

Glen Canyon Dam Adaptive Management Work Group Ad Hoc Committee on Strategic Planning

Report to AMWG, July 2001

Strategic Plan

This document consists of the following components, which should be viewed as an integrated whole. Together, they guide the work of the Glen Canyon Dam Adaptive Management Work Group.

- Vision and Mission
- Principles
- Goals
- Objectives
- Glossary

Vision and Mission

The Grand Canyon is a homeland for some, sacred to many, and a national treasure for all. In honor of past generations, and on behalf of those of the present and future, we envision an ecosystem where the resources and natural processes are in harmony under a stewardship worthy of the Grand Canyon.

We advise the Secretary of the Interior on how best to protect, mitigate adverse impacts to, and improve the integrity of the Colorado River ecosystem affected by Glen Canyon Dam, including natural biological diversity (emphasizing native biodiversity), traditional cultural properties, spiritual values, and cultural, physical, and recreational resources through the operation of Glen Canyon Dam and other means.

We do so in keeping with the federal trust responsibilities to Indian tribes, in compliance with applicable federal, state, and tribal laws, including the water delivery obligations of the Law of the River, and with due consideration to the economic value of power resources.

This will be accomplished through our long-term partnership utilizing the best available scientific and other information through an adaptive ecosystem management process.

Principles

The Glen Canyon Dam Adaptive Management Work Group embraces the following Principles. They guided development of the Goals and Objectives for the Glen Canyon Dam Adaptive Management Program (GCDAMP). These Principles are:

1. The Goals represent a set of desired outcomes that together will accomplish our Vision and achieve the purpose of the Grand Canyon Protection Act. Some of the Objectives and actions that fall under these Goals may not be the responsibility of the GCDAMP, and may be funded by other sources, but are included here for completeness.
2. The construction of Glen Canyon Dam and the introduction of non-native species have irreversibly changed the Colorado River ecosystem.
3. Much remains unknown about the Colorado River ecosystem below Glen Canyon Dam and how to achieve GCDAMP Goals.
4. The Colorado River ecosystem is a managed ecosystem. An ecosystem management approach, in lieu of an issues, species, or resources approach, will guide our efforts. Management efforts will prevent any further human-induced extirpation or extinction of native species.
5. An adaptive management approach will be used to achieve GCDAMP Goals, through experimentation and monitoring, to meet the intent of the Grand Canyon Protection Act, the Environmental Impact Statement, and the Record of Decision.
6. Dam operations and management actions will be tried that attempt to return ecosystem patterns and processes to their range of natural variability. When this is not appropriate, experiments will be conducted to test other approaches.
7. Because management actions to achieve a Goal may benefit one resource or value and adversely affect another, those action alternatives that benefit all resources and values will be pursued first. When this is not possible, actions that have a neutral impact, or as a last resort, actions that minimize negative impacts on other resources will be pursued, consistent with the final Glen Canyon Dam EIS and the Record of Decision.
8. If the target of a management objective proves to be inappropriate, unrealistic, or unattainable, the AMP will reevaluate that target and the methods used to attain it.
9. Recognizing the diverse perspectives and spiritual values of the stakeholders, the unique aesthetic value of the Grand Canyon will be respected and enhanced.

Goals

1. Protect or improve the aquatic foodbase so that it will support viable populations of desired species at higher trophic levels.
2. Maintain or attain viable populations of existing native fish, remove jeopardy from humpback chub and razorback sucker, and prevent adverse modification to their critical habitat.
3. Restore populations of extirpated species, as feasible and advisable.
4. Maintain a wild reproducing population of rainbow trout above the Paria River, to the extent practicable and consistent with the maintenance of viable populations of native fish.
5. Maintain or attain viable populations of Kanab ambersnail.
6. Protect or improve the biotic riparian and spring communities, including threatened and endangered species and their critical habitat.
7. Establish water temperature, quality, and flow dynamics to achieve GCDAMP ecosystem goals.
8. Maintain or attain levels of sediment storage within the main channel and along shorelines to achieve GCDAMP ecosystem goals.
9. Maintain or improve the quality of recreational experiences for users of the Colorado River ecosystem, within the framework of GCDAMP ecosystem goals.
10. Maintain power production capacity and energy generation, and increase where feasible and advisable, within the framework of GCDAMP ecosystem goals.
11. Preserve, protect, manage, and treat cultural resources for the inspiration and benefit of past, present and future generations.
12. Maintain a high quality monitoring, research, and adaptive management program.

