Glen Canyon Dam Adaptive Management Work Group
Agenda Item Information
February 3-4, 2010

Agenda Item

Scientific Controls in Adaptive Management

Action Requested

✓ Feedback requested from AMWG members.

Presenter

Larry Stevens, AMWG Representative, Grand Canyon Wildlands Council

Previous Action Taken

None

Relevant Science

See below.

Background Information

In scientific experiments, controls are used as reference conditions to compare the results of scientific treatments; however, interpretation of the results of complex experiments, such as large river stewardship efforts, benefit from consideration of several different kinds of controls. This presentation will briefly describe several types of controls that can be used to improve scientific adaptive ecosystem management in the Colorado River ecosystem affected by Glen Canyon Dam. The presentation outline follows.

CONCEPTS AND SCIENTIFIC CONTROLS IN ADAPTIVE MANAGEMENT OF THE COLORADO RIVER ECOSYSTEM AFFECTED BY GLEN CANYON DAM: A PRESENTATION TO AMWG, FEBRUARY 2010

Larry Stevens, Grand Canyon Wildlands Council, Inc., Flagstaff, AZ

A. Introduction: scientific methods in river ecosystem ecology and management

1. Guiding concepts in river ecosystem ecology and management
2. Information assessment in relation to CRE concept model
3. Scientific controls needed to ground CRE AEM

B. River ecosystem ecology and management theory

1. River continuum concept (Vannote et al. 1980)
    a. "Longitudinal" physical-biological change over stream order
    b. The "river" as linked aquatic-riparian systems (Hupp 1988)
2. Nutrient spiraling model (Elwood et al. 1983)
3. Flood pulse hypothesis (Junk et al. 1989)
4. River productivity model (Thorpe and DeLong 1994)

   a. Light limitations in canyon-bound rivers (Yard et al. 2005)
5. Serial discontinuity model (Ward and Stanford 1983)
   a. Flow regulation simplifies the aquatic domain but amplifies riparian ecosystem complexity through circuitous recovery of CRE (Stevens et al. 1997)
6. Hydrograph restoration hypothesis (Poff et al. 1997)
7. Roles of science in river management (Schmidt et al. 1998)
   a. Distinguish desired levels of restoration (none to pristine condition)
   b. Relationship to DFC's
   c. Reality check requires high quality data and reference to scientific controls

C. Scientific information quality assessment and controls

1. Pullin and Knight (2003, 2006) for review and integration of AMP science
2. Controls for understanding river ecosystems (e.g. Bauer 1994): empirical, experimental, modelling (info available for Q-flow, S-sediment, T-temperature, V-veg, F-fauna, C-cultural & socioeconomics)
   a. Empirical - Pre-dam versus post-dam (Q, S, T, ~V, ~S)
   b. Empirical - Change over time within dammed segment (Q, S, T, ~V, ~fish, ~C)
   c. Empirical -"Longitudinal" through length of affected river (Q, S, T, ~V, C)
   d. **Empirical - Upstream (undammed) vs. downstream (dammed) (Q, ~S, ~T, ~fish)**
   e. Experiments
      1) ***In situ* small-scale experiments (e.g., HBC drift)**
      2) *In situ* large-scale experiments (HFE's ~Q, S, T, ~V,~C)
      3) *Ex situ* small scale experiments (S, benthos, fish)
   f. Spatial scaling-up models - from tributaries to mainstream (~Q, ~S, ~T, ~fish)
   g. Modeling processes and testing models (Q,S,T,~fish,~C)

3. **Cataract Canyon: an essential, under-examined control**
   a. Geomorphic similarities to Glen and Grand Canyons
   b. Nearly all processes of DFCs more or less intact
   c. Status of native fish, riparian vegetation, wildlife?

