

Quantifying Flow Criteria for Fish and Wildlife and Their Habitats



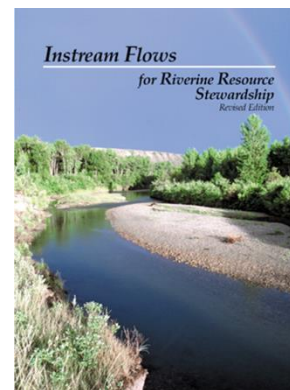
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North Coast Regional Water Quality Control Board
Instream Flows Workshop
March 11, 2015



Outcome

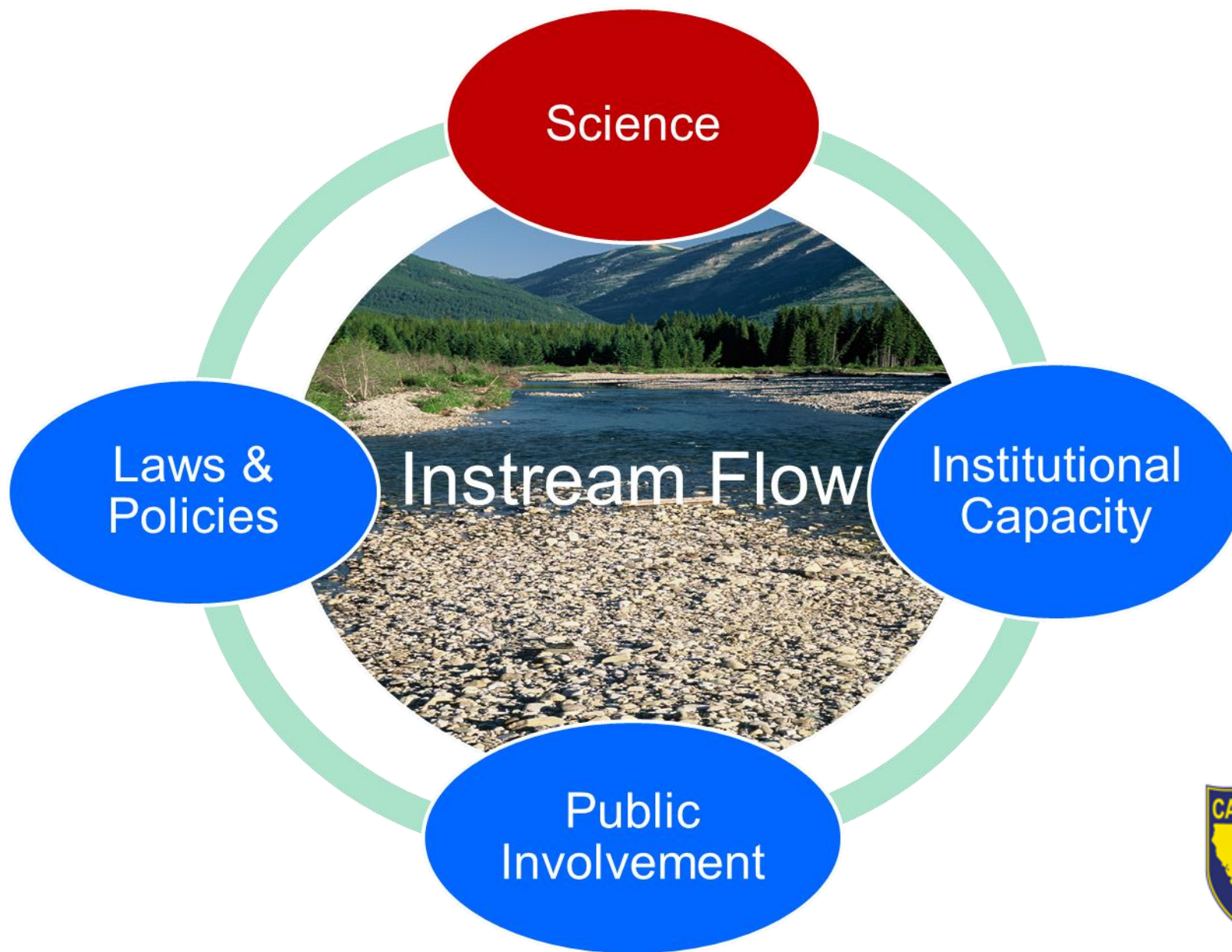
- General understanding of common methods available to quantify flow criteria for fish and wildlife.
- Considerations when selecting such methods.



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- There are a large number of proven, acceptable methods to chose from for quantifying flow needs.
 - No single best method or flow (*think flow regimes*)...



Information in this presentation is from publications and policies of the Instream Flow Council.
Tom Annear (Wyoming Game and Fish) also provided information.



Methods Evolution

- 1960's – Water Quality
- 1970's – Hydrologic Statistics
- 1980's - Quantitative Biology Models
- 1990's - Ecosystem Processes
- 2000's – Holistic Methods



Models - What Can They Tell Us?

- A considerable amount about individual habitat elements such as:
 - Short-term survival of organisms
 - Long-term persistence of habitat
 - Long-term persistence of organisms

Models help with the decision making process..



Precision vs Accuracy of Models

Do you need to know the PRECISE effect or result?

“Exactly how many fish will result from a particular flow level?”

- Few situations where field studies can consistently provide such precision.
- Precise answers are unrealistic since we are modeling ecosystem processes.

Or just ACCURATELY predict trends?

- If used properly, available models and knowledge of ecological processes does allow scientists to predict trends associated with different flow regimes with reasonable accuracy.