Goal 1. Protect or improve the aquatic foodbase so that it will support viable populations of desired species at higher trophic levels.

MO #	Perform some action	On some element	On some attribute	At some place	From the current level	To the target level	Comments
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The target for all the Management Objectives in Goal 1 is adequate food availability to support trout and native fish above the Paria River, and native fish below the Paria River. <u>Linkages:</u> See the numbers of fish desired under Goals 2, 3, and 4.									
1.1	Maintain or attain	Primary producers: algae on hard substrates, rooted macrophytes on soft substrates, and diatoms	Biomass	Mainstem from Glen Canyon Dam to the Paria River in both pools and on cobble bars identified by specific sampling sites	$x \pm y \text{ g/m}^2$ (Cobble) ⁰ $a \pm b \text{ g/m}^2$ (Pool) (To be provided from Shannon et al.)			$x \pm y \text{ g/m}^2$ (Cobble) $a \pm b \text{ g/m}^2$ (Pool) (Need to resolve differences between data from Shannon et al. and AGFD.)	Also see McKinney et al. 1999 ⁽²²⁾
			Composition		River Mile	% Algae	% Macrophytes	Information Need	Given the change in composition, the idea of Cladophora as a keystone species has been called into question. Scientists have said composition is an Information Need and should not be broken down below algae and macrophytes at this point in time.
					Pools				
						IN	IN		
						IN	IN		
						IN	IN		
					Cobbles				
						IN	IN		
						IN	IN		
						IN	IN		

Goal 1. Protect or improve the aquatic foodbase so that it will support viable populations of desired species at higher trophic levels.

MO #	Perform some action	On some element	On some attribute	At some place	From the current level	To the target level	Comments		
1.2	Maintain or attain	Benthic invertebrates	Biomass	Mainstem from Glen Canyon Dam to Paria River	x +/- y g/m ² (Cobble) a +/- b g/m ² (Pool)		x +/- y g/m ² (Cobble) a +/- b g/m ² (Pool)	Also see McKinney et al. 1999 ⁽²²⁾ Metric is relative % of species.	
			Composition		<p><u>Cobble:</u> ___ % Tubificids ___ % <i>Gammarus</i> ___ % Chironomids ___ % Gastropods ___ % Other</p> <p><u>Pool:</u> ___ % Tubificids ___ % <i>Gammarus</i> ___ % Chironomids ___ % Gastropods ___ % Other</p> (Data to be filled in by Joe Shannon and AGFD.)	Information Need			
1.3	Maintain or attain	Primary producers: algae on hard substrates, rooted macrophytes on soft substrates, and diatoms	Biomass	Mainstem below the Paria River on cobble bars identified by specific sampling sites	River Mile	g/m ²	50 g/m ²⁽²⁷⁾	Information Need Metric is relative % of algal species. MAMB is for miscellaneous algae, macrophytes, and bryophytes	
			Cobble						
			2						
			61						
			68						
			127						
			205						
			Composition		River Mile	% Algae	% Macrophytes		Information Need Metric is relative % of algal species. MAMB is for miscellaneous algae, macrophytes, and bryophytes
			Pools						
			2						
			61						
			68						
			127						
			205						
Cobble									
2									
61									
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Goal 1. Protect or improve the aquatic foodbase so that it will support viable populations of desired species at higher trophic levels.

MO #	Perform some action	On some element	On some attribute	At some place	From the current level	To the target level	Comments
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1.4	Maintain or attain	Benthic invertebrates	Biomass	Mainstem below the Paria River	0.960 g/m ² (Cobble) ⁽²⁷⁾ 0.054 g/m ² (Pool) ⁽²⁷⁾		To be provided based on 1996-97 data.	Metric is relative % of species.
			Composition		<u>Cobble:</u> ___ % Tubificids ___ % <i>Gammarus</i> ___ % Chironomids ___ % Gastropods ___ % Other <u>Pool:</u> ___ % Tubificids ___ % <i>Gammarus</i> ___ % Chironomids ___ % Gastropods ___ % Other	Obtain from literature		
1.5	Maintain or attain	Foodbase drift: Diptera <i>Gammarus</i> Other Bugs CPOM FPOM DOC	Abundance	Mainstem below GCD	River Mile	AFDW	To be provided based on 1996-97 data.)	
					2			
					61			
					68			
					127			
					205			

