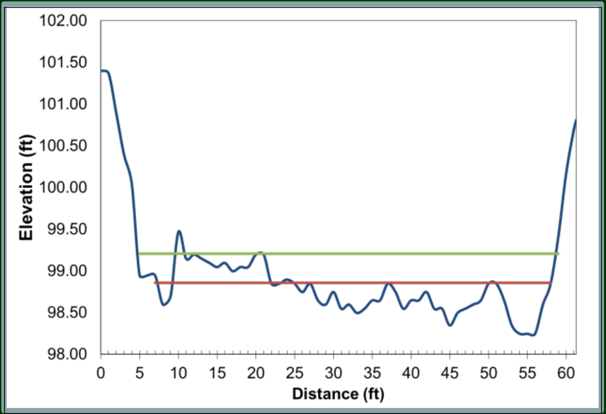
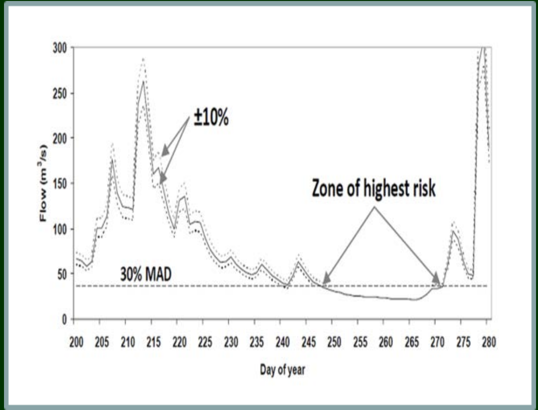
Assessing Aquatic Habitat Connectivity and Low-flow Ecological Thresholds





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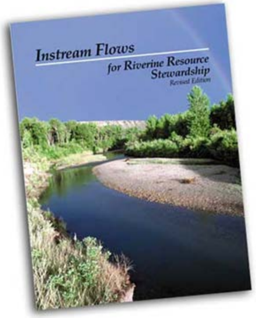
Outcome

- General understanding of some of the methods available to assess aquatic habitat connectivity and low-flow ecological thresholds
- Considerations when selecting such methods
- Availability of CDFW Instream Flow Program QA/QC instream flow tools (standard operating procedures, guidance documents, FAQ sheets, checklists, .).

- No single best method or flow (*think flow regimes*)

What is Instream Flow & Why is it Important?

= water flowing in a stream.



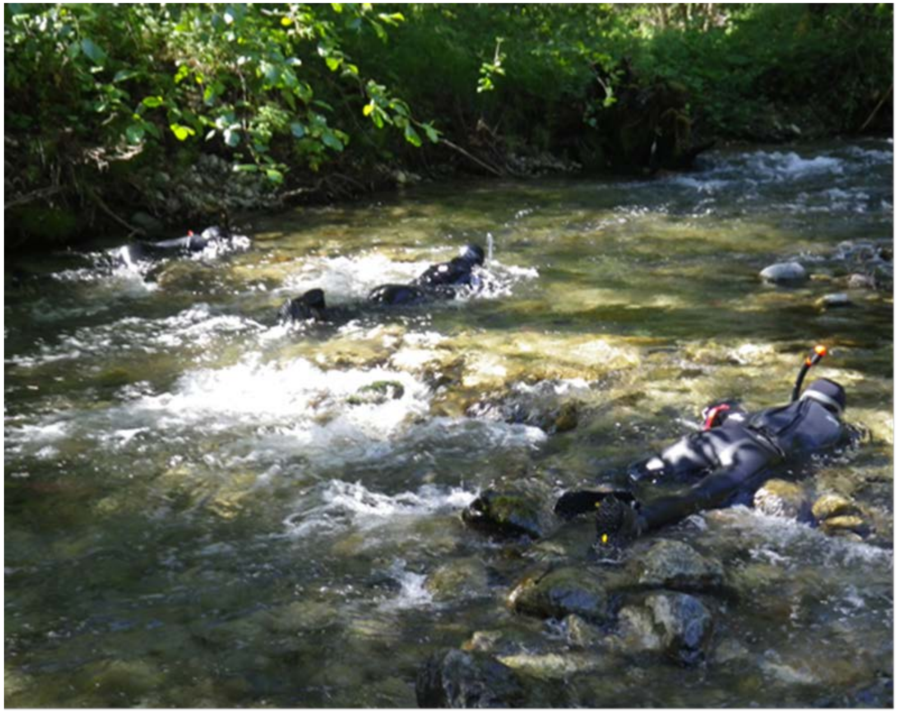
- Most streams have some level of flow, but flow is no guarantee that all is well for organisms (including humans) that depend on the river's resources.
- Natural resource managers are faced with the complicated task of protecting and restoring public values to rivers while honoring existing uses.
- A good understanding of how instream flow levels and regimes relate to the many beneficial values and services of rivers (i.e., flood mitigation, waters supplies, biological productivity, recreation, …) and the scale of alteration from the natural condition, is necessary for informed river management.

