QUESTION: Can a Flood Stage occur in a Wilderness?

10:55 - 11:45am … Determination of "Meaningful" Stages and Flows

- **For ALL sites within CBRFC's forecast area**
- **Bankfull, Flood, Moderate, Major, Maximum using Return Frequencies**
  (and "best guess" based on 25 years of experience at being sometimes wrong)
- ***Bill Reed - Senior Hydrologist – CBRFC***

Purpose

Flood, Moderate, Major

Bank, Screen, Scr Rate, Sig Rate

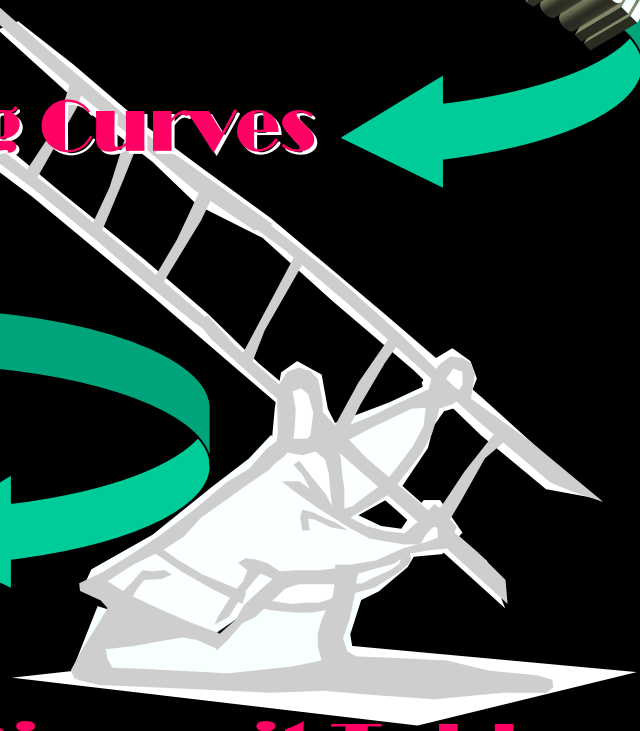
Ultimate Screen

Synthetic Rating Curves

Conservative

Internally Consistent

Reiterative



Rivercrit Table

8(concepts)*2(hg+q)*719(flow points) = 11,504(things) +

If too high ~ missed events.

Conservative is in between.

If too low ~ false alarms.

Internally Consistent If you believe one set of values (e.g., moderate flood) then you can believe all others (e.g., bankfull).

Reiterative If one value is changed, then all other values for that site were rechecked. After first definition, values were refined using continuum.

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Rivercrit Table

Ultimate Screen coming soon!

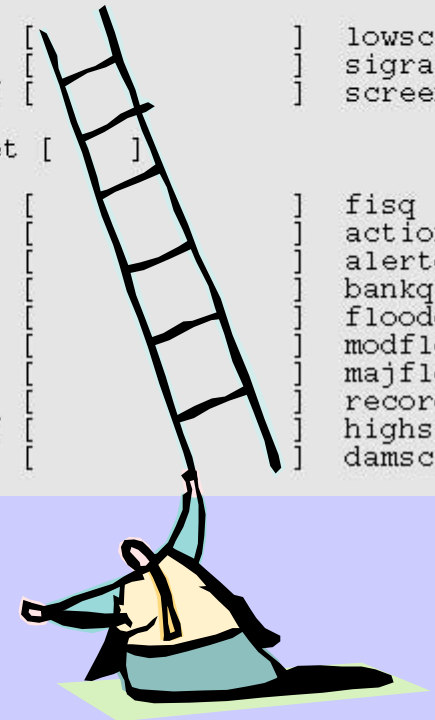
Exceed

rivercrit (modified)

File Edit Search Preferences Shell Macro Windows

```
PERFORM:   Query  Next  Previous  View  Add  Update  Remove  Table  Screen  ...
Searches the active database table.              ** 1: rivercrit table**
lid          [         ]  pe1 [ ]  pe2 [ ]  vdtime [           ]

                STAGE                          FLOW                QUALITY CODE

lowscreen    [              ] lowscreenf  [              ]  lowscreenq  [ ]
sigrate      [              ] sigratef    [              ]  sigrateq    [ ]
screenrate   [              ] screenratef [              ]  screenrateq [ ]

           sigratet     [    ]  screenratet [    ]

fis          [              ] fisf        [              ]  fisq        [ ]
action       [              ] actionf     [              ]  actionq     [ ]
alert        [              ] alertf      [              ]  alertq      [ ]
bank         [              ] bankf       [              ]  bankq       [ ]
flood        [              ] floodf      [              ]  floodq      [ ]
modflood     [              ] modfloodf   [              ]  modfloodq   [ ]
majflood     [              ] majfloodf   [              ]  majfloodq   [ ]
record       [              ] recordf     [              ]  recordq     [ ]
highscreen   [              ] highscreenf [              ]  highscreenq [ ]
damscreen    [              ] damscreenf  [              ]  damscreenq  [ ]
```

All values will have a home.



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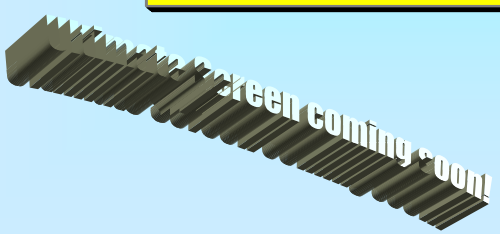
purpose

- Flood, Moderate, Major
  - Flood Potential Outlook
  - Webpage hydrograph display color code
  - General Site Information
  - Synthetic Rating Curves

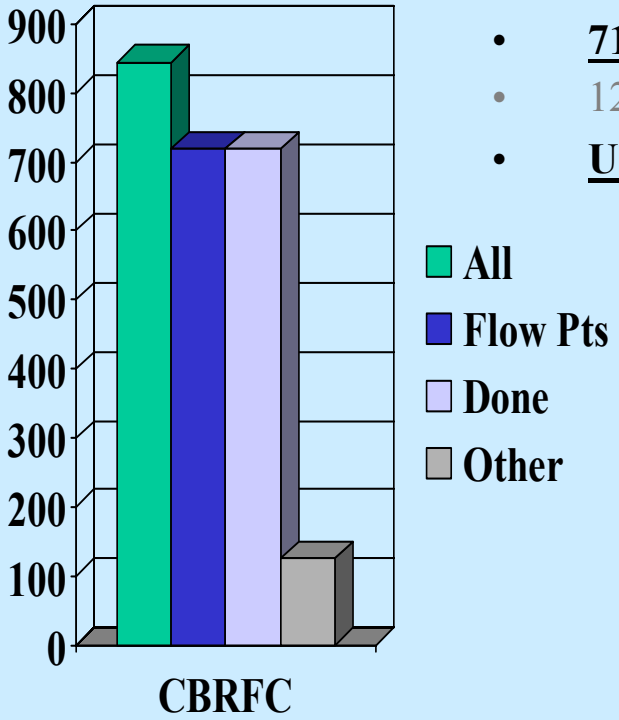
- Bankfull
  - Signficant Rate
  - Synthetic Rating Curves
  - River Review Program

- Screen, Screen Rate
  - Quality Control



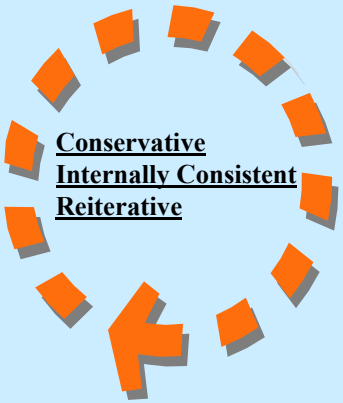
- Signficant Rate
  - River Review Program

Flood, Moderate, Major



- 844 points in JMP
- **719 Flow Points --- DONE**
- 125 other (Reservoirs / Canals / Tunnels / Diversion Structures)
- **Used E-19s for 119 sites**, often only flood defined (600 wbr)

- ❖ **Q --- Return Intervals, 416 okay** (428 adjusted) --- Flood Hydrology **does not necessarily fit** NWS anthropocentric definition of Flood Stage
- ❖ **Stage --- Rating Curves, 342 okay** (377 wbr) --- Flood Hydraulics, **often significant flows have not been measured** (rating curves can be meaningless during floods if not properly extended)
- ❖ **Conceptual Fluvial Geomorphology** --- Interrelationship of Basin Characteristics, Channel Geometry, and Flood Hydraulics
- ❖ **Limiting Factors** --- Storm Size, Storm Track, Elevation Threshold, and Basin Size
- ❖ **Regionalization** --- Event Medians by Region



- ➢ **Checked against bankfull**
- ➢ **Checked against "flow of record"** when meaningful --- often used to extend rating curve (372 hg / 425 q)
- ➢ **Sometimes "stage of record" does not have same datum as rating curve**
- ➢ **Scour and fill can cause rating curves to change during floods**

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Conceptual Fluvial Geomorphology --- Interrelationship of Basin Characteristics, Channel Geometry, and Flood Hydraulics

1. **Bankfull is the top of active channel and has a recurrence interval of 2 to 10 years (*perhaps as great as 25-year event*).** **From USGS Water Supply Paper 2433 (less than 200 square miles)**

2. **Bankfull depth is related to stream order or drainage area within regions of similar climate and geology.**

3. **Bankfull depth can be less than channel full (*mostly ignored for our purposes*), and flood depth is usually greater than bankfull depth.**

4. **Flows for a given event or recurrence interval will usually increase as drainage area increases (RIVER CONTINUUM, adjusted previously calculated values to fit; all basins); however, even though the flows will increase, the landforms inundated will remain similar.**

5. **Larger rivers can have headwaters in multiple flood regions.**

6. **Episodic stripping of sediment and vegetation can occur during large floods followed by a long recovery phase dominated by frequent, low magnitude events (*rating curve may be different during large events*).**

7. **Structures (e.g., levees, dikes), channelization, and other "improvements" can cause perturbations.**

8. **Flood Stage as defined by NWS may not be a function of bankfull.**

9. **Flood Flow as defined by NWS may not be a function of recurrence interval.**

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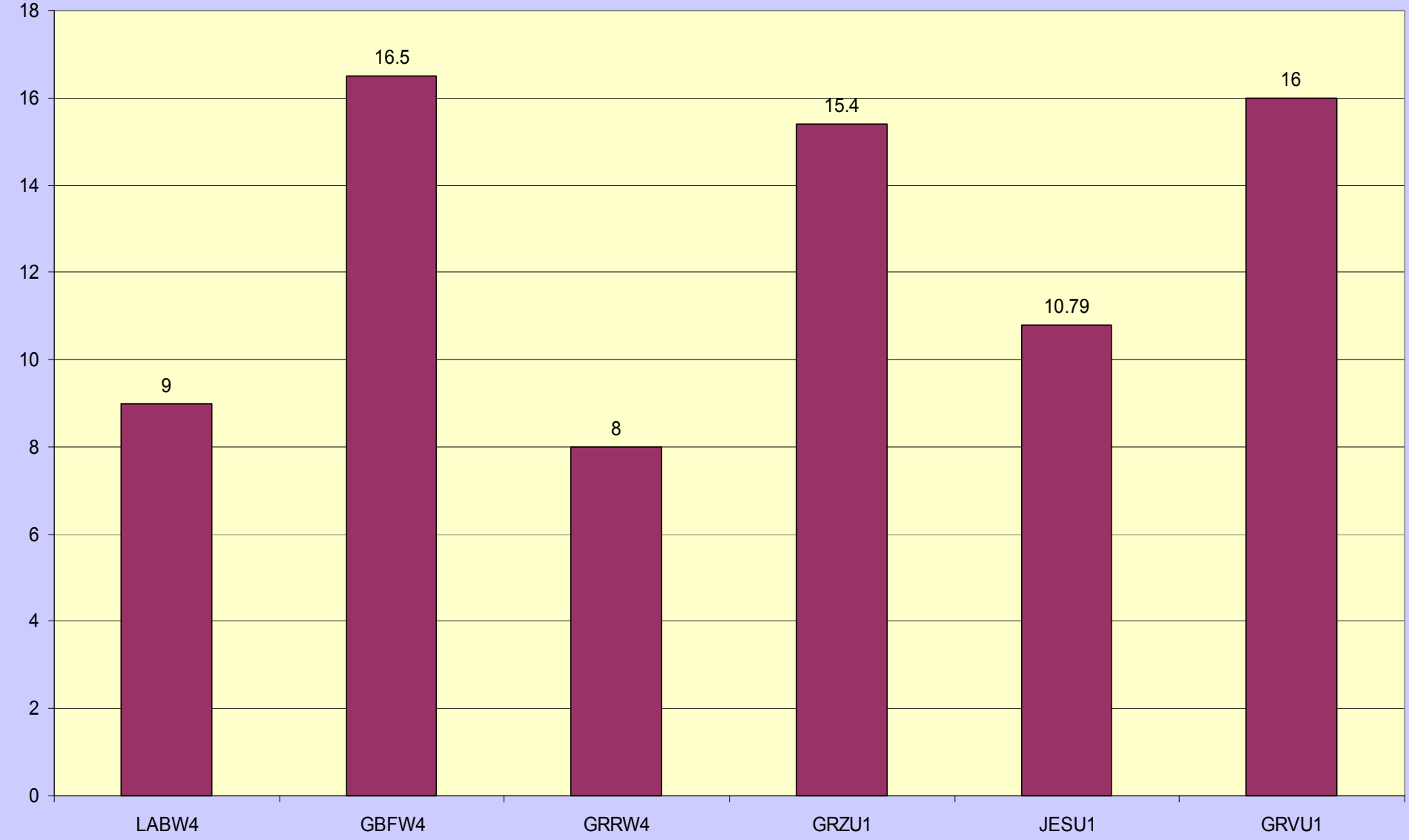
Green River Flood Stage from E-19's
upstream to downstream,i.e., drainage area increases from left to right



No obvious pattern.

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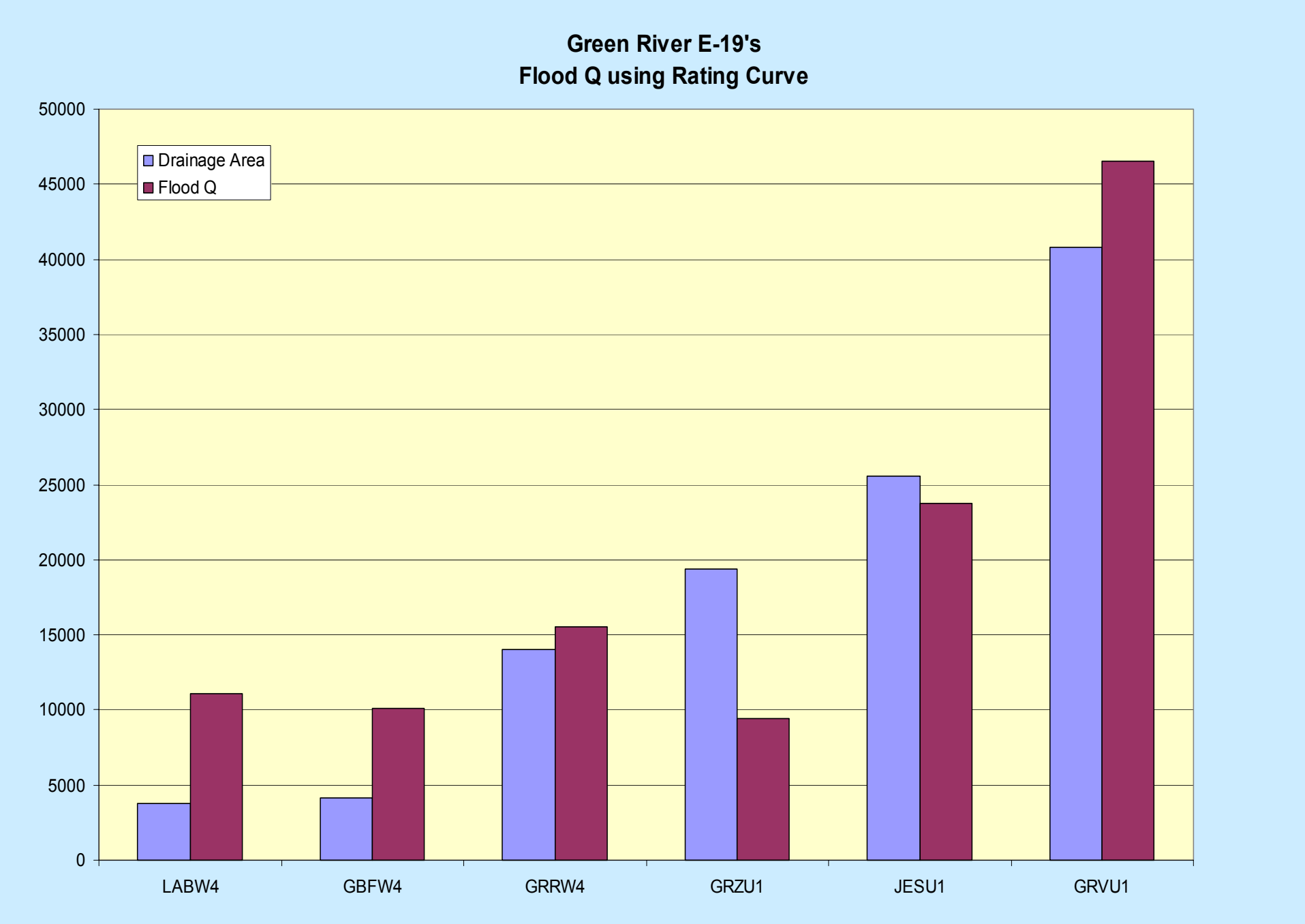

Pattern followed by 66% of sites.

