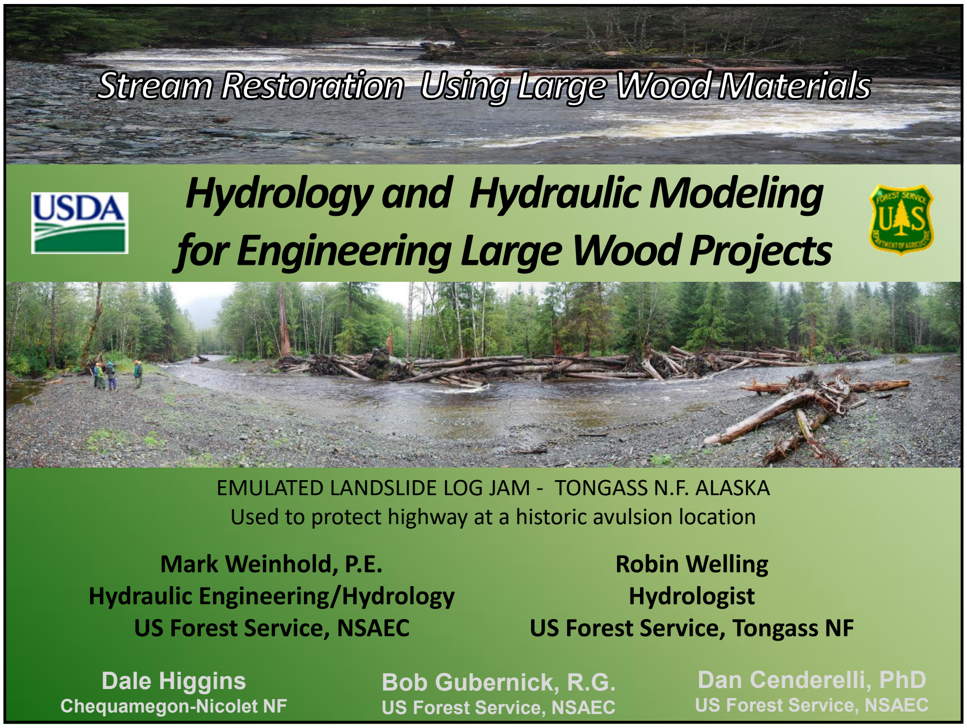
Stream Restoration Using Large Wood Materials
USDA
Hydrology and Hydraulic Modeling
for Engineering Large Wood Projects
EMULATED LANDSLIDE LOG JAM - TONGASS N.F. ALASKA
Used to protect highway at a historic avulsion location
Mark Weinhold, P.E.
Hydraulic Engineering/Hydrology
US Forest Service, NSAEC
Robin Welling
Hydrologist
US Forest Service, Tongass NF
Dale Higgins
Chequamegon-Nicolet NF
Bob Gubernick, R.G.
US Forest Service, NSAEC
Dan Cenderelli, PhD
US Forest Service, NSAEC


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Information Needs and Methods
Constructed Apex Log Jam Tongass N.F.
• Complexity of design
• Scale of project (large or small)
• Risk (close to private property or critical infrastructure)
• Permitting requirements

How much analysis / modeling is required?

Small streams (BFW < 20-ft ±) / Low risk sites

- Usually headwater or tributary streams to larger rivers
- Far from infrastructure
- Single landowner encompasses project area and down stream reaches
- Trees length > bankfull width
- No floodplain permitting required
- Hydrology usually by regression equations
- Cross section analysis (Manning's equation) used to develop water surface/depth

Medium streams (20-ft < BFW > 50-ft)

Moderate to High Risk Sites

Harris River Tongass N.F., Ak.
Old growth reference reach

- Mainstem or tributary streams
- Proximity to infrastructure
- Single landowner encompasses project area and down stream reaches or adjacent private property
- Trees length ≥ bankfull width
- Floodplain permitting maybe required
- Cross section analysis (Manning's equation) or HEC-RAS used to develop water surface (Analysis commensurate with RISK!)

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Large streams (BFW > 50-ft ±)
High risk sites; Channel reconstruction

Lower Harris River, Tongass N.F., Ak.
Log Jam construction with Helicopter

- Mainstem or larger rivers
- Proximity to infrastructure
- Single landowner encompasses project area and down stream reaches or adjacent private property
- Trees length < bankfull width
- Floodplain permitting required
- Hydrology – check sensitivity of prediction error.
- HEC-RAS used to develop water surface (Analysis commensurate with RISK!)

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Stream Discharge Estimates

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Recurrence Interval :

$$\text{Recurrence Interval} = \frac{1}{\text{Exceedance Probability}} \times (100)$$

100 year flood = 1% exceedance probability

2 year flood = 50% exceedance probability

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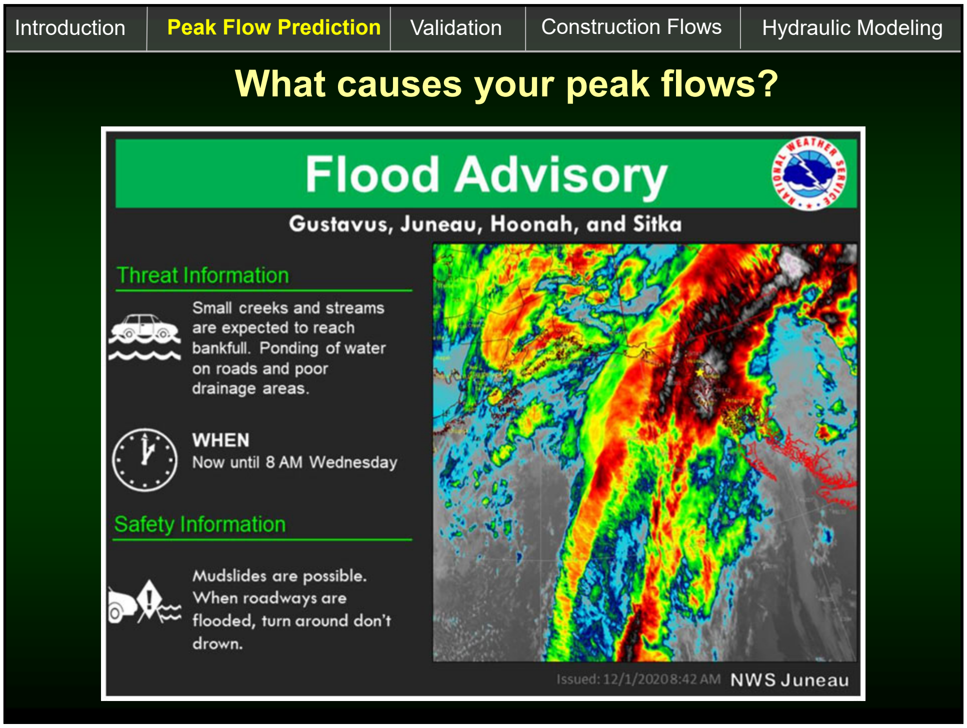
Sources of flow data

U.S. Geological Survey

- Web site – National Water Information Systems (NWIS) (http://water.usgs.gov/nwis/)
  - Mean daily, peak, and mean monthly values
- Published data summaries
  - Peak flow T-year return period flows; annual and monthly flow with exceedances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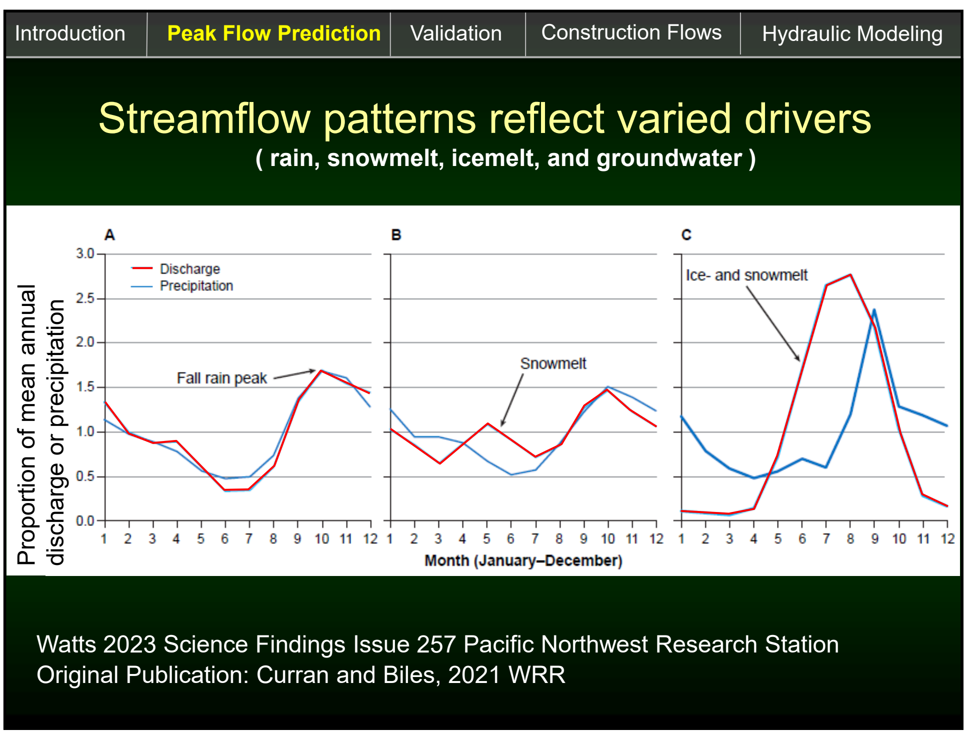
What causes your peak flows?
Flood Advisory
Gustavus, Juneau, Hoonah, and Sitka
Threat Information
Small creeks and streams are expected to reach bankfull. Ponding of water on roads and poor drainage areas.
WHEN
Now until 8 AM Wednesday
Safety Information
Mudslides are possible. When roadways are flooded, turn around don't drown.
Issued: 12/1/2020 8:42 AM
NWS Juneau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Streamflow patterns reflect varied drivers
(rain, snowmelt, icemelt, and groundwater)
A
B
C
Discharge
Precipitation
Fall rain peak
Snowmelt
Ice- and snowmelt
Proportion of mean annual discharge or precipitation
Month (January–December)
Watts 2023 Science Findings Issue 257 Pacific Northwest Research Station
Original Publication: Curran and Biles, 2021 WRR

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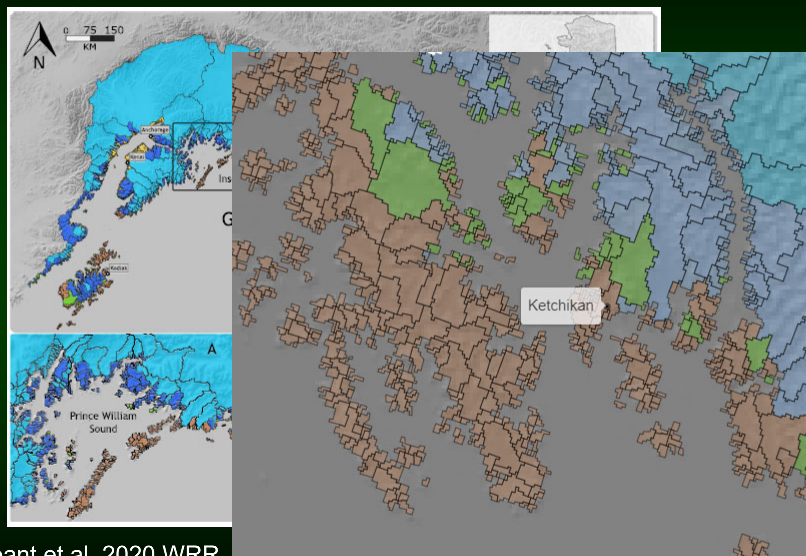
Streamflow patterns can vary from one watershed to the next



Sergeant et al. 2020 WRR
https://southeastakwatershedcoalition.shinyapps.io/watershed_classification/

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Predicting Peak Discharge

Photo: Mikko Wilson, KTOO

Case 1: Gaged sites

Case 2: Sites near gaged sites

Case 3: Ungaged sites (regional regression eqs)