Terminology

- *Instream Flows:* The amount of water in a stream to adequately provide for instream uses within the stream channel (i.e., aquatic organisms and riverine processes).
- *Ecological Flows:* The flows and water levels in a water body to sustain the ecological function of the flora and fauna, and habitat processes within that water body and its margins.
- *Environmental Flows:* The flows to sustain freshwater ecosystems and the human livelihoods and well-being that depend on these ecosystems.

Core Riverine Components

- Biology
- Connectivity
- Geomorphology
- Hydrology
- Water Quality



Step One – Define Study Area, Reaches, and Map Habitat Types

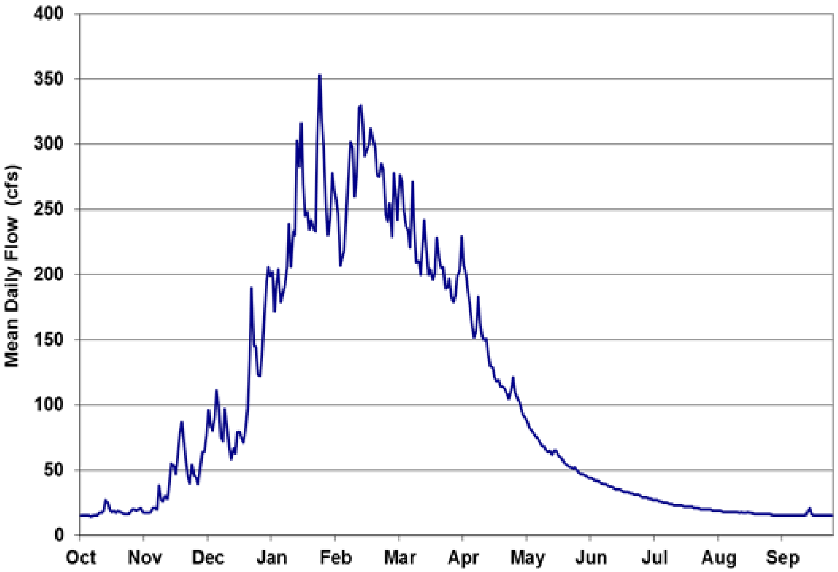
Goal:

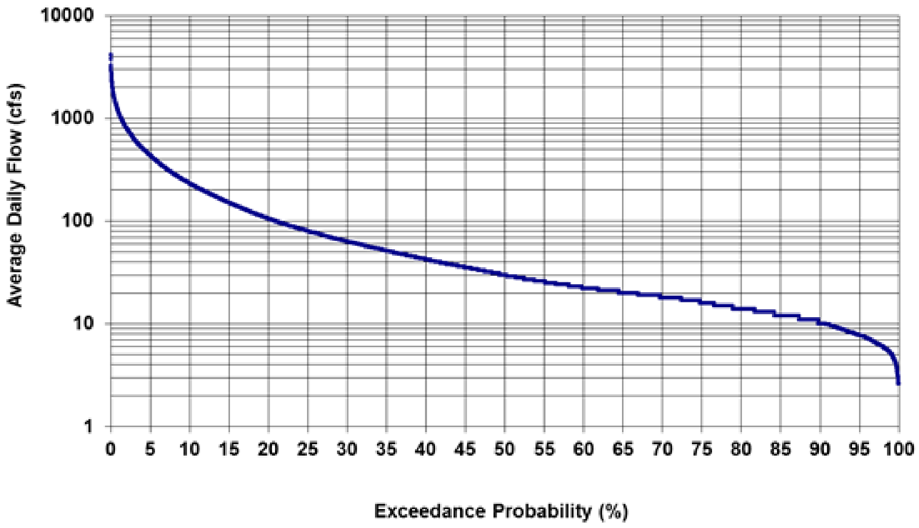
- Create inventory of habitat unit characteristics by type and distance within designated river reaches.

