FLASH FLOOD GUIDANCE

Where have we been ??

Where are we now ??

Where are we going ??

Modernized FFG

FFGS and ThreshR What is it ??

How Do We Calculate FFG Now ?

First of all, this was developed a long long time ago by the founding fathers of the CBRFC….

Input:

10 YR 1, 3, 6 hour return period precip amounts

Palmer Drought Index

Magic !!

Output:

1, 3, 6, hour flash flood guidance by WFO forecast zone

Palmer Drought Severity Index

- Developed in the 1960's by Wayne Palmer
- Uses Temperature and Rainfall info. to determine dryness
- Is most effective over the long term (several months)
- Not very effective in the short term (several weeks)
- It is issued weekly

Palmer Drought Effect

Basically - we use it to adjust the flash flood guidance

PDI = -4.9 VERY DRY

FF1 = 1.129 FF3 = 1.411 FF6 = 1.806

PDI = 0.0 "NORMAL"

FF1 = 1.065 FF3 = 1.331 FF6 = 1.704

PDI = 4.9 "VERY WET"

FF1 = 0.972 FF3 = 1.215 FF6 = 1.555

Ours Is Not The Only Guidance

Empirically derived rules of thumb:

1” or more in 1 hr or less

Other Rainfall Rate Rules

Those based on “meteorology of the day”

Most of these were developed at the WFO’s

Guidelines For Flash Flood Index

500 MB WIND SPEED	CAP	TRIGGER	PRECIPITABLE WATER			
			> 1.00	>.90-1.00	.50-.80	<.50
< 15 KTS	NO	YES	Very High	High	Mod-High	Low
		NO	High	Mod-High	Moderate	Low
	YES	YES	Mod-High	Low-Mod	Moderate	Low
		NO	Low-Mod	Low	Low	Low
15<25 KTS	NO	YES	High	Mod-High	Moderate	Low
		NO	Mod-High	Moderate	Low-Mod	Low
	YES	YES	Mod-High	Low-Mod	Low	Low
		NO	Low-Mod	Low	Low	Low
< =25 KTS	NO	YES	Mod-High	Moderate	Low-Mod	Low
		NO	Moderate	Low-Mod	Low	Low
	YES	YES	Low-Mod	Low	Low	Low
		NO	Low	Low	Low	Low

Primary Factors Affecting Flash Flooding

- Precipitation Intensity
- Terrain and Soil Characteristics
- Rainfall Duration and Total
- Antecedent Conditions
- Base Flow

Why A New Flash Flood Guidance System ??

The Modernized Flash Flood Guidance (FFG) System is a national program implemented by the Office of Hydrology to provide a standard methodology and finer resolution for calculating FFG.

To more effectively use the WSR-88D radar rainfall estimates in the flash flood program, FFG is needed on the same spatial grid scale. (nominally 4 km on a side, the HRAP grid).

The WFO application within the Flash Flood Monitoring and Prediction System (FFMP) will compare gridded FFG and rainfall estimates from the radar.

Some FFG System Comparisons

OLD SYSTEM		NEW SYSTEM
PDI	Soil Moisture	SAC-SMA
Rules of Thumb	Threshold Runoff	geophysical properties
Inherent in Study (empirical)	Rainfall Intensity & Duration	"SAC-SMA" (deficits satisfied)
Update Weekly	Frequency	Per OFS Run
Area (WFO zone)	Output	Gridded & Area

Modernized Flash Flood Guidance System
METHODOLOGY

Threshold Runoff:

A fixed value of runoff required to initiate flooding. It is based on geographic and hydrologic features of the stream channel and basin.

Soil Moisture State:

Changes continuously depending on precipitation and is maintained in the river forecast models (in our case sac-sma) maintained at the RFC's.

Flash Flood Guidance:

A derived amount of rainfall that is controlled by soil moisture state and threshold runoff

Threshold Runoff

Definition: $R = Qp / qp * A$

R = Threshold Runoff in inches

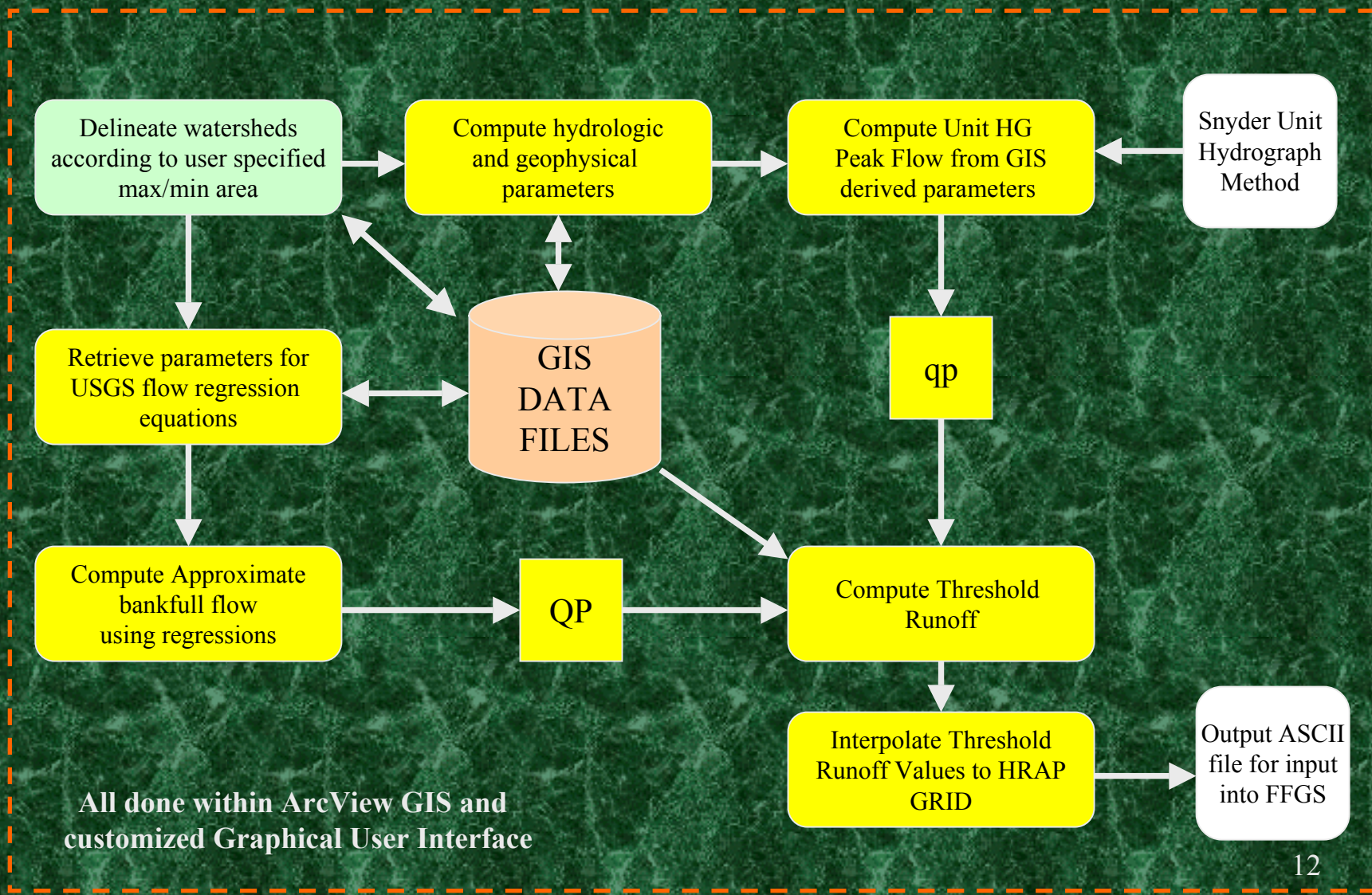
Qp = Bankfull discharge in cfs

qp = Unit HG peak flow in cfs per unit area in sq. miles (cfs/sq. mi)