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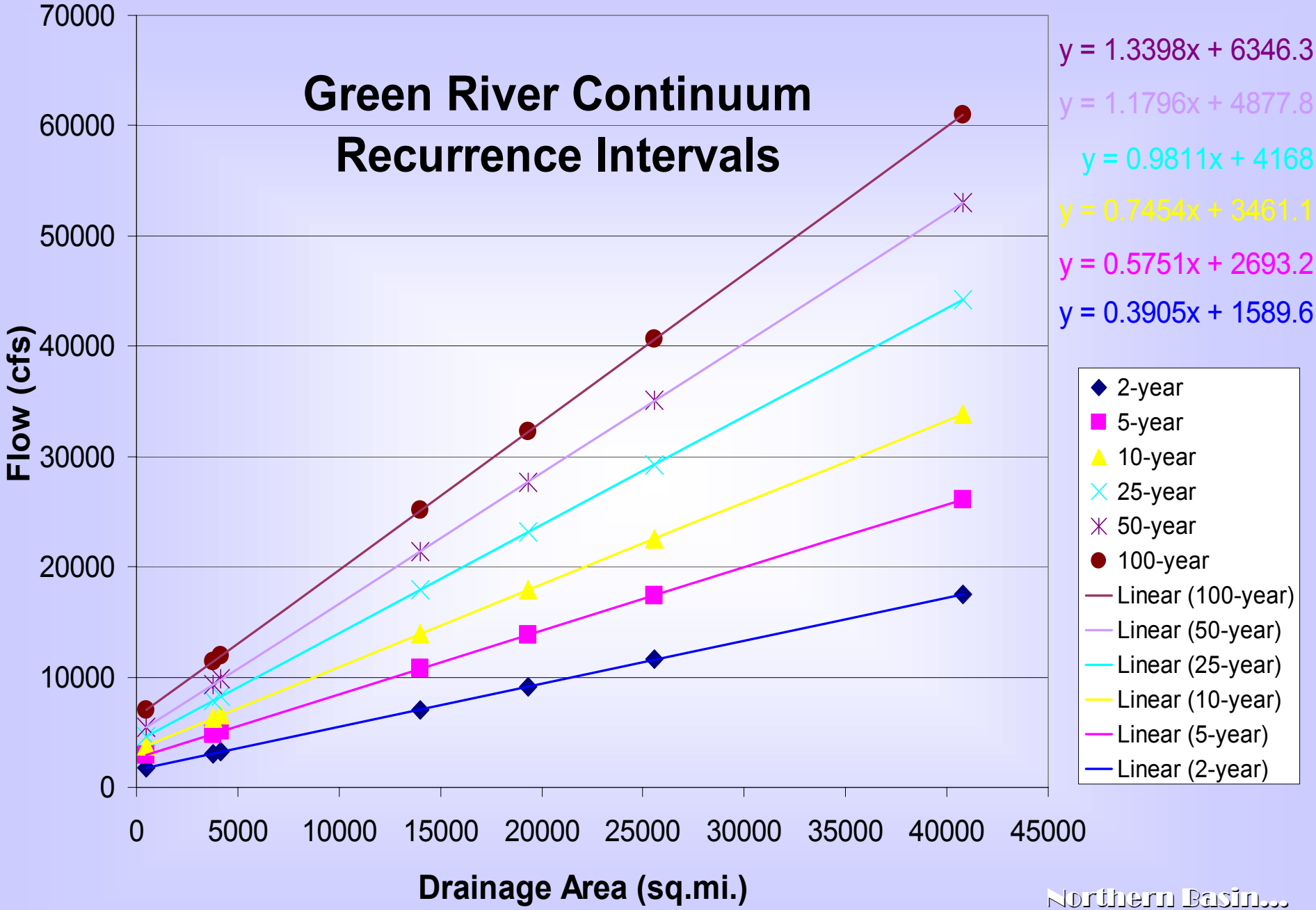

Northern Basin...

Each stream is unique, yet there is a logical a pattern.

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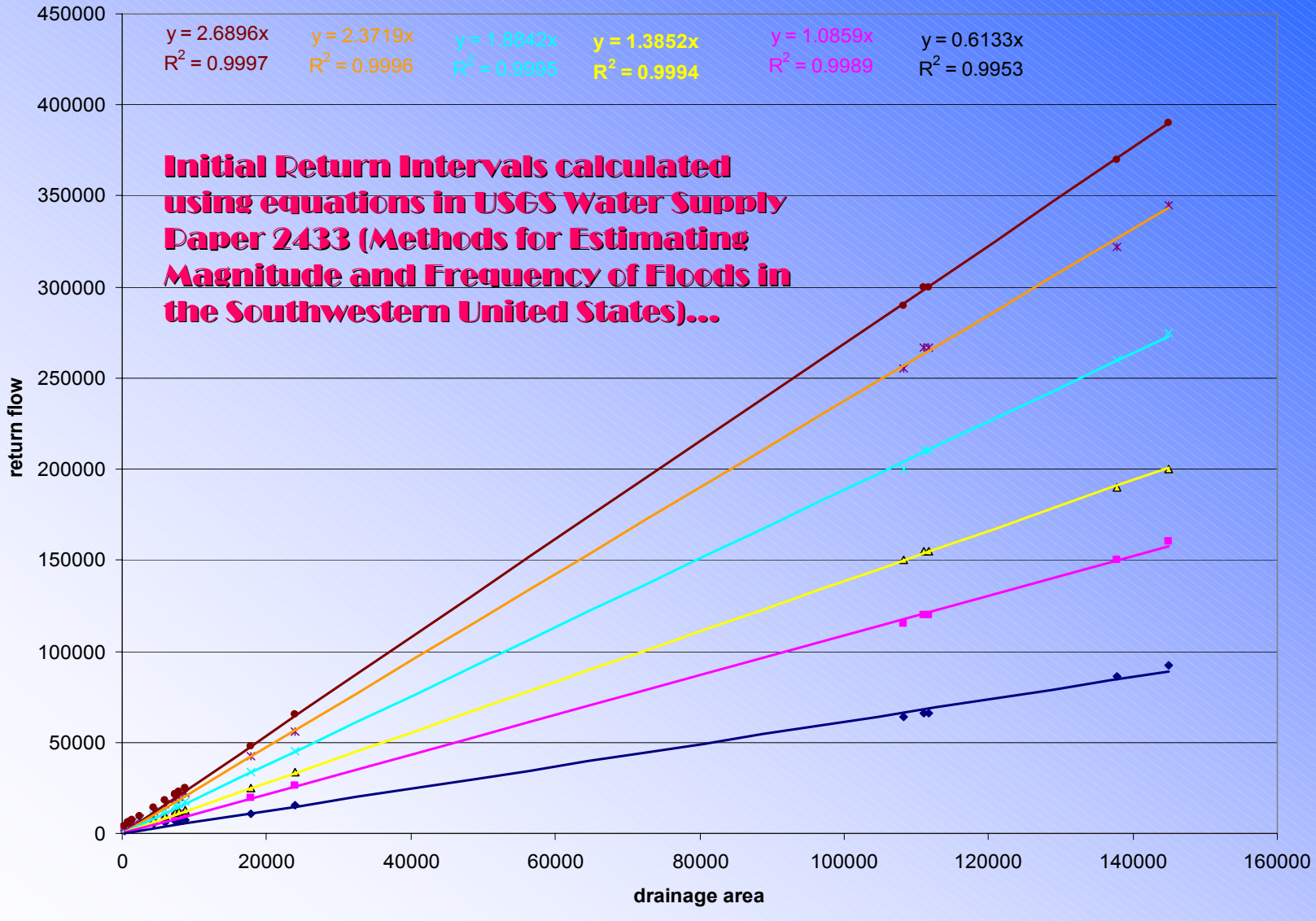
Colorado River Continuum



Goal: flow should increase as you move downstream; had to adjusted 8 of the 19 sites (42%); all major rivers should be checked; but this will take time. All drainage areas > 300 sq. mi.

Large Basin...

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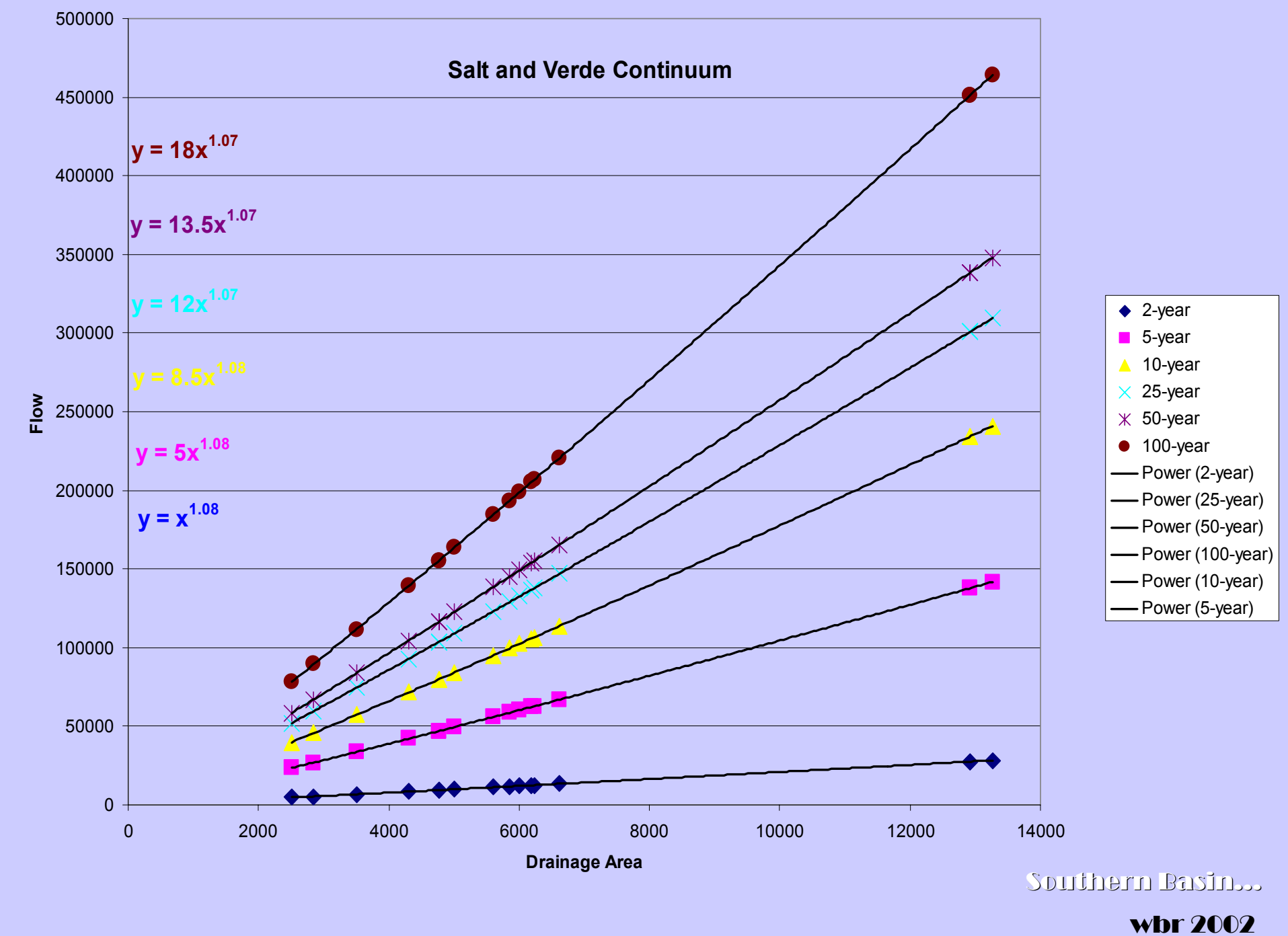

Southern Basin...

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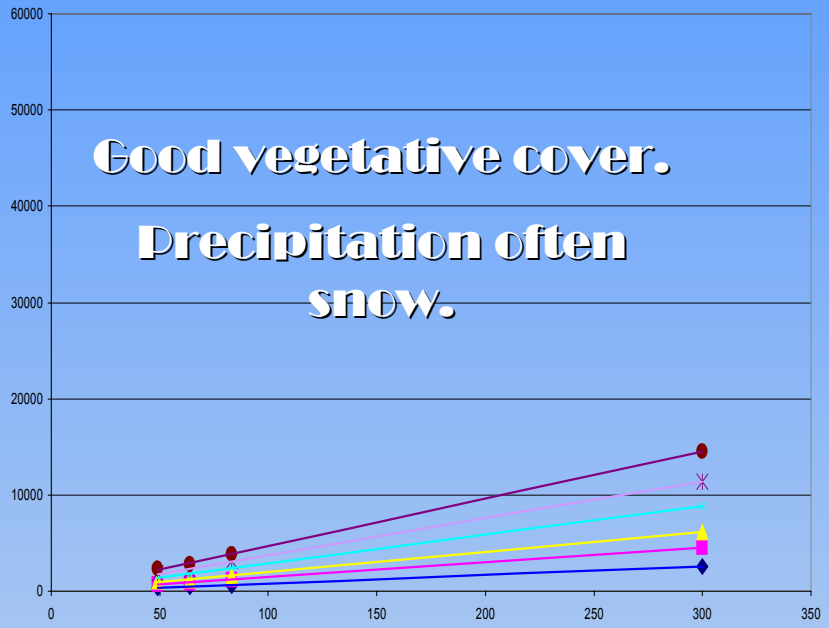
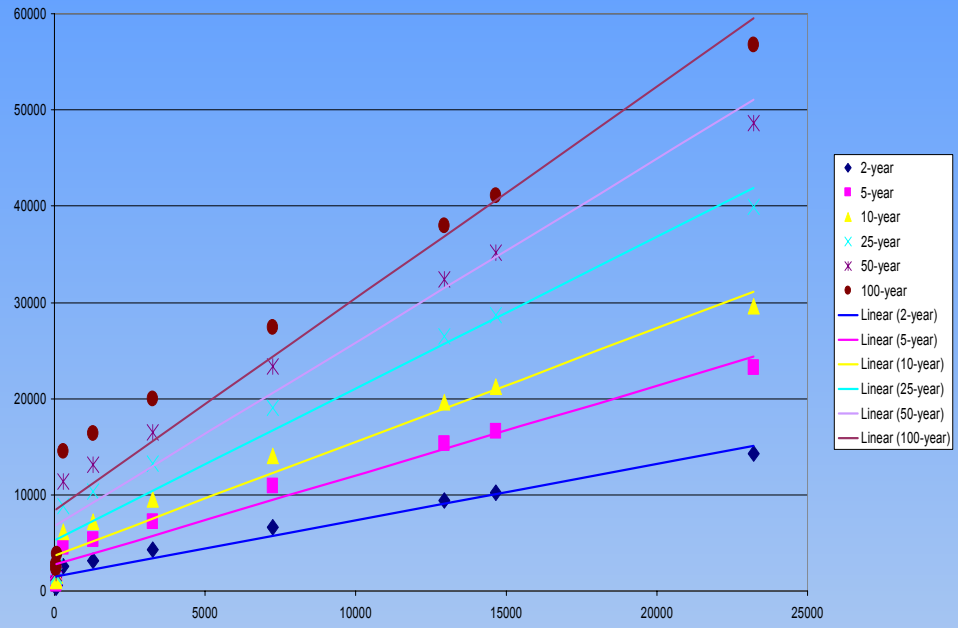
San Juan < or = 300 sq miles



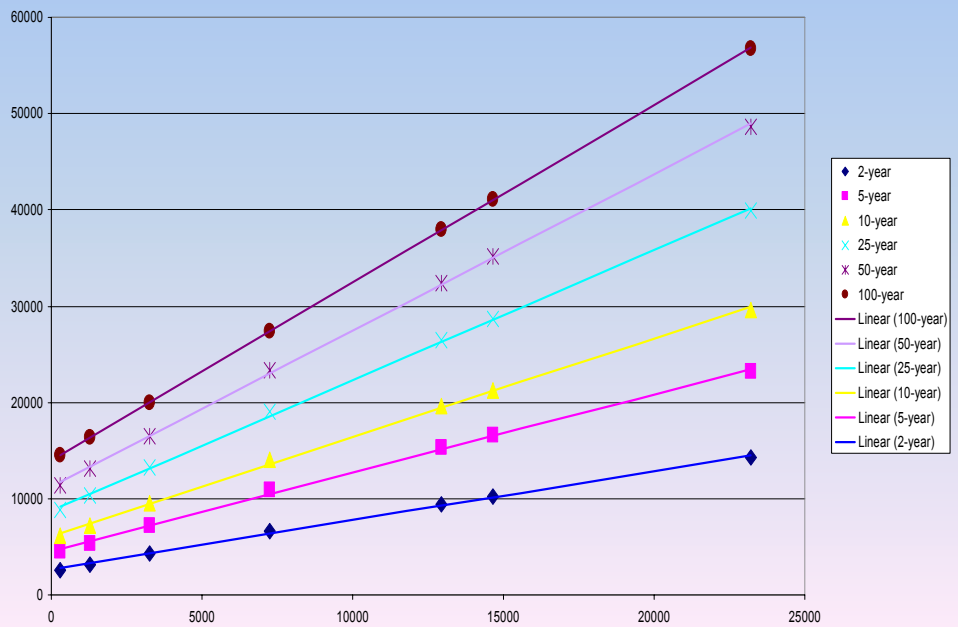
Good vegetative cover.

Precipitation often snow.

