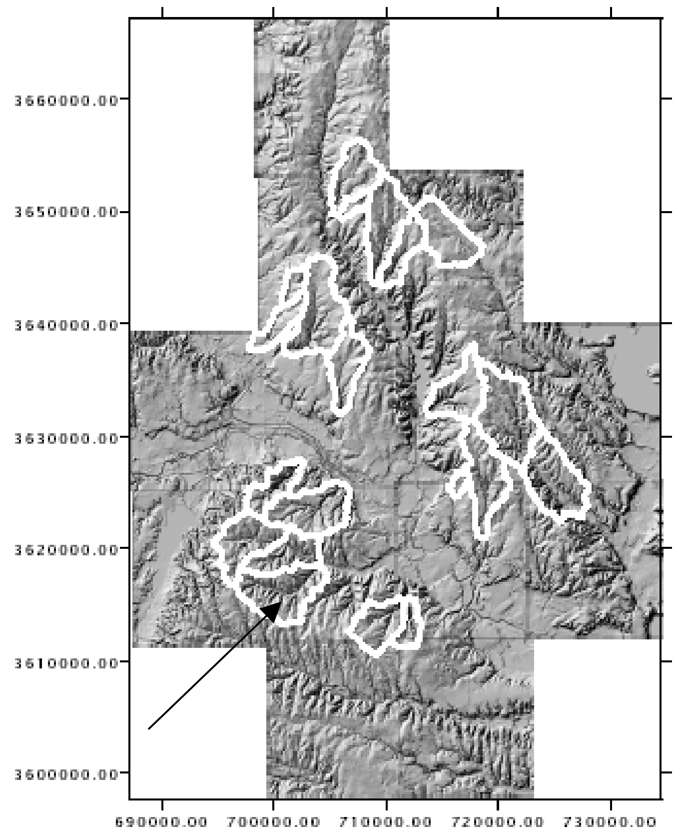
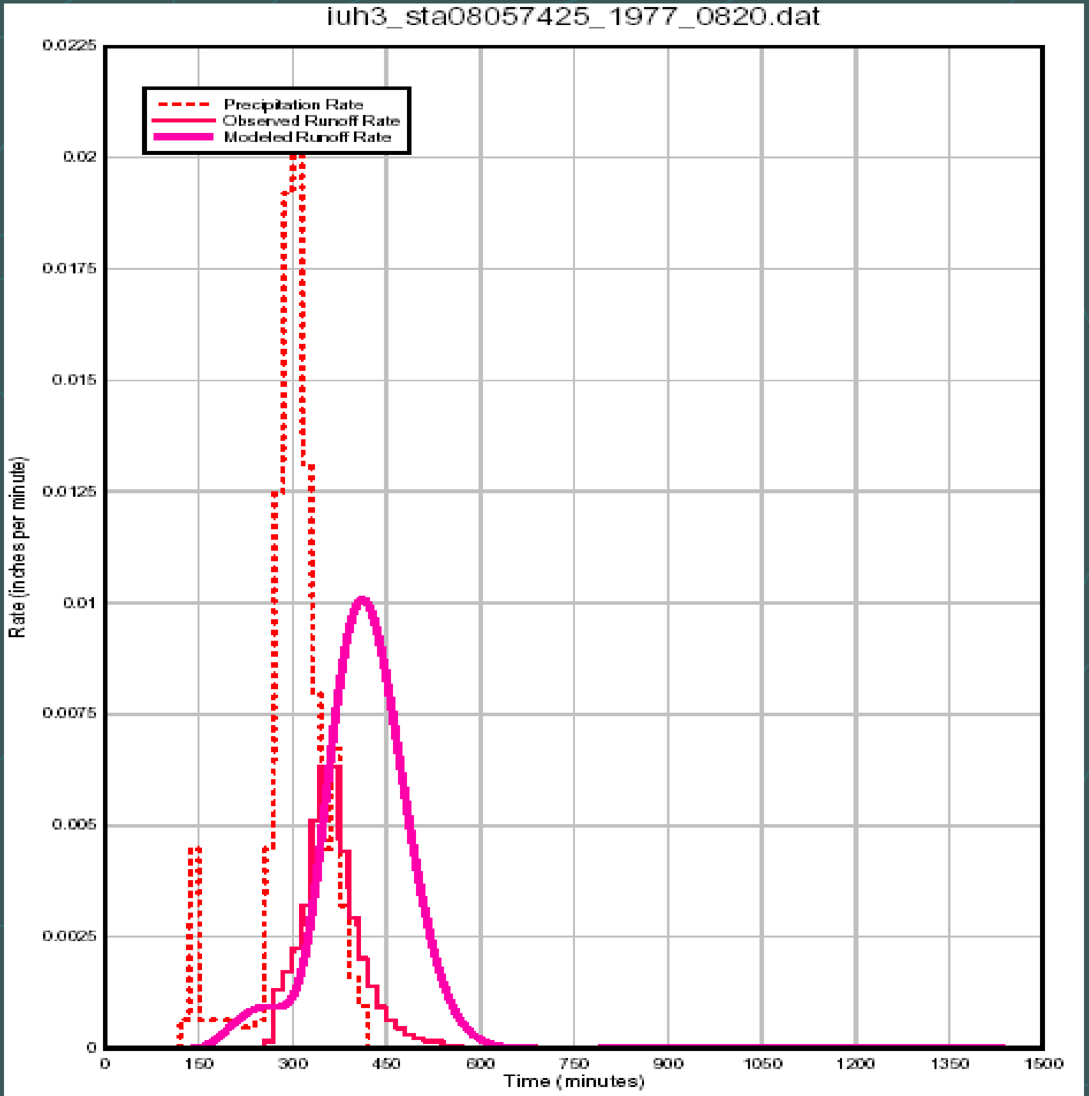