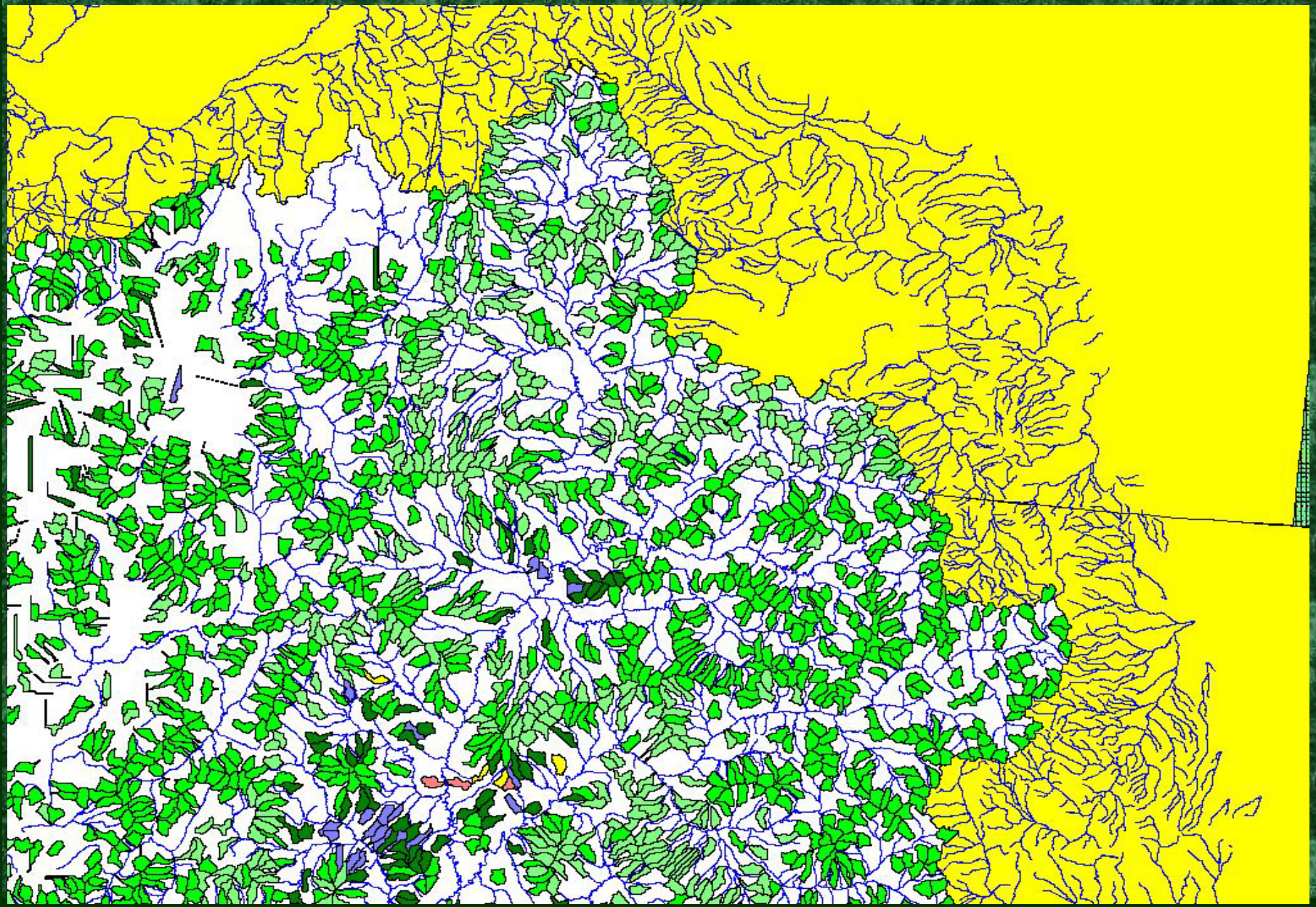
A = Area in square miles

ThreshR values are desired for thousands of small watersheds

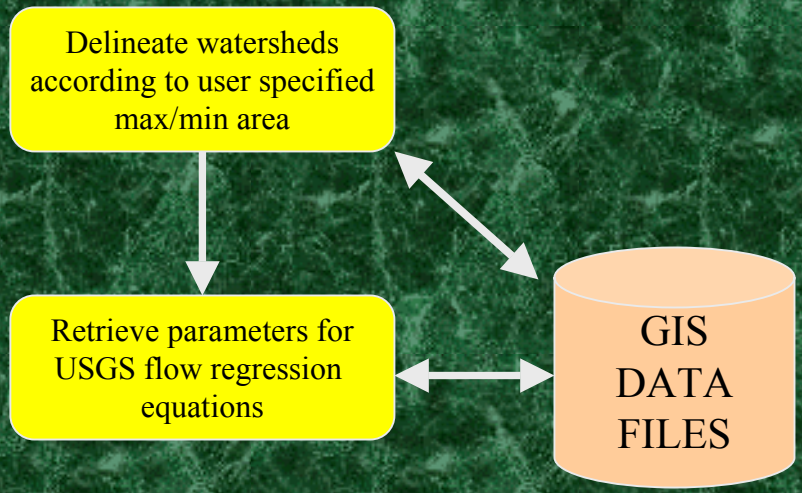
Threshold Runoff Calculation Procedure



River Basin Delineation – Range 20 to 100 square miles



Threshold Runoff Calculation Procedure



USGS Regions

UTAH: Northern Mountain Elevation Region A

$Q10 = .071A^{0.815}E^{2.70}$

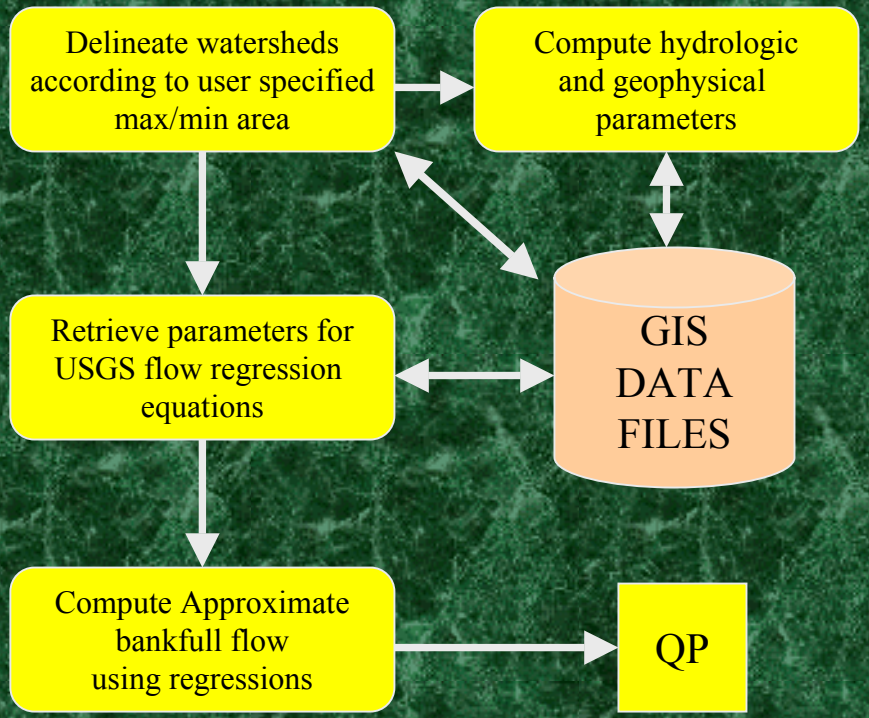
A = Area E = Elevation

COLO: Mountain Region

$Q10 = 86.1A^{0.699}SB^{0.635}$

A = Area
SB = Mean Basin Slope

Threshold Runoff Calculation Procedure



Retrieve and Compute parameters for Unit HG Peak

Example Parameters:

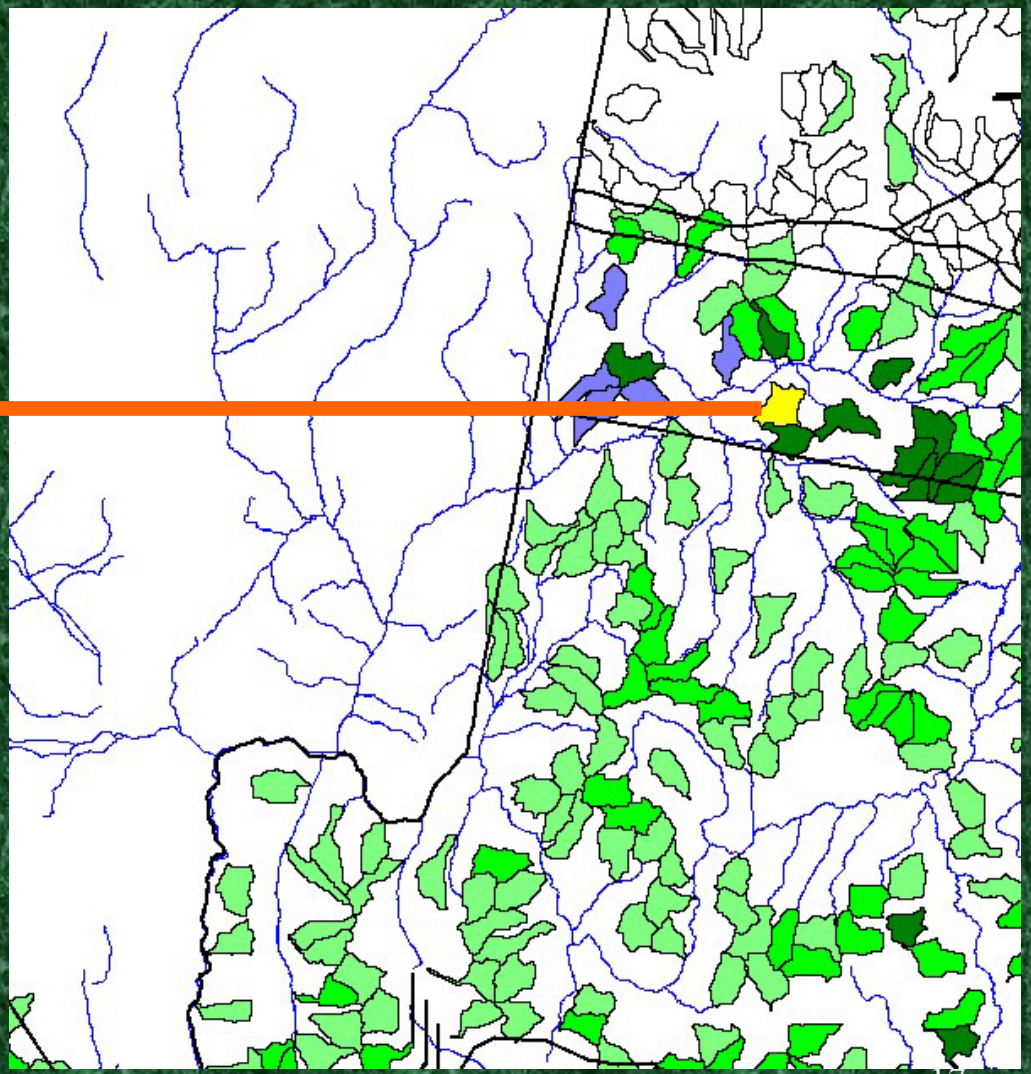
Area = 34.61 Miles

Elevation = 3494 Feet

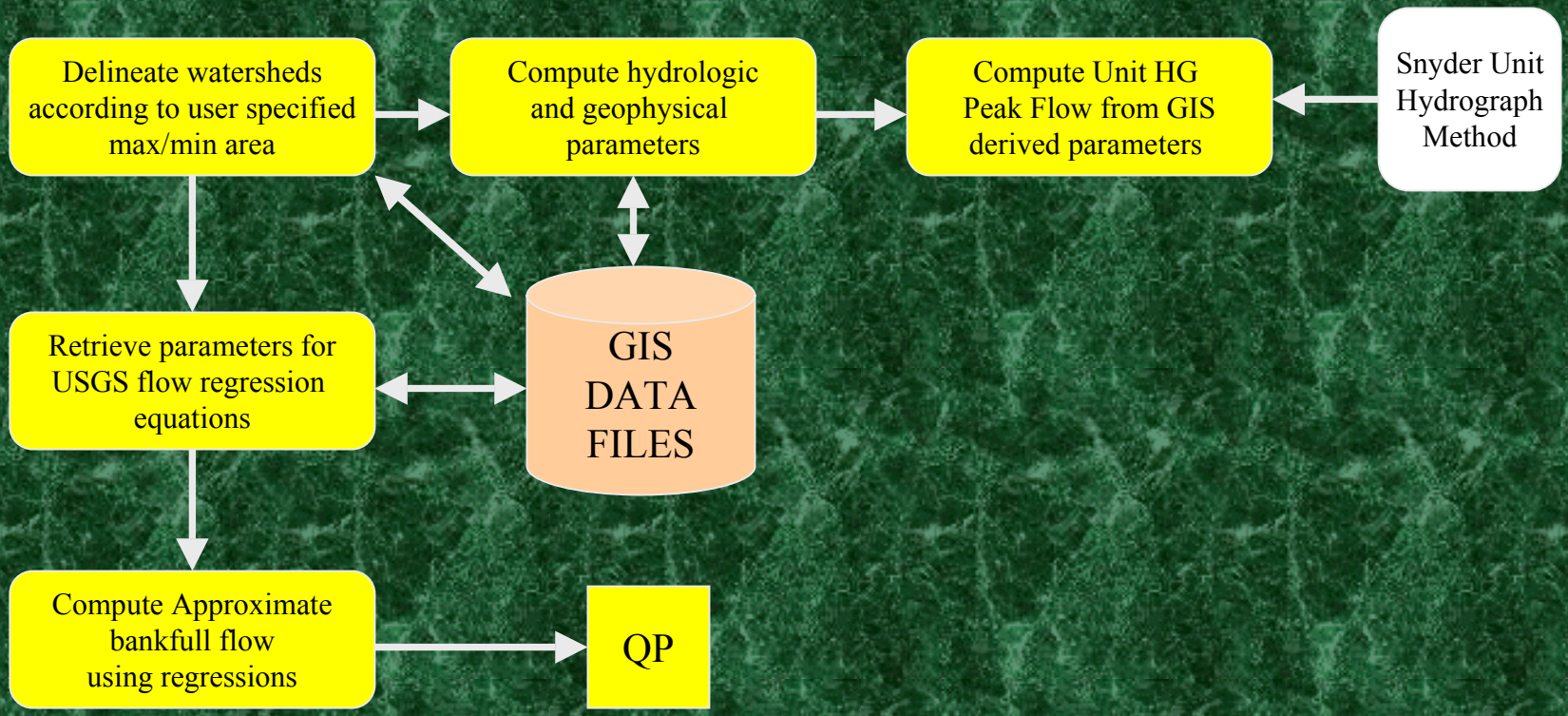
Channel Length = 10.25 miles

Channel Slope = 88.4 ft/mile

Channel Centroid = 5.05 miles



Threshold Runoff Calculation Procedure



Snyder Unit Hydrograph Method

$$qp = 640\ Cp\ A / t_p$$

Where:

qp = peak discharge per unit drainage area

Cp = Coefficient accounting for flood wave & storage conditions

A = Area

t_p = Basin Lag – relating rainfall duration and hydrograph peak *

Snyder Unit Hydrograph Method

$$qp = 640\ Cp\ A / t_p$$

$$t_p = C_t\ (\ LL_c\ )^{0.3}$$

Where:

C_t = is a coefficient representing variations of watershed slope and storage.

L = Length of main stream channel (longest flow path)

L_c = Length along main channel from the outlet to a channel point nearest the watershed centroid.

Snyder Unit Hydrograph Method

$$qp = 640\ C_p\ A / t_p$$

$$t_p = C_t\ (\ LL_c\ )^{\ 0.3}$$

C_p and C_t coefficients are usually derived from gaged watersheds in the same region – this is a problem in much of our remote areas

The coefficients are usually inversely related with C_p ranging from 0.4 – 0.8 and C_t in extreme terrain ranging from 0.4 to 8.0

How do we get these for our basins ?

Suggestions for Determining C_p and C_t Coefficients

Use nearby observed river gage data to calculate these and define them for a region. Scale issues exist.

Develop relationships between coefficients calculated from observed data and geophysical river basin characteristics, apply this relationship to other basins.

Interpolate calculated coefficients to a grid for input into the arcview threshr system.

Determine if studies have been done for the area of interest.