San Juan Continuum



San Juan > or = 300 sq miles



San Juan Continuum

Break in slope of relationships at 300 square miles (elevation 7000 feet). Had to adjust 4 of the 11 sites (36%).

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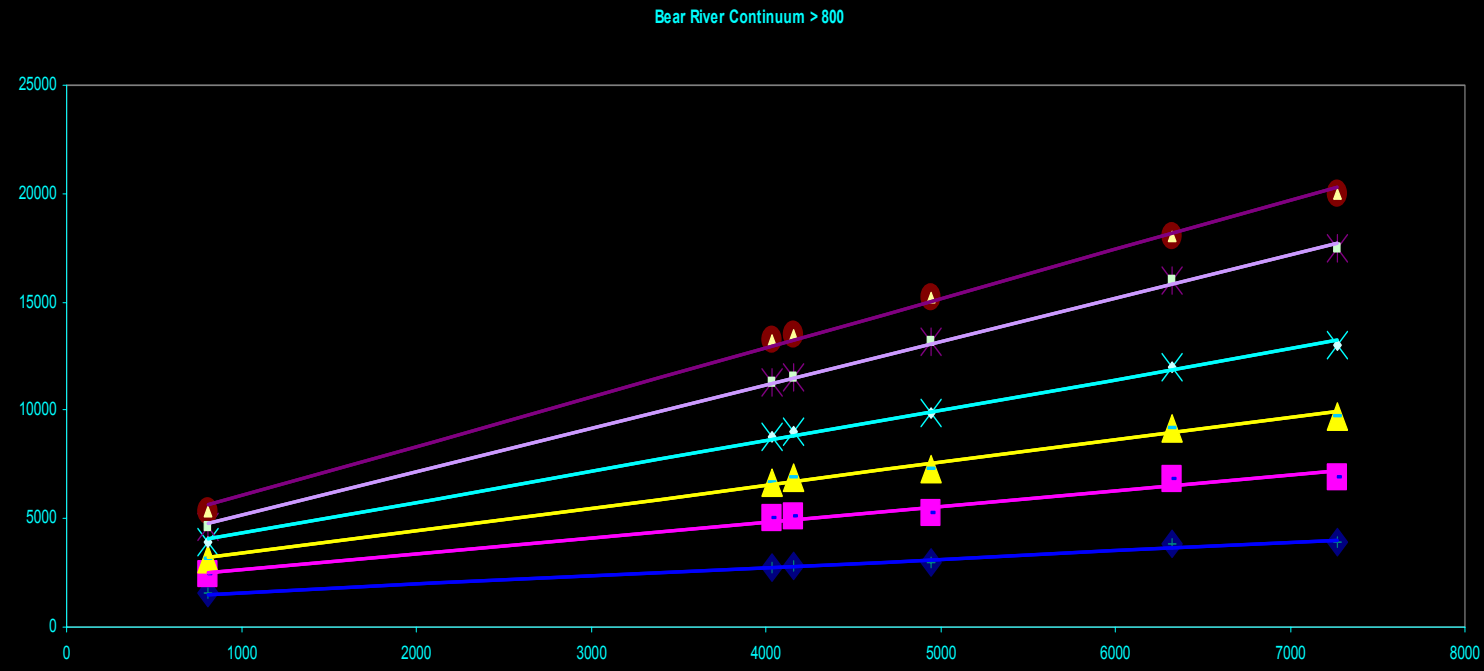
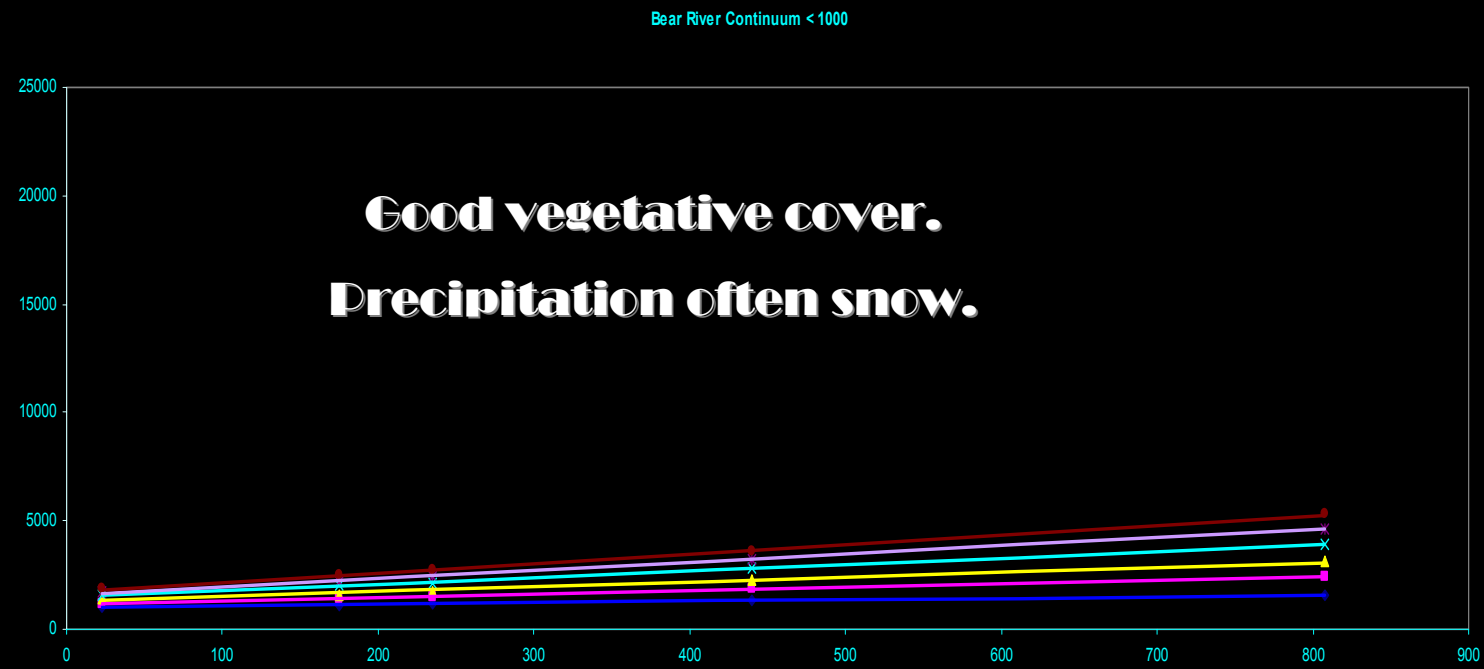


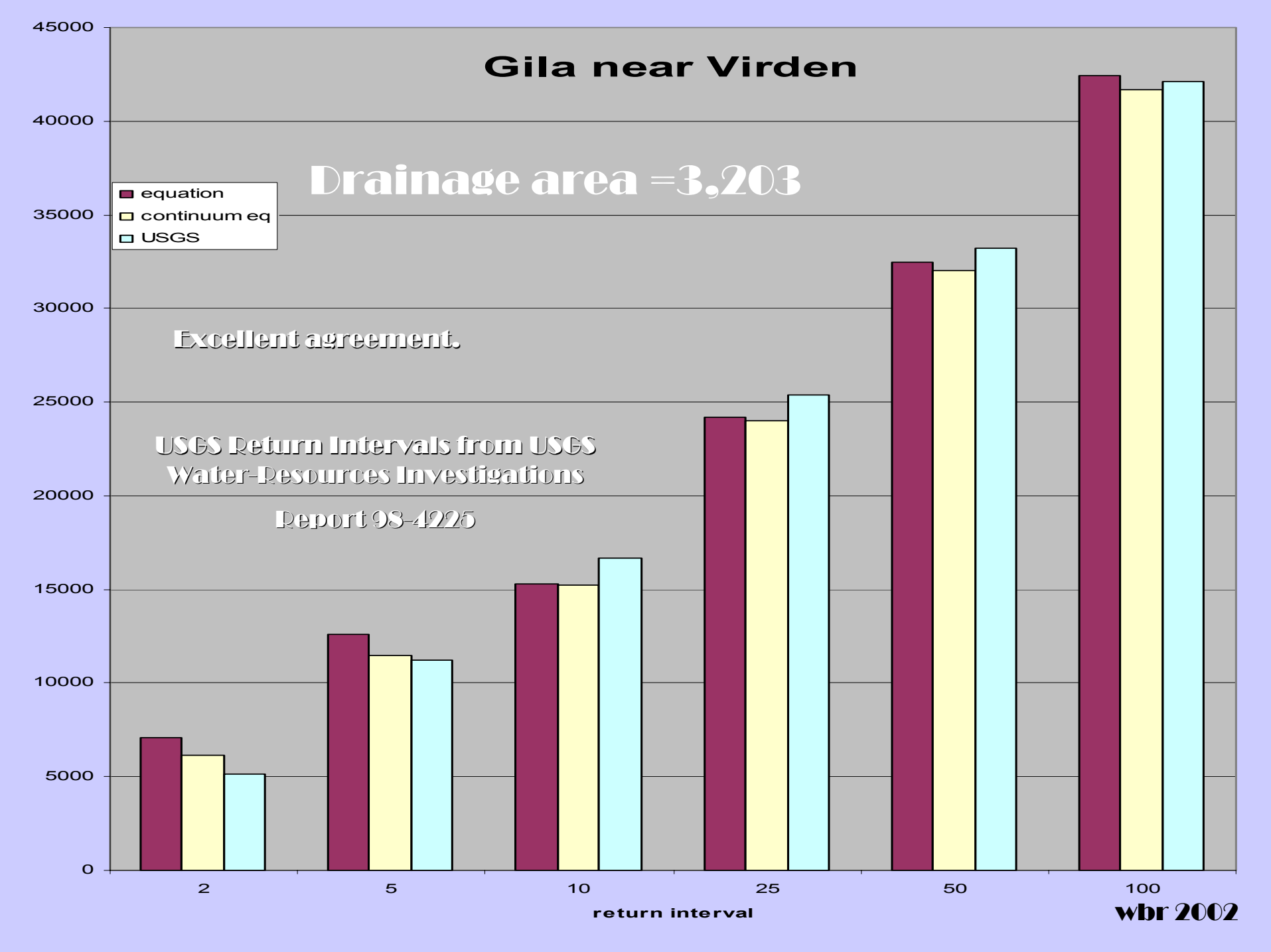
Bear River Continuum

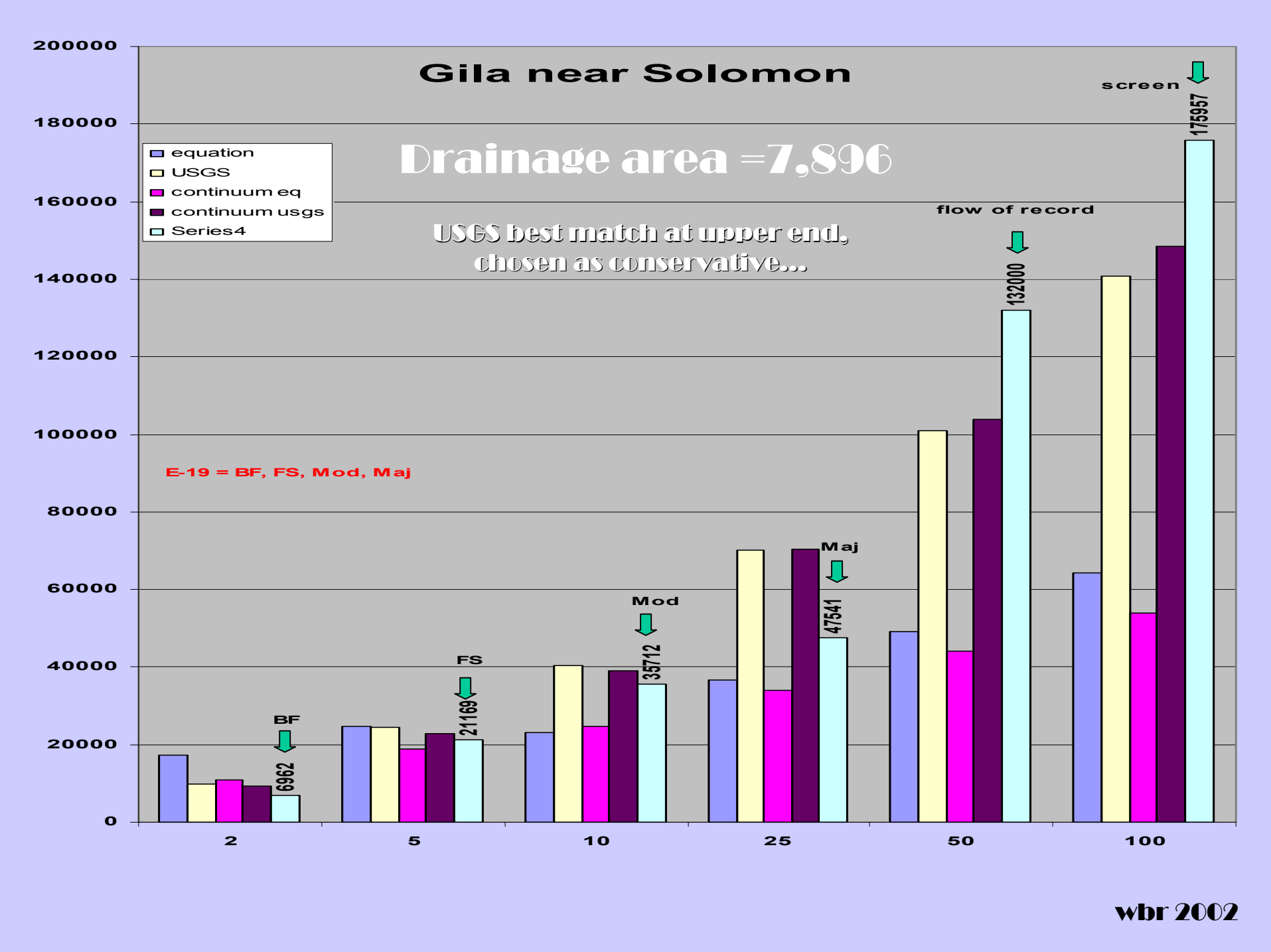


Good vegetative cover.

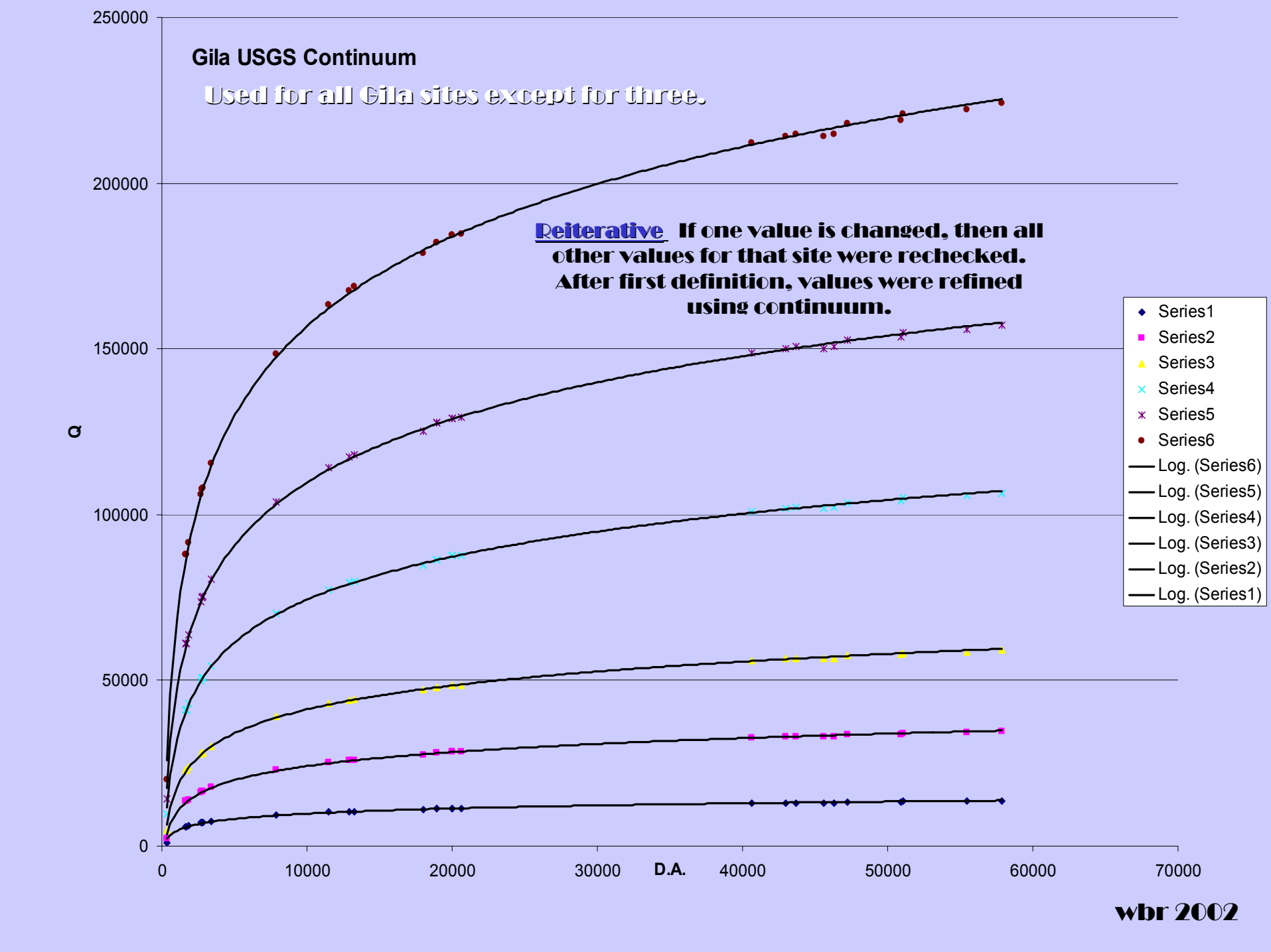
Precipitation often snow.