Figure 2. Map of the 21 study watersheds in the Dallas module overlain on a shaded relief mosaic derived from U.S.G.S. 30-meter digital elevation maps (DEM). Horizontal and vertical scales are meters Easting and Northing in UTM coordinates.

Woody Branch

- Dallas Module
  - ~11 sq.mi.



Fort Worth Module

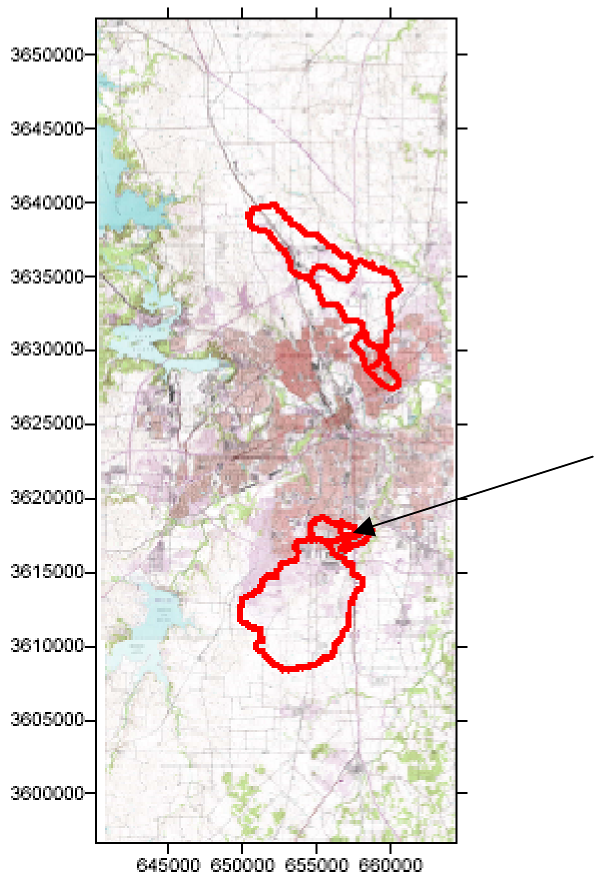


Figure 1. Map of the 8 study watersheds in the Fort Worth Module overlain on a mosaic of digital raster graphics (DRG) maps derived from U.S.G.S. 1:24000 series topographic quadrangle maps. Horizontal and vertical scales are meters Easting and Northing in UTM coordinates.