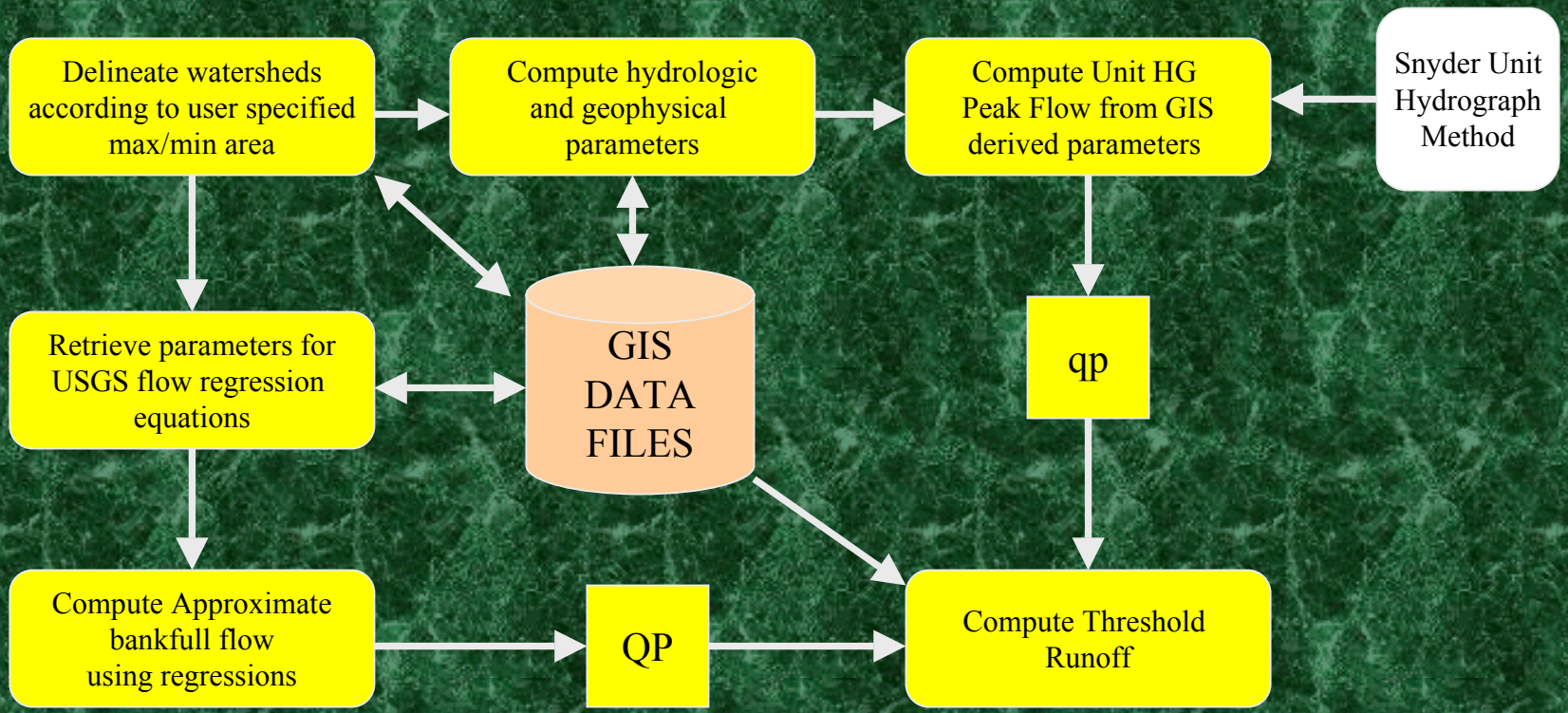
As a First Shot At These Coefficients

Using the SCS Method, assuming a runoff efficiency, and obtaining required geophysical characteristics from the Threshr/Arcview system, unit HG peak flows were calculated for all basins.

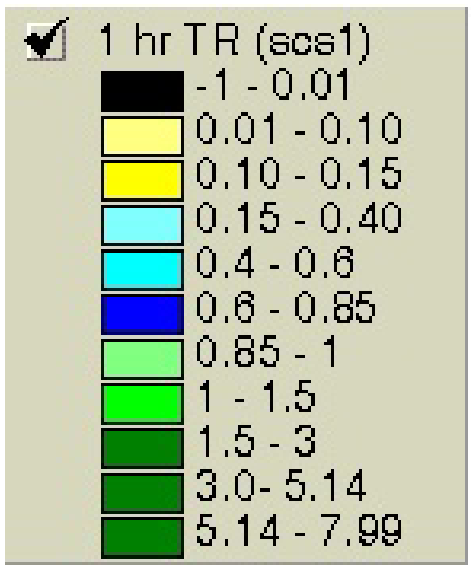
C_p and C_t coefficients were then calculated using the Snyder method for all the basins using output from the SCS method.

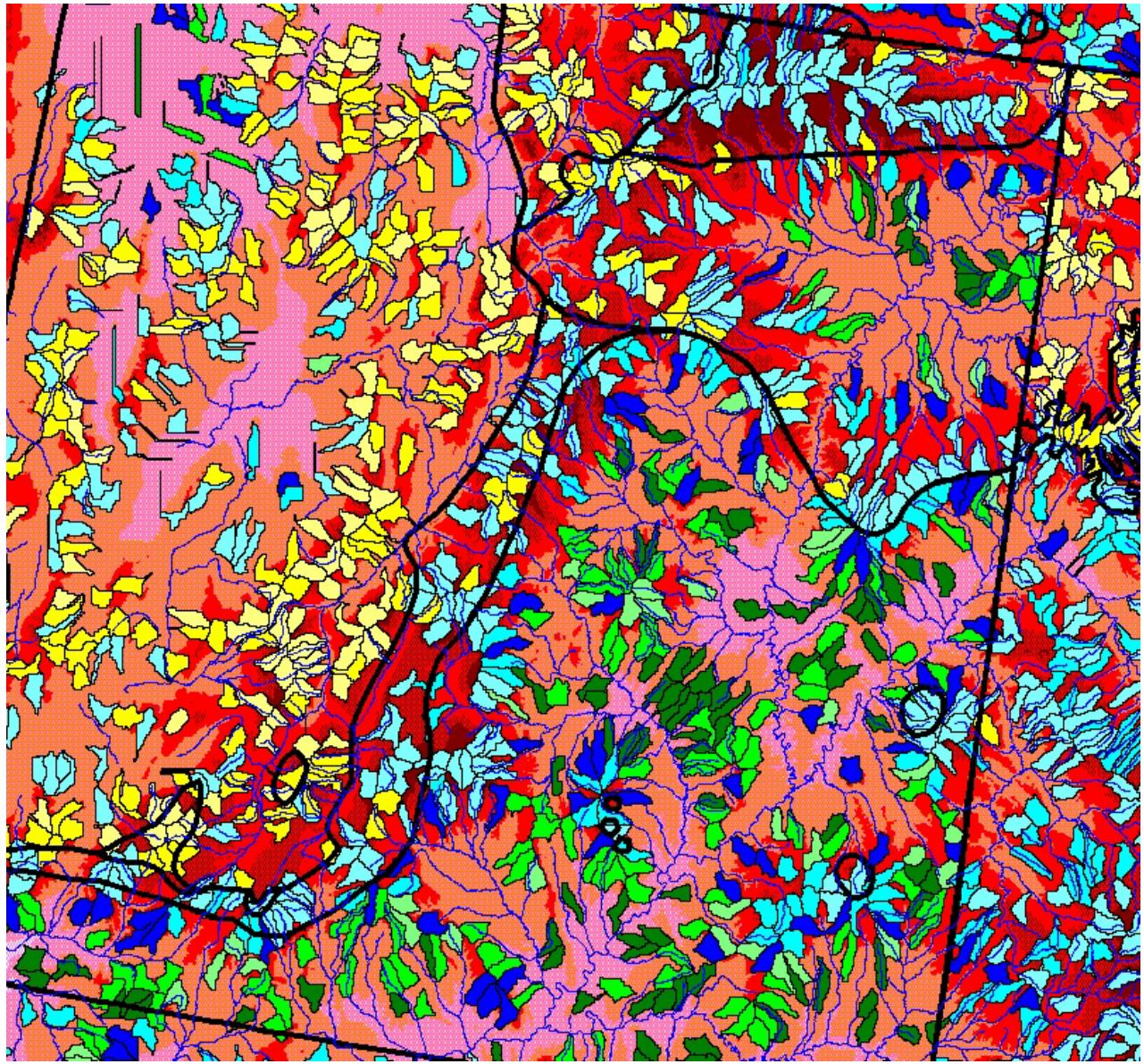
Relationships were then developed between basin geophysical characteristics and these coefficients, these relationships were then re-applied to the basins and new coefficients calculated.