Habitat Unit #	Type	Length (ft)	Pool Depth (ft)	Lat.	Long.
1	GLD	197		36.97239	121 50.660
2	RUN	77		36.17201	121 40.652
3	LGR	38		36.17193	121 40.644
4	GLD	82		36.17067	121 40.635
5	POOL	96	4.5	36.17034	121 40.407

- Habitat inventory used as a basis for selecting study sites, and/or transects for hydraulic habitat analysis, and other studies.

Step Two – Develop Understanding of Natural Unimpaired Flow Conditions





Important for identifying appropriate sampling times, and for use in calibrating hydraulic models.

Step Three - Consider Species/Lifestages Periodicities

South-central steelhead	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Adult Migration												
Spawning												
Egg Incubation												
Emergence/Fry												
Juvenile Rearing												
Smolt Emigration												

Aquatic Habitat Connectivity – Why is it Important?

- Fragmentation of aquatic habitat due to low flows, either natural or anthropogenic in nature, can result in a block in flow of nutrients and transfer of energy, and reduction in the total amount of habitat available for aquatic organisms to carry out their life cycles.

- At low flows, critical riffles may become natural barriers to upstream and downstream passage for salmonids, which in turn may prevent or delay:
  - adults from moving to and from spawning areas
  - rearing juvenile salmonids from being able to move between adequate summer freshwater rearing habitats, seek productive feeding areas, and avoid predation
  - smolts from migrating downstream to staging areas in brackish waters of lagoons and estuaries before the ocean

Assessing Aquatic Habitat Connectivity

- Specify which of 4 dimensions you're using (lateral, vertical, longitudinal, time)
- Identify which elements are of interest (organisms, chemistry, bedload, energy)
- Specify time and duration when needed
- Need other tools to assess needs for other riverine elements and processes

Assessing Aquatic Habitat Connectivity

Methods: Most involve site-specific field data collection.

(SWRCB 2014 also has a desktop formula to determine salmonid passage flows using hydrology data).

Empirical

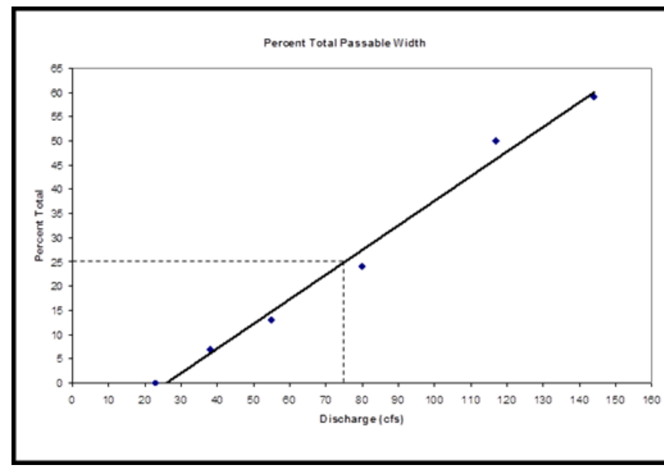
- Critical Riffle Analysis can address connectivity at riffle sites

Hydraulic Habitat Modeling

- Two dimensional (2D) models can address connectivity at the site and/or segment level

Critical Riffle Analysis

Critical riffles are those riffle habitats which may be particularly sensitive to changes in stream flow, and as such may prevent adult anadromous fish passage to and from spawning areas and/or may prevent movement of rearing juvenile salmonids (i.e., steelhead) between adequate summer rearing habitats.