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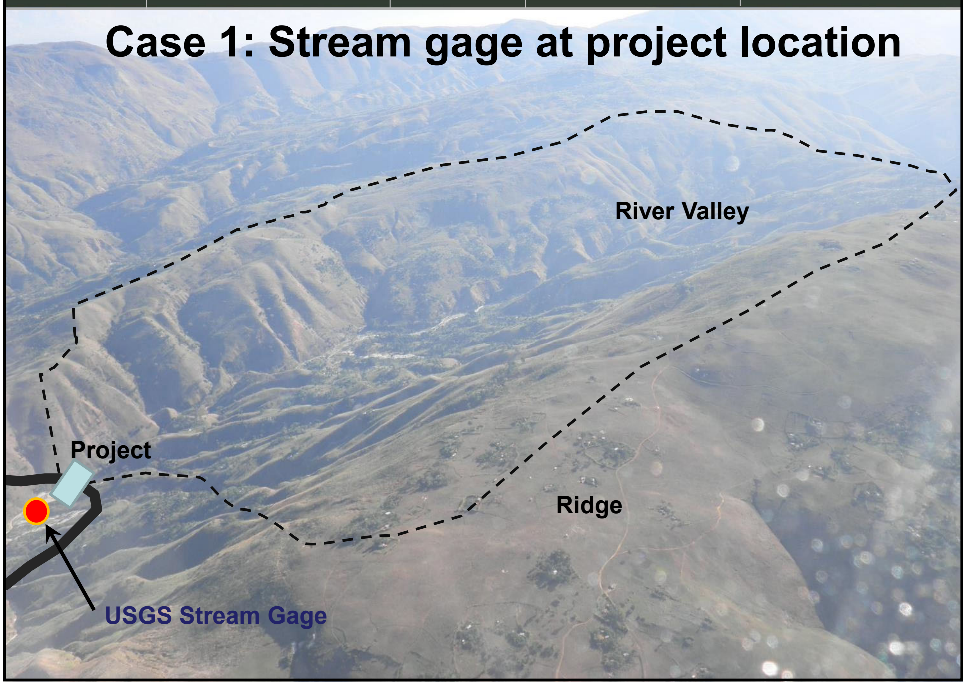
Case 1: Stream gage at project location



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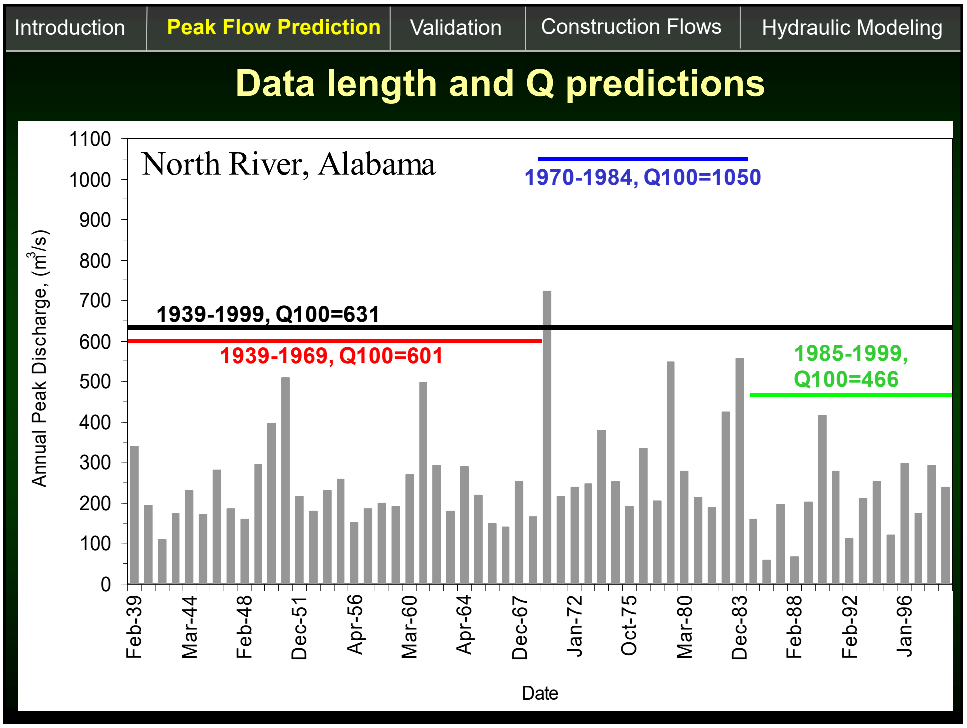
Period of record

Annual instantaneous peaks analyzed using the log Pearson III distribution (USGS Bulletin 17b, 1982)
- Recently updated: USGS Bulletin 17c, 2018.

Peak discharge estimates by recurrence interval
– Q_2 to Q_{100}+

Basin and stream parameters
– Drainage Area, mean basin elevation, precipitation, mean January temp, etc.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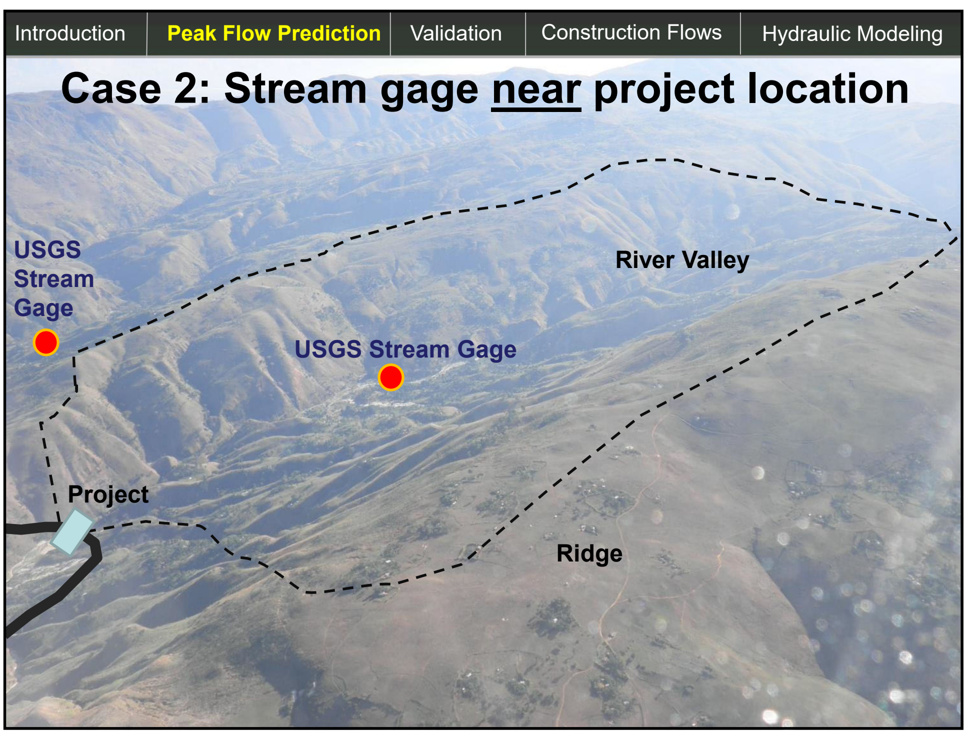
Data length and Q predictions
North River, Alabama
1970-1984, Q100=1050
1939-1999, Q100=631
1939-1969, Q100=601
1985-1999, Q100=466
Annual Peak Discharge, (m3/s)
Date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Case 2: Stream gage near project location
USGS Stream Gage
River Valley
USGS Stream Gage
Project
Ridge

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- **Case 2: Extrapolate from nearby gage**
  - Assumes similar topography, geology, vegetation, and other characteristics that may affect flood magnitude
  - General Rule: Ungaged drainage area should be between 0.5 and 1.5 of gaged site drainage area

$$Q_{100(ungaged)} = Q_{100(gaged)} \left(\frac{A_{ungaged}}{A_{gaged}}\right)^{X}$$

***X* = can vary by flood region and recurrence interval**

Reliability of estimates is a function of similarity!

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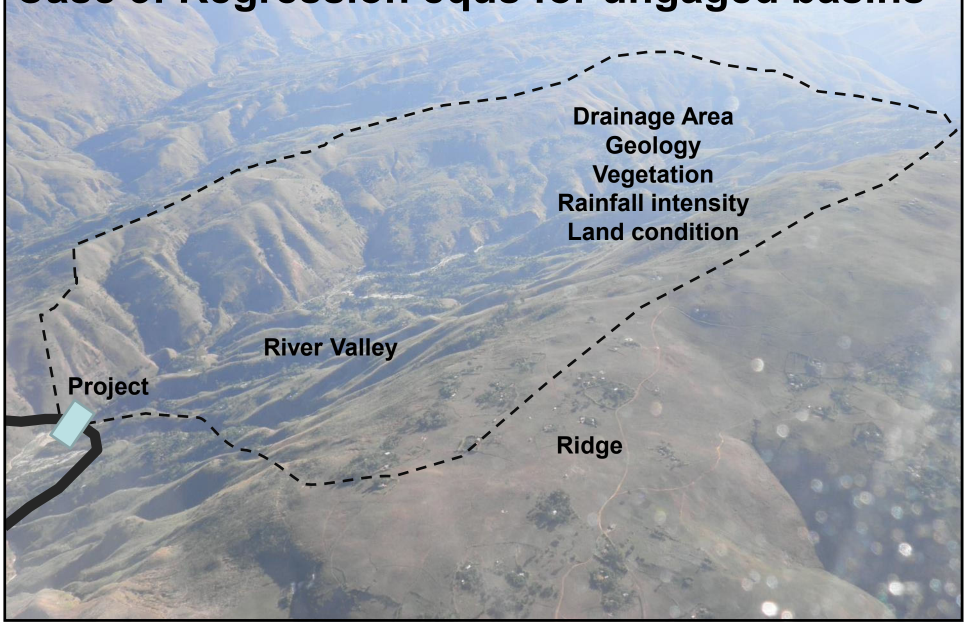
Case 3: Regression equs for ungaged basins



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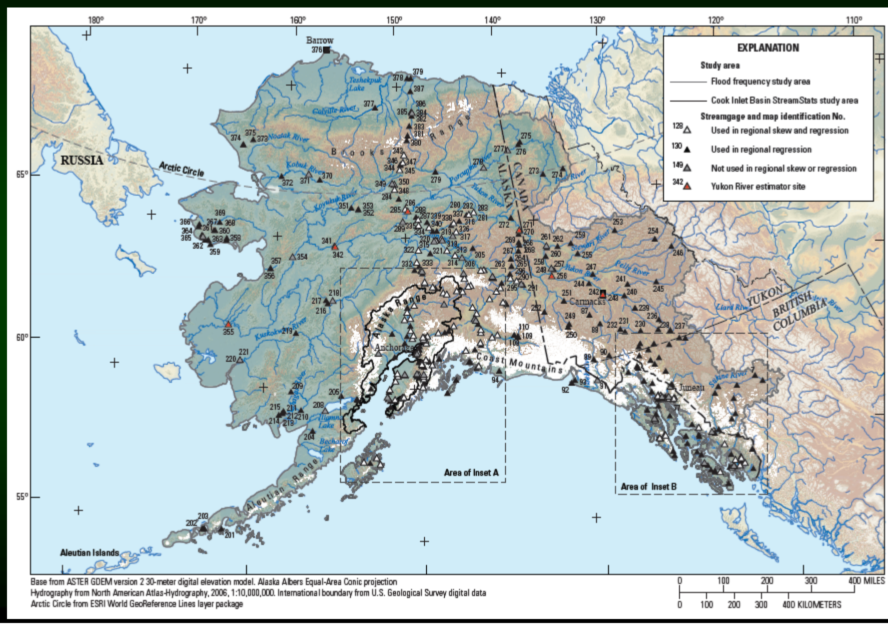
Density of gage network varies by state and region



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USGS regional regression equations

- Available for each State divided into hydrologic regions
- Equations dependent on nearby gage data
- Multiple regression of flow on watershed and climatic characteristics, yielding prediction equations of the form:

$$Q_T = aA^b B^c \ldots. N^n$$

- Standard errors of estimates are commonly 30 to 80+%

Publications and calculation tool available through National Streamflow Statistics Program https://www.usgs.gov/software/national-streamflow-statistics-nss-application-formerly-nss-program

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USGS regression equations for AK (Curran et. al, 2016)

Table 7. Regional regression equations for estimating annual exceedance-probability discharges for unregulated streams in Alaska and conterminous basins in Canada.

[**Regional regression equation:** DRNAREA, drainage area, in square miles; PRECPRIS00, basin average mean annual precipitation, in inches, for 1971 to 2000 from the PRISM climate dataset. **AVP:** Average variance of prediction. **SEP:** Average standard error of prediction. R^2_{pseudo}: pseudo coefficient of determination]

Percent annual exceedance probability	Regional regression equation for estimating annual exceedance probability discharge, in cubic feet per second[1,2]	AVP (log units)	SEP (percent)	R^2_{pseudo} (percent)
50	$0.944\ (DRNAREA)^{0.836}(PRECPRIS00)^{1.023}$	0.077	70.8	91.1
20	$2.47\ (DRNAREA)^{0.795}(PRECPRIS00)^{0.916}$	0.074	69.1	90.6
10	$4.01\ (DRNAREA)^{0.775}(PRECPRIS00)^{0.865}$	0.074	69.2	90.0
4	$6.53\ (DRNAREA)^{0.755}(PRECPRIS00)^{0.816}$	0.077	71.2	89.0
2	$8.79\ (DRNAREA)^{0.743}(PRECPRIS00)^{0.787}$	0.080	72.8	88.2
1	$11.4\ (DRNAREA)^{0.732}\ (PRECPRIS00)^{0.764}$	0.083	74.6	87.4
0.5	$14.3\ (DRNAREA)^{0.723}(PRECPRIS00)^{0.744}$	0.089	77.4	86.3
0.2	$18.7\ (DRNAREA)^{0.712}(PRECPRIS00)^{0.721}$	0.097	81.9	84.7

[1] Equations are valid for DRNAREA between 0.4 and 1,000 mi² with PRECPRIS00 between 8 and 280 in. and for DRNAREA greater than 1,000 and less than 31,100 mi² with PRECPRIS00 between 10 and 111 in.