Habitat Modeling Caveats

- Models manage uncertainty – not eliminate it.
- No model tells us everything we need to know.
- Relationship between flow and habitat is not linear.
- A flow that's good for one species may be detrimental to others.
- There is not a single best flow – think flow regimes.



Traditional Approach

- *One species*
- *One method / tool*
- *One flow (minimum)*
- *“Flat-lining” flow regime*



Flow Quantification Method Categories

Standard-setting methods (segments or regions)

- Single minimum threshold (bottom up)
- Presumptive standard (top down)

Incremental Methods

- Evaluate habitat vs. flow relationships
- Relate to a single riverine element at a time

Multiple component (holistic) methods

- The next generation (environmental flows)
- Integrates more than one component at a time



Core Riverine Components

- Biology
- Connectivity
- Geomorphology
- Hydrology
- Water Quality



Understanding the importance and addressing the inter-relations of the 5 riverine components is critical in any flow regime quantification exercise.



Hydrology Methods

- Indicators of Hydraulic Alteration (IHA)
- Range of Variability Approach (RVA)
- Flow duration curves (Q_{98})
- Alberta desk top method (protect % of flow)
- Richter presumptive standard

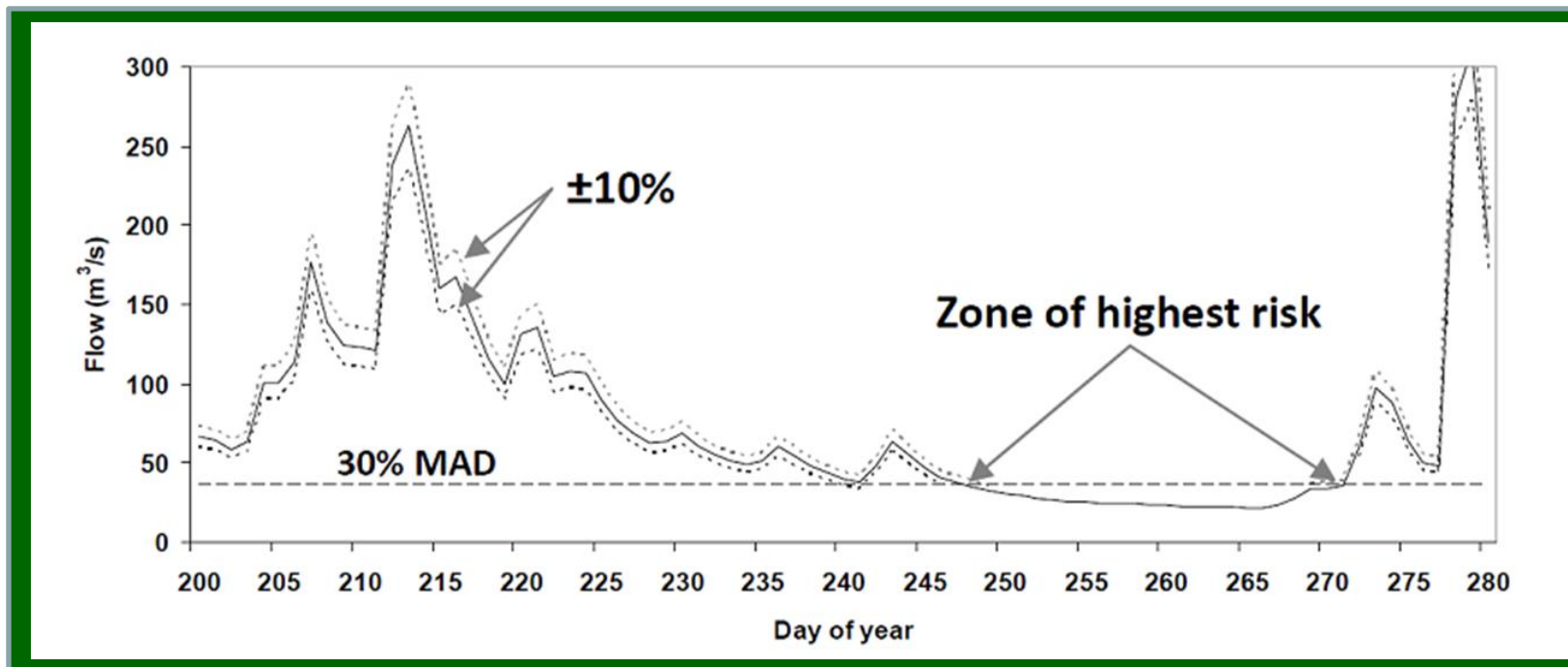
Of those shown here, the IHA model is the most widely used tool among IFC member agencies.



Presumptive Standard Approach

Depiction of Zone of Highest Risk

(Instantaneous Discharges < 30% (MAD) Mean Annual Discharge)



Source:



Fisheries and Oceans Canada
Pêches et Océans Canada
Science Sciences

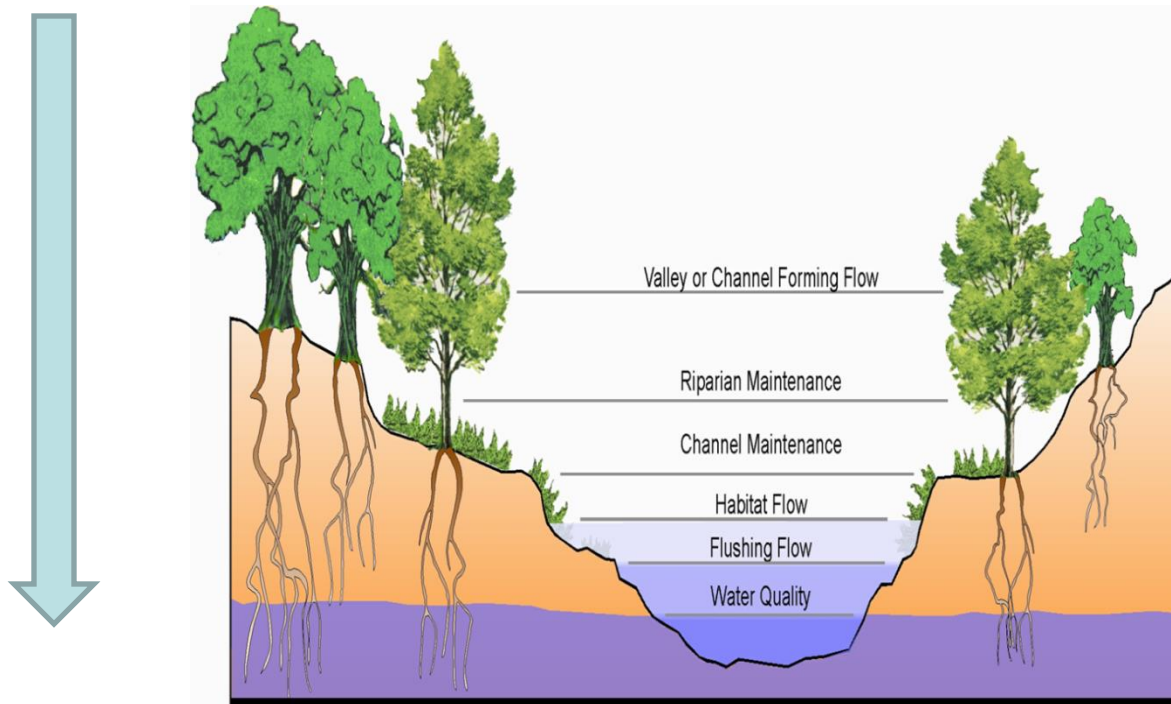
National Capital Region

Canadian Science Advisory Secretariat
Science Advisory Report 2013/017

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



Flow Protection



- Upside Down Instream Flow

This group of models (hydrology) typically used to identify how much water to leave – not necessarily to restore.

Note: If hydrologic patterns have been altered, the flows derived may be artificially lower.



Hydrology Model Considerations

- Long history of use (for some) – acceptance
- Good for describing hydrology (planning)
- Need long-term gage data
- Low to moderate effort
- Assumes relationship with biology
- May have different relationships with biology on different streams
- Need other tools to assess needs for other riverine elements or specific needs



Biology

- Single Transect Methods
- Tennant Method (and variations)
- Physical Habitat Simulation (PHABSIM)
- Two Dimensional Models (River 2D)

By far, the majority of instream flow quantification methods are based on some aspect of biology.



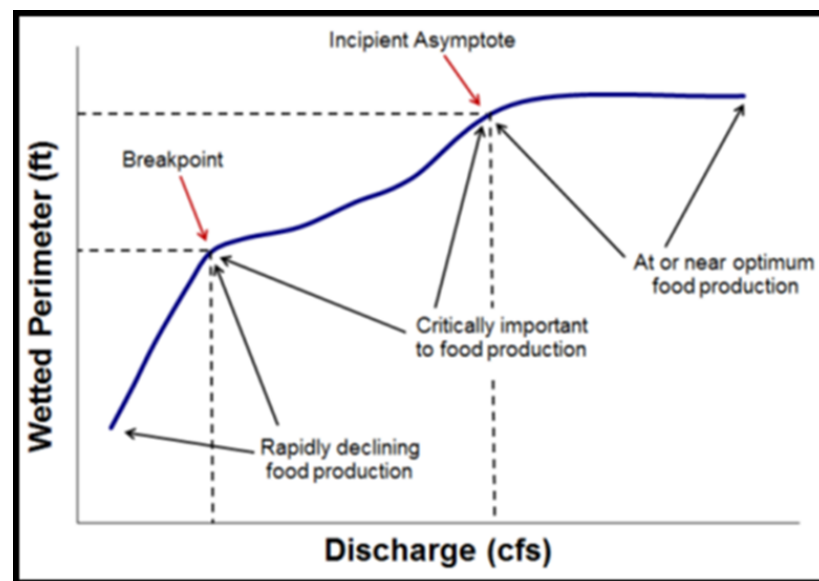
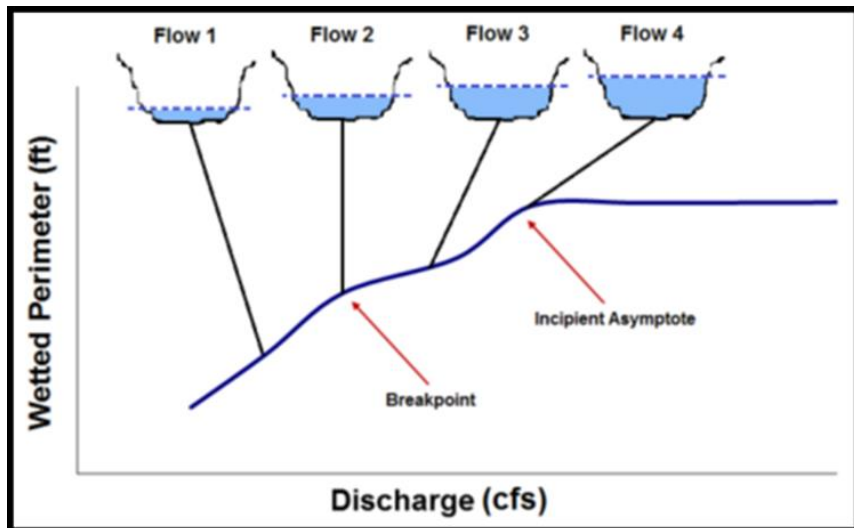
Single Transect Methods



Primarily used to estimate hydraulic characteristics over a range of flows (average depth, average velocity, wetted perimeter, and hydraulic radius).