**Goal 2. Maintain or attain viable populations of existing native fish,
remove jeopardy from humpback chub and razorback sucker, and prevent adverse modification to their critical habitat.**

MO #	Perform some action	On some element	On some attribute	At some place	From the current level	To the target level	Comments
2.1	Maintain or attain	Humpback chub (150 mm and larger) (Length is based on the size at which a HBC is able to be pit-tagged.)	Abundance	LCR aggregation (The definition of the LCR aggregation will be resolved following completion of the stock assessment workshop and the PEP review.)	4330-4811 individuals ⁽³⁾ with a mean of 4508 individuals	Information Need	The target is viable populations and removal of jeopardy. Target to be based on 91-96 population estimate, PVA, & N _c .
				Eight mainstem aggregations	Information Need ?? Confidence interval with a mean of 225 individuals??	Information Need	
2.2	Maintain or attain	Humpback chub (51 mm to 150 mm)	Year class strength	LCR aggregation	Information Need. Consider using a CPUE index for different year classes, at some place in the LCR at some time during the year.	Information Need. Intended to be an index that will indicate spawning success.	The target is viable populations and removal of jeopardy. Metric is “catch per unit effort” (CPUE). See Gorman and Bramblett. ⁽⁹⁾ See synthesis by Coggins.
				Eight mainstem aggregations	Information Need	Information Need	
2.3	Maintain or attain	Humpback chub (> 200 mm) (This is the length at which 50% of the fish are thought to be sexually mature.)	Recruitment	LCR aggregation	Information Need	Information Need	The target is viable populations and removal of jeopardy.
				8 mainstem aggregations	Information Need	Information Need	
2.4	Establish	Humpback chub	Spawning aggregation	CRE below GCD	One spawning aggregation in the LCR	A second spawning aggregation	The target is removal of jeopardy.

Goal 2. Maintain or attain viable populations of existing native fish, remove jeopardy from humpback chub and razorback sucker, and prevent adverse modification to their critical habitat.

MO #	Perform some action	On some element	On some attribute	At some place	From the current level	To the target level	Comments
2.5	Attain	Humpback chub	Condition	LCR aggregation	Information Need	Information Need. There should be a minimum threshold.	The target is viable populations and removal of jeopardy. PEP should be asked to evaluate the method that would be used to calculate condition and the value to be established as the threshold.
				8 mainstem aggregations	Information Need	Information Need	
			Disease and other parasites	LCR aggregation	Information Need	Information Need	
				8 mainstem aggregations	Information Need	Information Need	
2.6	Reduce	Native fish	Mortality due to non-native fish predation as a % of overall mortality	LCR	Information Need	Information Need	The target is reduction of non-native fish predation so it does not impinge on native fish viability. <u>Linkages:</u> The native fish MOs in Goal 2 and Goal 3.
				Mainstem	Information Need	Information Need	
2.7	Attain	Razorback sucker	Abundance	CRE below GCD	0 individuals ⁽⁹⁾	Information Need	The target is derived from the capability of the habitat to support the species, and includes the removal of jeopardy.
2.8	Maintain	Flannelmouth sucker	Abundance	CRE below GCD	AGFD to provide ⁽⁹⁾	Information Need	Appropriate metric to be determined. The target is viable populations.
			Distribution		AGFD to provide ⁽⁹⁾	Information Need	
		Bluehead sucker	Abundance		AGFD to provide ⁽⁹⁾	Information Need	
			Distribution		AGFD to provide ⁽⁹⁾	Information Need	
		Speckled dace	Abundance		AGFD to provide ⁽⁹⁾	Information Need	
			Distribution		AGFD to provide ⁽⁹⁾	Information Need	

Goal 3. Restore populations of extirpated species, as feasible and advisable.

MO #	Perform some action	On some element	On some attribute	At some place	From the current level	To the target level	Comments
3.1	Restore	Colorado pikeminnow	Abundance	CRE downstream of GCD	0 individuals ⁽⁹⁾	Information Need	
		Bonytail			0 individuals ⁽⁹⁾	Information Need	
		Roundtail Chub			0 individuals ⁽⁹⁾	Information Need	
		River otter			0 individuals ⁽¹⁰⁾	Information Need	

Goal 4. Maintain a wild reproducing population of rainbow trout above the Paria River, to the extent practicable and consistent with the maintenance of viable populations of native fish.