D. How would ecological assessment of Cataract Canyon help the GCD-AMP

1. Understanding natural process and component variability, and non-native impacts
2. Clarify differences between "stakeholder wish lists", "science wish lists", and "agency wish lists"; and "informed, defensible experiments and management actions"
   a. Ground and refine DFCs and ecosystem "wish lists"
   b. Test preconceptions about restoration before implementation
3. How to develop and access information?
   a. Cataract Canyon is defined as out of AMWG scope
   b. Fund assessment through NPS, USGS, academic avenues?

Suggested motion to be proposed at next AMWG meeting:

"AMWG directs the TWG to work with GCMRC and the Science Advisors to assess the need for a state-of-knowledge ecological assessment of Cataract Canyon to refine understanding and implications of AMP management of the CRE in relation to DFC's and AMP goals and objectives. This assessment also should recommend further information needs and study design elements for using Cataract Canyon as a scientific control for CRE management. This review is requested by June 2011."

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TABLE 1: HIERARCHY OF EVIDENCE QUALITY (FROM PULLIN AND KNIGHT 2003, 2006).

Category	Quality of Evidence
I	Strong evidence obtained from at least one properly designed, randomized controlled trial of appropriate size
II-1	Evidence from well designed controlled trials with randomization
II-2	Evidence from a comparison of differences between sites with and without (controls) a desired species or community
II-3	Evidence obtained from multiple time series or from dramatic results in uncontrolled experiments
III	Opinions of respected authorities based on qualitative field evidence, descriptive studies or reports of expert committees
IV	Evidence inadequate owing to problems of methodology (e.g. sample size, length or comprehensiveness of monitoring) or conflicts of evidence

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SCIENTIFIC CONCEPTS AND CONTROLS IN ADAPTIVE MANAGEMENT OF THE COLORADO RIVER ECOSYSTEM AFFECTED BY GLEN CANYON DAM:

A PRESENTATION TO AMWG, FEBRUARY 2010

Larry Stevens, Senior Ecologist
Grand Canyon Wildlands Council, Inc., Flagstaff, AZ

Is our understanding of Glen Canyon Dam impacts on the Colorado River ecosystem sufficient to allow the AMP to recommend clear, sound, achievable goals for sustainable stewardship?

1. Guiding concepts in river ecosystem ecology and management

2. Information assessment in relation to CRE concept model

3. Scientific controls needed to ground CRE AEM and DFC definition

THE RIVER CONTINUUM CONCEPT (Vannote et al. 1980)

River ecosystems formed and dominated by geomorphological and hydrologic processes

Rivers function as a gradient (continuum), changing with spatial scale

Riverine ecological communities organized in relation to these factors, in open dynamic equilibrium with hydrogeology

Disputed by Amoros et al. 1987 and Sedell et al. 1989 because of geomorphic variability among reaches (lag effects also exist Between reaches).