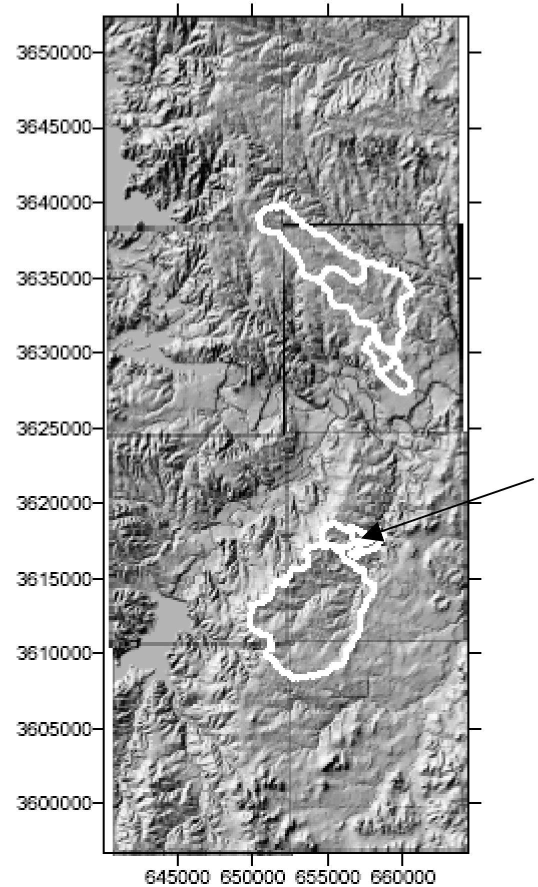
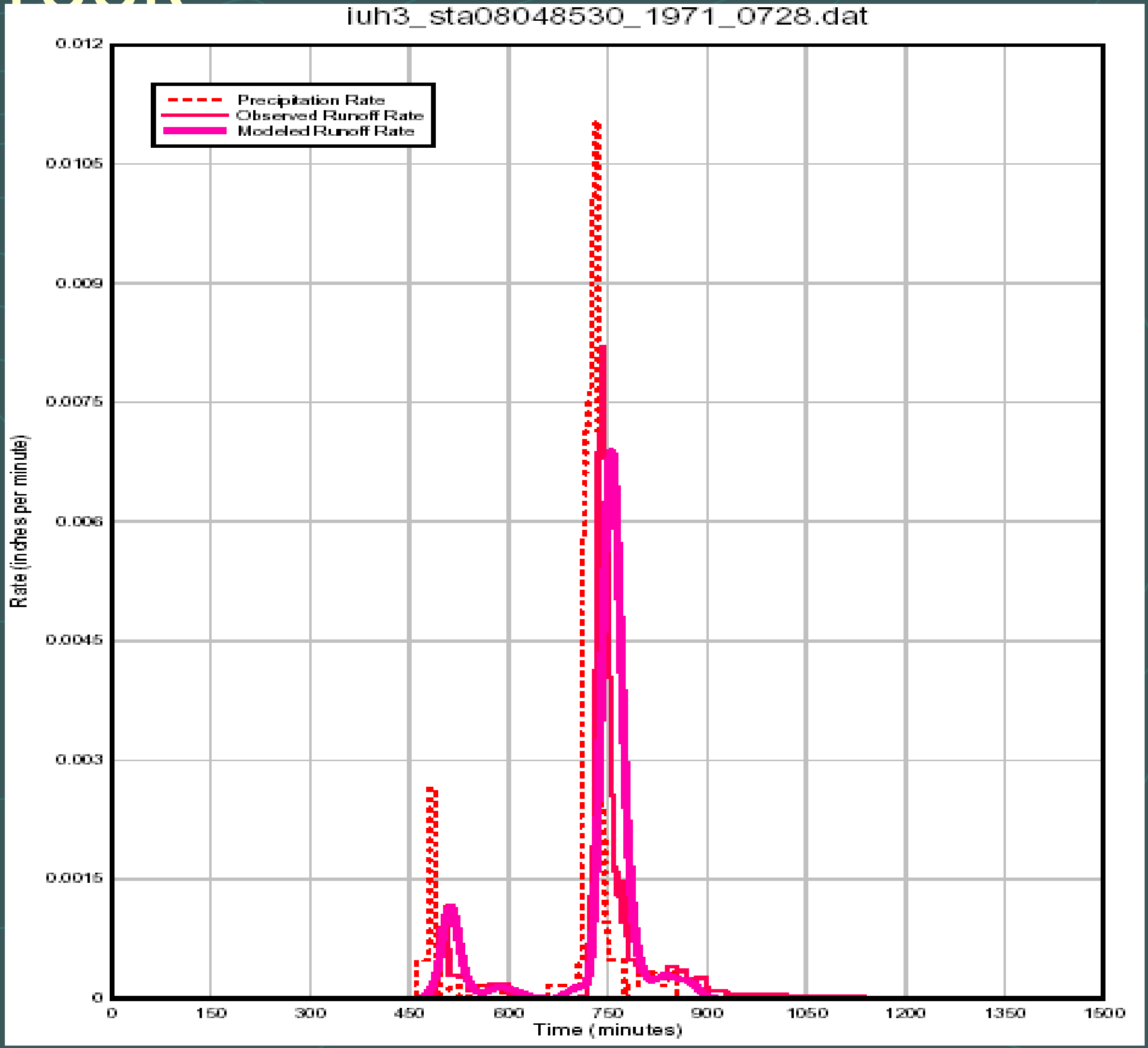


Figure 2. Map of the 8 study watersheds in the Fort Worth Module overlain on a mosaic of shaded relief maps derived from U.S.G.S. 30-meter digital elevation maps (DEM). Horizontal and vertical scales are meters Easting and Northing in UTM coordinates.