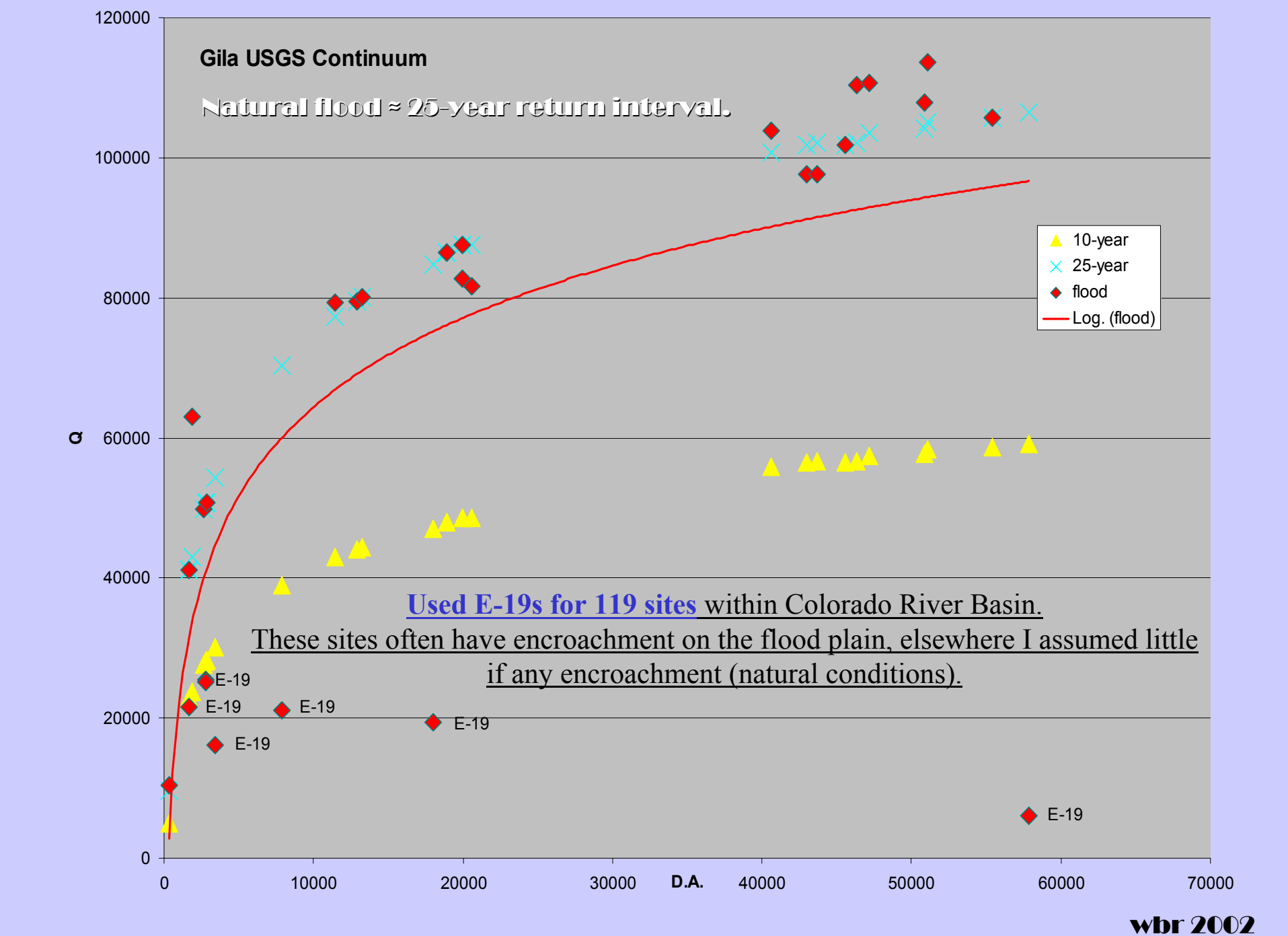
Another example of break in slope (elevation 6500 feet).


Gila near Virden
Drainage area =3,203
equation
continuum eq
USGS
Excellent agreement.
USGS Return Intervals from USGS
Water-Resources Investigations
Report 98-4225
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
2
5
10
25
50
100
return interval
wbr 2002


Gila near Solomon
Drainage area =7,896
USGS best match at upper end,
chosen as conservative…
equation
USGS
continuum eq
continuum usgs
Series4
E-19 = BF, FS, Mod, Maj
BF
6962
FS
21169
Mod
35712
Maj
47541
flow of record
132000
screen
175957
200000
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
2
5
10
25
50
100

wbr 2002


Gila USGS Continuum
Used for all Gila sites except for three.
Reiterative If one value is changed, then all other values for that site were rechecked. After first definition, values were refined using continuum.
Q
D.A.
250000
200000
150000
100000
50000
0
0
10000
20000
30000
40000
50000
60000
70000
Series1
Series2
Series3
Series4
Series5
Series6
Log. (Series6)
Log. (Series5)
Log. (Series4)
Log. (Series3)
Log. (Series2)
Log. (Series1)
wbr 2002


Gila USGS Continuum
Natural flood ≈ 25-year return interval.
10-year
25-year
flood
Log. (flood)
Q
D.A.
120000
100000
80000
60000
40000
20000
0
0
10000
20000
30000
40000
50000
60000
70000
E-19
E-19
E-19
E-19
E-19
E-19
Used E-19s for 119 sites within Colorado River Basin.
These sites often have encroachment on the flood plain, elsewhere I assumed little if any encroachment (natural conditions).

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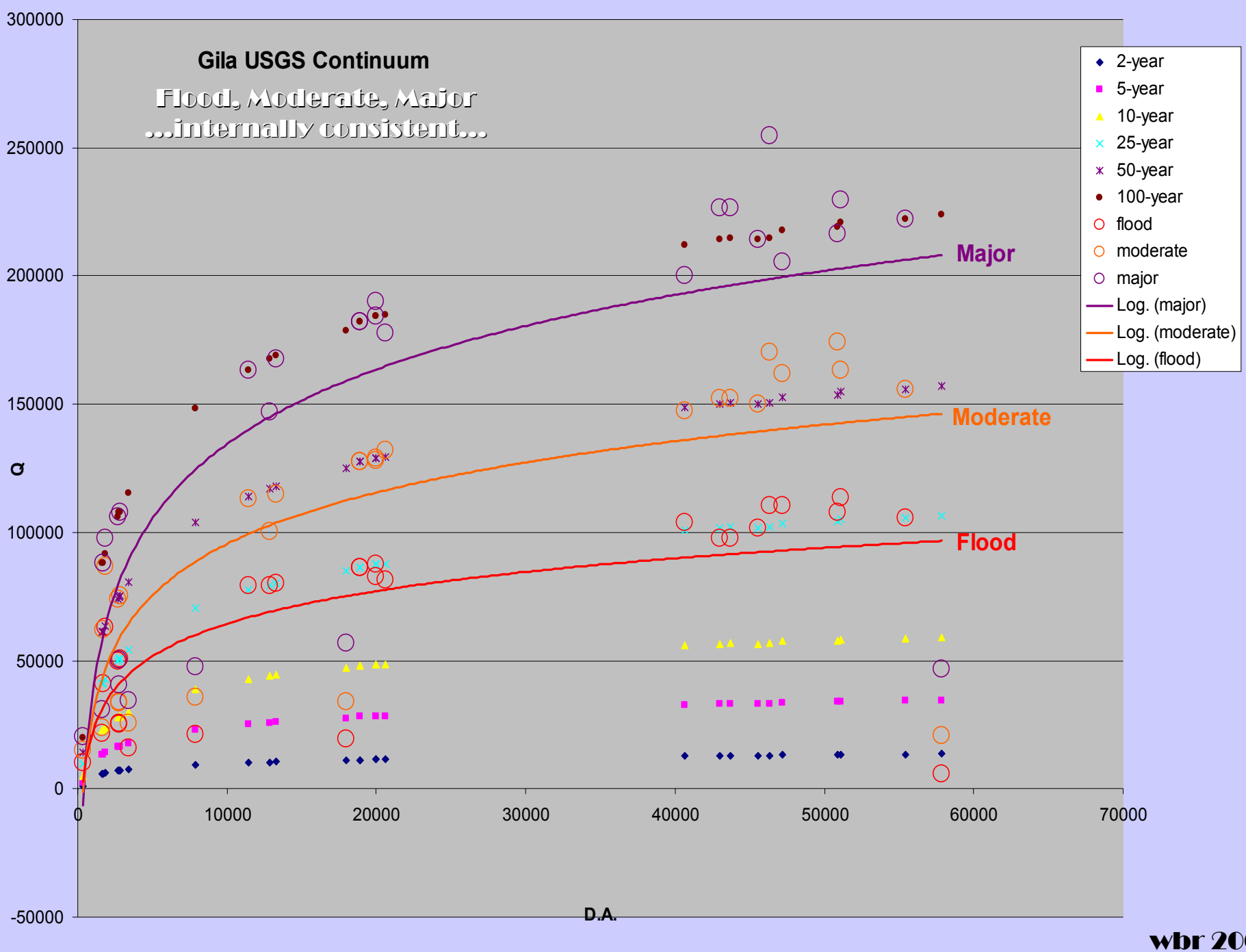
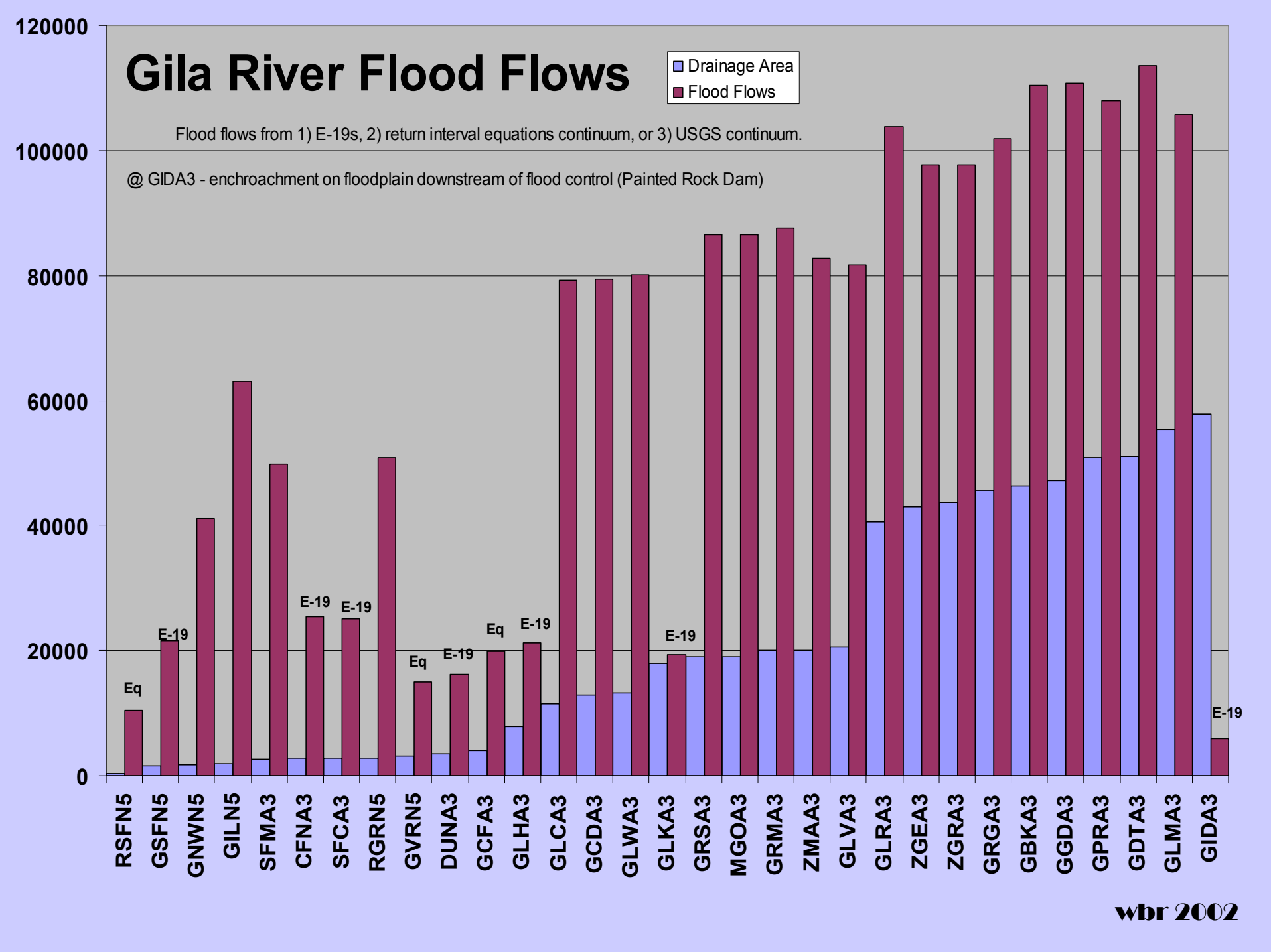
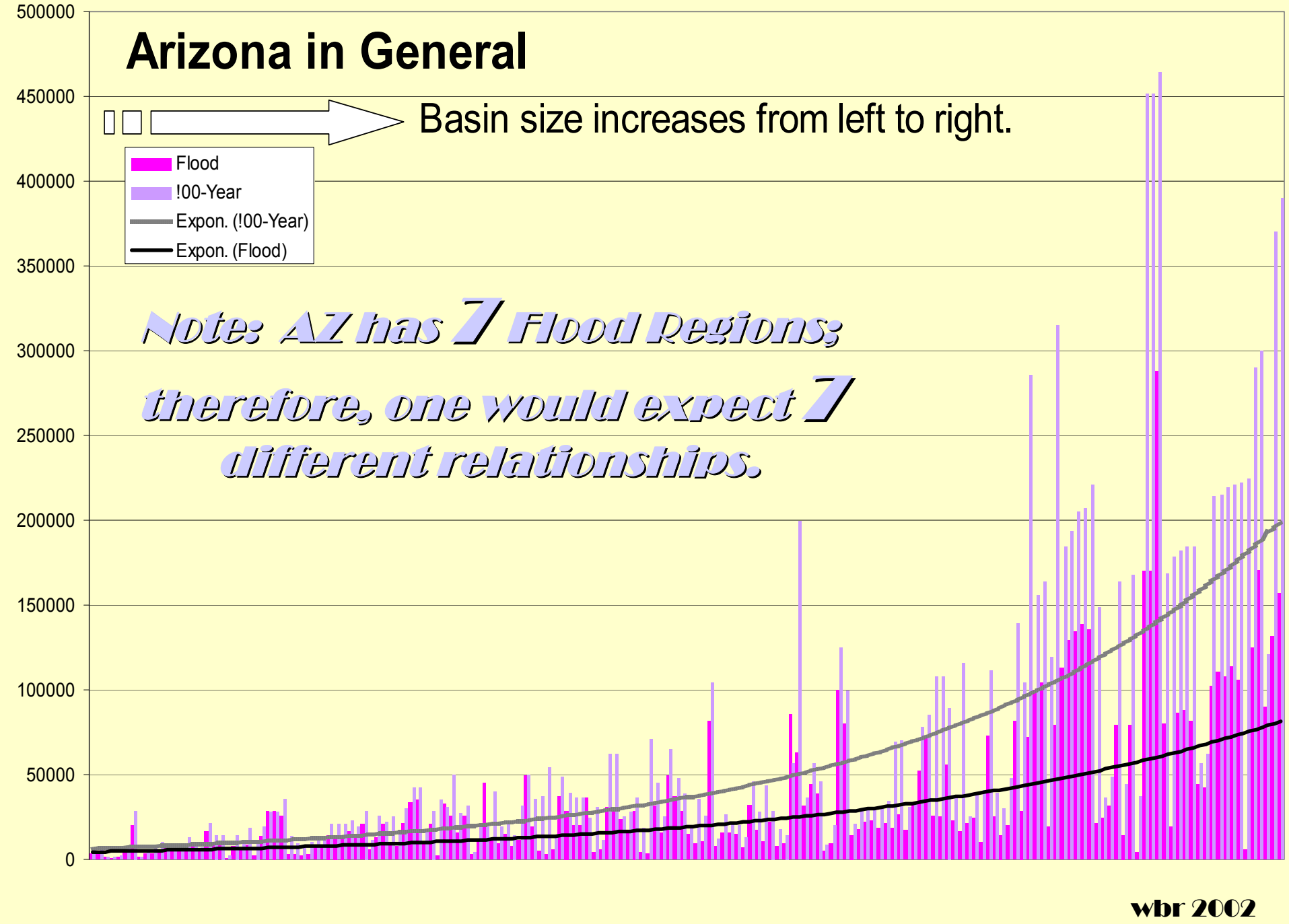
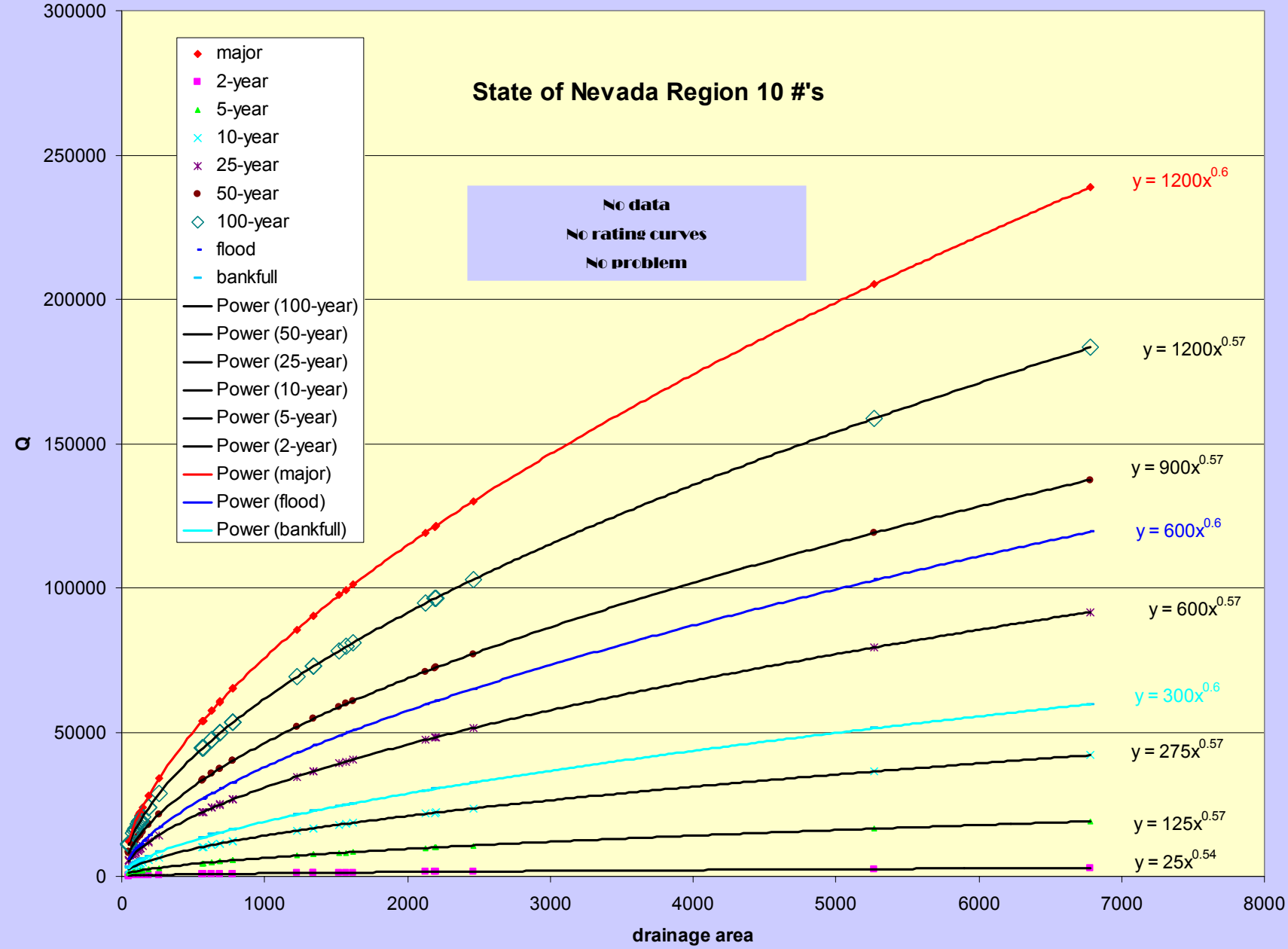