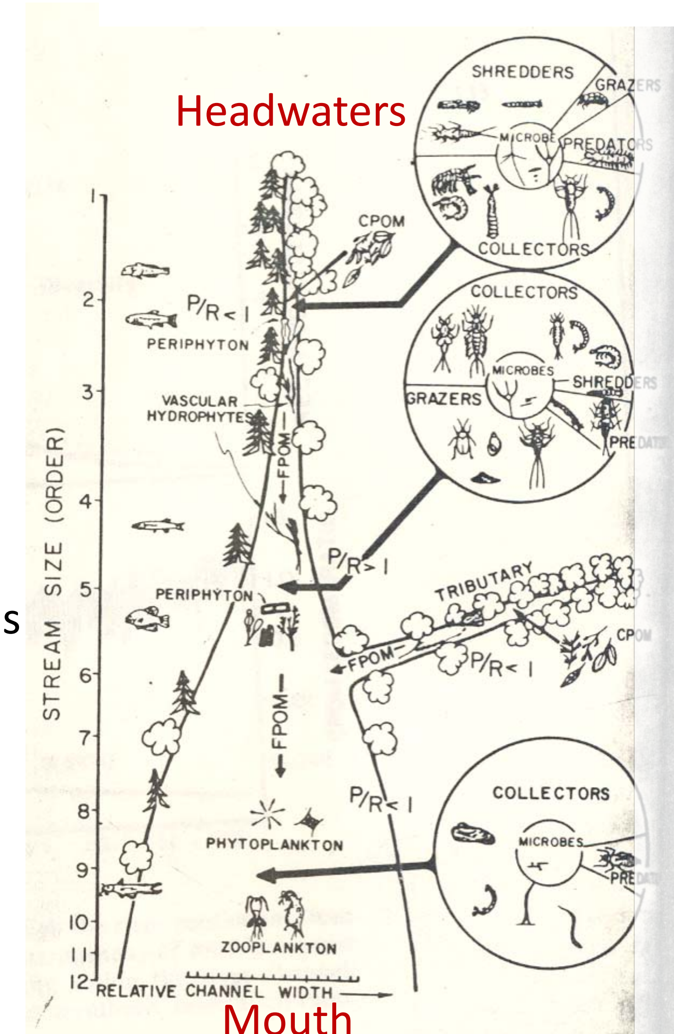

FIG. 1. A proposed relationship between stream size and the progressive shift in structural and functional attributes of lotic communities. See text for fuller explanation.

Social Complexity:
Cumulative upstream-downstream use conflict politics, multiagency mgt., extent of flow regulation, restoration potential, social polarization, role of science in management

↓

Human Impacts:
Human pop. size & use intensity, impacts of flow alteration, alteration of floodplains, dominance of non-native species, species endangerment, ecosystem simplification.

↓

Nutrient Spiraling Model (Webster 1975, Elwood et al. 1983, etc.)

Elements are recycled downstream with increased velocity and turbidity, in generally increasingly longer cycles

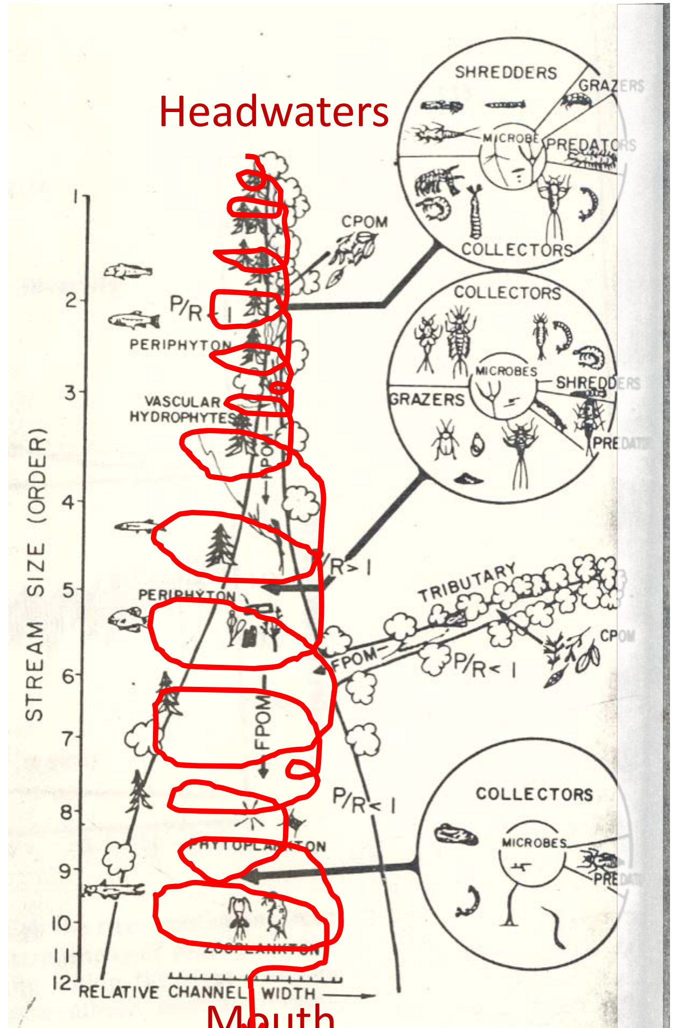

FIG. 1. A proposed relationship between stream size the progressive shift in structural and functional attri of lotic communities. See text for fuller explanation.