Sycamore Creek

- Fort Worth
  - ~ 1 sq. mi.



San Antonio Module

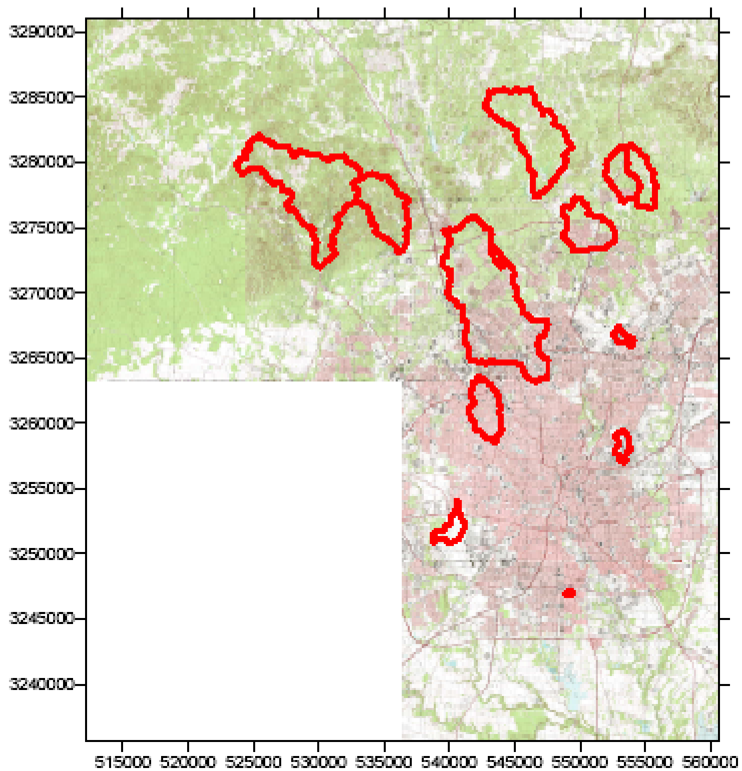


Figure 1. Map of the 13 study watersheds in the San Antonio Module overlain on a mosaic of digital raster graphics (DRG) maps derived from U.S.G.S. 1:24000 series topographic quadrangle maps. Horizontal and vertical scales are meters Easting and Northing in UTM coordinates.

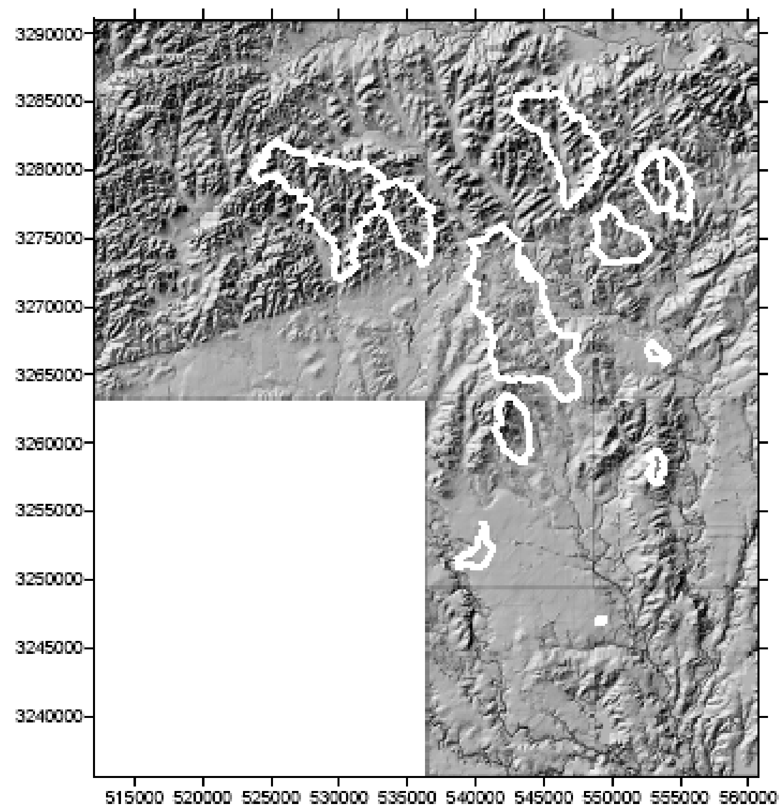


Figure 2. Map of the 13 study watersheds in the San Antonio module overlain on a shaded relief mosaic derived from U.S.G.S. 30-meter digital elevation maps (DEM). Horizontal and vertical scales are meters Easting and Northing in UTM coordinates.