Threshold Runoff Calculation Procedure

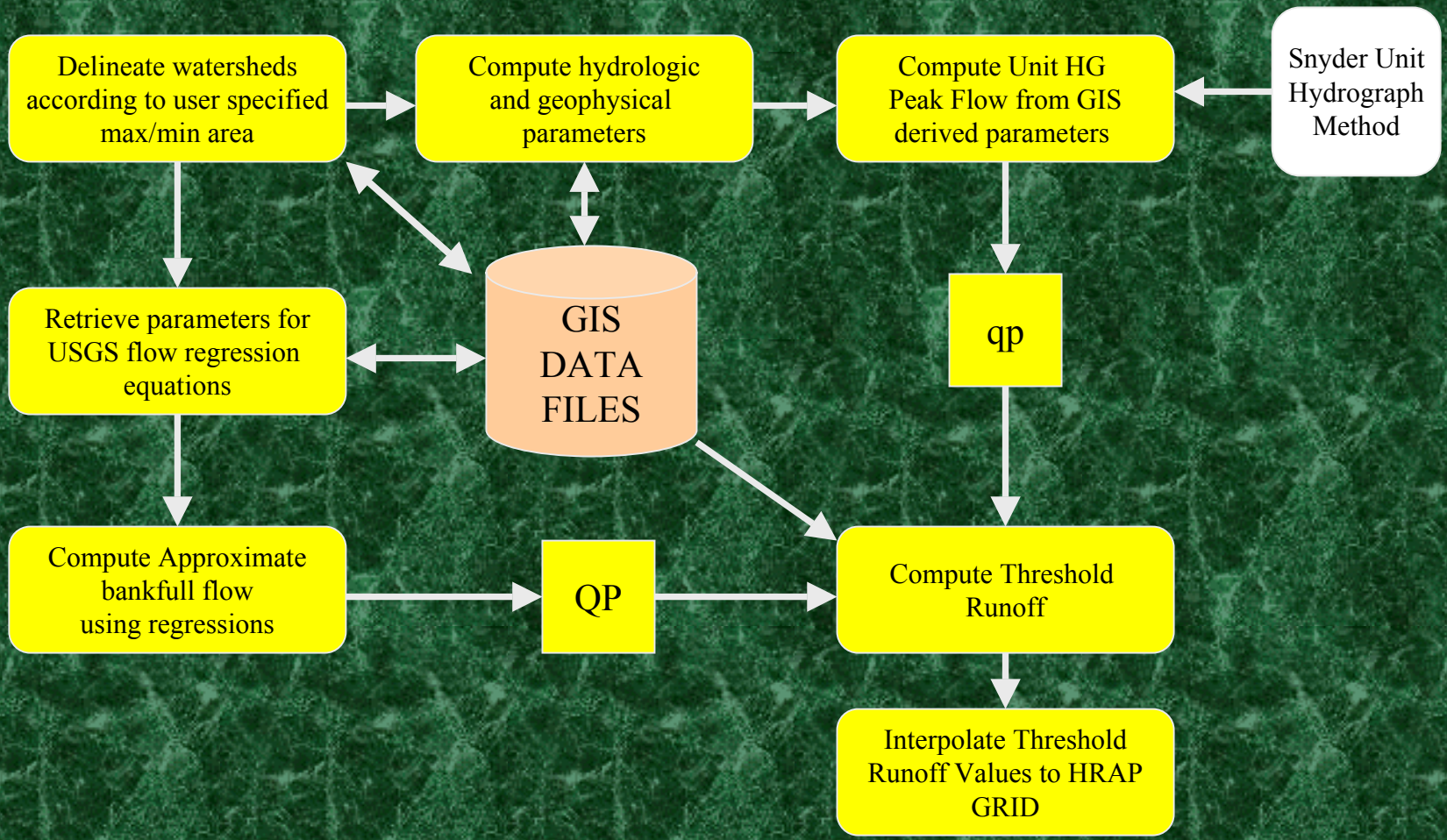


Initial Threshold Runoff Results – 1 Hour TR

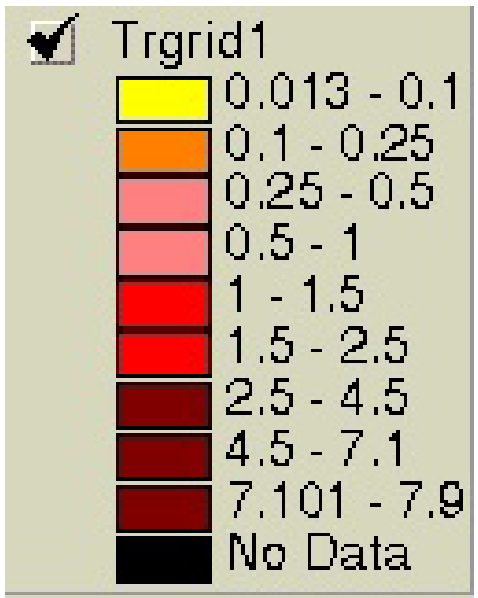


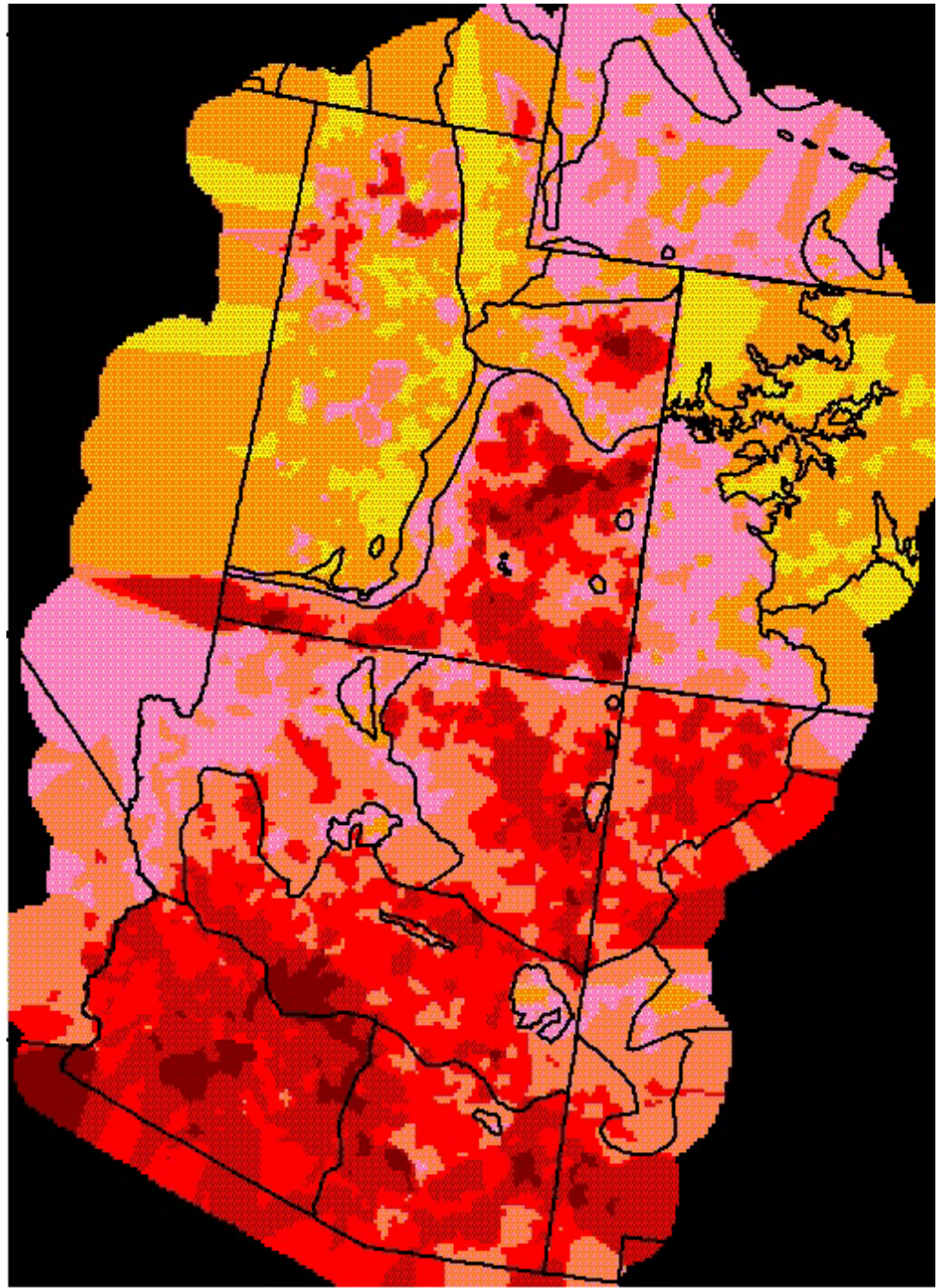


Threshold Runoff Calculation Procedure

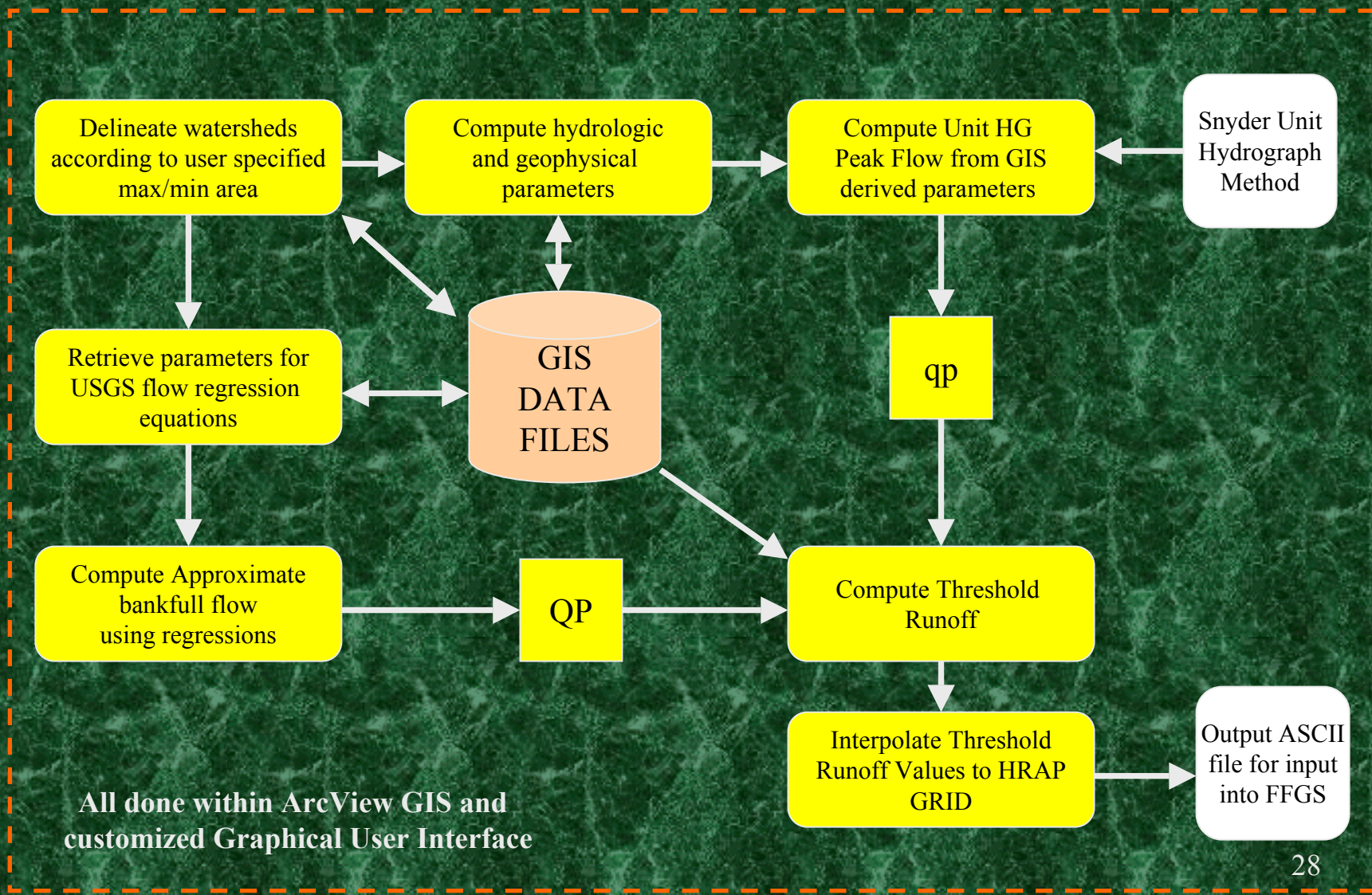


Threshr HRAP Gridded Values





Threshold Runoff Calculation Procedure



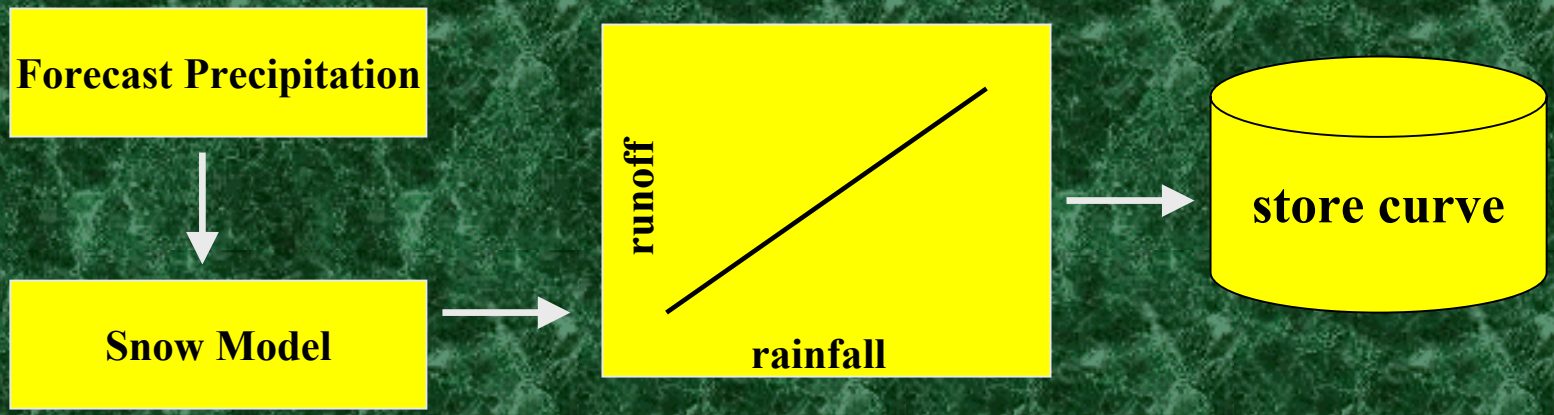
Flash Flood Guidance Operation

Defined within OFS Segments

FFG UPPER

EWFA3HUF EF WHITE-APACHE 0

EWFA3H SAC-SMA UPPER SNOW-17 UPPER