OTHER RELATED CONCEPTS IN RIVER ECOLOGY

Flood Pulse Model (Junk et al. 1989)

Flood disturbance (duration, magnitude, frequency, and seasonal timing) affect channel and floodplain regeneration processes, and native taxa are adapted to that disturbance regime. Headwater reaches are often more regularly but less intensively disturbed than lowermost reaches.

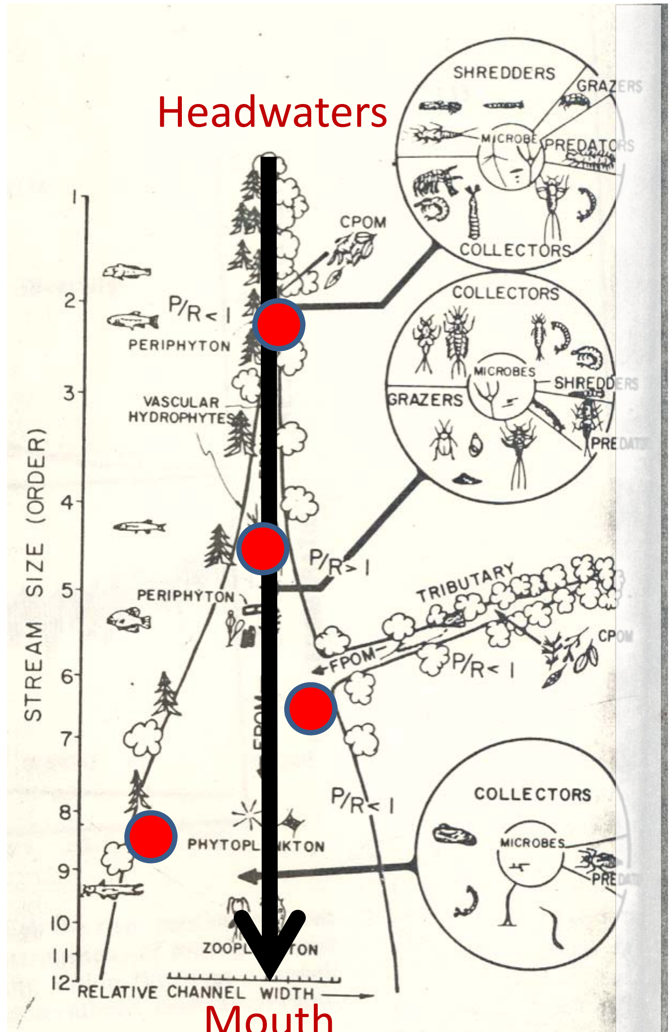

FIG. 1. A proposed relationship between stream size and the progressive shift in structural and functional attributes of lotic communities. See text for fuller explanation.

River Productivity Model (Thorp and DeLong 1994)

Microhabitats within the river ecosystem provide critical spawning, rearing, food, and habitat resources. Tributary mouths, backwaters, subsurface springs, and other such microsites may play a disproportionately important role in river ecosystem function.