Small Rural Module

- 10 maps to show all watersheds
  - Wide geographic distribution
  - Similar in appearance to the urban clusters

Colorado/Deep

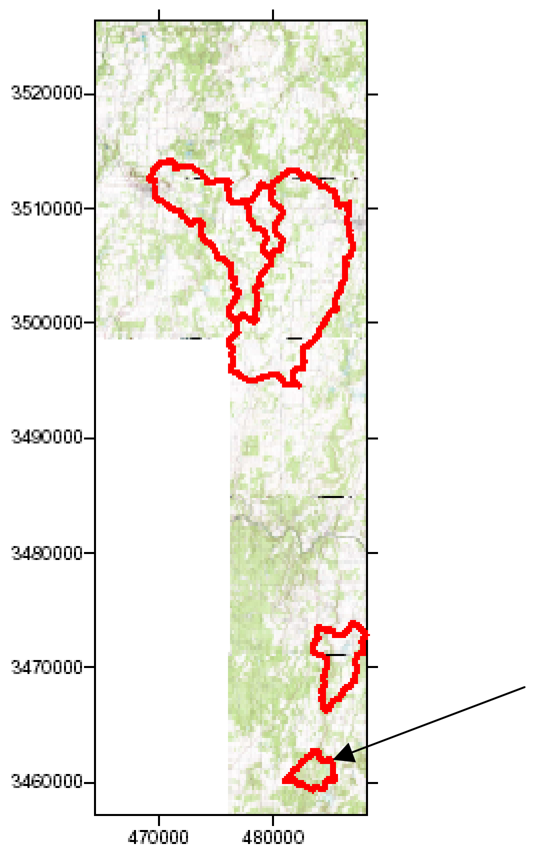


Figure 1. Map of 5 study watersheds in Small Rural (/colorado/deep&mukewater/) module overlain on a mosaic of digital raster graphics (DRG) maps derived from U.S.G.S. 1:24000 series topographic maps. Horizontal and vertical scales are meters Easting and Northing in UTM coordinates.