[2] Equations are not suitable for use in the Aleutian Islands and other islands outside the study area.

2003 publication, tools, data https://pubs.usgs.gov/wri/wri034188/
2016 publication, tools, data https://pubs.usgs.gov/publication/sir20165024

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Curran et al. 2016 Application of Methods Tool

A test of an unregulated site in Alaska or conterminous basins in Canada

Enter the explanatory variables:

Drainage area, in square miles	DRNAREA	2.49	Equations are valid for DRNAREA between 0.4 and 1,000 mi² with PRECPRIS00 between 8 and 280 inches, and for DRNAREA greater than 1,000 and less than 31,100 mi² with PRECPRIS00 between 10 and 111 inches.
Mean annual precipitation from 1971-2000 PRISM data, in inches	PRECPRIS00	104	

Warnings regarding range of variables:

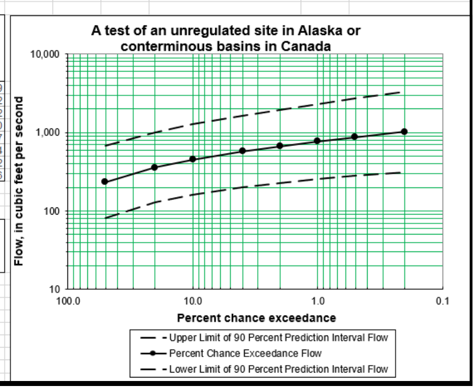
50% exceedance or 2-year flood – 234 cfs 90% CI [81.7, 671 cfs]

Results:

Percent chance exceedance	Percent chance exceedance flow, in ft³/s	Lower limit of 90 percent prediction interval flow, in ft³/s	Upper limit of 90 percent prediction interval flow, in ft³/s	$-SEP_{P,I}$ (percent)	$+SEP_{P,I}$ (percent)	Average $SEP_{P,I}$ (percent)
50	234	81.7	671	-47.2	89.3	70.9
20	359	128	1,010	-46.5	87.0	69.2
10	452	161	1,270	-46.5	87.0	69.2
4	575	201	1,650	-47.2	89.4	71.0
2	670	229	1,960	-47.9	91.8	72.7
1	773	258	2,310	-48.5	94.2	74.4
0.5	876	283	2,710	-49.5	98.2	77.2
0.2	1,020	313	3,310	-51.1	104.4	81.6

Notes

Differences in rounding of equation parameters can produce minor differences between the results obtained using the regression equations in table 7 and using WREG software. The estimates in this spreadsheet use the regression equations as published in table 7. The regression estimates for streamgages shown in table 4 were computed using WREG during the regression analysis.



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Basin Characteristics

- Drainage area – Delineate in GIS from DEM
- Precipitation and other climate data – Zonal Statistics Tool in ArcGIS software
  - PRISM mean annual precipitation for AK 1971-2000:
    - https://irma.nps.gov/DataStore/Reference/Profile/2170508
  - PRISM mean monthly and annual precipitation and temperature 1981-2010:
    - https://prism.oregonstate.edu/projects/alaska.php
- Other useful characteristics: geographic location (latitude, frontal/interior), basin elevation, land cover (especially lakes and wetlands)
- Shortcuts: weather stations and nearby gages

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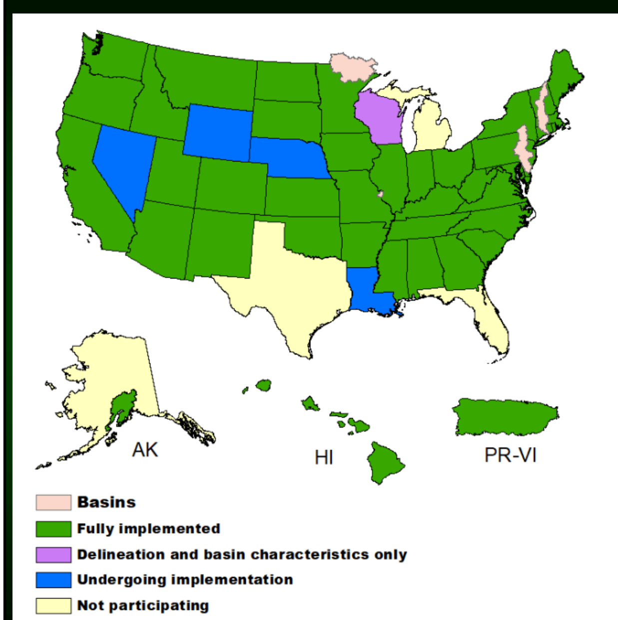
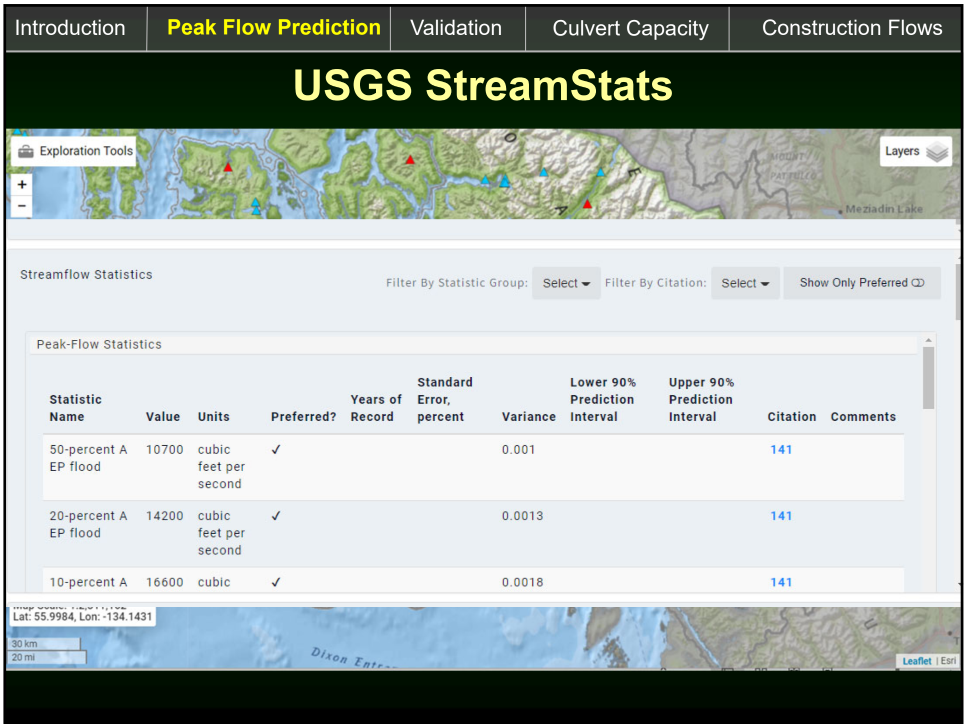


StreamStats: A Water Resources Web Application for Predicting Discharge

streamstats.usgs.gov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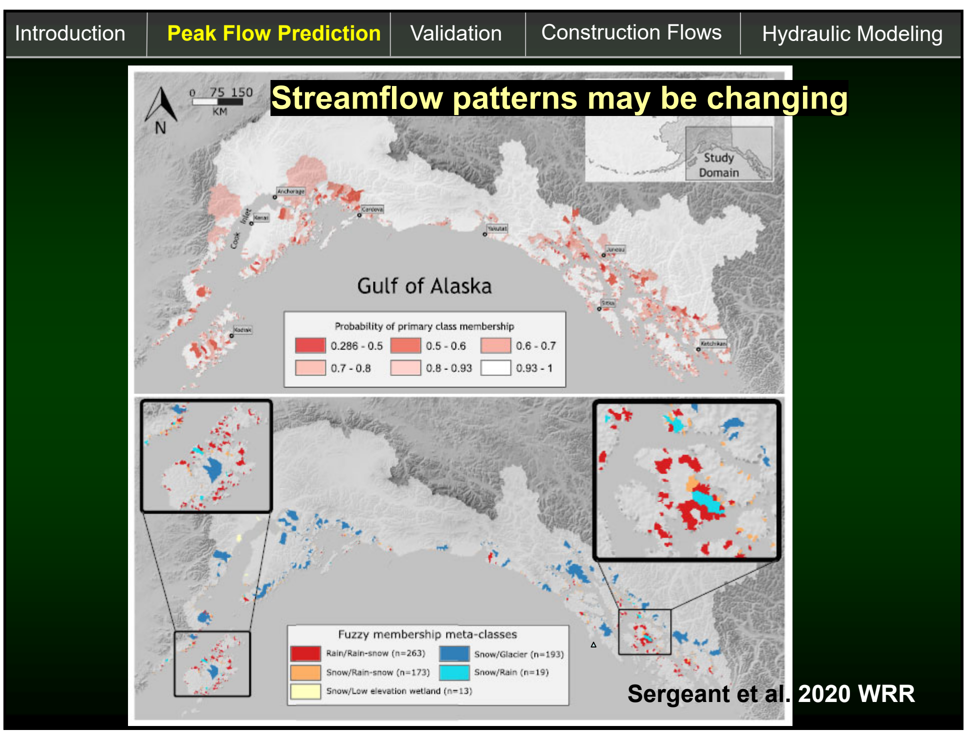
USGS StreamStats
Exploration Tools
Layers
Streamflow Statistics
Filter By Statistic Group: Select
Filter By Citation: Select
Show Only Preferred
Peak-Flow Statistics
Statistic Name | Value | Units | Preferred? | Years of Record | Standard Error, percent | Variance | Lower 90% Prediction Interval | Upper 90% Prediction Interval | Citation | Comments
50-percent AEP flood | 10700 | cubic feet per second | ✓ | 0.001 | 141
20-percent AEP flood | 14200 | cubic feet per second | ✓ | 0.0013 | 141
10-percent A | 16600 | cubic | ✓ | 0.0018 | 141
Lat: 55.9984, Lon: -134.1431
30 km
20 mi
Leaflet | Esri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Streamflow patterns may be changing
Study Domain
Gulf of Alaska
Probability of primary class membership
0.286 - 0.5
0.5 - 0.6
0.6 - 0.7
0.7 - 0.8
0.8 - 0.93
0.93 - 1
Fuzzy membership meta-classes
Rain/Rain-snow (n=263)
Snow/Glacier (n=193)
Snow/Rain-snow (n=173)
Snow/Rain (n=19)
Snow/Low elevation wetland (n=13)
Sergeant et al. 2020 WRR

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Anticipating future streamflow patterns

- Projected temperature and precipitation:
  - https://catalog.snap.uaf.edu/geonetwork/srv/eng/catalog.search#/search
- Precipitation projections for infrastructure projects
  - https://snap.uaf.edu/tools/future-alaska-precip
- Community Climate Charts
  - https://snap.uaf.edu/tools/community-charts

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Regional Regression Limitations

- Derive input variables using the same methods as those used to develop the equations
- Beware extrapolating flood estimates beyond the input data used to develop the equations
- Peak flow per unit area increases in smaller tributary areas (less storage and water gets to the channel faster) so adjust estimates accordingly for predictions in smaller watersheds

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Recommended Peak Flow Approach

- Understand the local hydrology – Know your nearby gages.
- Use multiple methods. “All models are wrong; but some are better than others.”
- Pay attention to Standard Errors of predictions.
- Consider future changes in climate and land use.
- Verify computations with field data if possible.