Species	Minimum Depth (ft)
Steelhead (adult)	0.7
Coho (adult)	0.6
Chinook (adult)	0.9
Salmonid (juvenile)	0.4

Critical Riffle Analysis

- Empirical method (Thompson 1972) for assessing fish passage and habitat connectivity (depth and velocity)
- Four to six sample events of range of flows
- Transect follows shallowest course bank to bank
- Depth criteria for adult steelhead from SWRCB
- Two metrics (percent total and percent contiguous) meeting the criteria are plotted to identify flows

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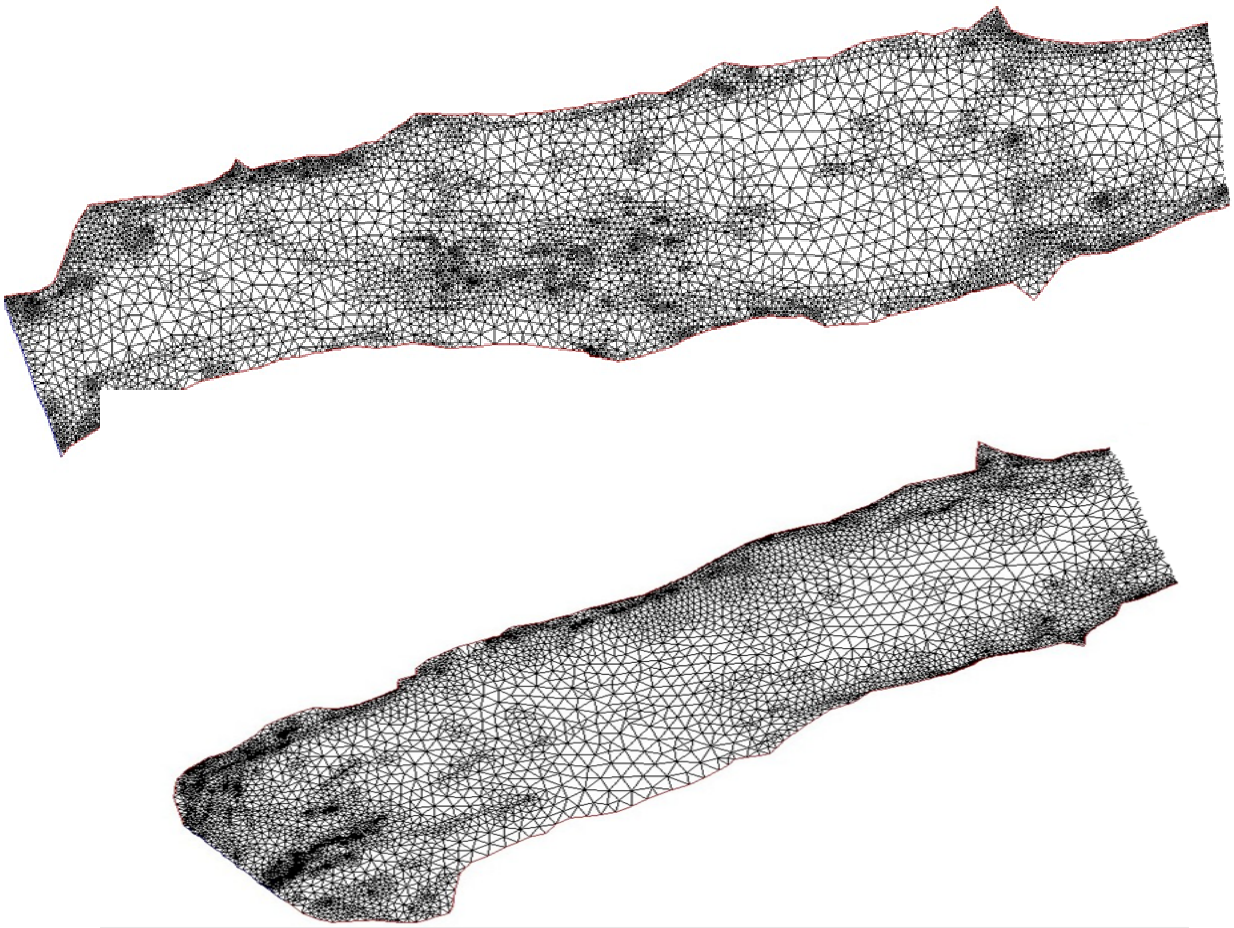
Considerations:

- *Can be used to identify protective (physical movement) flows – not minimum flows*
- Other factors also important to evaluate migratory success (length of riffle, availability of resting areas, condition of fish, temperature, ..)