Flash Flood Guidance Operation

Requires Basin Definition within OFS

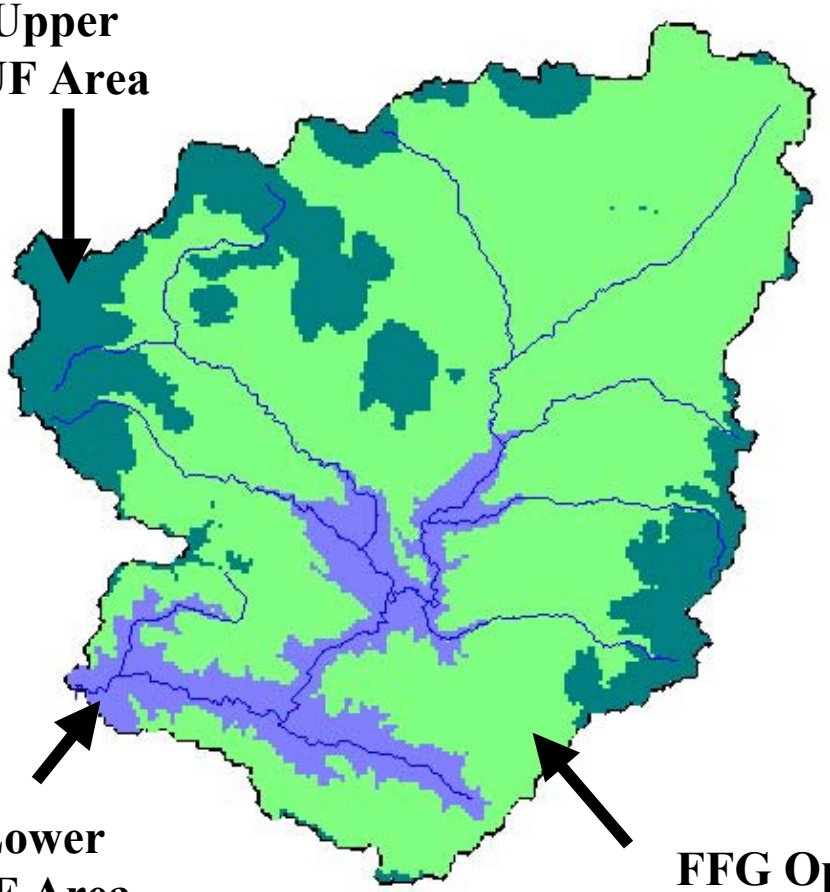
Typically basin definitions are associated with the MAP pre-processor routines (quadrants, thiessen polygons etc. vs. pre-determined station weights that western RFC's use.)

Ideally one FFG operation and one basin definition per segment sub-area.

These must all be defined in the OFS PPPDB files for the CBRFC. The location of these files were moved in the fs5 file structure since they require a lot of space.