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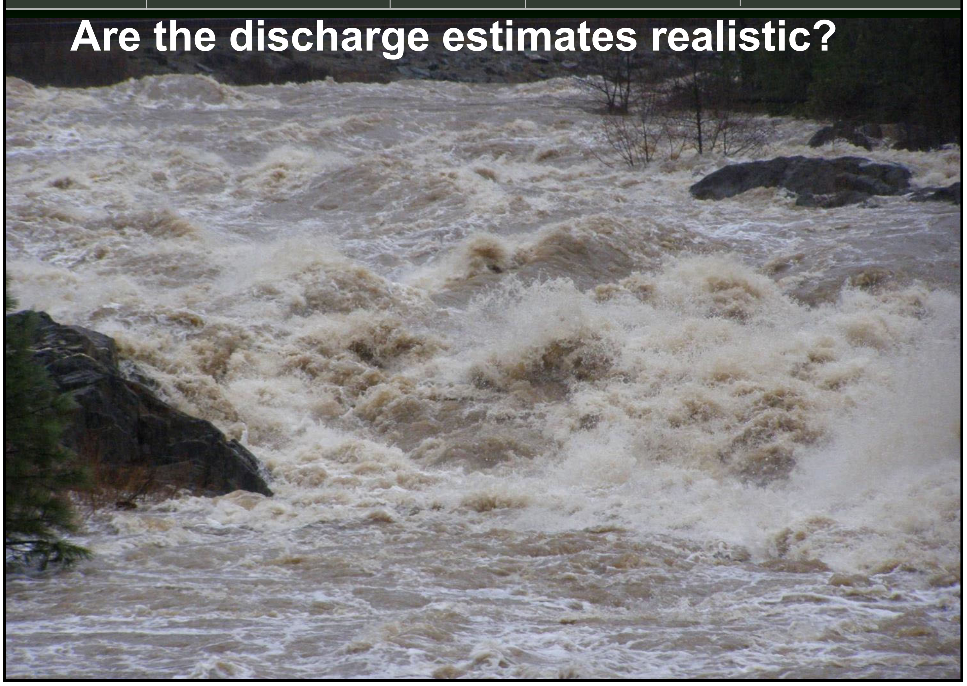
Are the discharge estimates realistic?



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Suggested reality checks

1. Look at nearby gages – unit discharge Q_{100}/A, Flood ratios Q_{100}/Q_2, influence on StreamStats predictions, etc.
2. Measured or modeled bankfull discharge
   - Modeled bankfull similar to predicted $Q_{1.5}$-Q_2?
     - Froude number < 1
     - Bankfull velocity ~ 4-7 cfs
3. Talk to long-time locals and look for recent flood evidence - model flow to determine peak discharge magnitude

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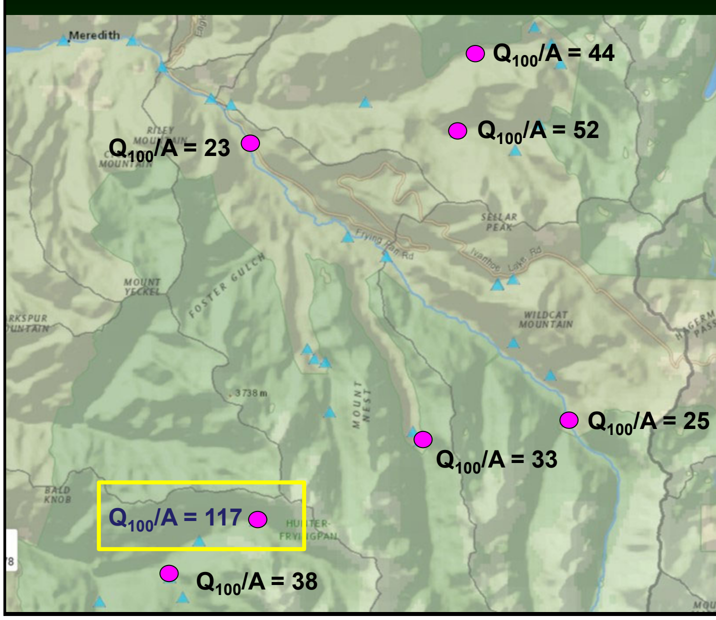
1) Mine information from nearby gauges



Unit Discharge:

Q_{100}/DA

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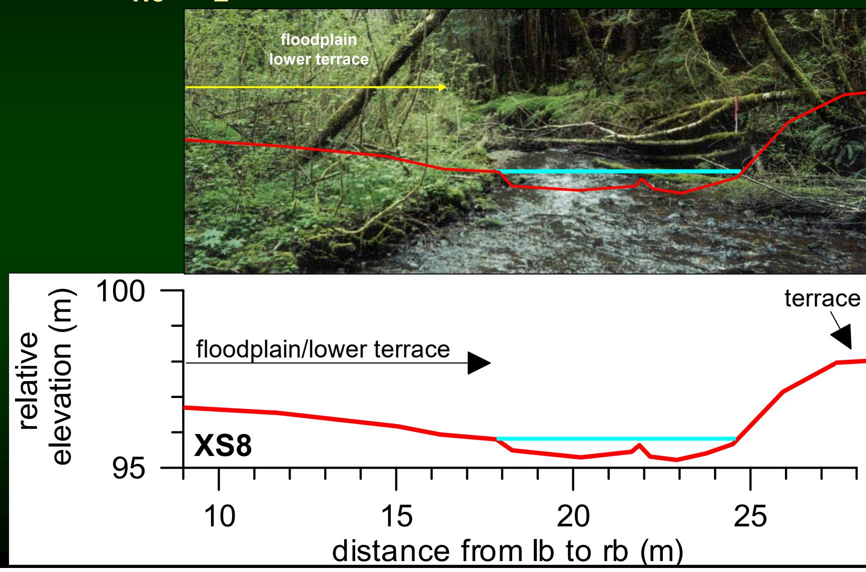
2) Model Bankfull Discharge and Compare $Q_{1.5}$-Q_2 with Regression Equations



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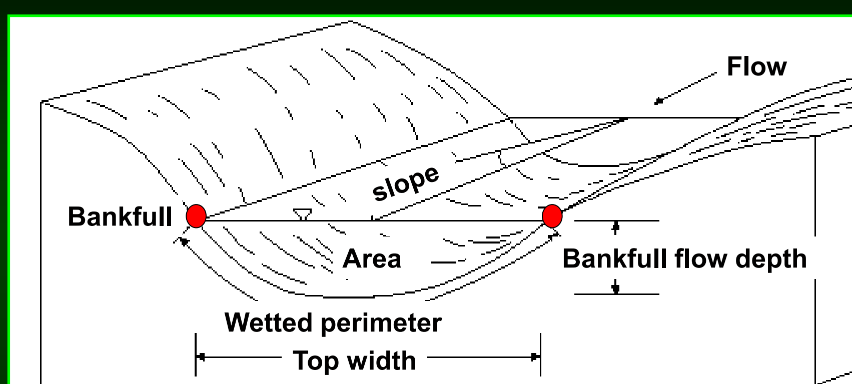
Using WinXSPro, HEC-RAS, EXCEL, etc.



$$Q_{bf} = \frac{1.49}{n} A_{bf} R_{bf}^{2/3} S^{1/2}$$

Similar to Regression $Q_{1.5} - Q_2$?

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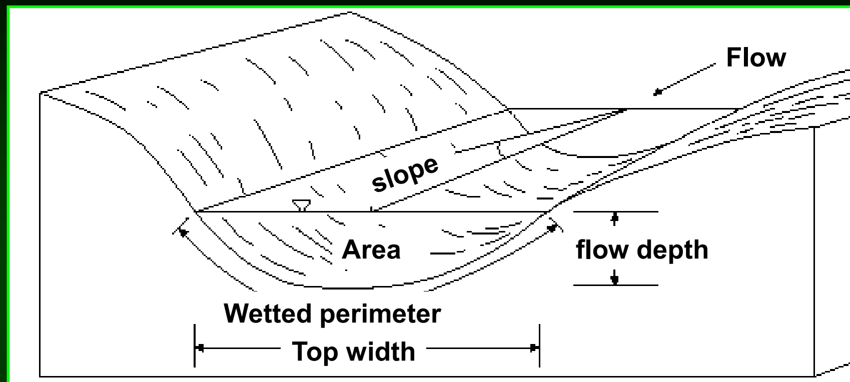

$$(Velocity)\ Vbf = \frac{1.49}{n}\left(R^{2/3}\right)S^{1/2} \sim 4\text{-}7\ \text{ft/sec}$$

$$(Froude\ Number)\ Fr = \frac{V}{\sqrt{gd}} < 1$$

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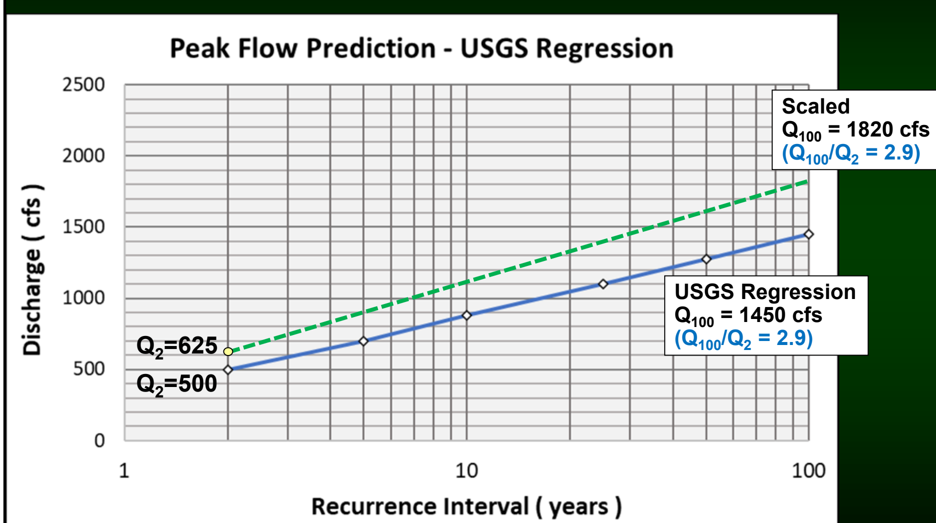
Adjusting Predictions with Field Data



Example: Q_2 regression of 500 cfs; Q_2 field verified of 625 cfs.

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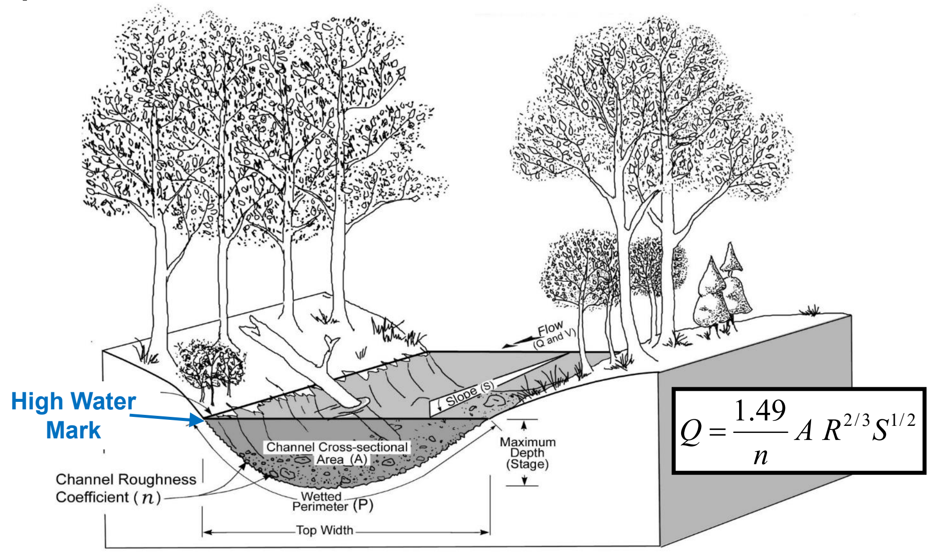
3) Model Flows Based on Past Flood Evidence



Use field evidence or local knowledge for high water marks

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Unreliable Discharge Estimates = Uncertain Infrastructure Future

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Summary

- **Predicted peak flows from regional regression equations have non-trivial uncertainty**
- **If the peak discharge estimates are unreliable, then the risk of failure increases**
- **Use field evidence and hydraulic models to verify peak discharge estimates**

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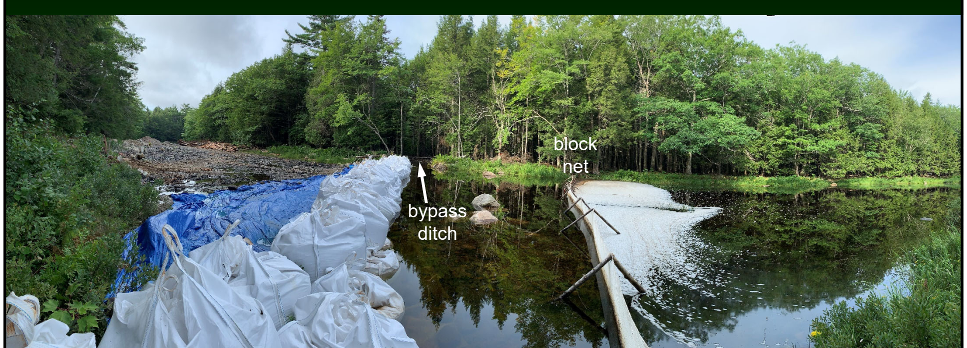
Estimating Construction Bypass Flows



Things You Need to Know…

- Duration of project
- Local forecast
- Local hydrology
- Consequences of failure

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Things You Need to Estimate…

- Anticipated stream flows:
  - Short-term (days)
    - Measured site flows
    - Exceedance flows (daily)
    - Average monthly flow
  - Long-term (weeks)
    - Average monthly flow + Fraction of Q_2
- Pipe, Pump or Ditch Capacity