Wetted Perimeter: Lower and Upper (Incipient Asymptote*) Breakpoints



* Term "Incipient Asymptote" coined by Dr. Rob Titus (CDFW)



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



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.

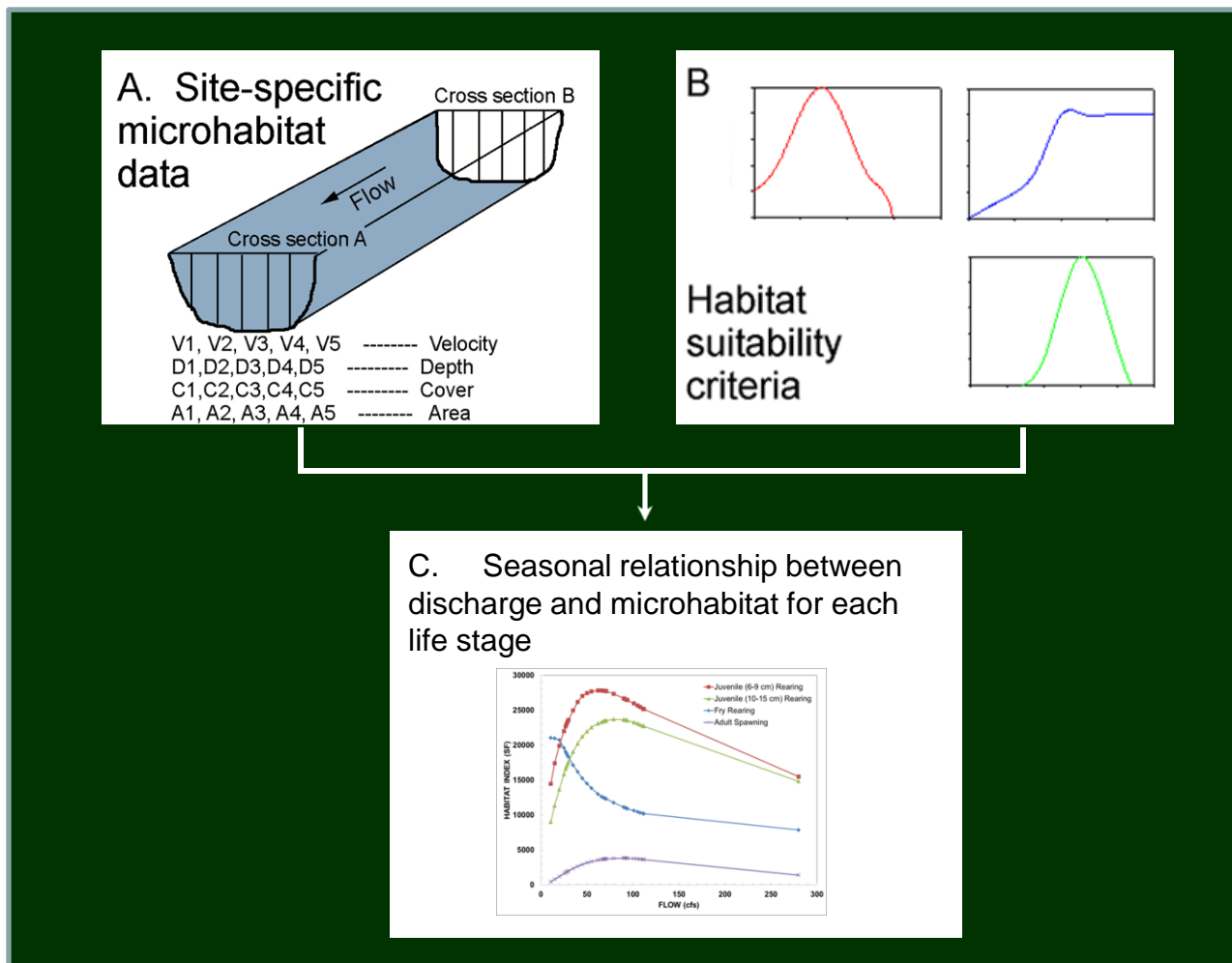


Tennant Method

- 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



Physical Habitat Simulation (PHABSIM)



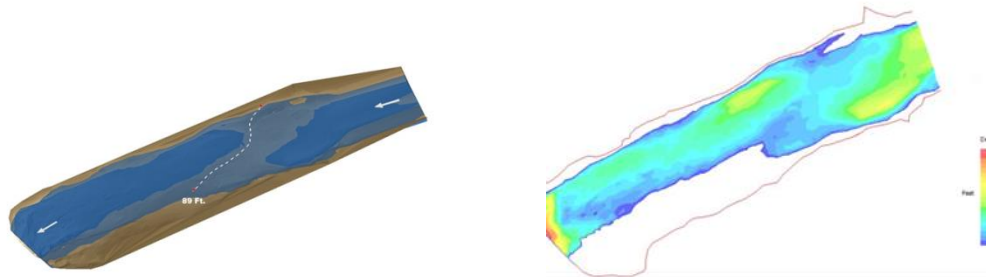
PHABSIM Concerns

- 1D hydraulic models simplify the channel
- Physical habitat suitability isn't the same as habitat
- Unknown relationship between WUA and fish biomass
- Need other models to quantify needs for other riverine purposes