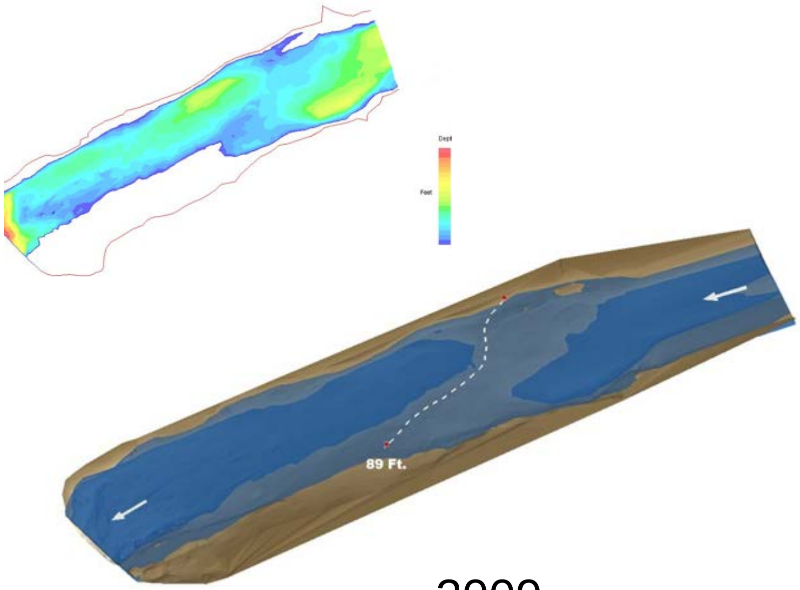
2D Hydraulic Habitat Models

- Total Station and prism used to survey bed topography and physical features
- Establish vertical benchmarks and tying vertical benchmarks together
- Measure stage of zero flow
- Collect water surface elevations at range of flows with autolevel and stadia rod

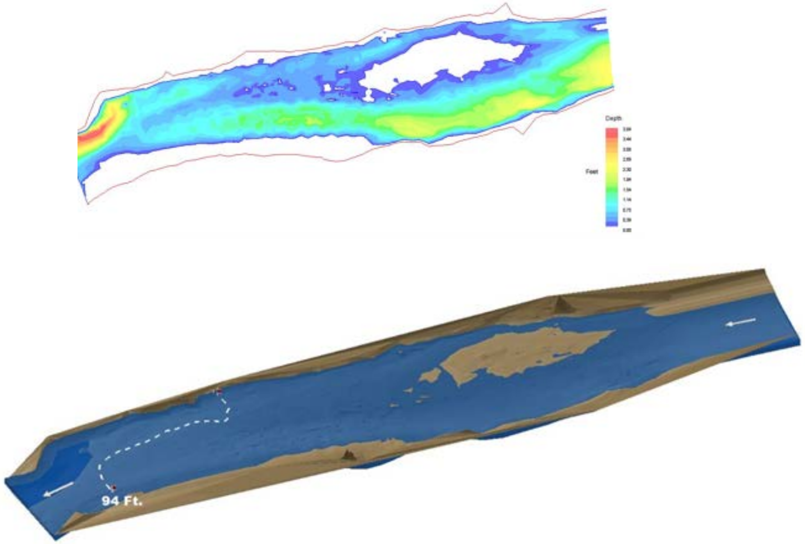
River 2D – Create Mesh Using Field Data for Models