Gila USGS Continuum
Flood, Moderate, Major
...internally consistent...
2-year
5-year
10-year
25-year
50-year
100-year
flood
moderate
major
Log. (major)
Log. (moderate)
Log. (flood)
Major
Moderate
Flood
Q
D.A.
300000
250000
200000
150000
100000
50000
0
-50000
0
10000
20000
30000
40000
50000
60000
70000

wbr 2002


Gila River Flood Flows
Drainage Area
Flood Flows
Flood flows from 1) E-19s, 2) return interval equations continuum, or 3) USGS continuum.
@ GIDA3 - enchroachment on floodplain downstream of flood control (Painted Rock Dam)
120000
100000
80000
60000
40000
20000
0
Eq
E-19
E-19
E-19
Eq
E-19
Eq
E-19
E-19
E-19
RSFN5
GSFN5
GNWN5
GILN5
SFMA3
CFNA3
SFCA3
RGRN5
GVRN5
DUNA3
GCFA3
GLHA3
GLCA3
GCDA3
GLWA3
GLKA3
GRSA3
MGOA3
GRMA3
ZMAA3
GLVA3
GLRA3
ZGEA3
ZGRA3
GRGA3
GBKA3
GGDA3
GPRA3
GDTA3
GLMA3
GIDA3
wbr 2002


Arizona in General
Basin size increases from left to right.
Flood
!00-Year
Expon. (!00-Year)
Expon. (Flood)
Note: AZ has 7 Flood Regions;
therefore, one would expect 7
different relationships.
500000
450000
400000
350000
300000
250000
200000
150000
100000
50000
0
wbr 2002


State of Nevada Region 10 #'s
No data
No rating curves
No problem
major
2-year
5-year
10-year
25-year
50-year
100-year
flood
bankfull
Power (100-year)
Power (50-year)
Power (25-year)
Power (10-year)
Power (5-year)
Power (2-year)
Power (major)
Power (flood)
Power (bankfull)
y = 1200x^0.6
y = 1200x^0.57
y = 900x^0.57
y = 600x^0.6
y = 600x^0.57
y = 300x^0.6
y = 275x^0.57
y = 125x^0.57
y = 25x^0.54
Q
drainage area
0
50000
100000
150000
200000
250000
300000
0
1000
2000
3000
4000
5000
6000
7000
8000

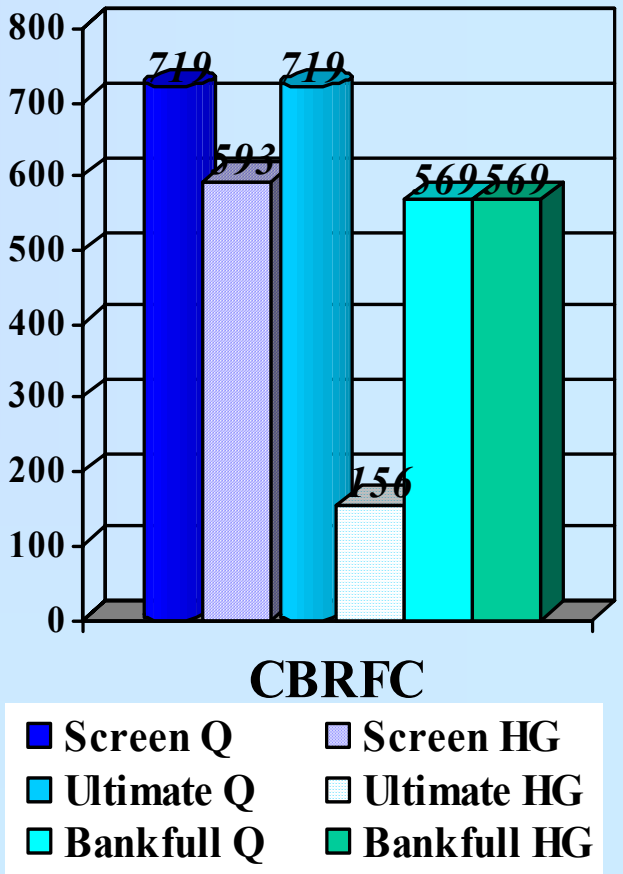
wbr 2002

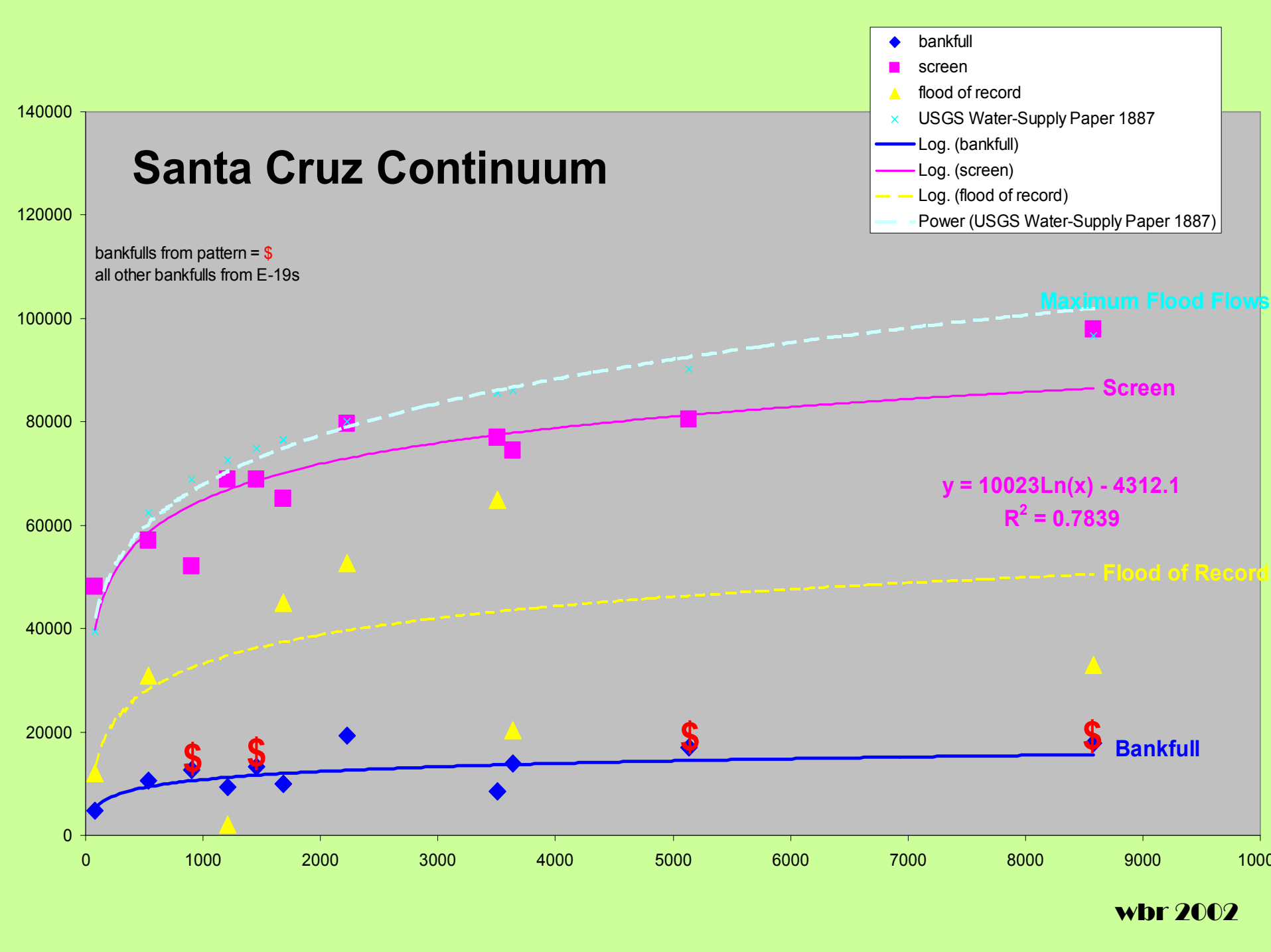
Bankfull, Screen, Scr Rate, and the Ultimate Screen Story

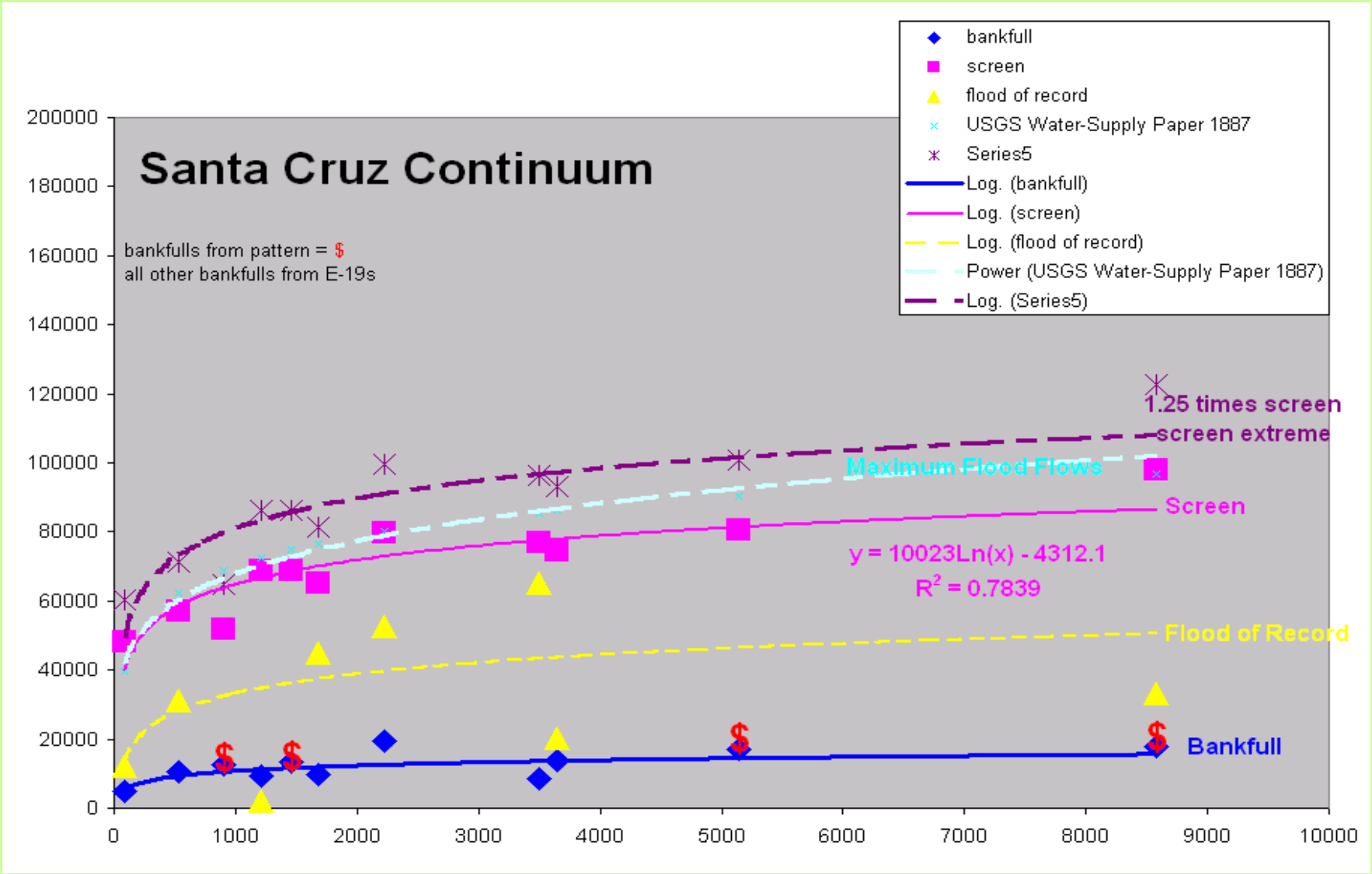
- **bank_hg determined** using patterns, e.g., the difference between flood_hg and moderate_hg is subtracted from flood_hg
- **bank_q determined** from rating curve using bank_hg and checked against expected return interval for basin size
- **screen_hg determined** using patterns, e.g., the difference between moderate_hg and major_hg is added to major_hg
- **screen_q determined** from rating curve using screen_hg and checked against 100 yr q eqn
- **screen_rate_q** = (screen_q)/3
- **screen_rate_hg** = (screen_hg)/2
- **sig_rate_hg** = (screen_rate_hg)/2
- **sig_rate_q** = (bank_q)/2
- screen_rate_q2 = (screen_q)/2
- screen_rate_q0 = |(sig_rate_q)+(screen_rate_q)|/2
- Nevada, Idaho, Wyoming, Colorado, New Mexico: done