MO #	Perform some action	On some element	On some attribute	At some place	From the current level	To the target level	Comments
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Linkages: See Issue Paper B (trout).									
4.1	Maintain or attain	Rainbow trout (RBT)	Abundance	Mainstem from Glen Canyon Dam to Paria River	260,000 +/- 30,000 Age II+ individuals ⁽²³⁾	100,000 Age II+ individuals	The target is adequate abundance of wild-reproducing Rainbow trout to maintain a quality recreational fishery, while not adversely affecting native fish population viability.		
					Electrofishing CPUE	Information Need			
					Proportional Stock Density (see below)	15%		Information Need	Might replace measure of "length at age" in the future. Value of metric needs to be assessed.
					Length at age	15" by Age III ⁽²³⁾		15 – 18" by Age III	
					Condition	$W_r = 0.82^{(23)}$		$W_r = 0.90$	
					Whirling disease and other parasitic infections	Absence		Absence	
					Spawning habitat	Information Need		Information Need	Metric is quality and abundance of habitat.
					Natural recruitment	100%		100%	This MO restates and measures the goal.
4.2	Limit	Lees Ferry RBT	Distribution	CRE below the Paria River	Information Need	Information Need. Need research and data that demonstrate predator / prey and competitive effect.	The target is minimal competitive or predator / prey effect on downstream native fish.		

Proportional Stock Density is the ratio that results by dividing the number of fish great than 16" by the number of all fish greater than 12". This provides a measure of the abundance of fish at a certain size, which should translate into a target for both abundance and length at age.

Goal 5. Maintain or attain viable populations of Kanab ambersnail.

MO #	Perform some action	On some element	On some attribute	At some place	From the current level	To the target level	Comments
5.1	Attain and maintain	Kanab ambersnail	Population	Vasey's Paradise	7100 (April 1999) 6400 (May 1999) 20,000 (July 1999) 35,000 (Sept/Oct 1999) (Individuals below 70,000 cfs stage) ⁽²⁴⁾	Information Need (to be measured in the spring and before any Management Action that may affect the population)	The metric is the population parameter(s) that indicate viability. The target is a viable population. "Viable" includes the entire population, not just those below 70,000 cfs. Management Action: monitor the KAS populations at Keyhole, Elves, and Deer Creek
5.2	Maintain	Kanab ambersnail	Habitat	Vasey's Paradise	82-99 m ² monkeyflower and 36.6 m ² watercress below 70,000 cfs stage. Information Need (for above new stage level when it is determined)	Information Need. An x-year running average greater than or equal to y% of the total area of occupied habitat measured at Vasey's in March 1996, with a minimal level TBD.	The target is the level needed to sustain a viable population. Purpose is to limit human impact, by intentional flooding or other actions, to habitats occupied by Kanab ambersnail.

Goal 6. Protect or improve the biotic riparian and spring communities, including threatened and endangered species and their critical habitat.

MO #	Perform some action	On some element	On some attribute	At some place	From the current level	To the target level	Comments
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The target is an achievable and appropriate mix of four types of communities: marsh, open sand beach, old high water zone (OHWZ), and new high water zone (NHWZ). All four communities are important for maintaining the diversity of wildlife, visitor use, and cultural resources. See the Riparian Issue Paper for more information.							
6.1	Maintain	Marsh community	Abundance	CRE below GCD, and above Lake Mead's water level as it fluctuates due to Hoover Dam operations	1215 patches (4.6 ha) ⁽⁷⁾	For an x-year running average of y or more marsh patches $\geq 10 \text{ m}^2$, as determined by standard criteria for wetland species, soil type, and wetted area.	See Kearsley ⁽¹⁵⁾ and Stevens et al. ⁽²⁹⁾ .
			Composition		Information Need	No loss of native species. Species are assumed still to be present when they have been detected by monitoring within the last 10 years.	
			Area		Information Need	For an x-year running average area equal to $\pm y\%$ of the area defined by aerial imaging in 2000.	
6.2	Maintain	New high water zone community	Patch number and distribution	CRE below GCD, and above Lake Mead's water level as it fluctuates due to Hoover Dam operations	Information Need	Information Need	The target is to allow for scouring of NHWZ vegetation to 1984 levels for patch number and distribution, and then allow its return through successional processes
			Composition		Information Need	Species are assumed still to be present when they have been detected by monitoring within the last 10 years.	The target is to allow no loss of native plant or animal species.
			Area		Information Need	For an x-year running average area equal to $\pm y\%$ of the area defined by aerial imaging in 2000.	NHWZ vegetation & sand beaches occur in the same strip of land. An increase to NHWZ vegetation will reduce the amount of open sand, and vice versa. These objectives are therefore closely linked to each other, as well as to the beach-building effects of BHBFs.