Sub-Divided Gila near Gila (GILN5)

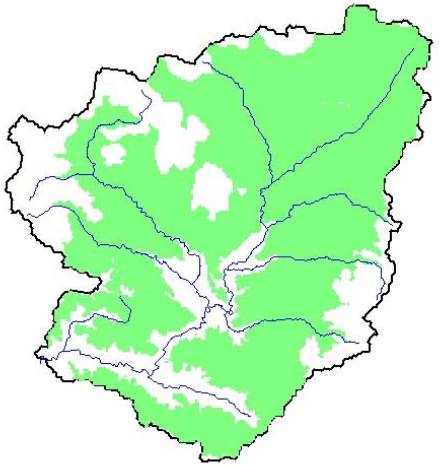
FFG Operation for Upper mapped to GILN5HUF Area

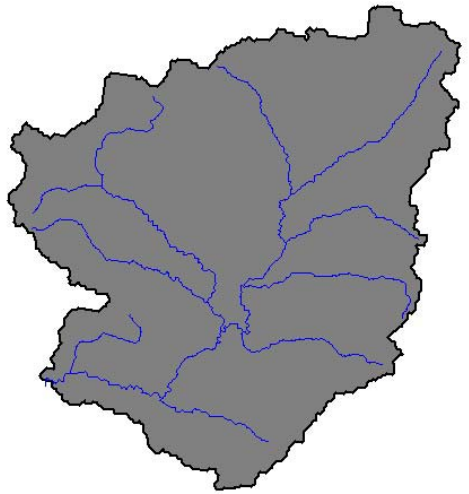


FFG Operation for Lower mapped to GILN5HLF Area

FFG Operation for Middle mapped to GILN5HMF Area

Flash Flood Guidance Operation





FFG - Flash Flood Guidance Operation

BASN – Basin Definition GILN5H

FFG MID

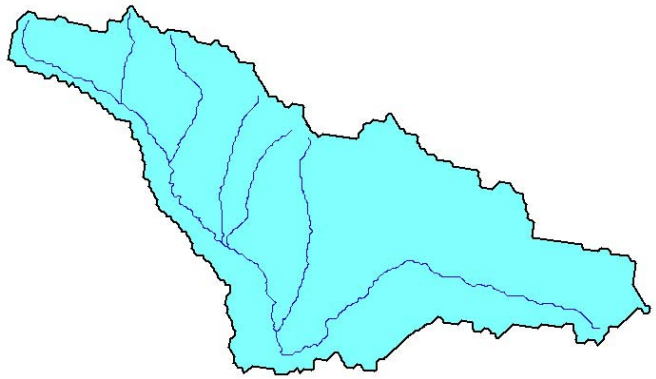
GILN5HMF GILA-GILA 0

GILN5H SAC-SMA UPPER SNOW-17 UPPER

Flash Flood Guidance Operation

Upper Area

Mapped to Entire Basin

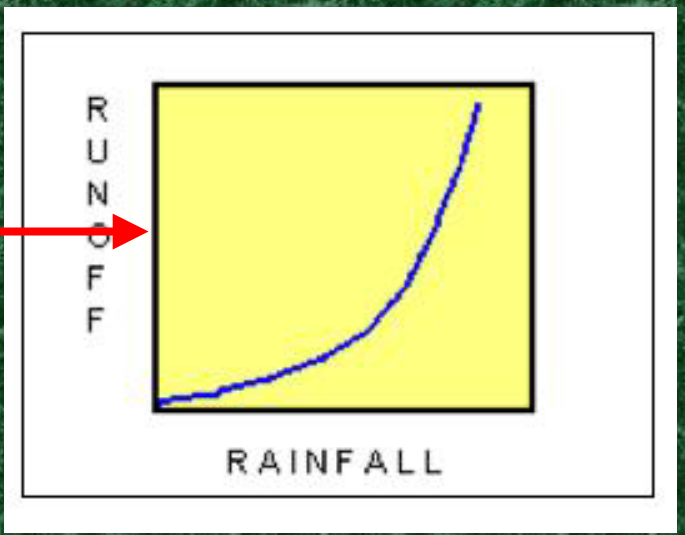


Flash Flood Guidance Operation

FFG Technique → Rainfall-Runoff Curve

```
@SETOPT
@COMPUTE FMAP
....
....
MOD
  .INCLUDE GN_F
...
FFG(2)
...
@STOP
```

threshold runoff



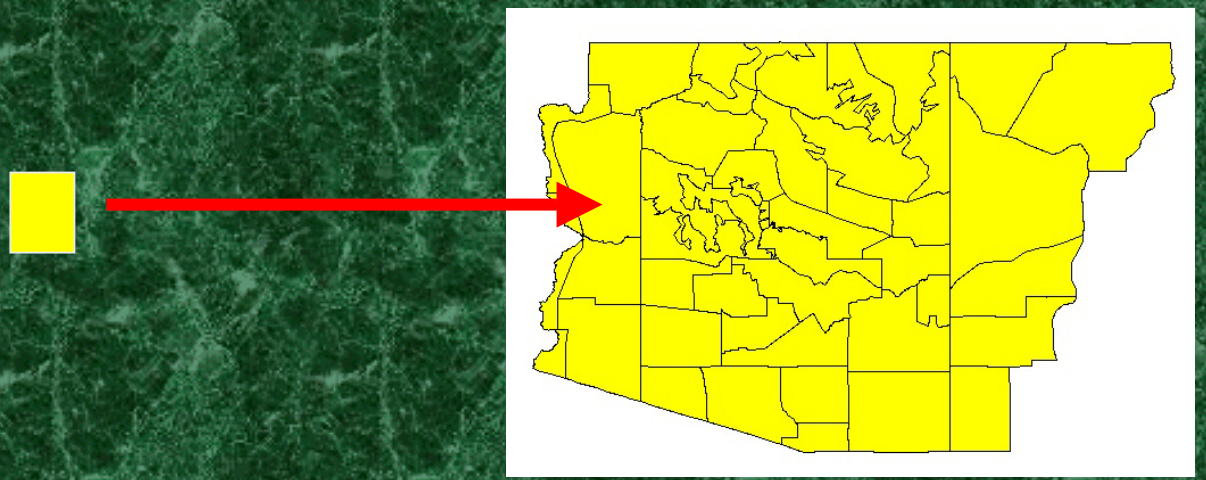
Flash Flood Guidance System

Threshold runoff and the rainfall runoff relationship are compared on a gridded level.

Gridded Flash Flood Guidance is produced (HRAP)

Grids are mapped back into areal FFG (Zone)

*** zones are also defined in nwsrfs using the ppinit BASN routine ***



FLASH FLOOD GUIDANCE OUTPUT

ZCZC SLCFFGAZ CSW
FOUS65 KSR 220825
FFGAZ
ZONE FLASH FLOOD GUIDANCE
COLORADO BASIN RIVER FORECAST CENTER…SALT LAKE CITY UT

ISSUED 0800 AM MDT TUE MAY 22 2001

Flash Flood Guidance is primarily dependent upon terrain and rainfall intensity. Flash Flood Guidance for urban areas and steep mountainous terrain may be less than indicated.

.B SLR 20010522 Z DH12/DC200105220825 /DUE/PFH/PFT/PFQ

:IDENT	1HR	3HR	6HR
AZZ001	3.4/	3.6/	3.7
AZZ002	4.3/	4.5/	4.5
AZZ003	4.3/	4.5/	4.5
AZZ004	3.4/	3.6/	3.7

:IDENT	1HR	3HR	6HR
AZZ001	1.4/	1.5/	2.0
AZZ002	1.4/	1.5/	2.0
AZZ003	1.4/	1.5/	2.0
AZZ004	1.6/	2.1/	2.3

Why Such High FFG Values ?