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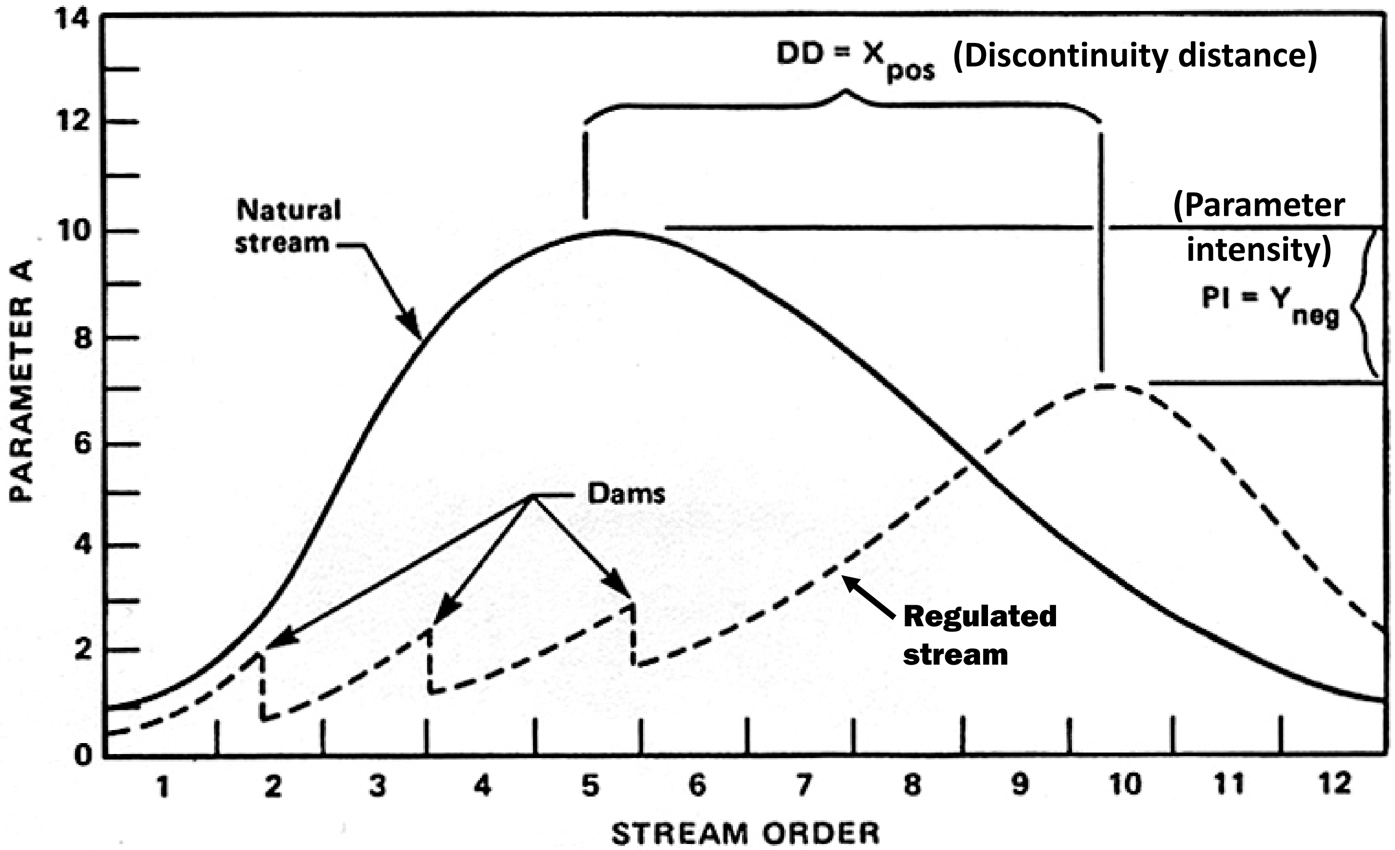
SERIAL DISCONTINUITY MODEL (WARD AND STANFORD 1983):

The location and size of a dam within a basin dictates
the potential for river ecosystem recovery over distance downstream from the dam.



River recovers quickly over distance from a small dam in the headwaters;
River recovery is prolonged or impossible with a large dam in a lower reach.

HOW TO KNOW WHAT TO BELIEVE IN SCIENCE:
HIERARCHICAL QUALITY OF EVIDENCE ON WHICH TO BASE MANAGEMENT DECISIONS (MODIFIED FROM PULLIN AND KNIGHT 2003, 2006)

CATEGORY	QUALITY OF EVIDENCE
Least reliable	Evidence inadequate owing to problems of methodology (e.g. sample size, length or comprehensiveness of monitoring, other statistical shortcomings) or conflicting evidence.
↓	Opinions of respected authorities based on qualitative field evidence, descriptive studies or reports of expert committees: *"Delphi process."*
↓	Evidence obtained from multiple time series or from dramatic results in uncontrolled experiments.
↓	Evidence from a comparison of differences between sites with and without controls.
↓	Evidence from well-designed controlled trials with randomization.
Most reliable	Strong evidence obtained from at least one properly designed, randomized controlled trial of appropriate size.