Goal 6. Protect or improve the biotic riparian and spring communities, including threatened and endangered species and their critical habitat.

MO #	Perform some action	On some element	On some attribute	At some place	From the current level	To the target level	Comments
6.3	Maintain	Old high water zone community	Abundance	CRE below GCD, and above Lake Mead's water level as it fluctuates due to Hoover Dam operations	In 1992, there was an estimated 1,870 acres of OHWZ vegetation (Stevens 1992).	Information Need	The target is no significant loss of area.
			Composition		Information Need	Information Need	The target is no loss of native plant or animal species.
			Distribution		Information Need	Information Need	
6.4	Maintain	Sand Beach community	Abundance	CRE below GCD, and above Lake Mead's water level as it fluctuates due to Hoover Dam operations	Information Need	Information Need	See Kearsley ⁽¹⁵⁾ and Stevens et al. ⁽²⁹⁾
			Composition		Information Need	Information Need	
			Distribution		Information Need	Information Need	
6.5	Reduce	Invasive non-native species	Abundance (Abundance refers to number of individuals within the species. These species should be limited to invasive ones, not just non-natives.)	CRE below GCD, and above Lake Mead's water level as it fluctuates due to Hoover Dam operations	95+ species (Plants) ⁽²⁸⁾ 3 species (Birds) ⁽²⁸⁾	No new non-native species. Invasive non-native species cover \leq x% of total riparian area. The targets are species-specific. (Information Need)	The target for abundance is the level at which these species do not impinge on biological, recreational, and cultural resources.
			Distribution		Information Need	Information Need	The target for distribution is no spreading of invasive non-native species to areas where they do not already occur.

Goal 6. Protect or improve the biotic riparian and spring communities, including threatened and endangered species and their critical habitat.

MO #	Perform some action	On some element	On some attribute	At some place	From the current level	To the target level	Comments
6.6	Maintain	Spring and wetland	Habitat occupied by rare and endemic species	CRE below GCD, and above Lake Mead's water level as it fluctuates due to Hoover Dam operations	Information Need	Information Need	The target is to maintain the capability of these habitats to support the rare and endemic species known to live there. The targets should recognize the dynamic nature of these habitats as influenced by flow events.
6.7	Maintain	Southwest willow flycatcher	Riparian habitat	CRE below GCD, and above Lake Mead's water level as it fluctuates due to Hoover Dam operations	Information Need	Information Need	The target is the capability of the habitat to support the species. The target is a dynamic mosaic of NHWZ, OHWZ, and marsh vegetation. The definition of critical habitat will change as we learn more about the species' needs.

Goal 7. Establish water temperature, quality, and flow dynamics to achieve GCDAMP ecosystem goals.

MO #	Perform some action	On some element	On some attribute	At some place	From the current level	To the target level	Comments
7.1	Attain	Water	Temperature range	Mainstem	6.93-18.56 °C ⁽¹⁷⁾	Information Need	The target may include several stations in the mainstem.
			Seasonal variability of temperature		Information Need	Information Need	
<p>The target for MO 7.1 is a temperature range and pattern of seasonal variability based on the range of natural variability, the physical capacity of the dam, and the range that optimizes conditions for the targeted resources. Targeted resources may include foodbase, native fish, trout, and people (human health and safety – microorganisms and hypothermia).</p> <p>Temperature patterns should have as their first priority the improvement of conditions for native biological resources, including native fish, and including foodbase and trout interactions. This is based on the special status of native fish. <u>Linkages</u>: MO 13; Principles 4, 6, and 7; and the Vision-Mission statement.</p>							
7.2	Maintain	Water	Quality	Mainstem	Information Need (for the specific water quality parameters to use).	Information Need	Parameters may include nutrients, salinity, pH, DO, nitrogen, phosphorus, microbes, and others. Data available from NASQWAN. ⁽³⁵⁾
<p>The target for MO 7.2 is water quality based on the range of natural variability, the physical capacity of the dam, the legally defined state water quality standards, and the range that optimizes conditions for the targeted resources. The targeted resources may include foodbase, native fish, trout, Southwestern willow flycatcher, riparian and spring communities, the recreational experience, and cultural resources. <u>Linkages</u>: Goals 1-3, 8-10, and 12.</p>							
7.3	Maintain	Flow dynamics	Power plant operations	Mainstem	ROD operating criteria	Dam operating criteria then in effect	See MO 50 for experimental flows.
			BHBF flows		Maximum 45,000 cfs (March to April)	Dam operating criteria then in effect	
			Habitat maintenance flows		ROD operating criteria	Dam operating criteria then in effect	

Goal 8. Maintain or attain levels of sediment storage within the main channel and along shorelines to achieve GCDAMP ecosystem goals.