Conservative
Internally Consistent
Reiterative

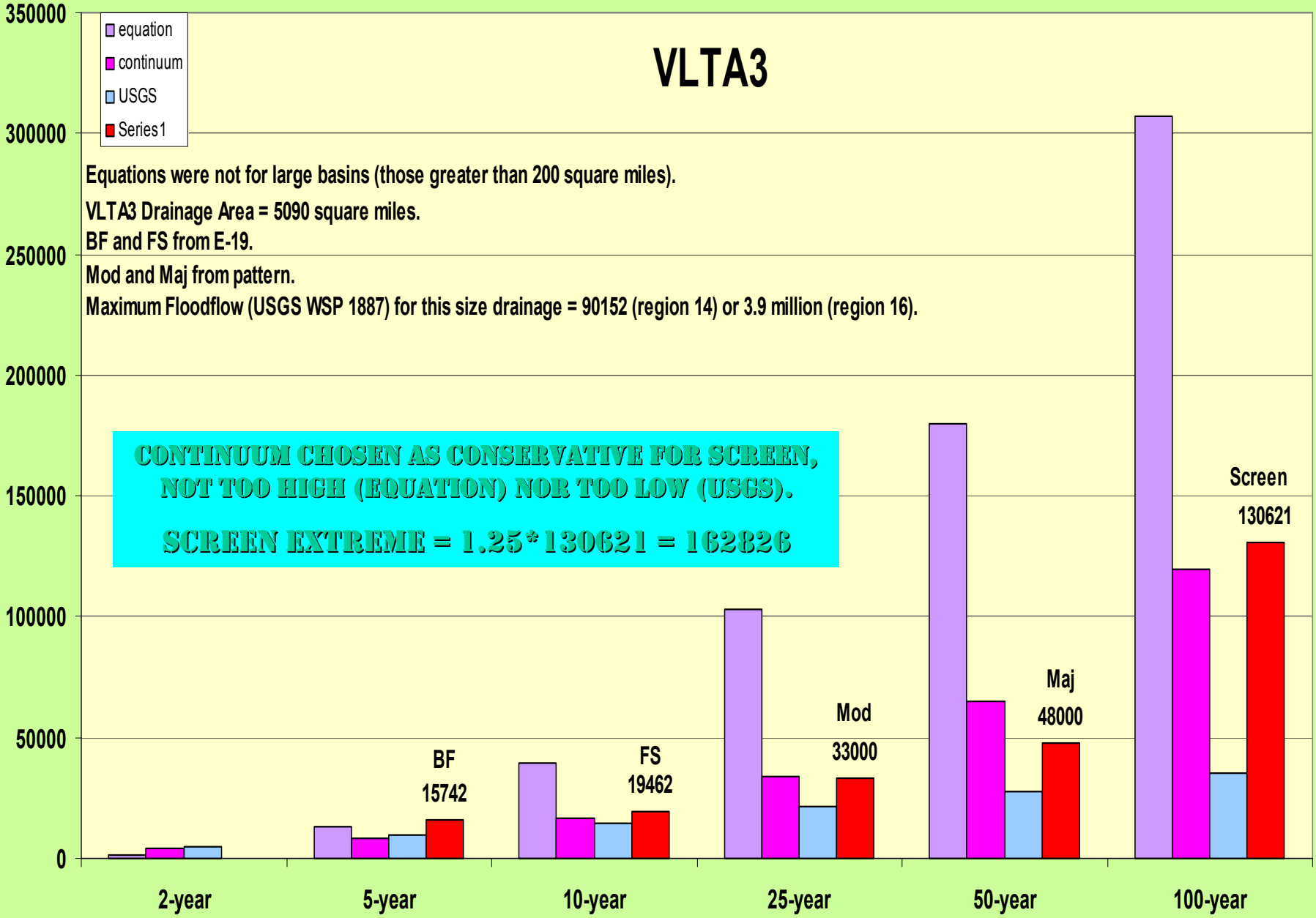
Sig Rate



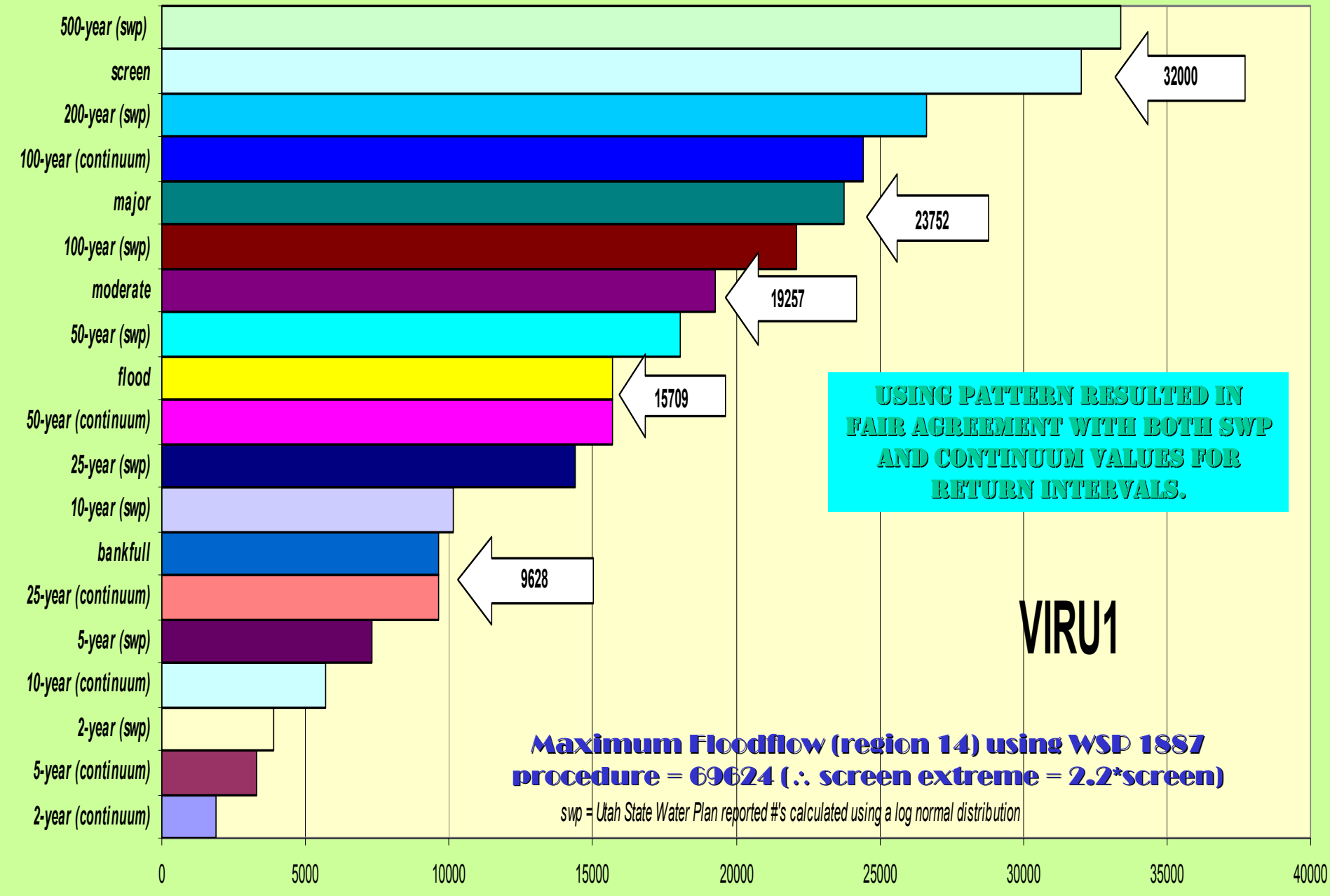

Santa Cruz Continuum
bankfull
screen
flood of record
USGS Water-Supply Paper 1887
Log. (bankfull)
Log. (screen)
Log. (flood of record)
Power (USGS Water-Supply Paper 1887)
bankfulls from pattern = $
all other bankfulls from E-19s
Maximum Flood Flows
Screen
y = 10023Ln(x) - 4312.1
R2 = 0.7839
Flood of Record
Bankfull
140000
120000
100000
80000
60000
40000
20000
0
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
wbr 2002


Santa Cruz Continuum
bankfulls from pattern = $
all other bankfulls from E-19s
bankfull
screen
flood of record
USGS Water-Supply Paper 1887
Series5
Log. (bankfull)
Log. (screen)
Log. (flood of record)
Power (USGS Water-Supply Paper 1887)
Log. (Series5)
1.25 times screen
screen extreme
Maximum Flood Flows
Screen
y = 10023Ln(x) - 4312.1
R² = 0.7839
Flood of Record
Bankfull
200000
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000

wbr 2002


VLTA3
equation
continuum
USGS
Series1
Equations were not for large basins (those greater than 200 square miles).
VLTA3 Drainage Area = 5090 square miles.
BF and FS from E-19.
Mod and Maj from pattern.
Maximum Floodflow (USGS WSP 1887) for this size drainage = 90152 (region 14) or 3.9 million (region 16).
CONTINUUM CHOSEN AS CONSERVATIVE FOR SCREEN, NOT TOO HIGH (EQUATION) NOR TOO LOW (USGS).
SCREEN EXTREME = 1.25*130621 = 162826
350000
300000
250000
200000
150000
100000
50000
0
BF
15742
FS
19462
Mod
33000
Maj
48000
Screen
130621
2-year
5-year
10-year
25-year
50-year
100-year

wbr 2002


500-year (swp)
screen
200-year (swp)
100-year (continuum)
major
100-year (swp)
moderate
50-year (swp)
flood
50-year (continuum)
25-year (swp)
10-year (swp)
bankfull
25-year (continuum)
5-year (swp)
10-year (continuum)
2-year (swp)
5-year (continuum)
2-year (continuum)
32000
23752
19257
15709
9628
0
5000
10000
15000
20000
25000
30000
35000
40000
USING PATTERN RESULTED IN FAIR AGREEMENT WITH BOTH SWP AND CONTINUUM VALUES FOR RETURN INTERVALS.
VIRU1
Maximum Floodflow (region 14) using WSP 1887 procedure = 69624 (∴ screen extreme = 2.2*screen)
swp = Utah State Water Plan reported #'s calculated using a log normal distribution

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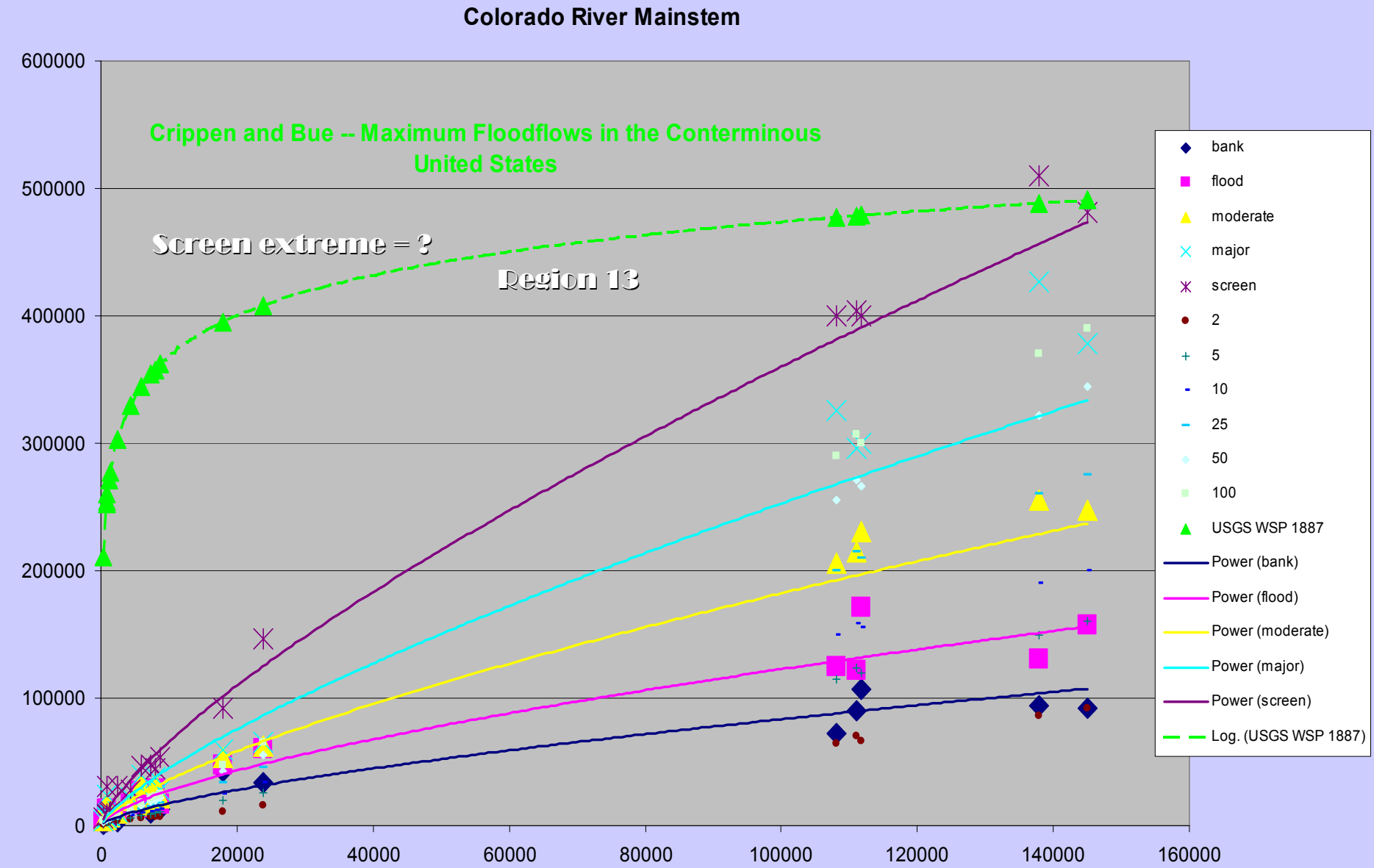

Bank, Flood, Moderate, Major, Screen . . .