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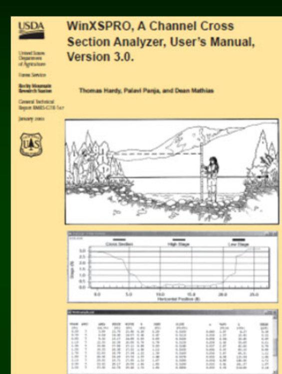
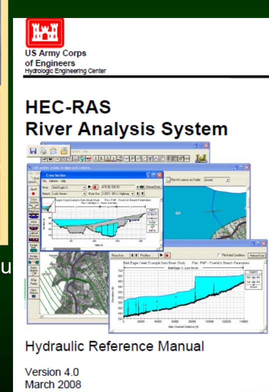
Route Flows to Determine Hydraulic Variables

A) single cross section analysis model (e.g., WinXSPRO)

B) reach-based, step-backwater model to define water-surface profiles (e.g. HEC-RAS)



http://www.stream.fs.fed.us/publications/winxspro.html



http://www.hec.usace.army.mil/software/hec-ras/

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Modeling Water Surface
- Single Cross Section Analysis

$$Q_{bf} = \frac{1.49}{n} A\, R^{2/3} S^{1/2}$$

A = Cross Section Area
R = Hydraulic Radius (Cross Section Area / Wetted Perimeter
S = Energy or Channel Slope
n = Manning's Roughness Coefficent

- For low-risk sites / small streams
- Assumes steady and uniform flow
- Doesn't account for backwater
- A, R, and S developed from survey data
- 'n' developed from tables or back calculated from Q measurements

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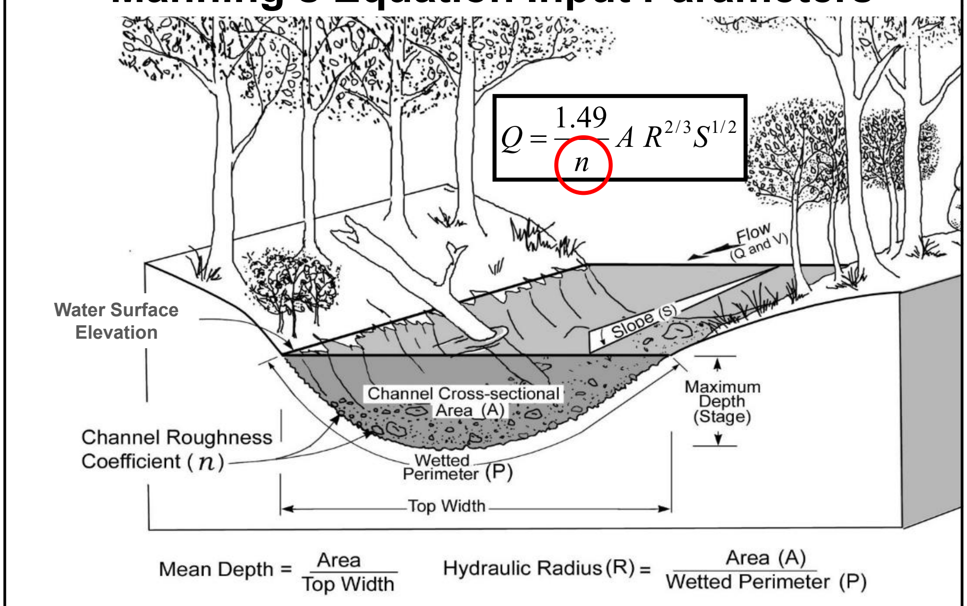
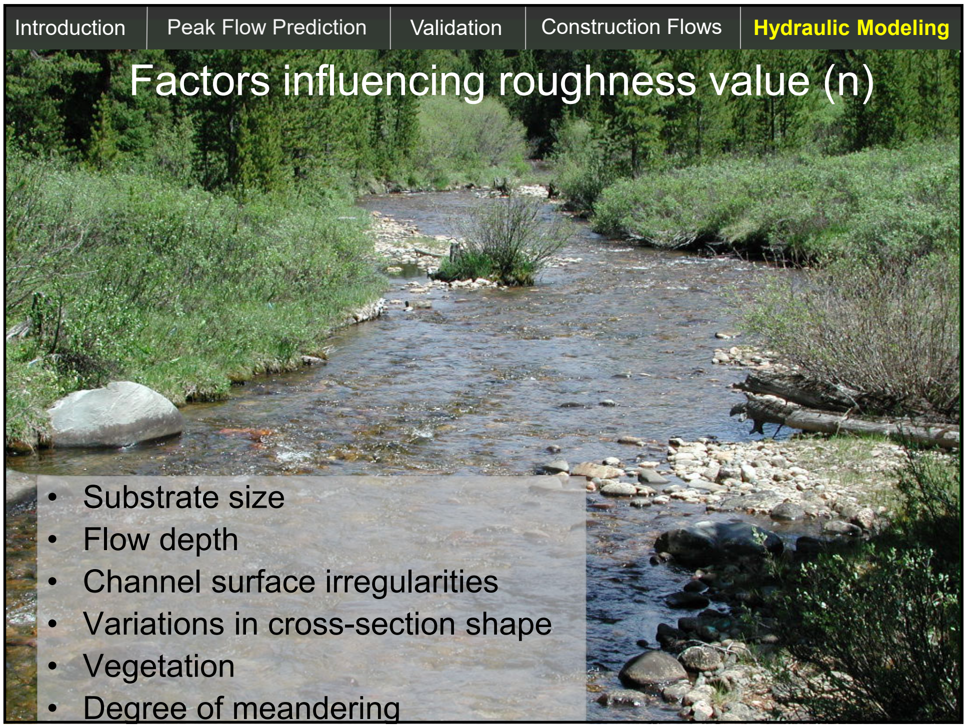
Manning's Equation Input Parameters





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Tabular Values

Manning's n for Channels (Chow, 1959).

Type of Channel and Description	Minimum	Normal	Maximum
Natural streams - minor streams (top width at floodstage < 100 ft)			
1. Main Channels			
a. clean, straight, full stage, no rifts or deep pools	0.025	0.030	0.033
b. same as above, but more stones and weeds	0.030	0.035	0.040
c. clean, winding, some pools and shoals	0.033	0.040	0.045
d. same as above, but some weeds and stones	0.035	0.045	0.050
e. same as above, lower stages, more ineffective slopes and sections	0.040	0.048	0.055
f. same as "d" with more stones	0.045	0.050	0.060
g. sluggish reaches, weedy, deep pools	0.050	0.070	0.080
h. very weedy reaches, deep pools, or floodways with heavy stand of timber and underbrush	0.075	0.100	0.150
2. Mountain streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high stages			
a. bottom: gravels, cobbles, and few boulders	0.030	0.040	0.050
b. bottom: cobbles with large boulders	0.040	0.050	0.070
3. Floodplains			
a. Pasture, no brush			
1.short grass	0.025	0.030	0.035
2. high grass	0.030	0.035	0.050
b. Cultivated areas			
1. no crop	0.020	0.030	0.040
2. mature row crops	0.025	0.035	0.045

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Photographic Methods

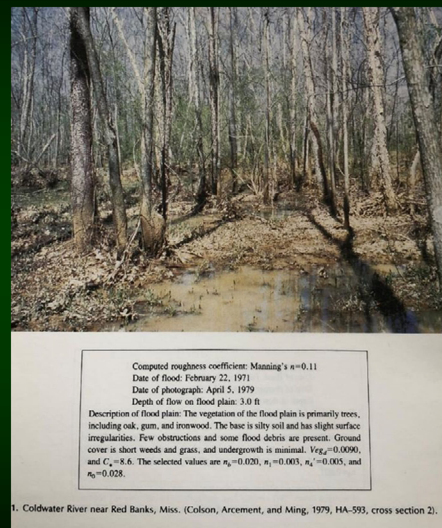
Guide for Selecting Manning's Roughness Coefficients for Natural Channels and Flood Plains

By GEORGE J. ARCEMENT, JR., and VERNE R. SCHNEIDER

Prepared in cooperation with the
U.S. Department of Transportation,
Federal Highway Administration

A guide presenting step-by-step procedures for selecting Manning's roughness coefficient, *n*, for natural channels and flood plains. Photographs of flood-plain segments can be used for comparison with similar flood plains to aid in assigning *n* values

U.S. GEOLOGICAL SURVEY WATER-SUPPLY PAPER 2339



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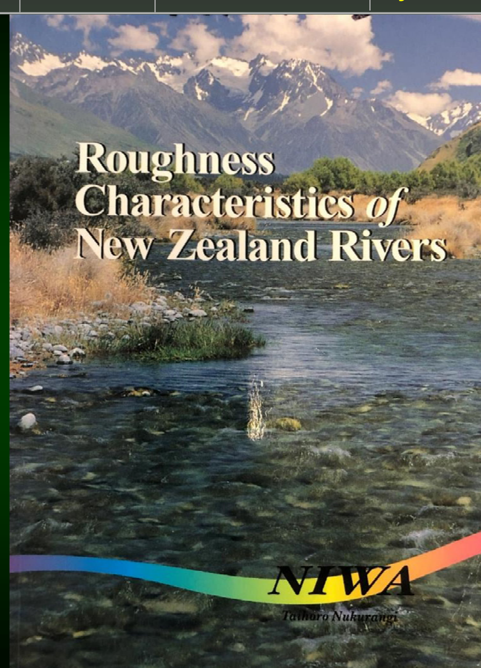
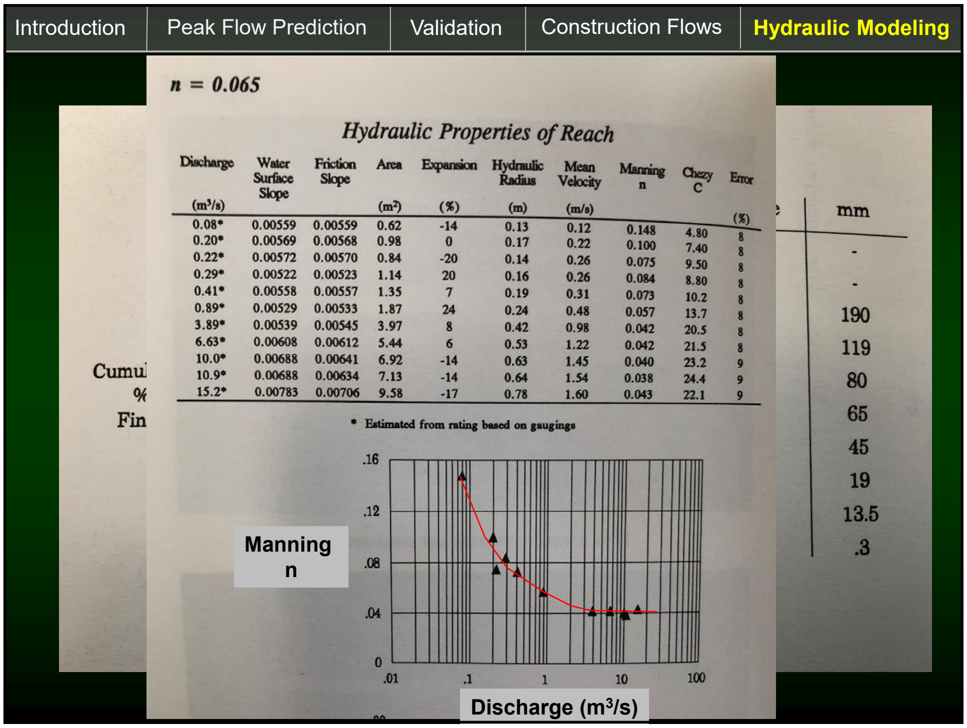
Photographic Methods





n = 0.065

Hydraulic Properties of Reach

Discharge (m^3/s)	Water Surface Slope	Friction Slope	Area (m^2)	Expansion (%)	Hydraulic Radius (m)	Mean Velocity (m/s)	Manning n	Chezy C	Error (%)
0.08*	0.00559	0.00559	0.62	-14	0.13	0.12	0.148	4.80	8
0.20*	0.00569	0.00568	0.98	0	0.17	0.22	0.100	7.40	8
0.22*	0.00572	0.00570	0.84	-20	0.14	0.26	0.075	9.50	8
0.29*	0.00522	0.00523	1.14	20	0.16	0.26	0.084	8.80	8
0.41*	0.00558	0.00557	1.35	7	0.19	0.31	0.073	10.2	8
0.89*	0.00529	0.00533	1.87	24	0.24	0.48	0.057	13.7	8
3.89*	0.00539	0.00545	3.97	8	0.42	0.98	0.042	20.5	8
6.63*	0.00608	0.00612	5.44	6	0.53	1.22	0.042	21.5	8
10.0*	0.00688	0.00641	6.92	-14	0.63	1.45	0.040	23.2	9
10.9*	0.00688	0.00634	7.13	-14	0.64	1.54	0.038	24.4	9
15.2*	0.00783	0.00706	9.58	-17	0.78	1.60	0.043	22.1	9