2D Hydraulic Habitat Models

- Total Station and prism used to survey bed topography and physical features
- Establish vertical benchmarks and tying vertical benchmarks together
- Measuring stage of zero flow
- Collecting water surface elevations at range of flows

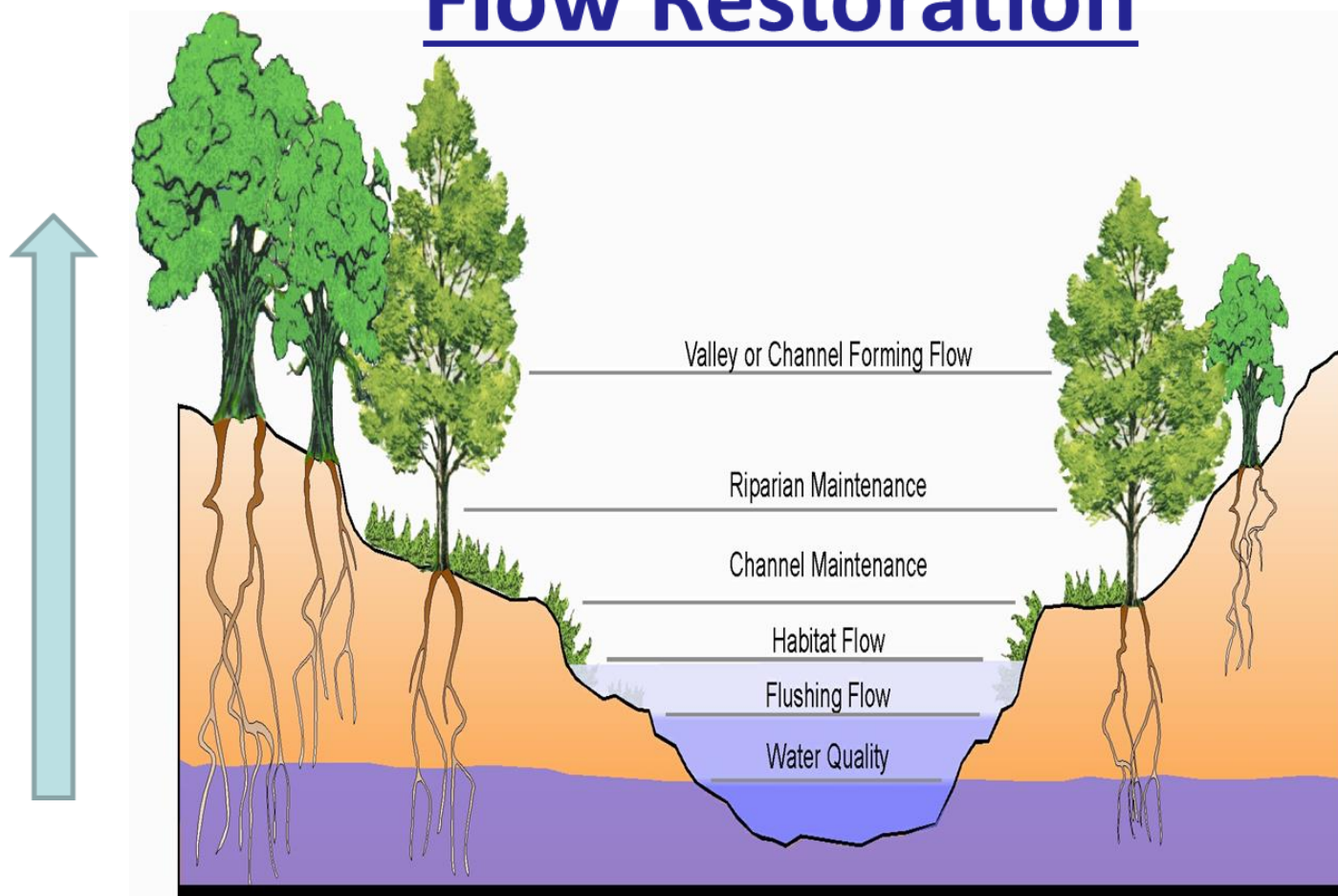


General 2D Model Considerations

- Different models available
- Focus on survival or habitat suitability
- Flow / habitat relationship may differ in different streams or stream segments
- Some address trade-offs
- Need other tools to assess needs for other riverine elements



Flow Restoration



- Bottom Up Instream Flow

This group of models (biology) is more effective for identifying how much water is needed to restore a fishery – and also to quantify mitigation needs.



Geomorphology

- Channel maintenance in gravel-bed streams
- Flushing flows
 - Empirical or office based
- Geomorphic classifications (Rosgen)
- HEC-6 and HEC-RAS

Considerations:

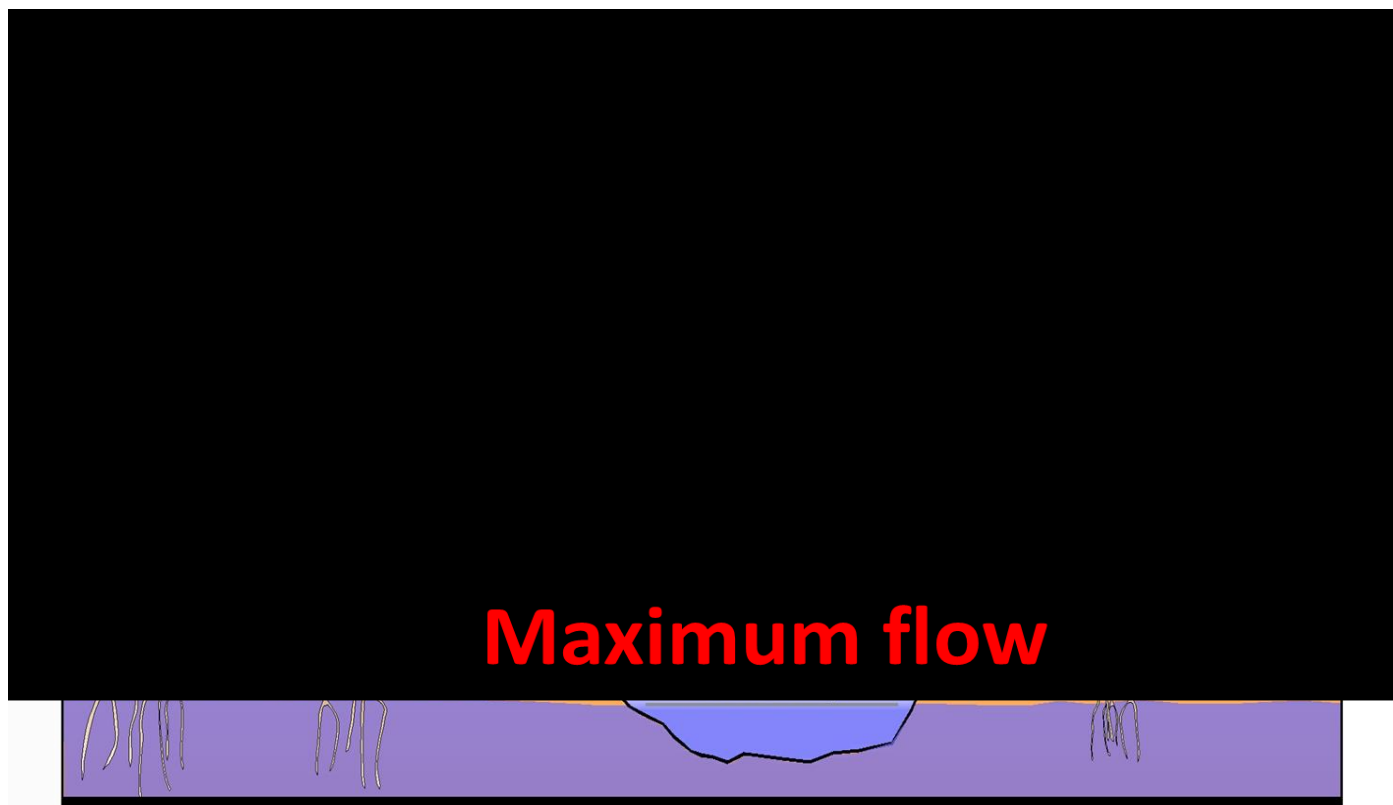
- Address long-term physical habitat (not tied to one species)
- Need specific timing, duration, ramping
- Need other tools to assess needs for other riverine elements



Water Quality

- Stream System Temperature (SSTEMP)
- Stream Network Temperature (SNTEMP)
- 7Q10
 - Often used as basis for setting instream flows in eastern and southern U.S.
 - Not an instream flow method with any value for protecting or restoring biological aspects of rivers.
 - Strictly a method that relates to maintaining established water quality standards.





- *Water quality models typically relate to minimum flows...*
- *Sometimes minimum flows become maximum flows..*
- *To provide meaningful, long-term ecological protection, it essential to talk in terms of flow regimes for multiple purposes whether achievable in the short-term or not.*



Connectivity Methods

Empirical Riverine Methods

- Critical Riffle Analysis can address connectivity at riffle sites

Hydraulic Habitat Models

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

Estuary Methods

- Salinity-based inflow method
- Tidal distributary method

Regional Fish Passage Formula

- SWRCB North Coast Streams Policy (2014)

$$Q_{fp} = 19.3 Q_m D_{min}^{2.1} DA^{-0.71}$$

Visual Inspection



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



Holistic Methodologies

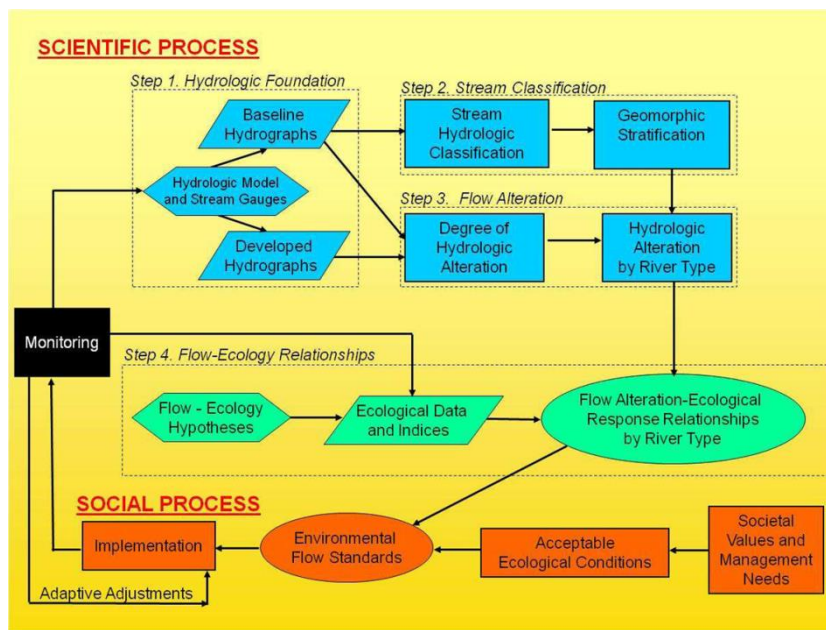
- Ecological Limits of Hydrologic Alteration (ELOHA)
- Bayesian Decision Models
- Demonstration Flow Assessments (DFA)

In the past decade or so, several tools have evolved to begin to address flow needs from a more holistic, community-based perspective. It seems likely that this trend will continue.