River 2D Hydraulic Habitat Models



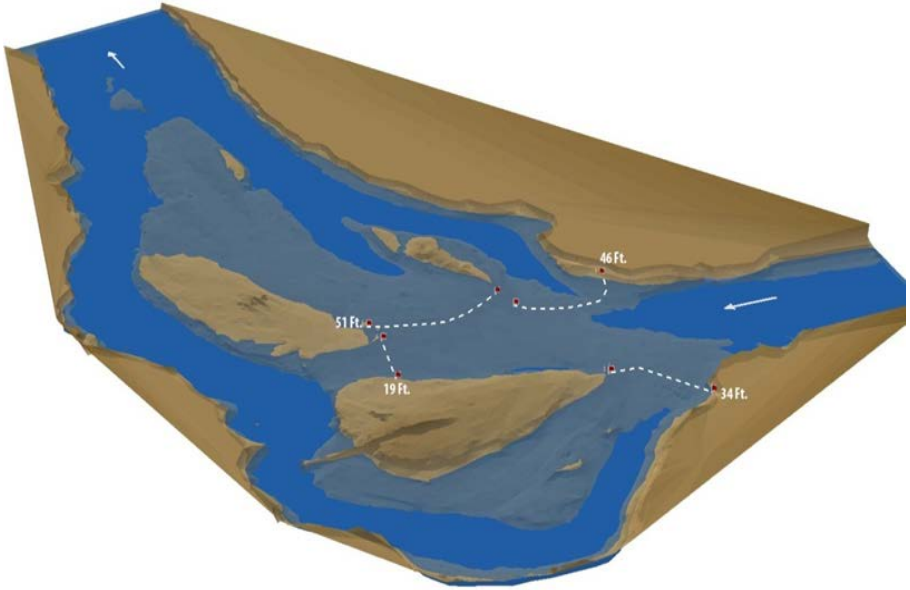
2009



2011

2D modeling simulates river hydraulics for a range of flows and can be used to evaluate flow and habitat relationships for various species and lifestages, including passage and habitat connectivity

River 2D Hydraulic Habitat Models



General Model Considerations

- Require accurate representation of bed topography
- Focus on habitat suitability (some focus on survival)
- Flow / habitat relationship may differ in different streams or stream segments
- Need other tools to assess needs for other riverine elements

Low-Flow Ecological Thresholds – Why Important?

- A low-flow "cut-off" is recognized as an important component of an overall instream flow regime prescription.

- The low-flow threshold can be applied to conserve fisheries, and widely recognized that having such a threshold can preserve ecosystem structure and function in riverine ecosystems that support fisheries (DFO, 2013).

Methods:

Hydrological (office) Methods

- Tennant
- Presumptive Standard (Richter et al. 2011)

Single Transect (field) Methods

- Wetted Perimeter

Tennant Method

Narrative Description of Flow	April to September	October to March
Flushing or maximum flow	200% from 48 to 72 hours	
Optimum range of flow	60-100%	60-100%
Outstanding habitat	60%	40%
Excellent habitat	50%	30%
Good habitat	40%	20%
Fair or degrading habitat	30%	10%
Poor or minimum habitat	10%	10%
Severe degradation	<10%	<10%

Many people think of Tennant as an office based, single-flow setting tool. The fact is that Tennant never intended this method to be used that way. Rather, any flow set using the technique should be validated in the field and the tool should be used to establish a range of flows.

Tennant Method

- Can set threshold flows or regimes
- Need long-term gage data
- Limited ability to identify trade-offs
- Majority of challenges have been successfully defended (widely accepted method)
- Need other tools to assess needs for other riverine elements

A key consideration with a hydrology method is that if hydrologic patterns have been altered, the flows derived may be artificially lower.

Presumptive Standard Approach

- Richter et al. (2011) recommends using a presumptive standard approach to prevent aquatic ecosystem degradation.