* Estimated from rating based on gaugings

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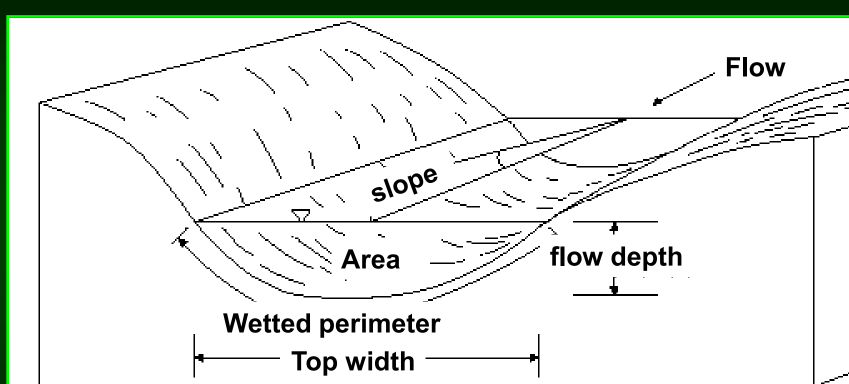
Back Calculate from Discharge Measurement



$$n = \frac{1.49}{Q} A R^{2/3} S^{1/2}$$

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Empirical Roughness Equations

Limerinos (1970)	$n = [0.1129R^{0.167}] / \{[2.0 \log (R/d_{84})] + 1.16\}$
Hey (1979)	$(1/f)^{0.5} = 2.03 \log (11.1R/3.5d_{84})$ upper limit $(1/f)^{0.5} = 2.03 \log (13.46R/3.5d_{84})$ lower limit
Hey (1979)	$n = [0.1129R^{0.167}] / [2.03 \log (11.1R/3.5d_{84})]$ upper limit $n = [0.1129R^{0.167}] / [2.03 \log (13.46R/3.5d_{84})]$ lower limit
Jarrett (1985)	$n = 0.32\ S_f^{0.38}\ R^{-0.16}$
Bathurst (1985)	$(8/f)^{0.5} = 5.62 \log (d/d_{84}) + 4$
Bathurst (1985)	$n = [0.3193R^{0.167}] / \{[5.62 \log (R/d_{84})] + 4\}$

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Empirical Roughness Equation Suitability

Data Summaries	Discharge Q (cfs)	Width W (ft)	Slope(1) Sw or Sr (%)	Flow Depth(2) R or d (ft)	Particle Size D50 (mm)	Particle Size D84 (mm)	Relative Submergence(3) R/D84 or d/D84	Bedform Variation SigmaZ (ft)	Relative Submergence(4) Hm/SigmaZ	Predicted Manning's n at Bankfull
	Jarrett (1984)									0.0648
Median	385	70.5	0.650	1.77	122	335	1.72	NA	NA	
25th - 75th Percentile	118 - 1388	46.0 - 95.0	0.400 - 1.90	1.12 - 2.97	91 - 183	244 - 442	1.10 - 2.70	NA	NA	
Minimum - Maximum	12.0 - 4530	22.0 - 170.0	0.200 - 3.90	0.50 - 5.51	15 - 427	91 - 792	0.38 - 10.83	NA	NA	
	Limerinos (1970)									0.0505
Median	1470	NA	NA	3.24	122	274	3.49	NA	NA	
25th - 75th Percentile	954 - 2375	NA	NA	2.64 - 3.85	27 - 157	107 - 393	1.94 - 10.43	NA	NA	
Minimum - Maximum	211 - 15200	NA	NA	1.03 - 10.90	7 - 253	19 - 747	0.90 - 68.55	NA	NA	
	Hey (1979)									0.0516
Median	463	NA	0.350	1.47	NA	80	5.66	NA	NA	
25th - 75th Percentile	202 - 844	NA	0.281 - 0.666	1.06 - 2.01	NA	65 - 100	4.14 - 10.11	NA	NA	
Minimum - Maximum	35.1 - 6704	NA	0.090 - 3.100	0.46 - 7.30	NA	46 - 250	0.71 - 17.24	NA	NA	
	Bathurst (1985)									0.0446
Median	294	61.8	1.060	1.42	123	242	1.35	NA	NA	
25th - 75th Percentile	83.0 - 873	48.8 - 83.9	0.828 - 1.315	0.86 - 2.45	89 - 172	190 - 400	0.83 - 2.30	NA	NA	
Minimum - Maximum	4.84 - 6887	16.6 - 163.4	0.398 - 3.730	0.33 - 5.25	60 - 343	113 - 740	0.43 - 11.43	NA	NA	
	Lee and Ferguson (2002)									0.0267
Median	NA	NA	NA	NA	NA	NA	NA	NA	NA	
25th - 75th Percentile	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Minimum - Maximum	0.035 - 134	4.59 - 16.74	2.70 - 18.40	NA	150 - 360(5)	300 - 780(5)	0.10 - 1.40	NA	NA	
	Yochum et al. (2012)									0.0477
Median	7.77	9.51	9.60	0.56	94	207	0.91	0.56	2.59	
25th - 75th Percentile	3.53 - 16.51	6.56 - 11.8	7.40 - 13.35	0.38 - 0.71	57 - 151	151 - 333	0.56 - 1.38	0.42 - 0.83	1.97 - 3.29	
Minimum - Maximum	0.35 - 65.69	2.30 - 22.0	1.30 - 20.80	0.15 - 4.59	7 - 450	50 - 1350	0.16 - 4.44	0.095 - 1.96	0.88 - 12.07	

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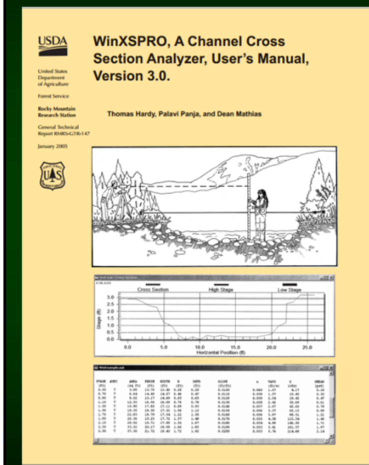
Modeling Low Risk & Simple Sites

Single Cross Section



- Single cross sections analyzer for simple channels. Single cross section does not determine backwater effects.
- Requires "uniform flow" conditions – typically in a riffle with a consistent slope and width and no downstream conditions creating backwater effects.

$$Q = \frac{1.49}{n} A\, R^{2/3} S^{1/2}$$

WinXSPRO is available from the Stream Systems Technology Center
http://www.stream.fs.fed.us/publications/winxspro.html

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XStream…the new WinXSPRO

Version 1.00

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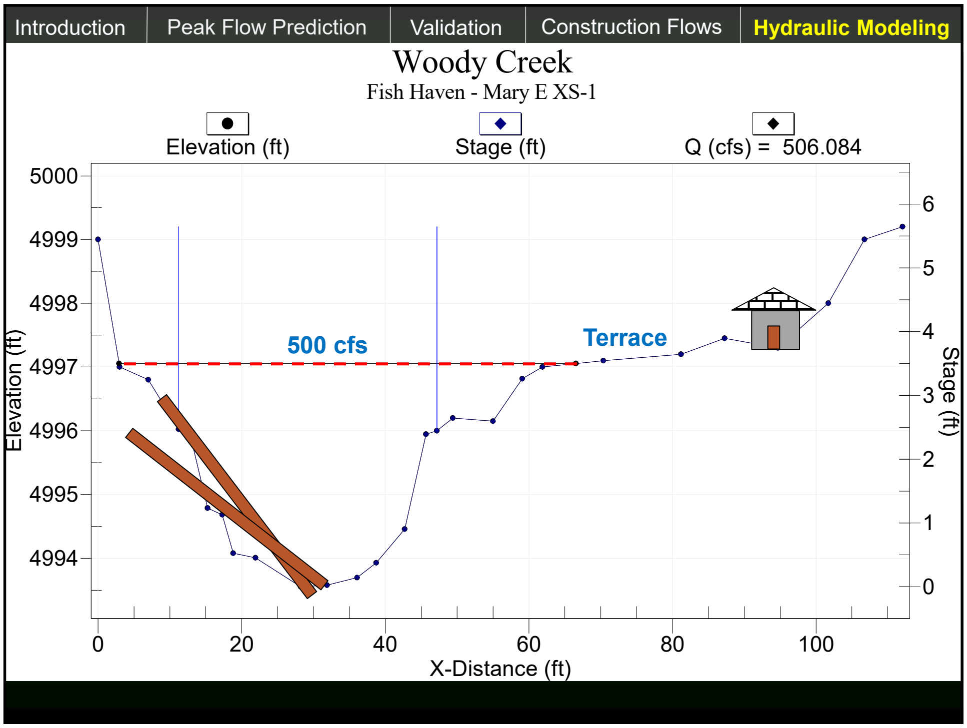
Dr. Thomas Hardy and USDA Forest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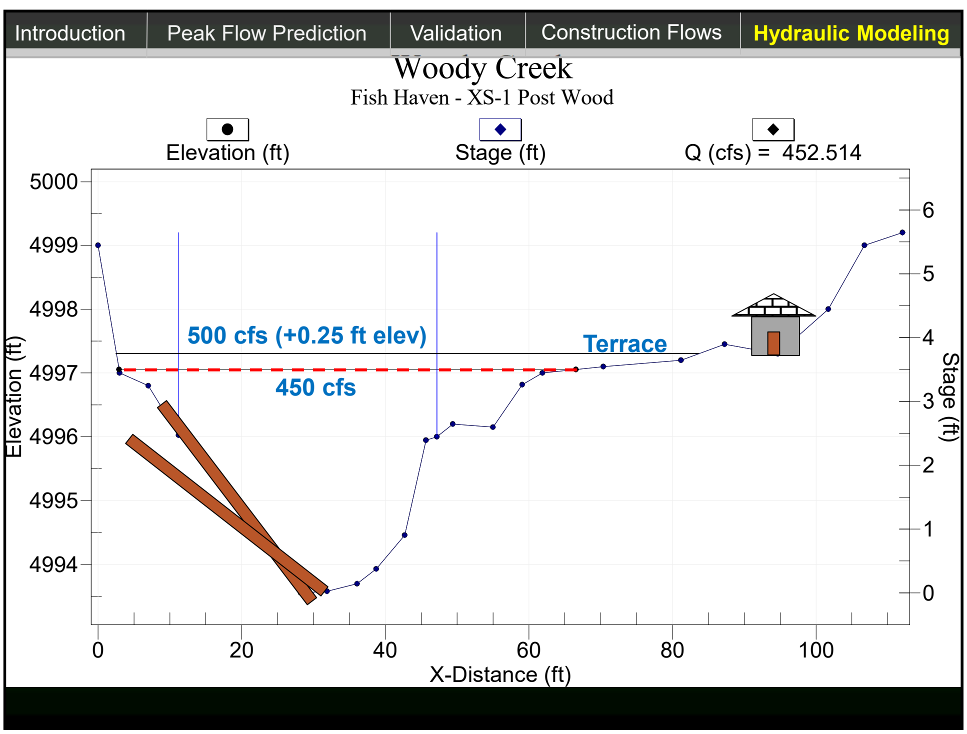
Hydraulic Modeling
Woody Creek
Fish Haven - Mary E XS-1
Elevation (ft)
Stage (ft)
Q (cfs) = 506.084
500 cfs
Terrace
X-Distance (ft)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Woody Creek
Fish Haven - XS-1 Post Wood
Elevation (ft)
Stage (ft)
Q (cfs) = 452.514
500 cfs (+0.25 ft elev)
Terrace
450 cfs
X-Distance (ft)

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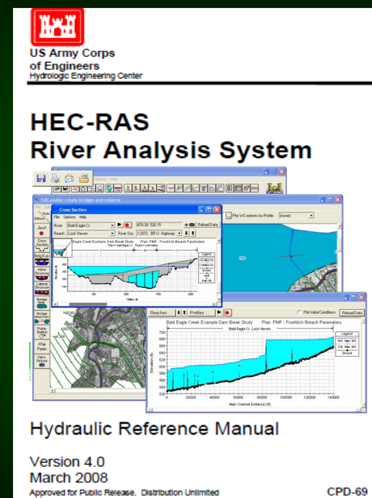
Modeling Moderate to High Risk sites

HEC-RAS is a reach-based, 1-D step-backwater model used define water-surface profiles and other hydraulic properties

Model features:

- Multiple cross sections connected in space
- Energy equation is iteratively solved for water surface elevations at successive cross sections
- Allows input of contraction and expansion coefficients
- Allows designation of ineffective flow areas
- Allows input of dimensions and locations of large wood structure(s)
- Can model multiple flow scenarios



http://www.hec.usace.army.mil/software/hec-ras/

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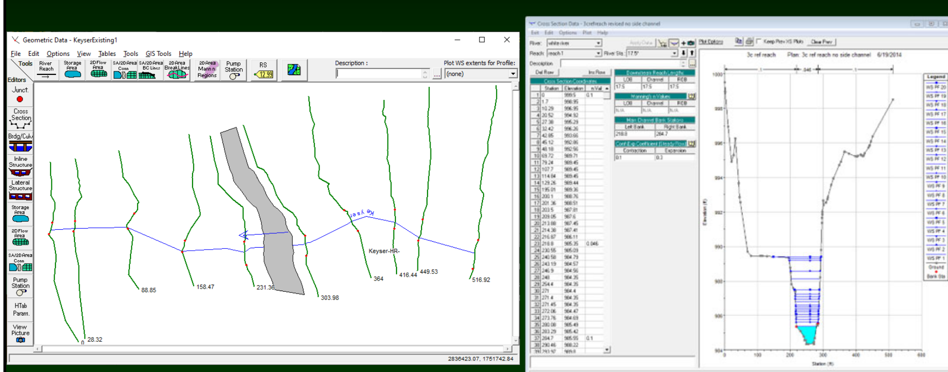
HEC-RAS hydraulic geometry data



- Reach data (profile) entered from downstream (station 0) to upstream.
- Cross section data (station, elevation) taken from river left to right looking downstream. Cross sections should be perpendicular to the direction of the flood.