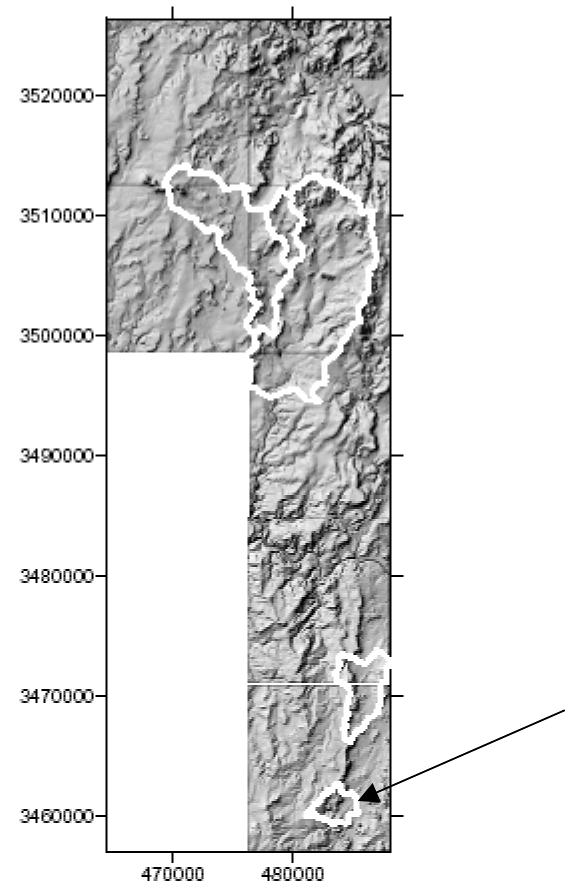
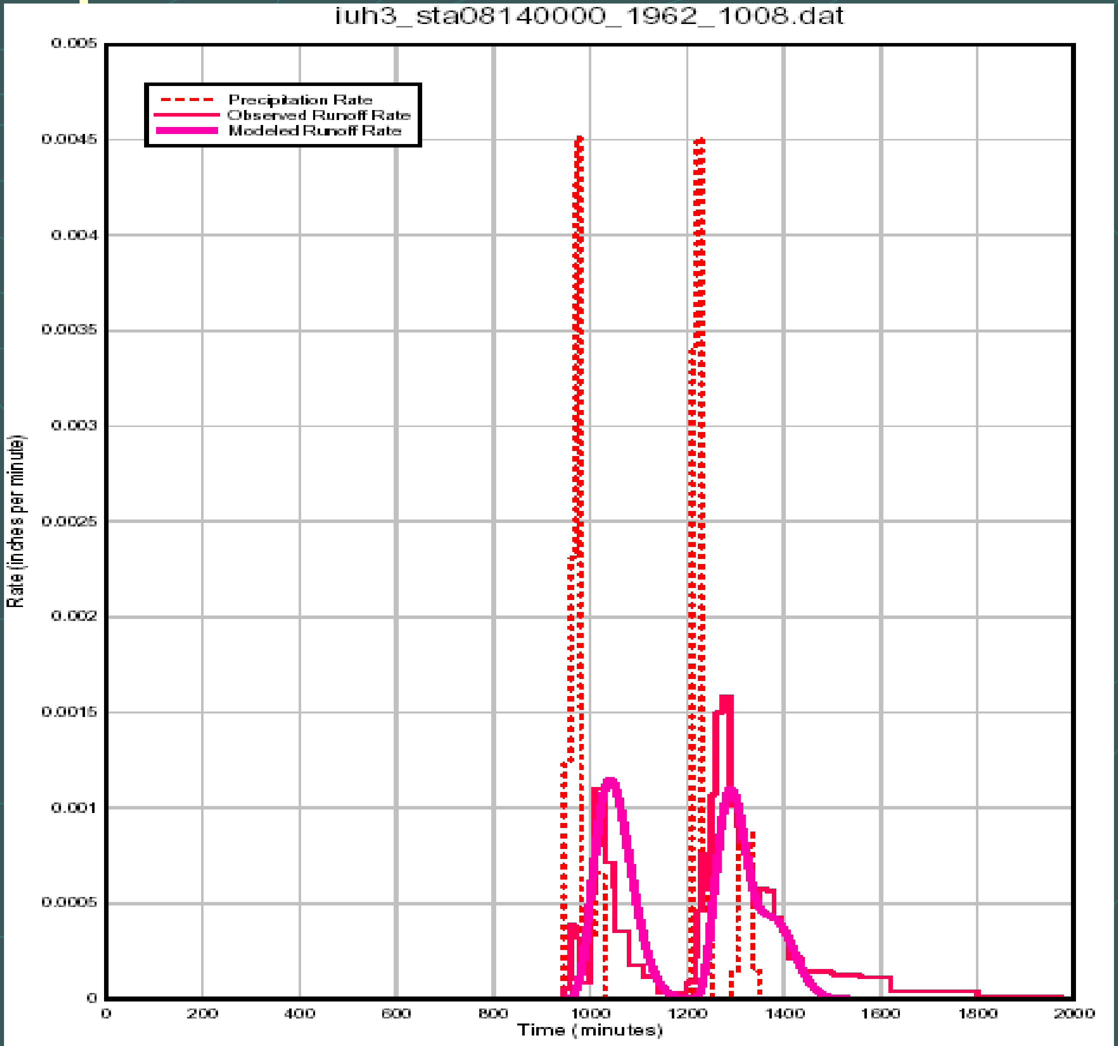


Figure 2. Map of 5 study watersheds in Small Rural (/colorado/deep&mukewater/) module overlain on a shaded relief mosaic derived from U.S.G.S. 30-meter digital elevation maps (DEM). Horizontal and vertical scales are meters Easting and Northing in UTM coordinates.

Colorado/Deep

- Small Rural
  - ~ 5 sq.mi.