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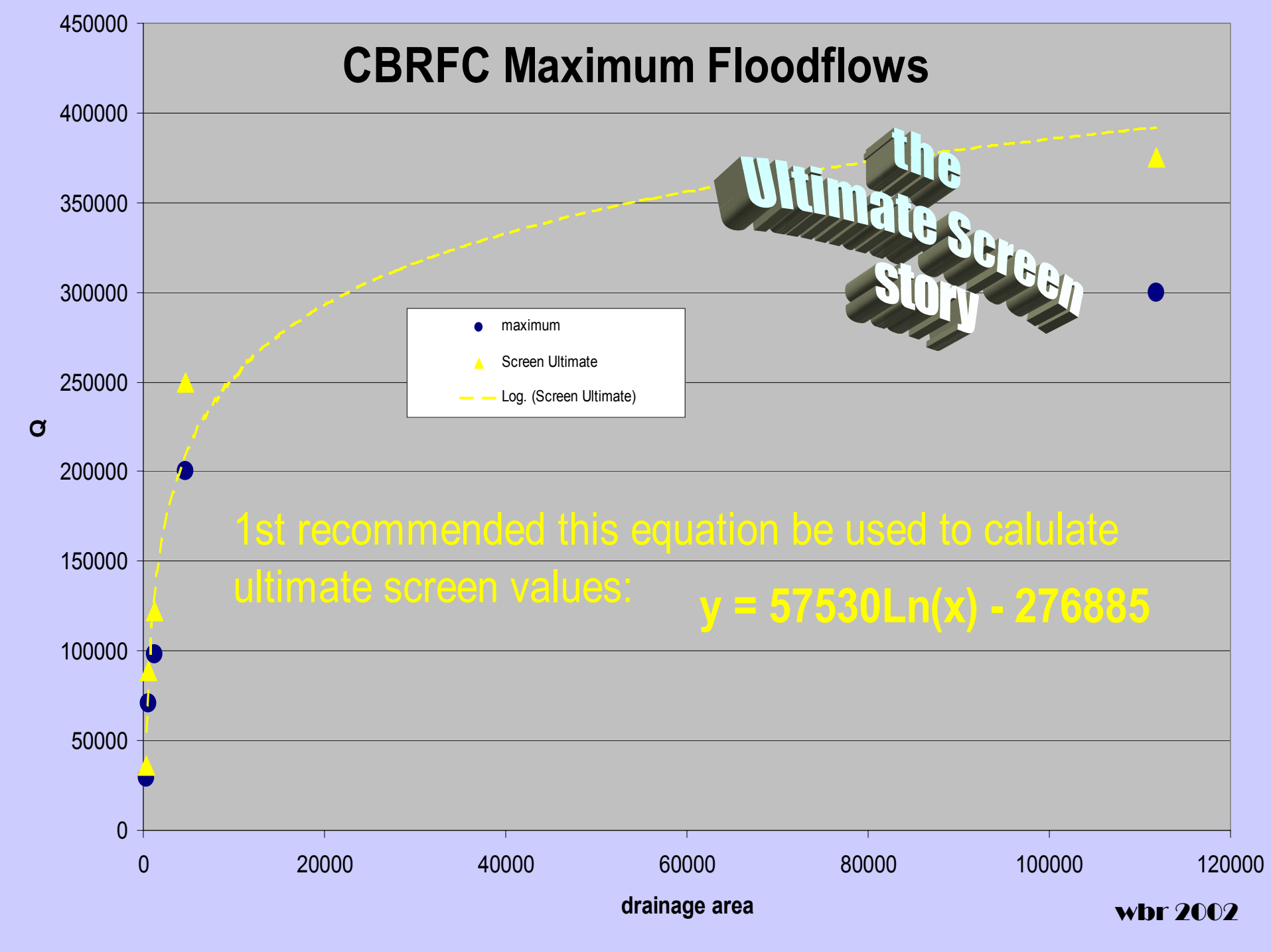
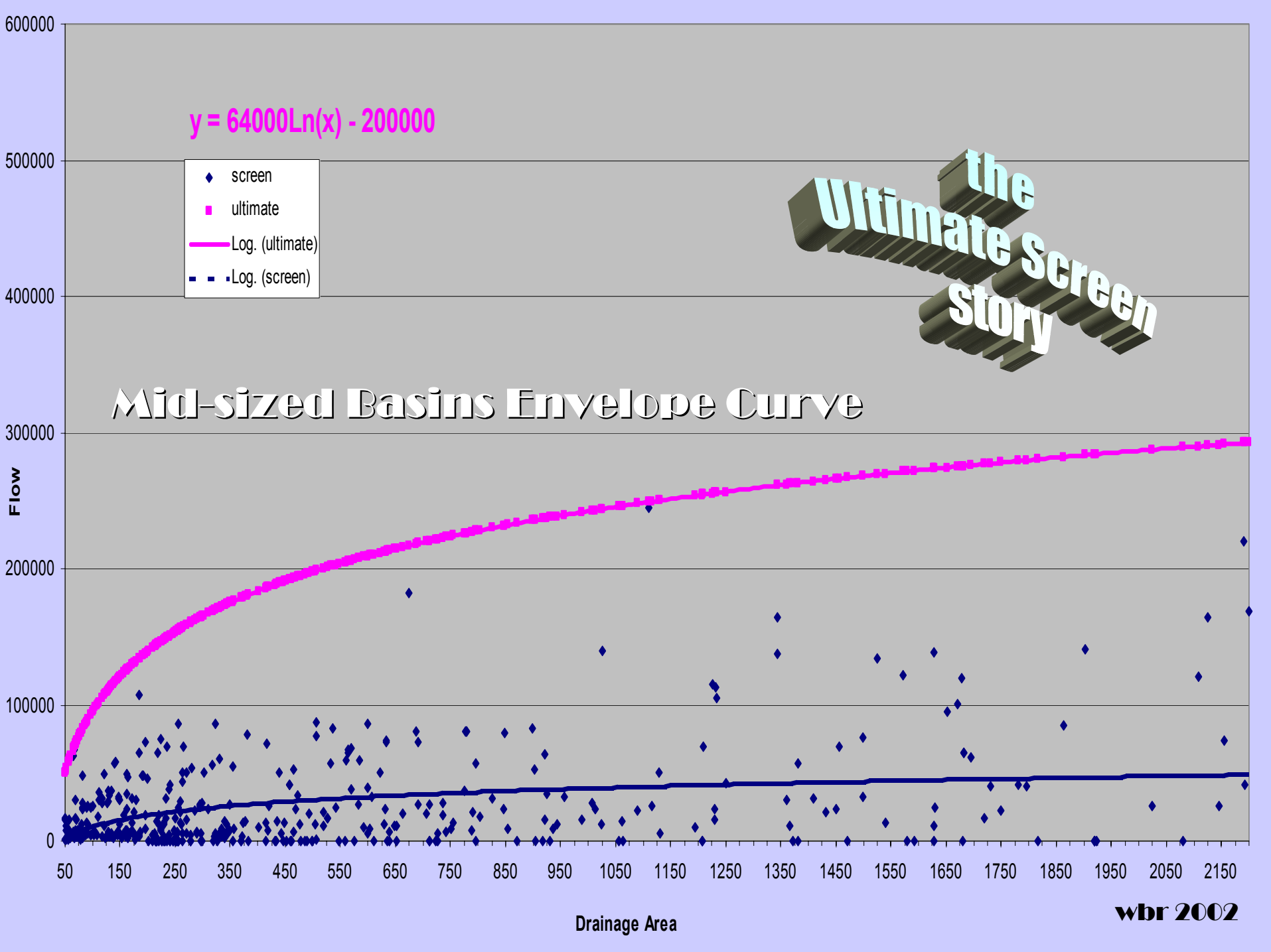
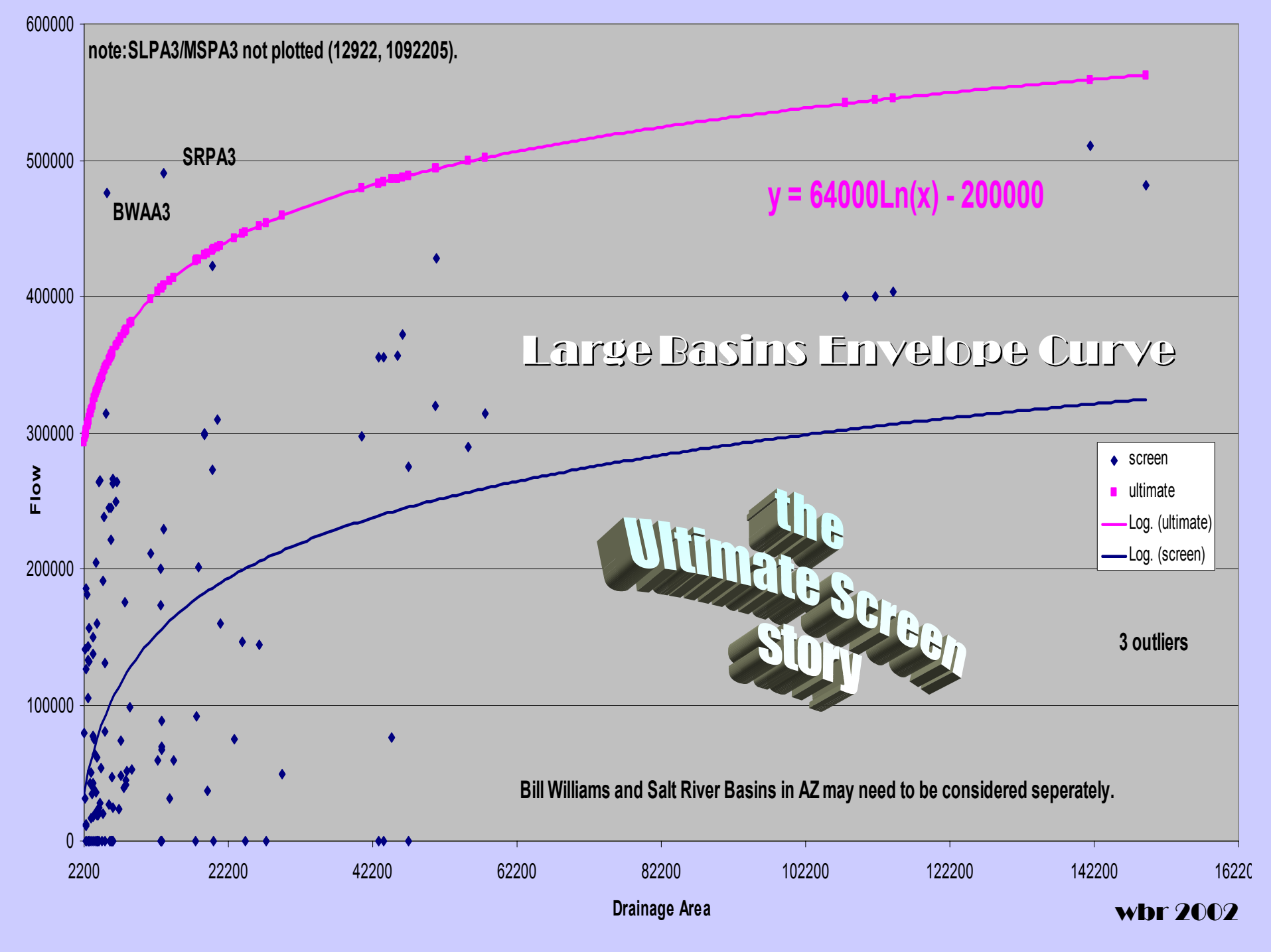
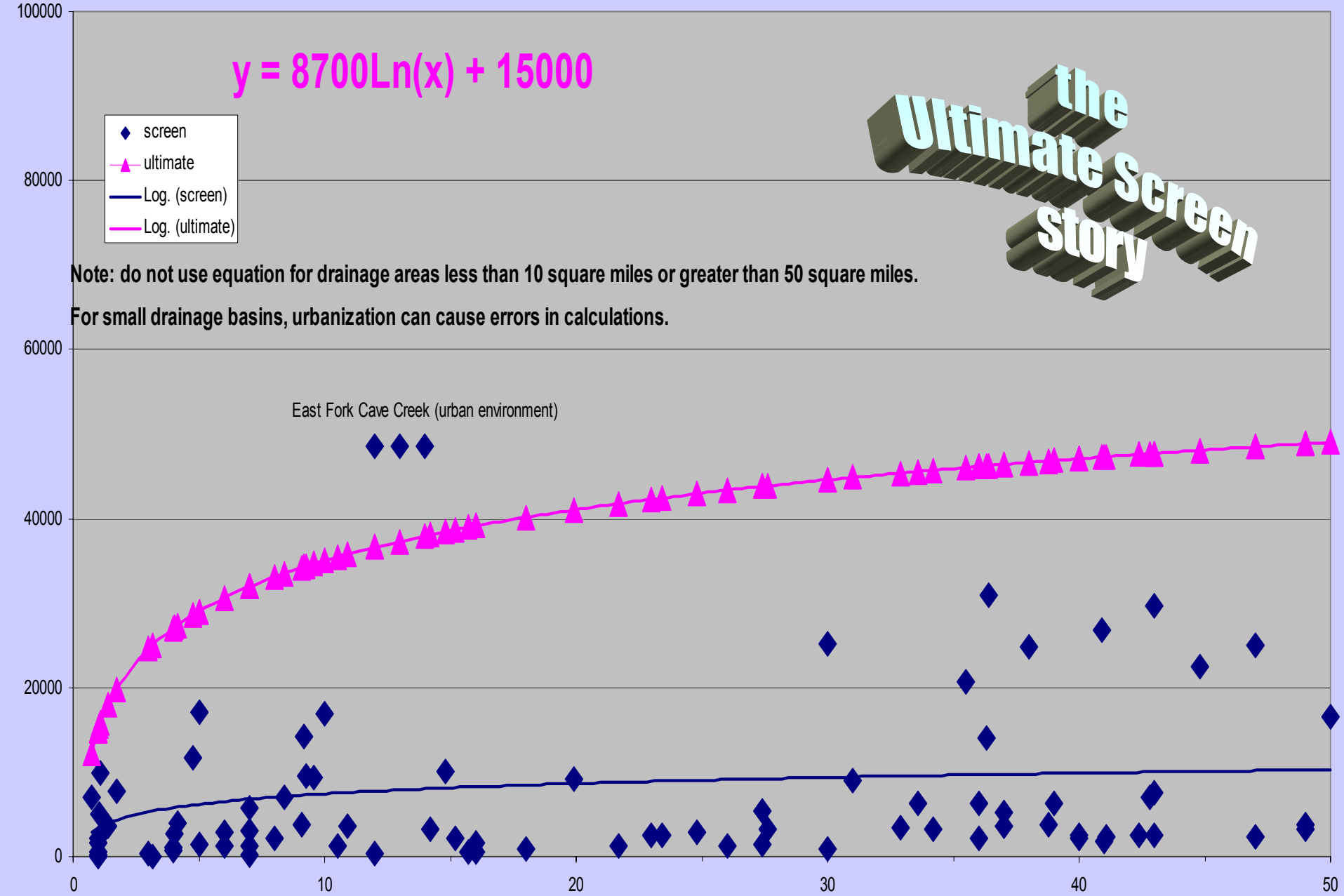

CBRFC Maximum Floodflows
the Ultimate Screen Story
maximum
Screen Ultimate
Log. (Screen Ultimate)
1st recommended this equation be used to calulate ultimate screen values:
y = 57530Ln(x) - 276885
Q
drainage area
450000
400000
350000
300000
250000
200000
150000
100000
50000
0
0
20000
40000
60000
80000
100000
120000
wbr 2002


y = 64000Ln(x) - 200000
screen
ultimate
Log. (ultimate)
Log. (screen)
the Ultimate Screen Story
Mid-sized Basins Envelope Curve
Flow
Drainage Area
600000
500000
400000
300000
200000
100000
0
50
150
250
350
450
550
650
750
850
950
1050
1150
1250
1350
1450
1550
1650
1750
1850
1950
2050
2150
wbr 2002


note:SLPA3/MSPA3 not plotted (12922, 1092205).
SRPA3
BWAA3
y = 64000Ln(x) - 200000
Large Basins Envelope Curve
the Ultimate Screen Story
screen
ultimate
Log. (ultimate)
Log. (screen)
3 outliers
Bill Williams and Salt River Basins in AZ may need to be considered seperately.
Flow
Drainage Area
600000
500000
400000
300000
200000
100000
0
2200
22200
42200
62200
82200
102200
122200
142200
wbr 2002



Small Basins Envelope Curve

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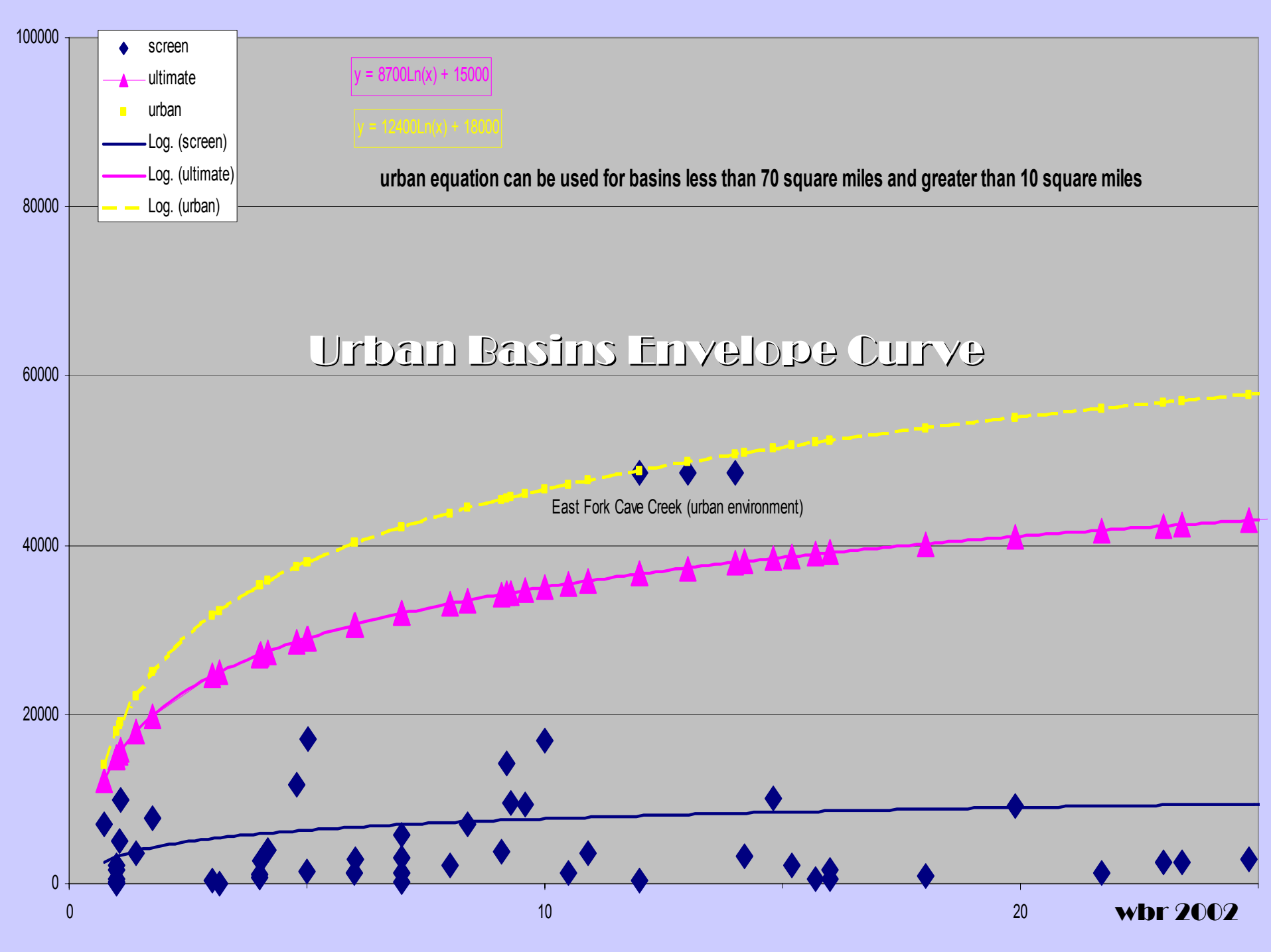
screen
ultimate
urban
Log. (screen)
Log. (ultimate)
Log. (urban)
y = 8700Ln(x) + 15000
y = 12400Ln(x) + 18000
urban equation can be used for basins less than 70 square miles and greater than 10 square miles
Urban Basins Envelope Curve
East Fork Cave Creek (urban environment)
100000
80000
60000
40000
20000
0
0
10
20
wbr 2002

Basins that did not fit and were changed:

1) AFRA3 (changed from 248775 to 300000)
2) BWPA3 (349275 to 500000)
3) BWAA3 (340221 to 400000)
4) MSPA3 (405868 to 1250000)
5) SLPA3 (405868 to 1250000)
6) SRPA3 (407535 to 550000)
7) BEVC2 (8443 to 19982)
8) DRSA3 (17287 to 53746)
9) GFHA3 (3495 to 13964)
10) MCCA3 (7960 to 48610)
11) MECA3 (7315 to 48610)
12) MEFA3 (6619 to 48610)
13) RINA3 (18079 to 45074)
14) SBCA3 (16055 to 41384)
15) TQRA3 (17722 to 60000)
16) BLRA3 (16601 to 32000)
17) HAUA3 (16485 to 32000)

18) BUKA3 (13674 to 72000)
19) CHFA3 (13004 to 26000)
20) CMWA3 (17518 TO 34000)
21) GRNA3 (16647 TO 49570)
22) GRWA3 (18309 TO 36000)
23) OWCA3 (13345 TO 26000)
24) OPWA3 (18697 TO 36000)
25) RVWA3 (10146 TO 20000)
26) ULVN2 (18496 TO 50000)
27) ZDYA3 (14295 TO 72000)

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Small Basins less than 10 square miles.

Ultimate = 2 times Screen

1. AWHA3
2. BOOC2
3. CCNU1
4. CLWC2
5. CWDA3
6. DDMA3
7. FCTA3
8. GFHA3
9. LCPU1
10. MSKA3
11. NTCA3
12. PCRA3
13. PTBC2
14. RBCU1
15. RGRA3
16. RLMC2
17. SCXU1
18. SRTA3
19. WSPU1
20. ZHRA3
21. BUYA3
22. COWA3
23. CTCU1
24. EKSC2
25. EVPA3
26. EWDC2
27. FRMU1
28. GCRC2
29. HUAA3
30. KJDC2
31. MVDC2
32. OWEC2
33. PRSI1
34. RCRU1
35. RMSA3
36. SRTU1
37. TLOC2
38. ZBCA3

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No Drainage Area Reported

All values suspect.