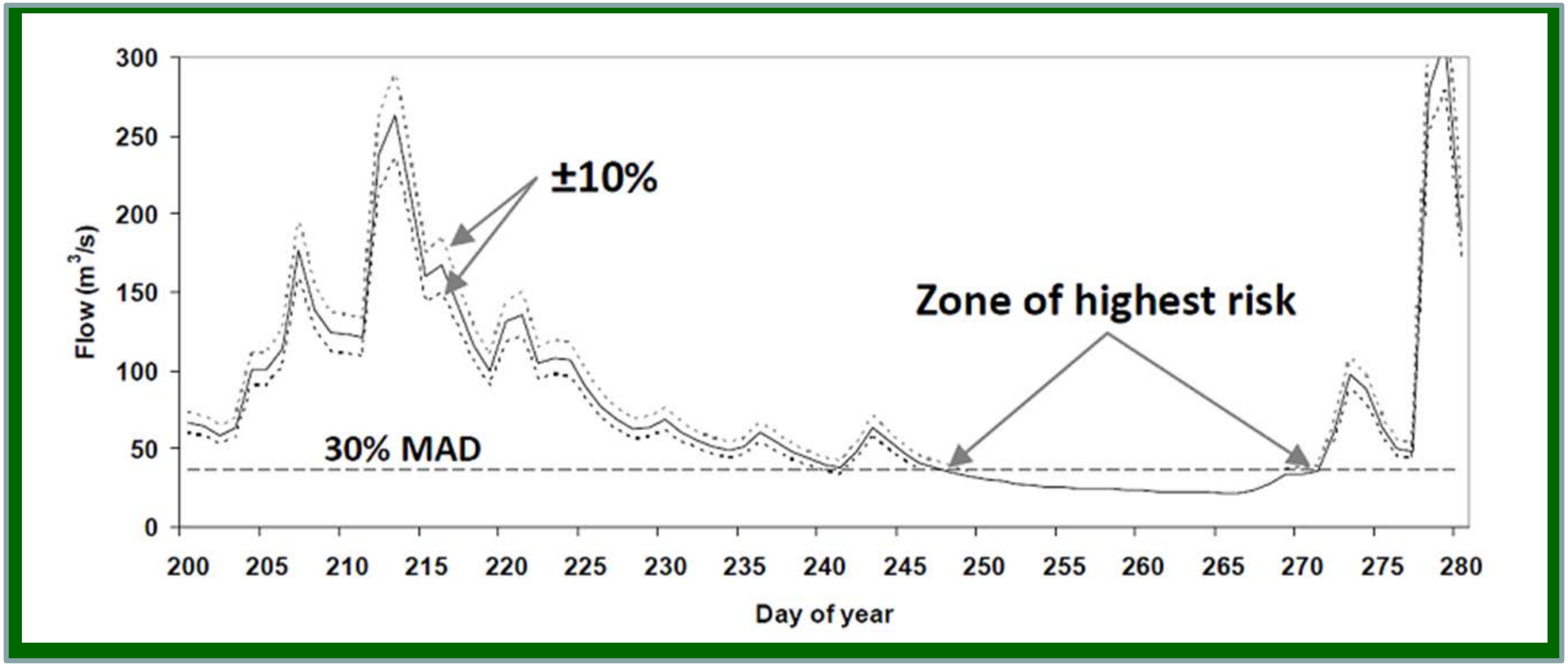
  - daily flow alterations of no more than 10%-20%

  - 30% of the MAD for low-flow threshold

  (less than 30% MAD requires detailed studies)

Presumptive Standard Approach

Depiction of Zone of Highest Risk (Instantaneous Discharges < 30% MAD)



Source:

Fisheries and Oceans Canada / Pêches et Océans Canada
Science / Sciences
National Capital Region
Canadian Science Advisory Secretariat
Science Advisory Report 2013/017

FRAMEWORK FOR ASSESSING THE ECOLOGICAL FLOW REQUIREMENTS TO SUPPORT FISHERIES IN CANADA

Single Transect Methods (Wetted Perimeter)

- Low to moderate effort
- Long history of use
- Only useful for setting threshold flows
- Limited ability to identify trade-offs
- Doesn’t address flow variability needs
- Need other tools to assess needs for other riverine elements (i.e., salmonid rearing)

Wetted Perimeter Method

Goal:

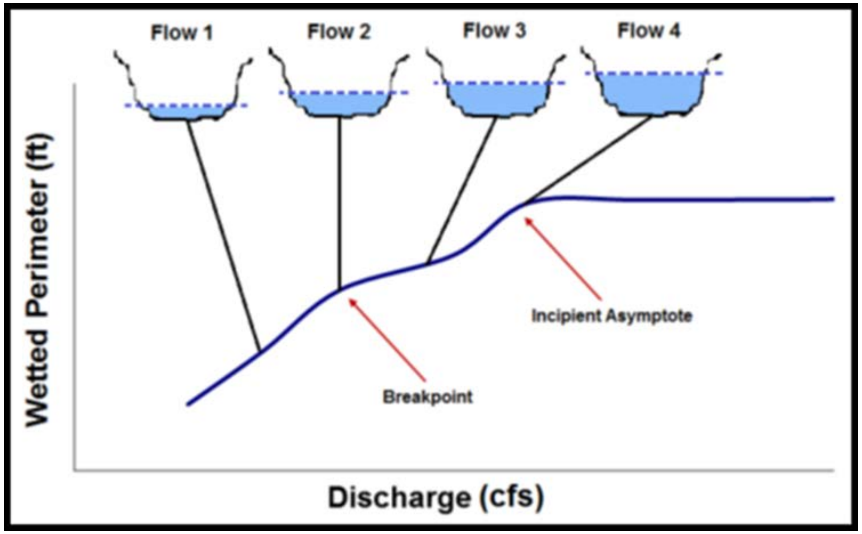
Identify low-flow ecological threshold for ecology (benthic invertebrate) and fishery using site-specific data and manning's equation