Scientific understanding is advanced most convincingly through comparison of experiment results with controls.

USE OF VARIOUS STUDY TYPES AND CONTROLS FOR UNDERSTANDING GCD IMPACTS ON THE CRE (White = study designs used by AMP, blue=little used, black = not used)

Study Type	Type of Control	Flow	Sediment	T & WQ	AQ Food Base	Fish	Vegetation	Terr. Fauna	Cultural	Economic
Empirical	Pre-dam versus post-dam	Yes	Yes	Some	No	No	Some	No	No	Yes
Empirical	Change over time within dammed segment	Yes	Yes	Some	Some	Yes	Little	No	Some	Yes
Empirical	"Longitudinal" through length of affected river	Yes	Yes	Yes	Some	Some	Little	No	Some	n/a
Empirical	Upstream (undammed) vs. downstream (dammed)	Some	Some	Little	Little	Little	No	No	Little	Little
Experimental	*In situ* fine-scale experiments	Little	Little	Some	Some	Little	No	No	No	n/a
Experimental	*In situ* coarse-scale experiments (HFE's)	Yes	Yes	Yes	No	Some	Some	Little	Yes	Yes
Experimental	*Ex situ* fine-scale experiments	No	Some	No	Some	Some	No	No	No	n/a
Modeling	Spatial scaling-up from tributaries to mainstream	Some	Some	No	Some	Some	No	No	No	n/a
Modeling	In-system & process models	Yes	Yes	Yes	Some	2 spp	Little	No	Yes	Yes
Modeling	Between-system process models	Some	Little	Some	Little	Some	No	No	Little	Some

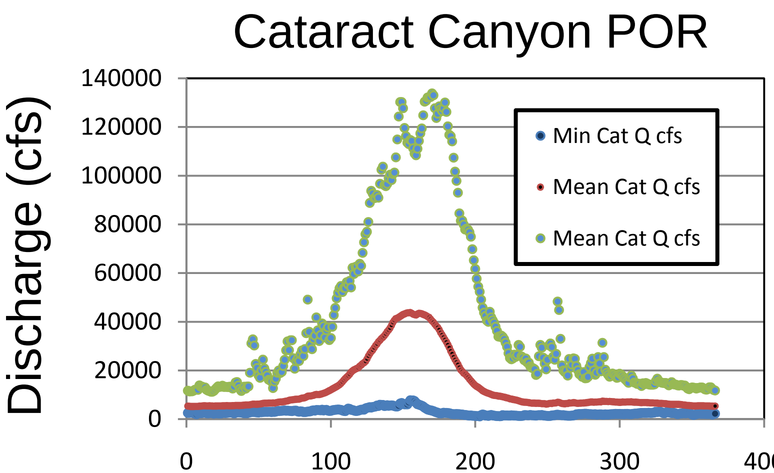
CATARACT CANYON:
AN OVERLOOKED REFERENCE REACH FOR THE CRE?