1) CGJC2
2) CTRU1
3) FWGC2
4) MDEA3
5) MGEA3
6) MMOA3
7) MNHA3
8) MWKA3
9) PRLU1
10) RLCA3
11) RLDA3
12) RNCA3
13) TAKC2
14) ZCCA3
15) ZFRA3
16) ZPFA3

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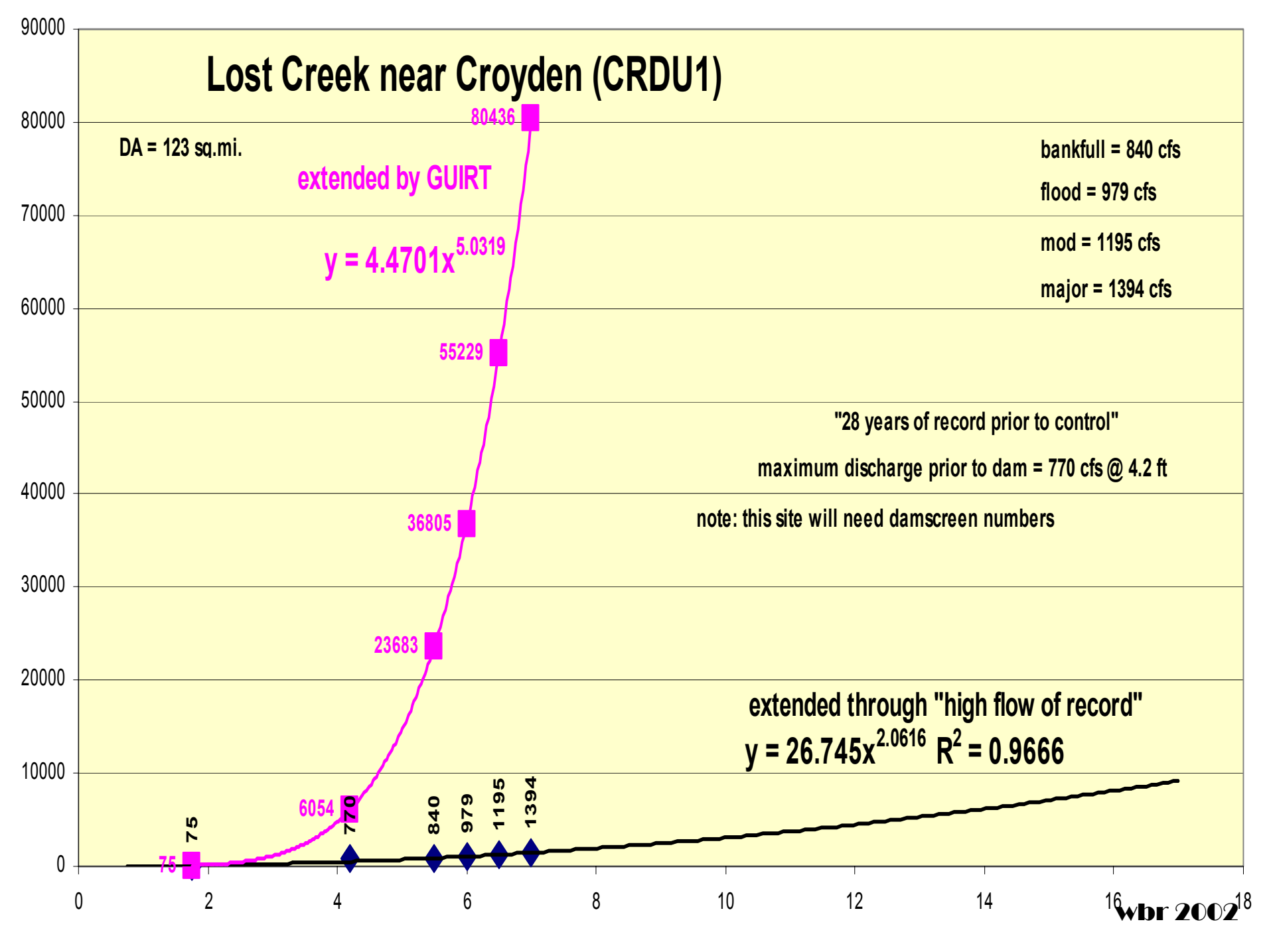
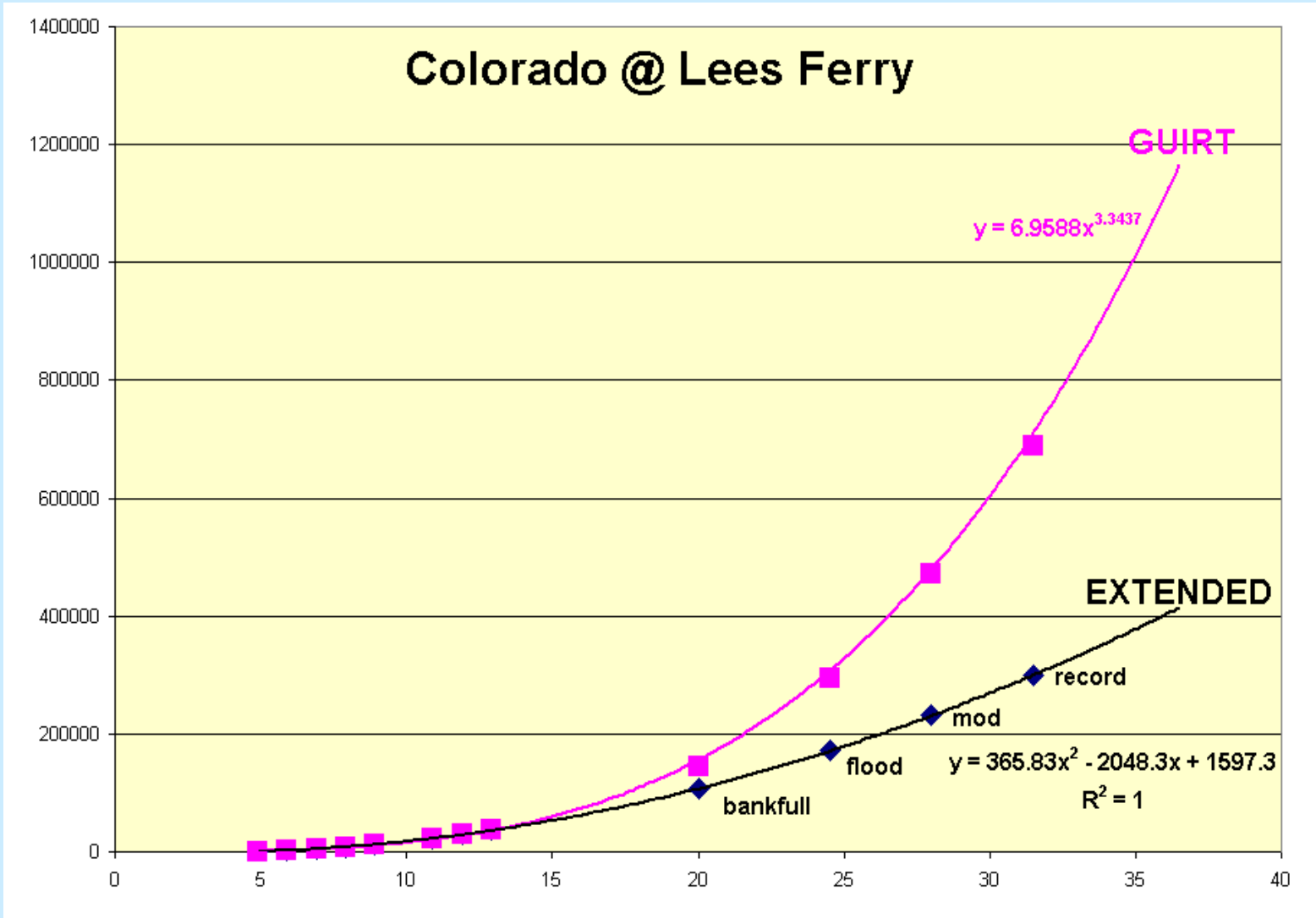
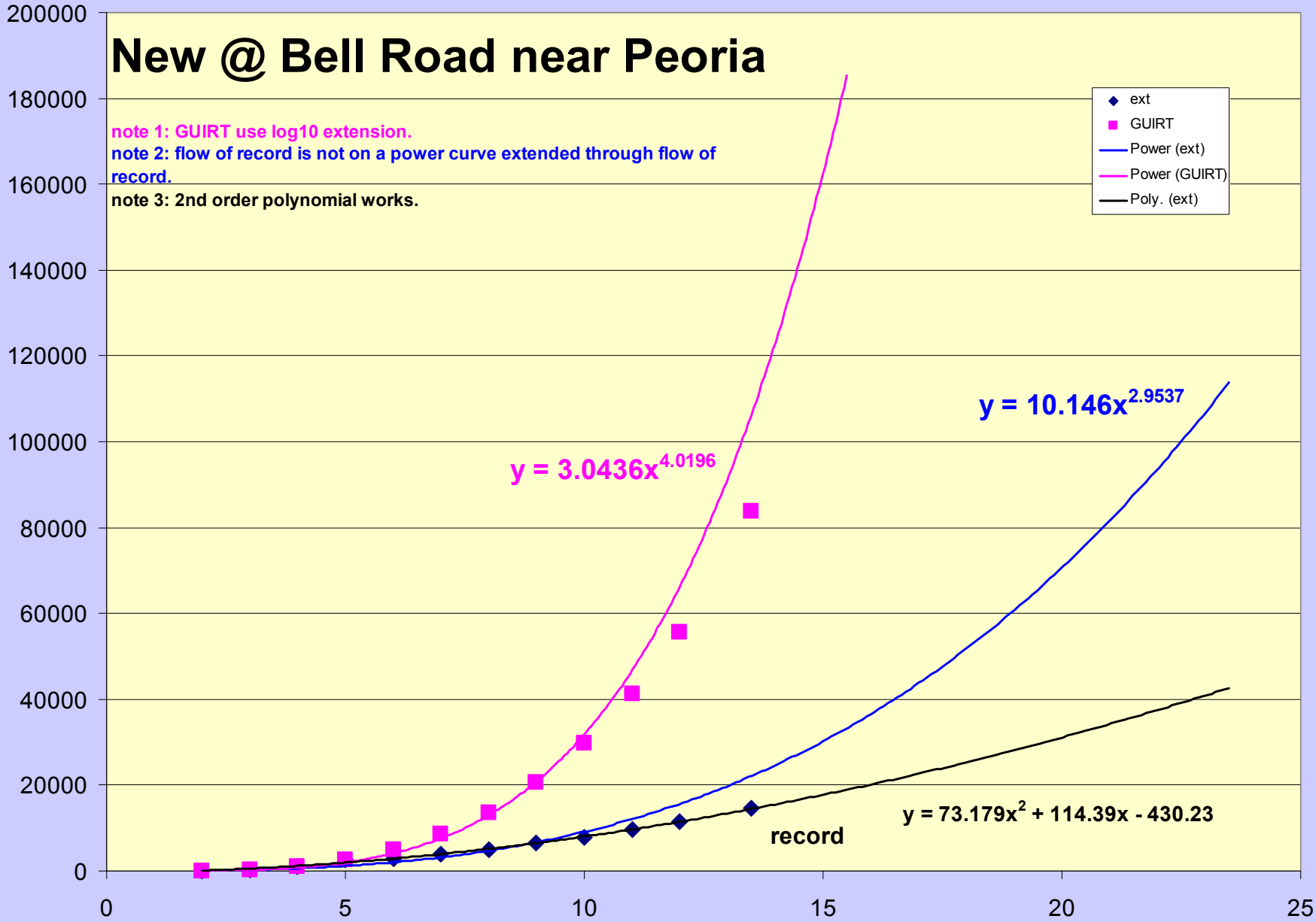
Extending Rating Curves

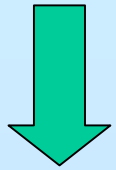

Lost Creek near Croyden (CRDU1)
DA = 123 sq.mi.
extended by GUIRT
y = 4.4701x^5.0319
bankfull = 840 cfs
flood = 979 cfs
mod = 1195 cfs
major = 1394 cfs
"28 years of record prior to control"
maximum discharge prior to dam = 770 cfs @ 4.2 ft
note: this site will need damscreen numbers
extended through "high flow of record"
y = 26.745x^2.0616 R^2 = 0.9666
80436
55229
36805
23683
6054
75
75
770
840
979
1195
1394
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
0
2
4
6
8
10
12
14
16
18
wbr 2002


Colorado @ Lees Ferry
GUIRT
y = 6.9588x^3.3437
EXTENDED
record
mod
flood
bankfull
y = 365.83x^2 - 2048.3x + 1597.3
R^2 = 1
1400000
1200000
1000000
800000
600000
400000
200000
0
0
5
10
15
20
25
30
35
40

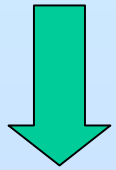

New @ Bell Road near Peoria
note 1: GUIRT use log10 extension.
note 2: flow of record is not on a power curve extended through flow of record.
note 3: 2nd order polynomial works.
ext
GUIRT
Power (ext)
Power (GUIRT)
Poly. (ext)
y = 3.0436x^4.0196
y = 10.146x^2.9537
y = 73.179x^2 + 114.39x - 430.23
record
200000
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
0
5
10
15
20
25

wbr 2002

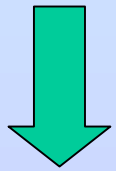
Synthetic Rating Curves



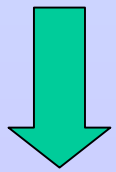
Flood, Moderate, Major, Bankfull (all sites).



Flow of Record (173 sites where synthetic curves needed).

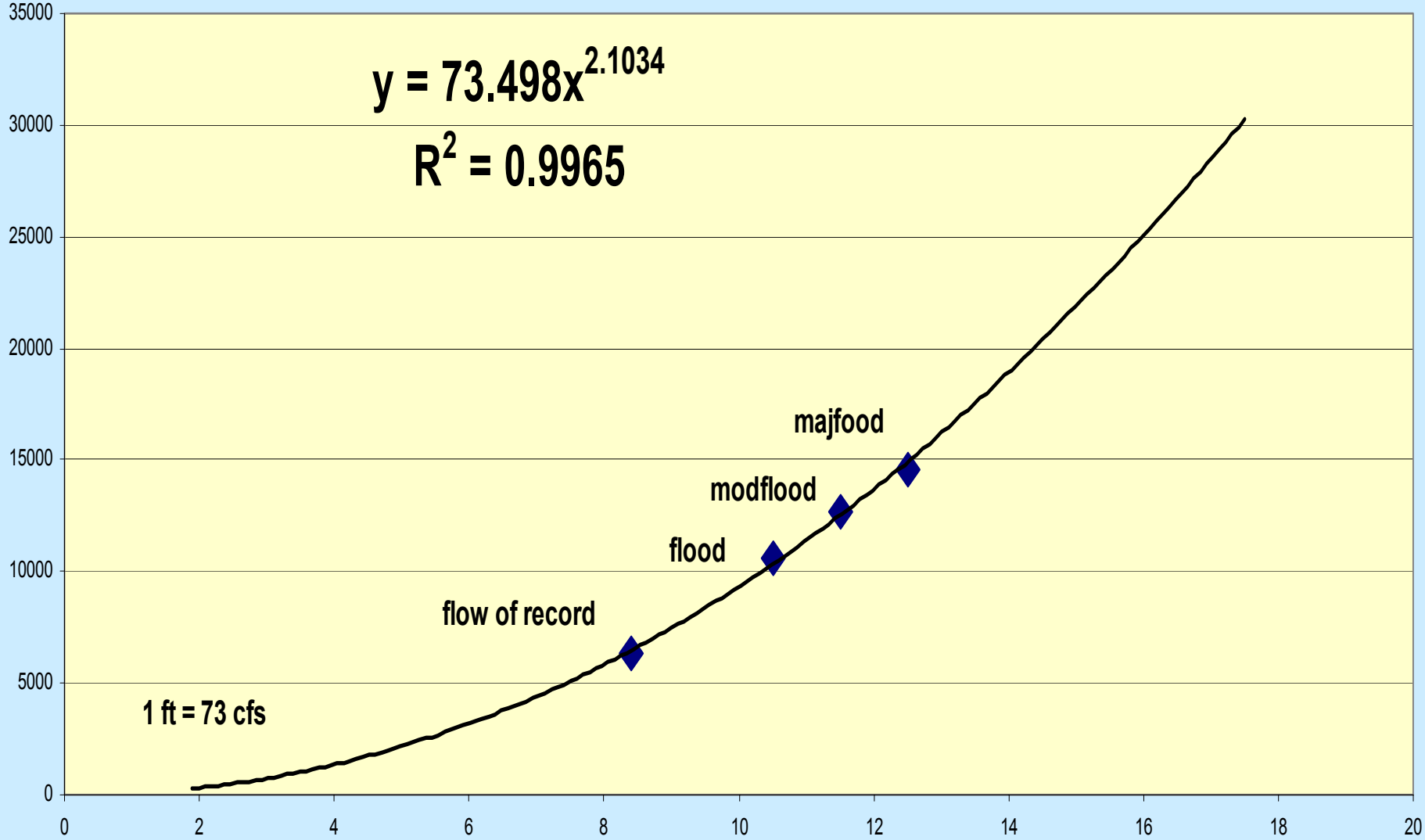


Assumed 0 flow is at or near 0 stage (1,1-100).



Fitted 6 data points with a power curve in a spreadsheet.

Bear @ Soda Springs
Synthetic Rating Curve Example



Bankfull assumed to be flow of record; river is controlled.

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Next

- Dambreak_hg
- Dambreak_q
- Floodplain Delineation