Brazos/Pond-Elm

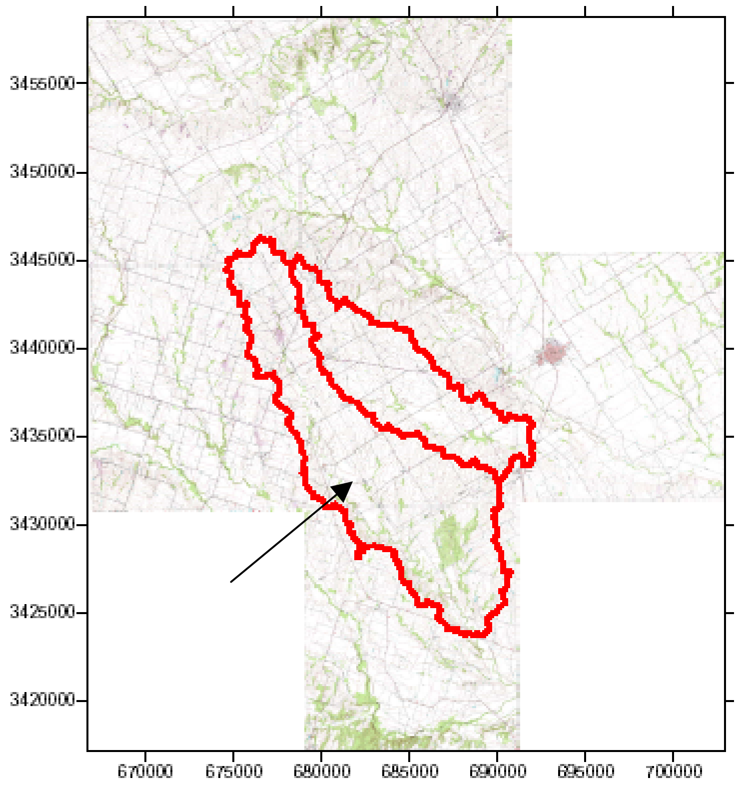


Figure 1. Map of 2 study watersheds in Small Rural (/brasos/pond_elm) module overlain on a mosaic of digital raster graphics (DRG) maps derived from U.S.G.S. 1:24000 series topographic quadrangle maps. Horizontal and vertical scales are meters Easting and Northing in UTM coordinates.

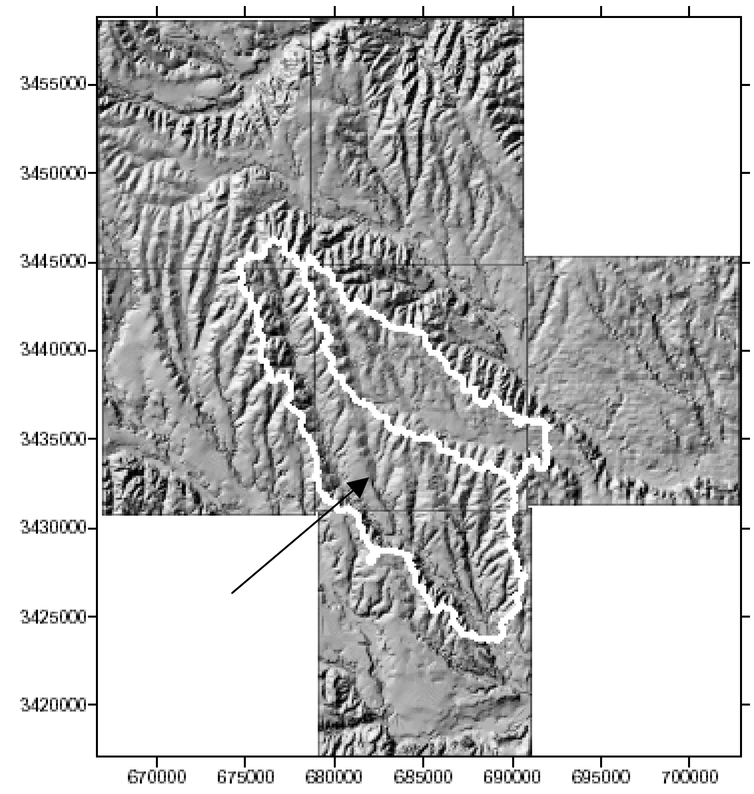
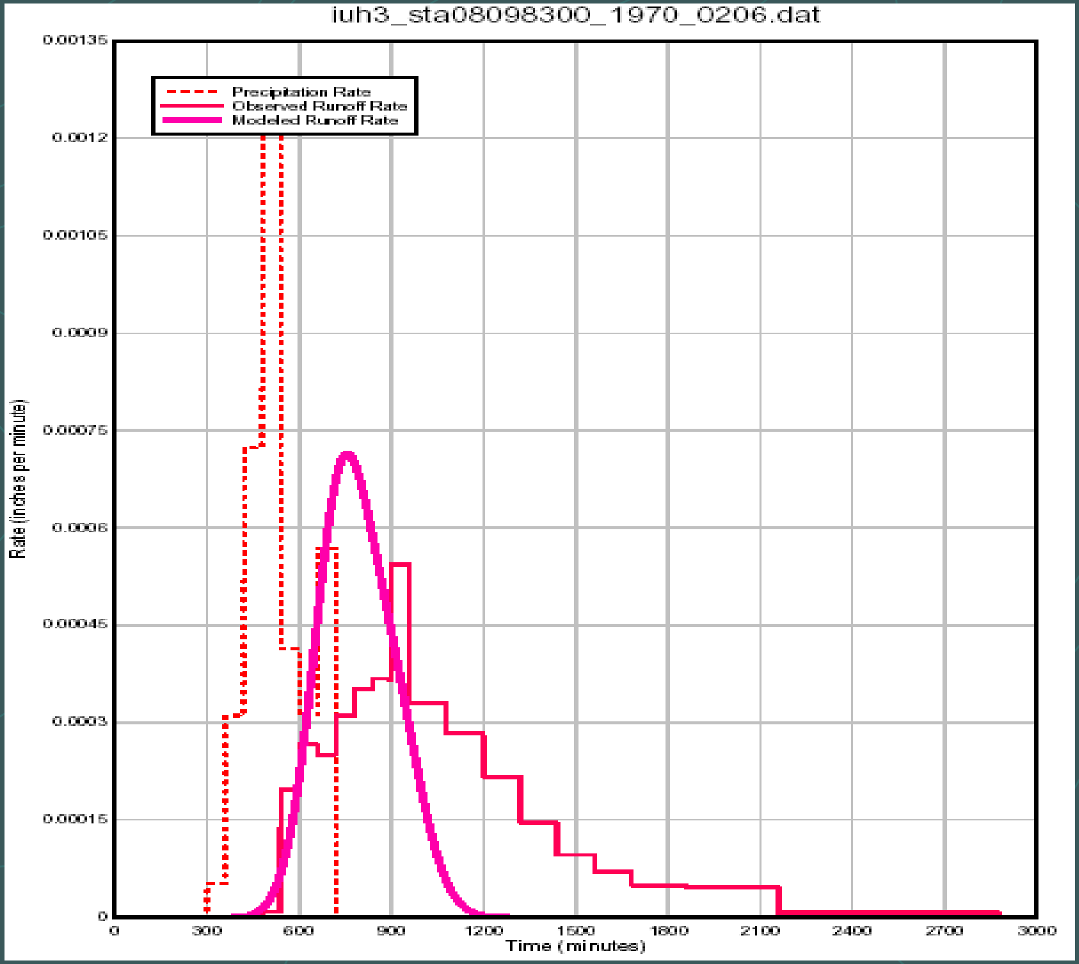