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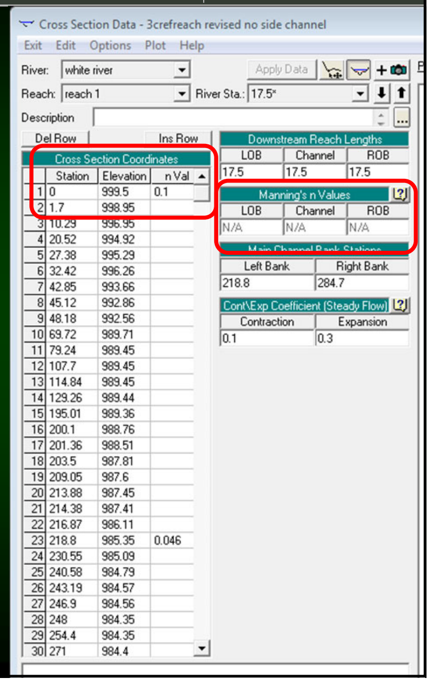
Manning's Roughness Values

- Determined by direct or indirect methods (from flow measurement, look up tables, or empirical equations
- Can be set based on stationing for different parts of the cross section (channel, floodplain)
- Can be set horizontally and vertically
- Require station/elevation and n values



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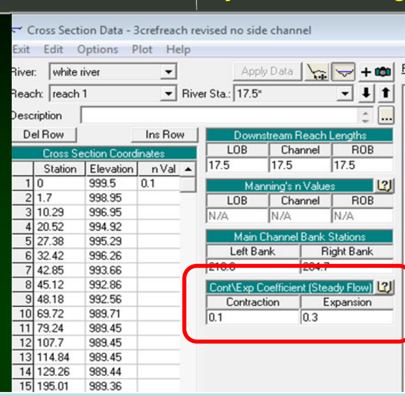
Expansion/Contraction Coefficients

- Used to evaluate the amount of energy loss that occurs changes in channel widths
- Typically in subcritical flow regime



Subcritical Flow Contraction and Expansion Coefficients

Location	Contraction	Expansion
No transition loss	0.0	0.0
Gradual transitions	0.1	0.3
Typical bridge sections	0.3	0.5
Abrupt transitions	0.6	0.8

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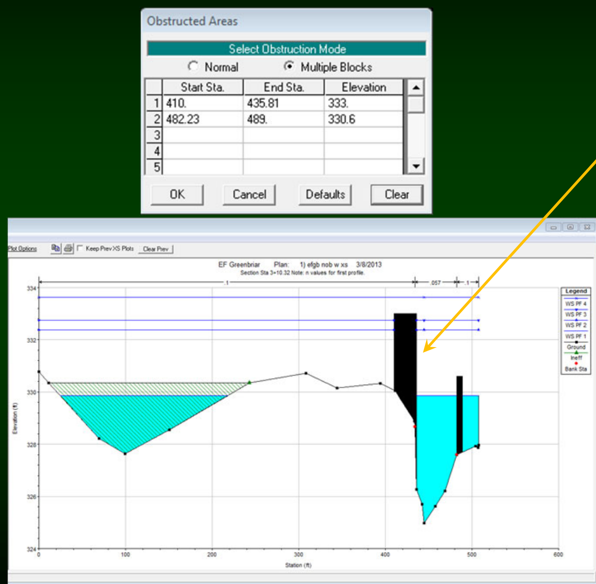
HEC-RAS hydraulic geometry data



Obstructions

- This is where we modify the cross section to include our LW structure
- Obstruction tool allows simple blocks to be blocked out, can also directly modify the cross section and adjust Mannings for that area

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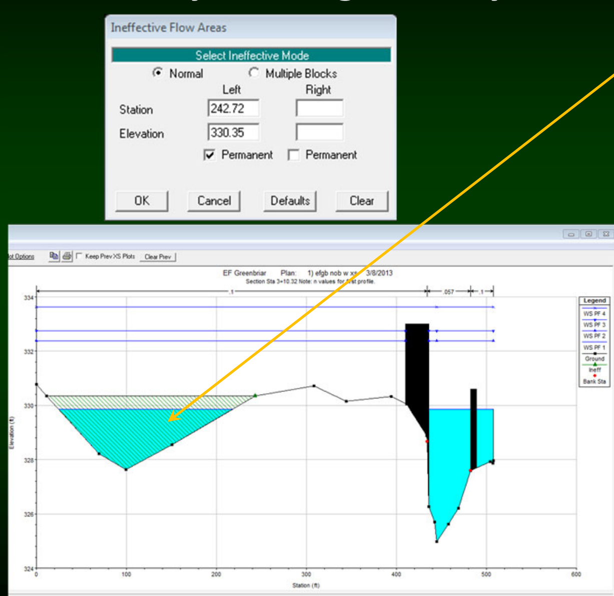
HEC-RAS hydraulic geometry data



Ineffective Flow Areas

- Areas like small side channels and depressions, eddies, where no real flow is conveyed (storage only)
- Ineffective flow tool allows simple blocks to be blocked out, can also directly modify the cross section

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HEC-RAS hydraulic geometry data

Model Output

- **Standard and custom output tables available**
- **Provides hydraulic computations for water depth, channel shear stress, average velocity, etc.**
- **Provides graphical outputs of water surface profiles, cross sections, and perspective views.**

Profile Output Table - SED ENT

File Options Std. Tables User Tables Locations Help

HEC-RAS Plan: ob major River: EF GreenBriar Reach: EFGB dwnstr

Reach	River Sta	Profile	Q Total	Q Channel	E.G. Slope	Top Width	Top W Act Chan	Hydr Radius	Hydr Radius C	Shear Total	Shear Chan	Vel Chnl	W.S. Elev	Min Ch El	Invert Slope	Froude # Chl	Area Channel
			(cfs)	(cfs)	(ft/ft)	(ft)	(ft)	(ft)	(ft)	(lb/sq ft)	(lb/sq ft)	(ft/s)	(ft)	(ft)			(sq ft)
EFGB dwnstr	404.3	PF 1	1442.00	1319.87	0.009609	409.63	48.29	0.62	3.57	0.37	2.14	7.56	331.25	326.58	0.0095	0.70	174.49
EFGB dwnstr	404.3	PF 2	5053.00	2675.66	0.008819	507.74	48.29	2.49	5.60	1.37	3.08	9.78	333.30	326.58	0.0095	0.72	273.59
EFGB dwnstr	404.3	PF 3	6047.00	2969.84	0.008743	507.74	48.29	2.86	5.98	1.56	3.26	10.17	333.68	326.58	0.0095	0.73	292.02
EFGB dwnstr	404.3	PF 4	8660.00	3703.15	0.008654	507.74	48.29	3.71	6.85	2.01	3.70	11.07	334.56	326.58	0.0095	0.74	334.38
EFGB dwnstr	364.3	PF 1	1442.00	1325.57	0.011493	343.85	48.29	1.82	3.42	1.30	2.46	7.93	330.53	326.01	0.0191	0.75	167.16
EFGB dwnstr	364.3	PF 2	5053.00	2625.57	0.007898	507.74	48.29	2.59	5.72	1.28	2.82	9.39	332.86	326.01	0.0191	0.69	279.60
EFGB dwnstr	364.3	PF 3	6047.00	2928.51	0.007991	507.74	48.29	2.95	6.09	1.47	3.04	9.84	333.23	326.01	0.0191	0.70	297.49
EFGB dwnstr	364.3	PF 4	8660.00	3674.89	0.008131	507.74	48.29	3.79	6.94	1.92	3.52	10.84	334.09	326.01	0.0191	0.72	339.13
EFGB dwnstr	310.32	PF 1	1442.00	1341.56	0.016186	257.62	46.42	2.88	3.40	2.91	3.44	7.51	329.85	324.98	0.0123	0.67	178.72
EFGB dwnstr	310.32	PF 2	5053.00	2561.59	0.011627	481.93	46.42	2.46	5.34	1.79	3.88	8.59	332.43	324.98	0.0123	0.60	298.13
EFGB dwnstr	310.32	PF 3	6047.00	2795.24	0.011468	481.93	46.42	2.83	5.63	2.03	4.03	8.84	332.82	324.98	0.0123	0.60	316.34
EFGB dwnstr	310.32	PF 4	8660.00	3385.19	0.011544	507.74	48.29	3.53	6.17	2.54	4.44	9.42	333.71	324.98	0.0123	0.61	359.26

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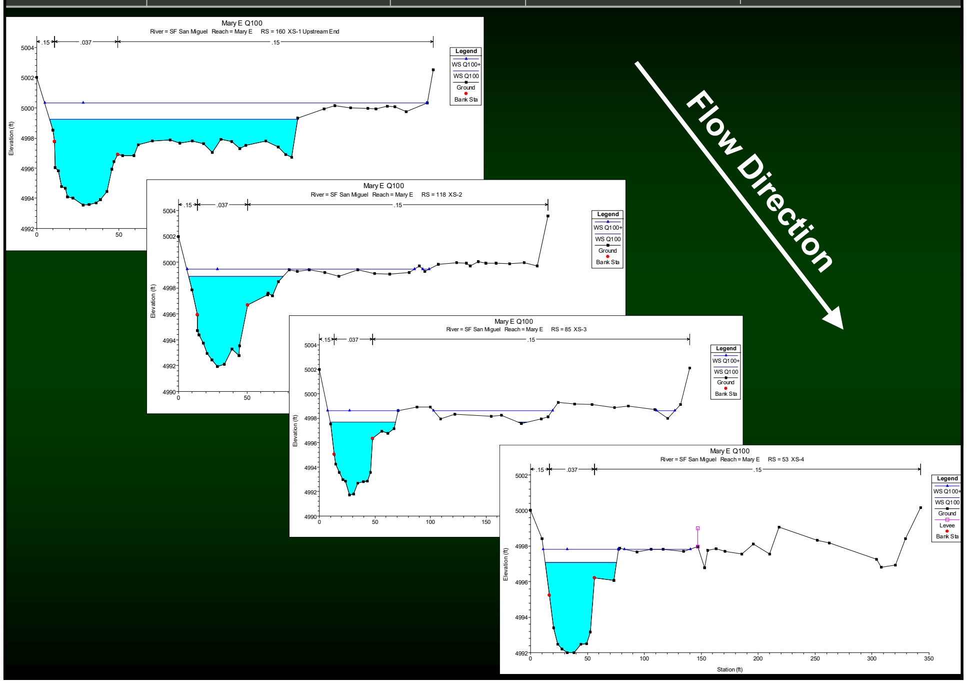