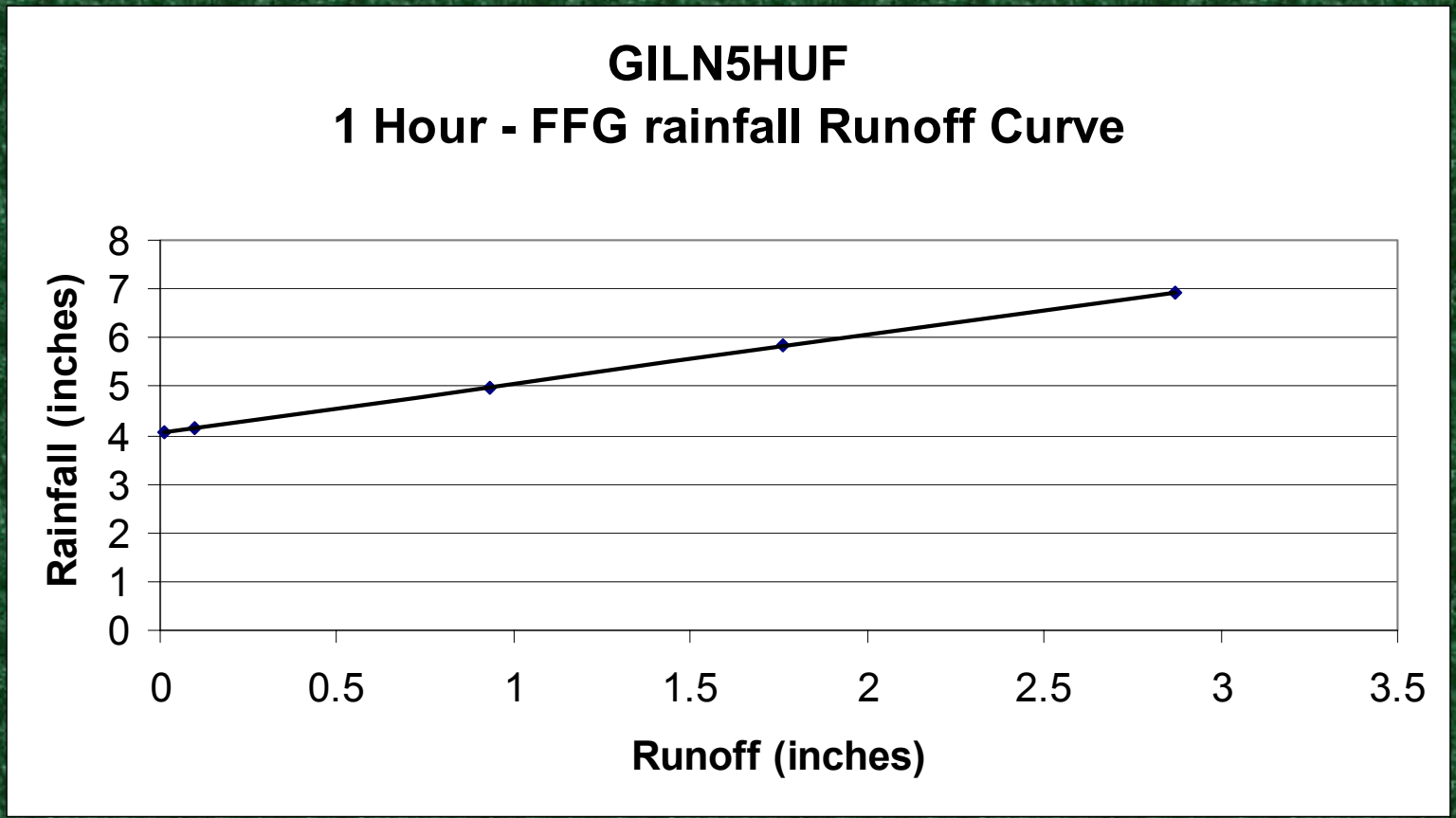
Questionable ThreshR Values

- Incorrect return frequency assumptions
- Questionable unit hydrograph results
- Poor resolution DEM data in low relief areas
- Questionable USGS regressions for peak flow, etc. etc.

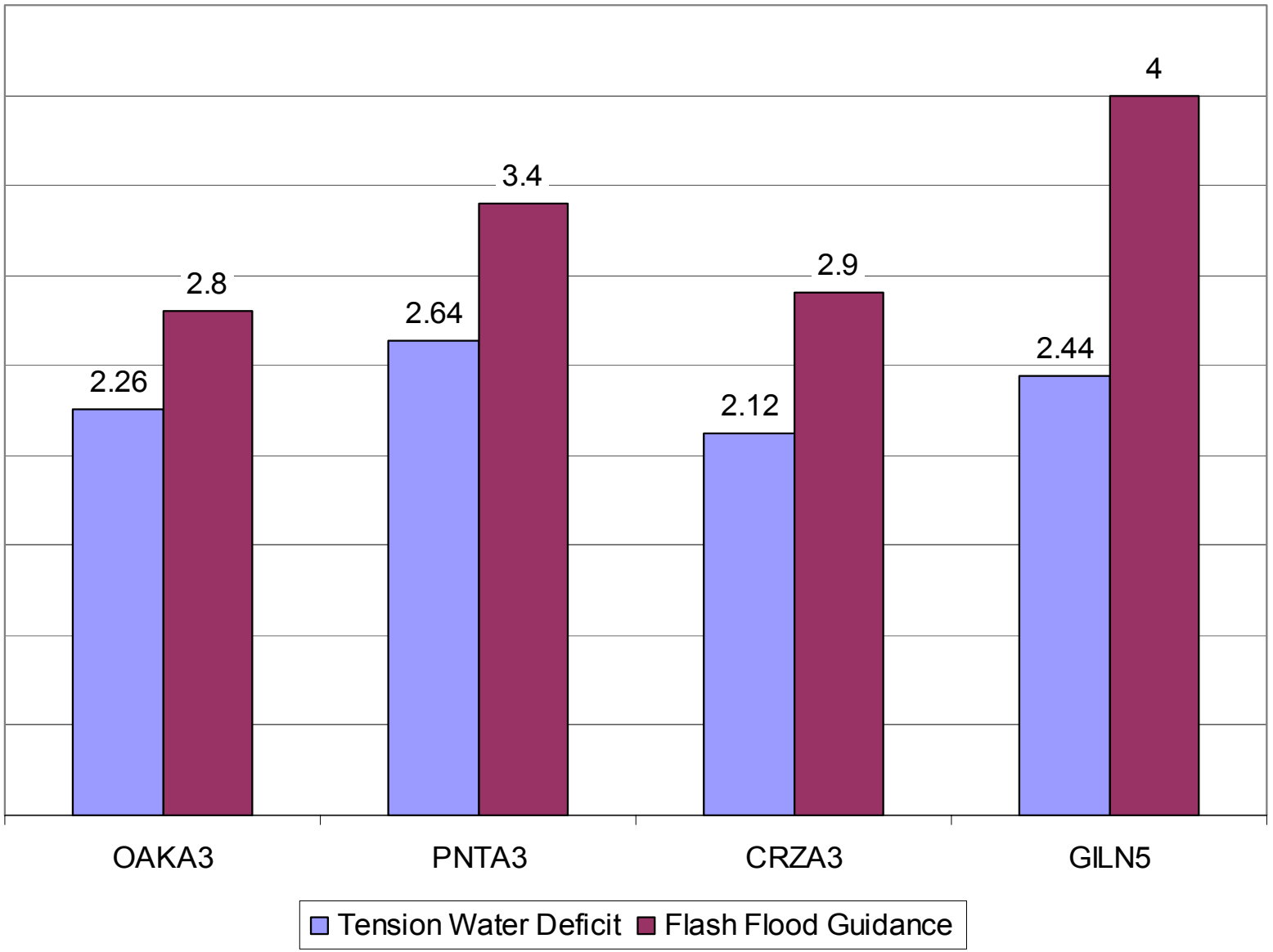
NWSRFS Limitations

FFG SYSTEM: RAINFALL-RUNOFF CURVE

*** Tension Water Deficit must be satisfied before runoff is generated ***



UZTWD and FFG



Why Such High FFG Values ?

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- Questionable USGS regressions for peak flow, etc. etc.

NWSRFS Limitations

- Scale Issues – Time Steps…Basin Size…Precip Catchment…etc.
- Regional characteristics of a flash flood

The Next Move ?

Adjustments to FFG Output Values

OH has added an adjustment factor option that can be applied to the output from the FFG program.

OH has added an impervious factor option to be applied at the grid level.

Important to continue to focus and issue guidance based on what we know, incorporating experience, rules of thumb, existing guidance, etc.

Define Remaining Basins and Zones in NWSRFS

Re-Define remaining Segments

Provide Feedback as this is an evolving program

Modernized FFG - SUMMARY

Strengths

Account for basin geophysical characteristics/GIS

Update frequency & accounting for the latest conditions

Weaknesses

Precipitation intensity – difficult to account for in sac-sma

Meteorology is somewhat underplayed

Limited methods for determining unit hydrograph peaks

Use of SAC-SMA considering the scale issues

DEM resolution is limited for defining flash flood size basins

Modernized FFG - SUMMARY

Weaknesses

Verification – Threshr/Reality Check:

Threshold runoff, bankfull, and FFG output

Verdict still out

Value of the USGS regressions – OH questioning these

However no RFC's are currently using Threshold Runoff results obtained from this system.

Modernized FFG - SUMMARY

*** last slide ***

Can we utilize this system at our office now given its current state, should we use it ?

How soon can we switch over to it ?

When can the entire CBRFC be converted to it ?

Improvements and modifications should be emphasized and are required ?