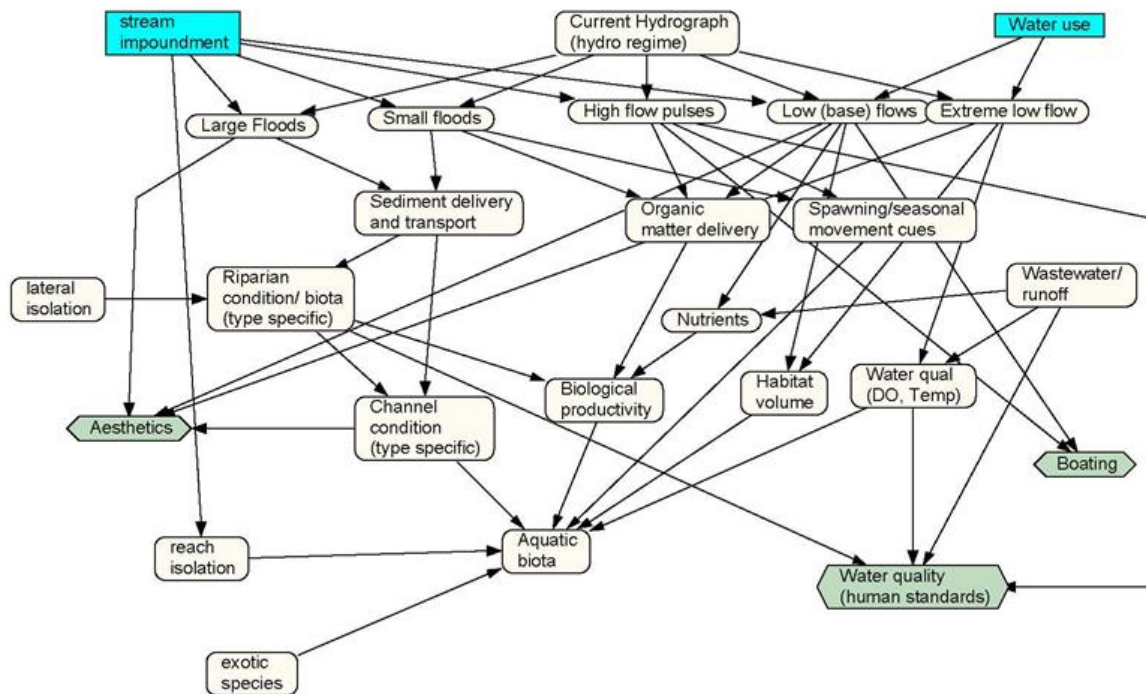
Ecological Limits of Hydrologic Alteration (ELOHA)

- Links hydrological alteration (IHA) with ecology
 - Requires good hydrological data
 - Requires information about ecological processes



ELOHA provides a decision-making process rather than representing a discrete replicable model.

Bayesian Decision Models



Bayesian Decision Models are essentially probability assessment tools.



Demonstration Flow Assessment (DFA)



Can and should be a scientifically controlled and repeatable exercise.



What about professional judgment?



None of the technical methods described here or used anywhere in the world is capable of making decisions of flow in the absence of objective interpretations.



Stream Flow Gages



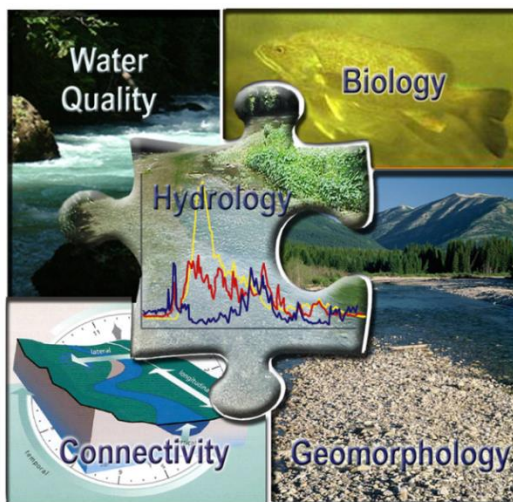
Most important monitoring information needed is always “more gage data”.



Putting it all together

The fact is there are a large number of proven, acceptable methods to chose from for quantifying flow needs.

The challenge is to use the right tool to provide the needed information.