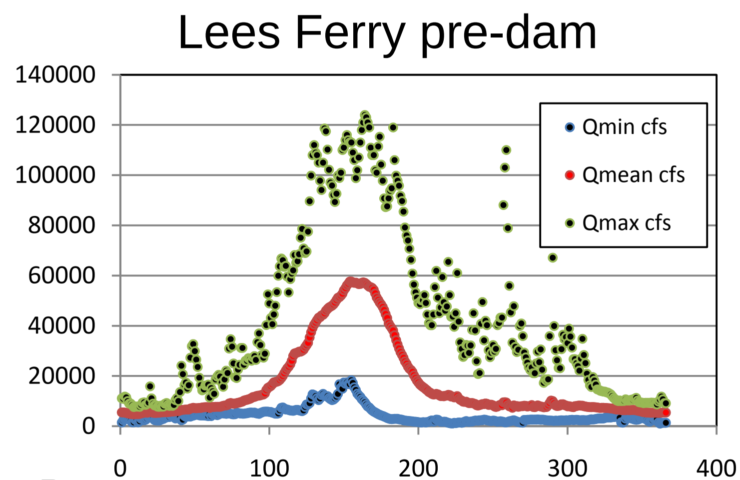



CATARACT CANYON
(Colo. R. upstream from Lake Powell)

- Largely unaltered by flow regulation
- Relatively natural, highly variable flow, sediment flux, water quality, water temperature regimes
- Last remaining site at which to understand range of natural variability in a large southwestern river
- Site from which to measure extent of serial discontinuity in CRE

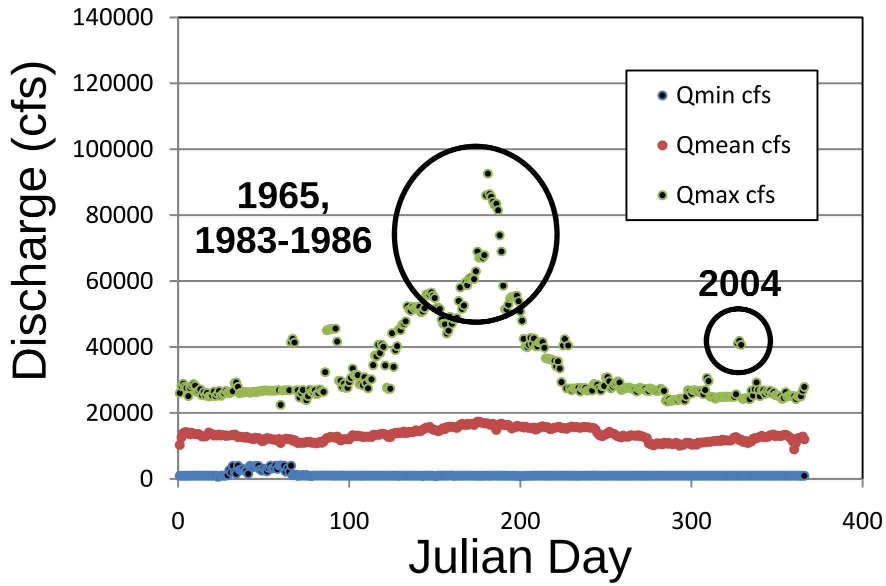
COMPARATIVE HYDROGRAPHS: CATARACT CANYON AND LEES FERRY





Julian Day

Lees Ferry post-dam



~ Natural flows in Cataract Canyon, but what about condition of other resources (esp. native fish)?

HOW WOULD ECOLOGICAL ASSESSMENT OF CATARACT CANYON AID THE GCE-AMP?

A. Understanding natural process and component variability, and non-native spp. impacts
B. Clarify differences between stakeholder, science, and agency "wish lists"
   1. Informed, defensible comparisons, experiments, and management actions
   2. Ground and refine CRE DFCs
   3. Test preconceptions about ecosystem management before implementation
C. How to develop and access information?
   1. Is Cataract Canyon out of AMWG scope? <u>and</u> not in present budget
   2. Conduct a pilot evaluation of information to determine relevance to AMP
   3. If warranted, fund ecological analysis through NPS, USGS, academic venues, or AMP

SUGGESTED WORDING FOR A MOTION FOR THE NEXT AMWG MEETING

"AMWG directs the TWG to work with GCMRC and the Science Advisors to assess the need for a state-of-knowledge ecological evaluation of the Colorado River ecosystem in Cataract Canyon to refine understanding and implications of AMP management of the CRE in relation to DFC's and AMP goals and objectives. If judged to be relevant to the AMP, this assessment also should recommend further information needs and study design elements for the use of Cataract Canyon as a scientific control for CRE management."