Figure 2. Map of 2 study watersheds in Small Rural module (/brasos/pond_elm) overlain on a shaded relief mosaic derived from U.S.G.S. 30-meter digitial elevation maps (DEM). Horizontal and vertical scales are meters Easting and Northing in UTM coordinates.

Brazos/Pond-Elm

- Small Rural
  - ~ 23 sq.mi.



Summary and Conclusions

- Statistical methods (regression models).
  - Produces qualitatively reasonable results based on three simple to determine physical characteristics
    - (the method can be performed manually).
  - The approach is compatible with current modeling methodology after some variable transformations (not presented) and offers the ability to compare performance with actual events.
- Time-area using particle tracking an alternate approach to produce a unit hydrograph model.
  - Examples using quadratic model, single calibration by trial and error on Ash Creek and same values used for all other watersheds.
  - Demonstrates that a significant component of watershed response is explained entirely by watershed topography.

Summary and Conclusions

- Time-area (continued)
  - Will incorporate more complex physics at significant computation cost.
  - NOT FAST. It takes a long time to track the particles.
  - Feasible on purpose-built cluster computer.
- Fails at about 100 sq.mi.
  - Unknown if this is a computational issue, or a fundamental limitation.

Project Status

- 0-4193 is completed. Several research products (reports) published by U.S.G.S.
  - 1 year implementation project to train selected design engineers how to use the distribution models.
- 0-4194 is near completion. Final report around late August.
  - 1 year modification to examine infiltration capacity models as alternate rainfall-loss.
- 0-4696 is near completion. Final report around late August.

Future Directions

- Statistical models
  - Addition of improved loss model based on soil physics (infiltration capacity approaches).
  - Increase rainfall-runoff database to include more East Texas watersheds (Western Louisiana would be welcomed too!)
- Particle tracking methodology
  - Extension to Newtonian model, test on all watersheds (removes the pit handling algorithm common to all current terrain-based hydrologic models).

Find out more

- http://cleveland1.cive.uh.edu/webdocs/Texas_Hydrology/texas_hydrology.html
  - Databases are located at above URL.
  - Published reports (as .PDF).
  - Links to the other research teams.
  - "How-to" documents for:
    - Getting DRG/DEMs and preparing the ASCII grid without a GIS.
    - Building a cluster computer for these kinds of problems.