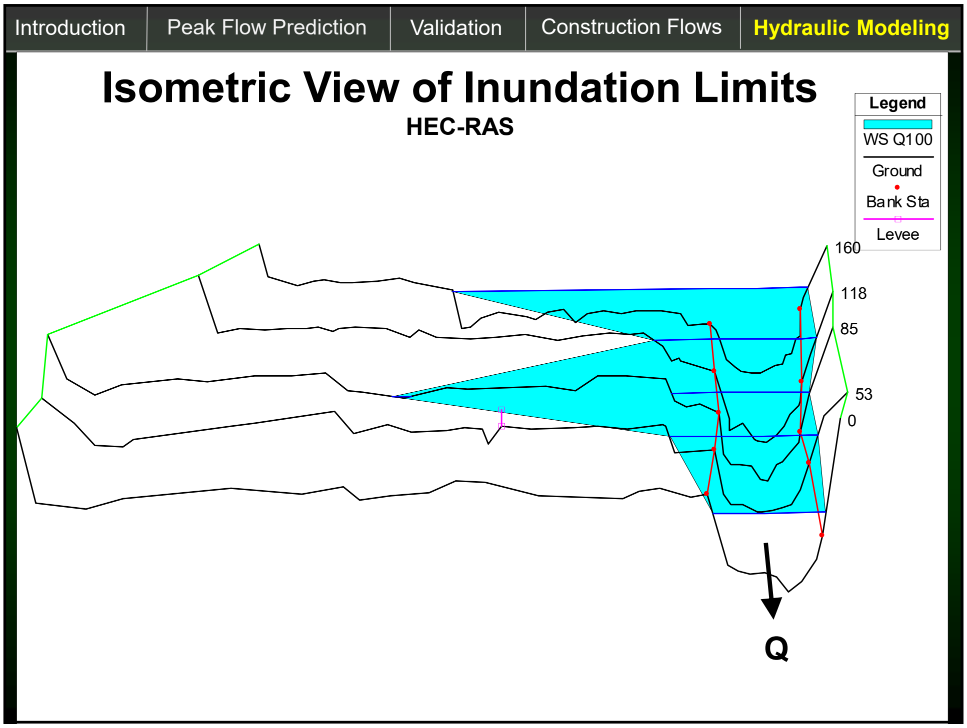
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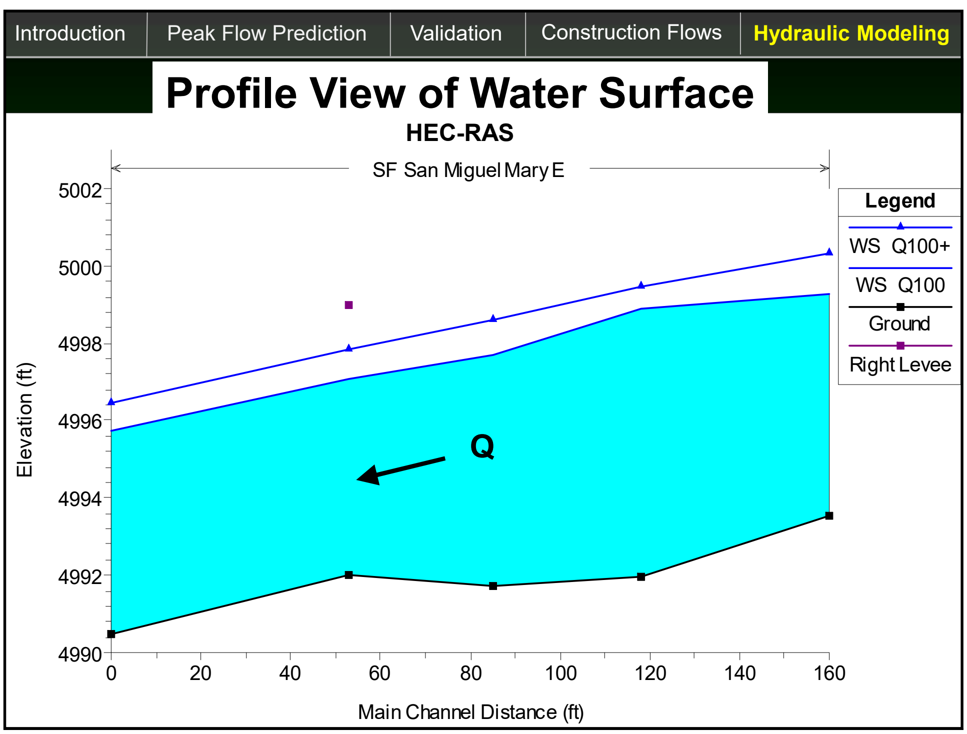
Isometric View of Inundation Limits
HEC-RAS
Legend
WS Q100
Ground
Bank Sta
Levee
160
118
85
53
0
Q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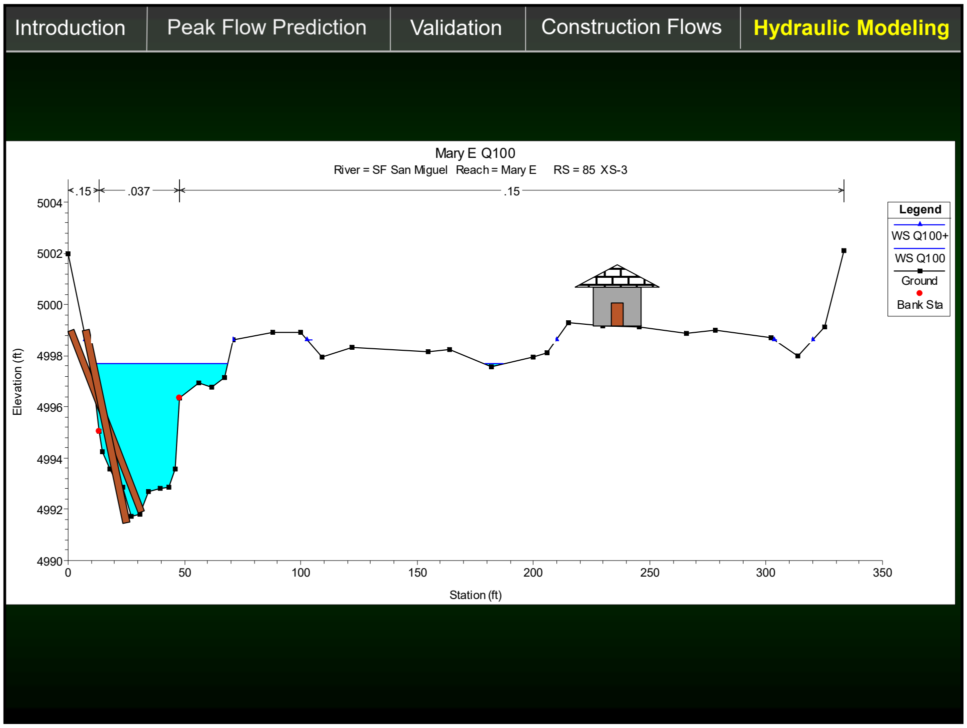
Profile View of Water Surface
HEC-RAS
SF San Miguel Mary E
Legend
WS Q100+
WS Q100
Ground
Right Levee
Q
Elevation (ft)
5002
5000
4998
4996
4994
4992
4990
0
20
40
60
80
100
120
140
160
Main Channel Distance (ft)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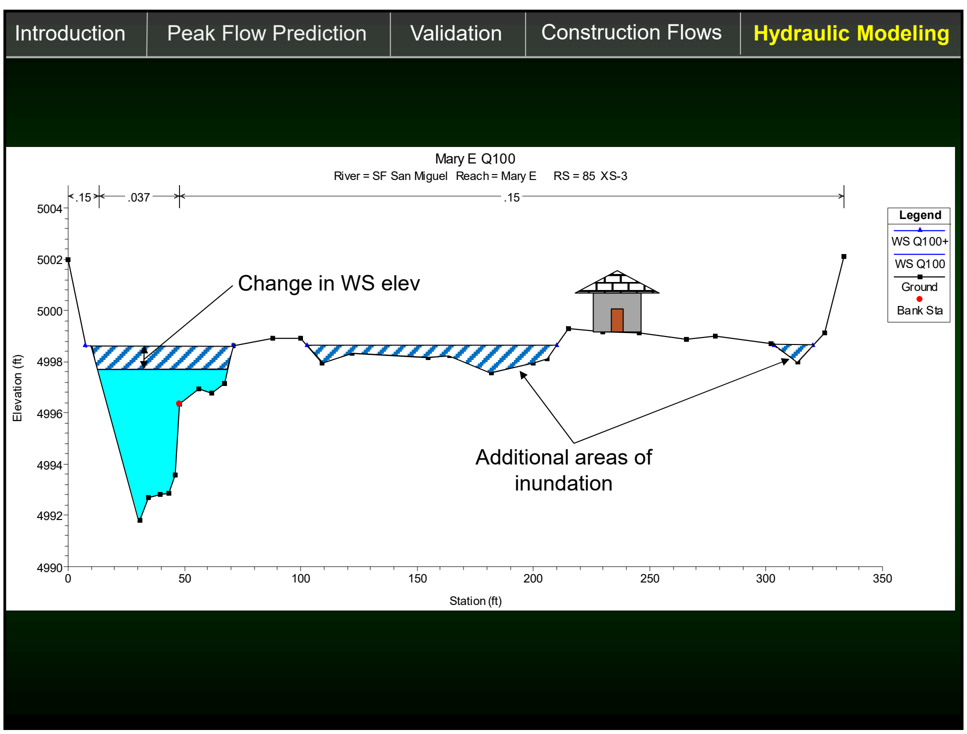
Mary E Q100
River = SF San Miguel Reach = Mary E RS = 85 XS-3
.15
.037
.15
Legend
WS Q100+
WS Q100
Ground
Bank Sta
Elevation (ft)
Station (ft)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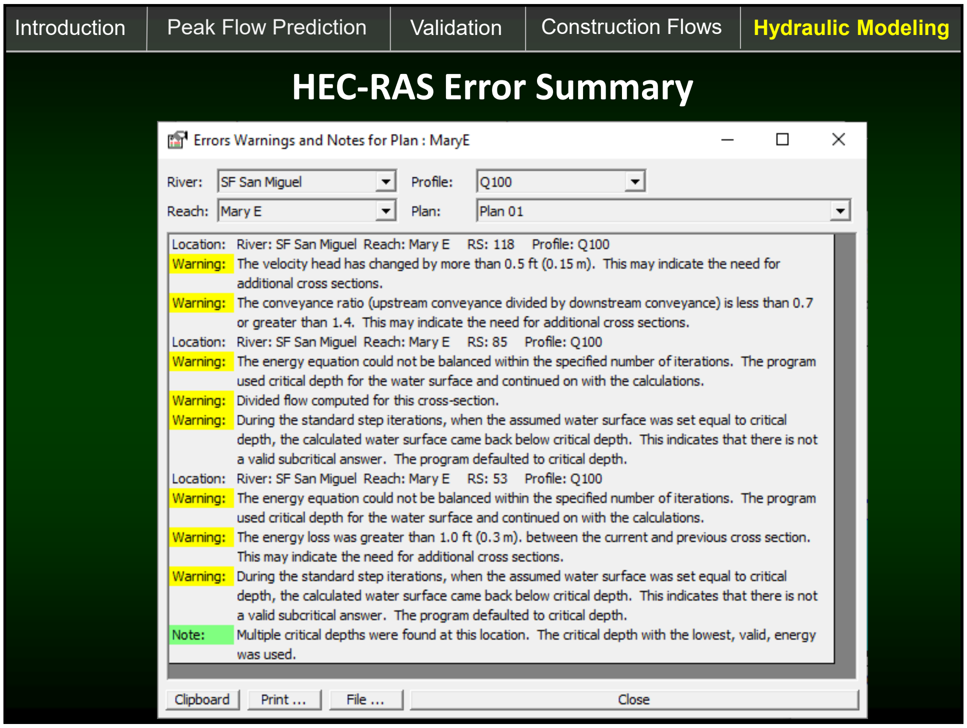
Mary E Q100
River = SF San Miguel Reach = Mary E RS = 85 XS-3
.15
.037
.15
Legend
WS Q100+
WS Q100
Ground
Bank Sta
Change in WS elev
Additional areas of inundation
Elevation (ft)
Station (ft)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HEC-RAS Error Summary
Errors Warnings and Notes for Plan : MaryE
River: SF San Miguel
Profile: Q100
Reach: Mary E
Plan: Plan 01
Location: River: SF San Miguel Reach: Mary E RS: 118 Profile: Q100
Warning: The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for additional cross sections.
Warning: The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than 1.4. This may indicate the need for additional cross sections.
Location: River: SF San Miguel Reach: Mary E RS: 85 Profile: Q100
Warning: The energy equation could not be balanced within the specified number of iterations. The program used critical depth for the water surface and continued on with the calculations.
Warning: Divided flow computed for this cross-section.
Warning: During the standard step iterations, when the assumed water surface was set equal to critical depth, the calculated water surface came back below critical depth. This indicates that there is not a valid subcritical answer. The program defaulted to critical depth.
Location: River: SF San Miguel Reach: Mary E RS: 53 Profile: Q100
Warning: The energy equation could not be balanced within the specified number of iterations. The program used critical depth for the water surface and continued on with the calculations.
Warning: The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section. This may indicate the need for additional cross sections.
Warning: During the standard step iterations, when the assumed water surface was set equal to critical depth, the calculated water surface came back below critical depth. This indicates that there is not a valid subcritical answer. The program defaulted to critical depth.
Note: Multiple critical depths were found at this location. The critical depth with the lowest, valid, energy was used.
Clipboard
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Close


Questions, Thoughts, Concerns?