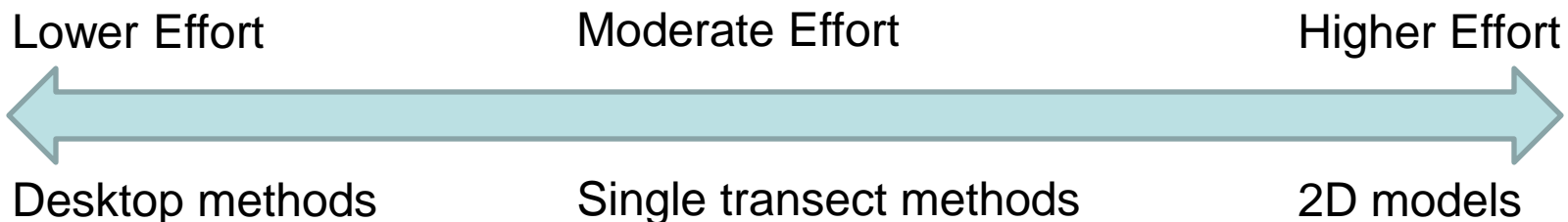
- *No single best method.*
- *Every situation is different so each has a unique solution.*
- *Good approach is to assess flow needs using a suite of methods to address specific flow components at specific times of the year (flow regimes).*



Coordination with CDFW

- CDFW Water Branch - technical oversight and review.
 - Public Resources Code (PRC) §10000-10005 studies.
 - 2015 Water Bond/Water Action Plan studies.
 - Other studies (grants, bypass flows, restoration, etc.).
-

Flow Studies:



CDFW Instream Flow QA Program – *QA/QC links data collection with decision making.*



Planning Flow Studies?

See CDFW Instream Flow QA Program for Guidance Documents, Checklists, Templates...

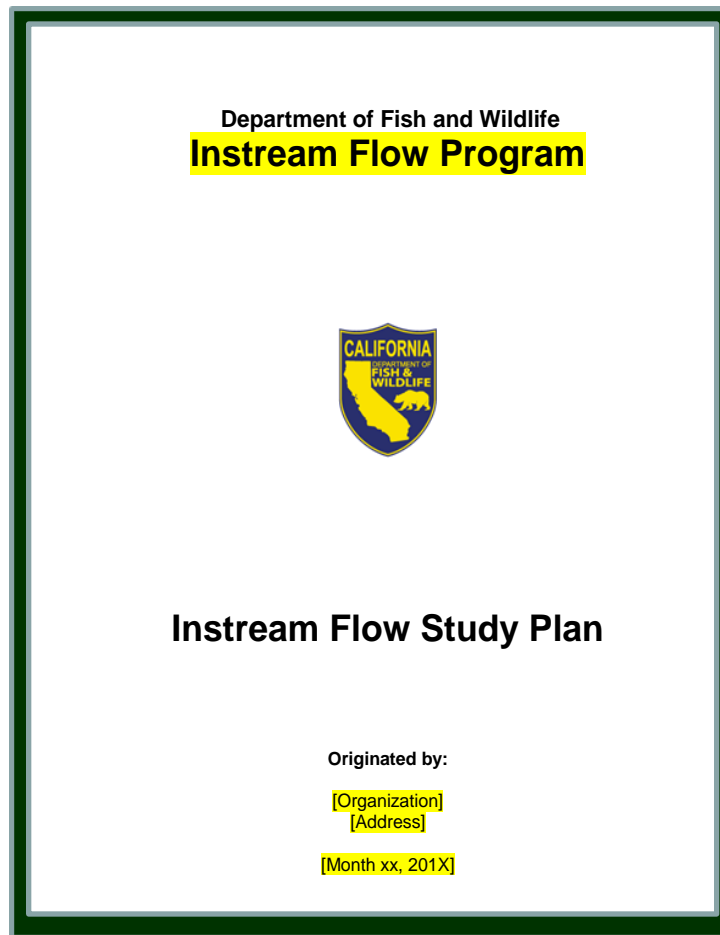


The cover of the document features a photograph of a stream with white water rapids. Below the image is the California Department of Fish and Wildlife logo and the title "INSTREAM FLOW PROGRAM" in large blue letters, with "INSTREAM FLOW STUDY RESULTS CHECKLIST" in smaller green letters below it.

The California Department of Fish and Wildlife (CDFW) is mandated to identify stream flow requirements for protection of fish and wildlife. The CDFW Instream Flow Program (IFP) may use study reports and data from internal or external sources to support development of flow requirements. Study reports and data from external sources are an essential source of information and allow the CDFW IFP to leverage funds and extend limited resources. To ensure the credibility, comparability, coordination and scientific defensibility of information on which the CDFW IFP relies, we review study plans and supporting information described in this checklist, as well as any other information that may be relevant for a particular study. Coordination with the CDFW IFP during project planning, study implementation and project reporting will help identify specific information needs. We ask that study proponents include the following categories of supporting information when submitting reports and/or data to the CDFW IFP:

- Copy of the original instream flow study plan for the project, including goals and objectives, as previously approved by CDFW IFP.** The study plan template can be found online at: http://www.dfg.ca.gov/water/instream_flow.html.
- A full description of the study design and methodology, including any modifications taken from the initial, approved instream flow study plan.** Detail justifications for any and all modifications taken from the original approved study plan during the course of the project. Modifications can include, but are not limited to, changes in:
 - Study design
 - Site selection and transect location strategy
 - Frequency of sampling
 - Timing of sampling
 - Target assessment flows
- Study site documentation, including:**
 - Detailed map(s) of the study area, indicating site locations and names
 - Pictures documenting each sampling site, including flow levels at each site during sampling
- Reach delineation and habitat mapping results:**
 - Inventory of habitat types present by reach

Continued on Next Page...



The cover of the document features the California Department of Fish and Wildlife logo at the top center. Below the logo, the title "Instream Flow Study Plan" is written in large black letters. At the bottom right, there is a box for "Originated by:" with fields for "[Organization]", "[Address]", and "[Month xx, 201X]".

Department of Fish and Wildlife
Instream Flow Program

CALIFORNIA
DEPARTMENT OF
FISH & WILDLIFE

Instream Flow Study Plan

Originated by:

[Organization]
[Address]

[Month xx, 201X]



http://www.dfg.ca.gov/water/instream_flow.html

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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*