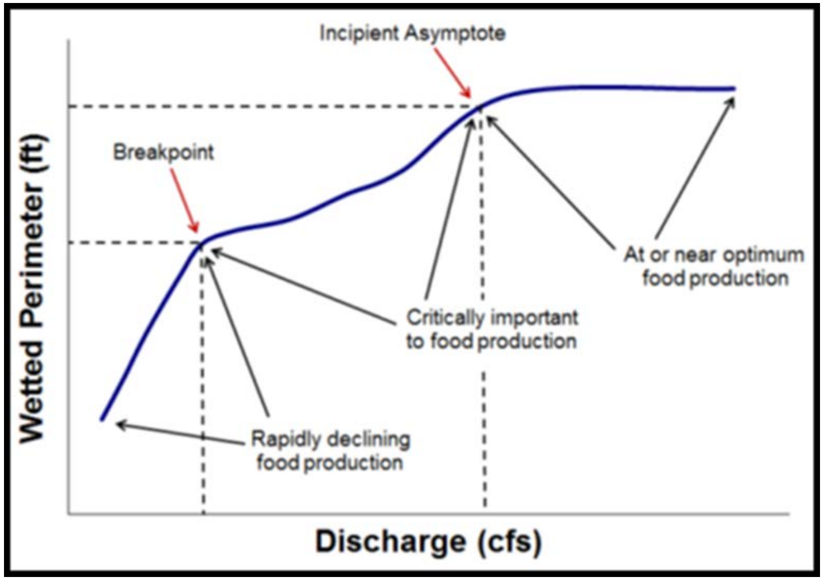
<u>Can be done with or without hydrological model</u>

Q = 1.486/n AR2/3S1/2 or n = 1.486/Q AR2/3S1/2

- Stratified random transect selection process at riffles
- Fixed cross-channel transects
- Three sets of survey data at various flows (water surface elevations, water depths, water velocities, substrate composition, stream width)

Wetted Perimeter: Upper and Lower Inflection Points





Overall Considerations

- Every situation is different so each has a unique solution
- Must consider natural water availability and water year/month types (wet, normal, dry)
- Habitat connectivity and low-flow threshold flows not always available under unimpaired flow conditions

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- Good approach is to assess flow needs using a suite of methods to address specific endpoints at specific times of the year

How Does One Determine How Much Water a River Needs?

- There is usually not just one flow level that a river needs to stay healthy.
- Using hydrology, biology, connectivity, geomorphology, and water quality to identify flow regimes for fish and wildlife.
- Inter- and intra-annual flow prescriptions are needed to preserve the ecological health of a river.
- Think flow regimes!

Acknowledgments:

CDFW Instream Flow Program

CDFW Biogeographic Database

U.S. Fish and Wildlife Instream Flow Group

The QA Research Group at Moss Landing Marine Laboratories

Instream Flow Council

INSTREAM FLOW COUNCIL

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Protecting Rivers and Lakes in the Face of Uncertainty

Third International Workshop on Instream Flows

Portland, Oregon – April 28-30, 2015

Problem-solving workshop focused on approaches and strategies that have effectively resolved uncertainty. Special emphasis placed on integrating new and traditional instream flow methods.

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DFG Instream Flow Program information at:
http://www.dfg.ca.gov/water/instream_flow.html

Instream Flow Council
http://www.instreamflowcouncil.org/

INSTREAM FLOW COUNCIL
Protecting, Maintaining, and Restoring Aquatic Ecosystems

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