MO #	Perform some action	On some element	On some attribute	At some place	From the current level	To the target level	Comments
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<p>The target for Goal 8 is enough sediment to achieve the biological, recreational, and cultural goals. Given limited sediment inputs, we need to retain enough sediment in the system to achieve ecosystem patterns in these goals). For the biological goals, the purposes are habitat and nutrient storage. For the cultural goal, the purposes are enhancing plant habitat and preserving historical properties. For recreational goals, the purposes are camping beaches and trout spawning habitat. <u>Linkages</u>: Recreational, biological, and cultural goals: 1-4, 7-10, and 12.</p>							
8.1	Maintain or attain	Sediment	Abundance	Main channel below 5,000 cfs	Information Need	Current volumes or higher (trend), including some timeframe based on tributary inputs and high flows timing (Information Need).	Metric is volume (m ³) as a rolling average.
			Grain-size		Information Need	Current level or finer (trend), including some timeframe based on reach, tributary inputs and high flows timing (Information Need).	Metric is D50 (median) grain size. Also, see Kondolf. ⁽¹⁶⁾
			Distribution		Information Need Current level to be obtained from side scan sonar and video (Anima) and/or multi-beam.	Current level or more areally extensive (trend), including some timeframe based on tributary inputs and high flows timing (Information Need).	Metric is patchiness and area (m ²) of sand on channel bottom.
8.2	Maintain or attain	Sediment	Abundance	Channel margins (not eddies) from 5,000 to 25,000 cfs	Information Need	Information Need, including some timeframe based on tributary inputs and high flows timing.	Metric is area (m ²) and volume (m ³) as a rolling average.
			Grain-size		Information Need	Information Need, including some timeframe based on tributary inputs and high flows timing.	Also, see Kondolf.
			Distribution		Information Need	Information Need, including some timeframe based on tributary inputs and high flows timing.	Metric is number of sandbars by reach.

Goal 8. Maintain or attain levels of sediment storage within the main channel and along shorelines to achieve GCDAMP ecosystem goals.

MO #	Perform some action	On some element	On some attribute	At some place	From the current level	To the target level	Comments
8.3	Maintain or attain	Sediment	Abundance	Eddies below 5,000 cfs	Information Need	Information Need, including some timeframe based on tributary inputs and high flows timing.	Metric is area (m ²) and volume (m ³) as a rolling average
			Grain-size		Information Need	Information Need, including some timeframe based on tributary inputs and high flows timing	
			Distribution		Information Need	Information Need, including some timeframe based on tributary inputs and high flows timing.	Metric is # of sandbars by reach
8.4	Maintain or attain	Sediment	Abundance	Eddies between 5,000 and 25,000 cfs	Information Need	Information Need, including some timeframe based on tributary inputs and high flows timing.	Metric is area (m ²) and volume (m ³) as a rolling average The target level should consider spawning habitat for trout in Glen Canyon and sediment needed for BHBFs.
			Grain-size		Information Need	Information Need, including some timeframe based on tributary inputs and high flows timing	The target level should consider spawning habitat for trout in Glen Canyon and sediment needed for BHBFs.
			Distribution		Information Need	Information Need, including some timeframe based on tributary inputs and high flows timing.	Metric is # of sandbars by reach The target level should consider spawning habitat for trout in Glen Canyon and sediment needed for BHBFs.

Goal 8. Maintain or attain levels of sediment storage within the main channel and along shorelines to achieve GCDAMP ecosystem goals.

MO #	Perform some action	On some element	On some attribute	At some place	From the current level	To the target level	Comments
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8.5*	Maintain or attain	Sediment	Abundance	Shorelines above 25,000 cfs	Information Need	Information Need	Metric is area (m ²) and volume (m ³) as a rolling average
			Grain-size		Information Need	Information Need	
			Distribution		Information Need	Information Need	Metric is # sandbars by reach

*This MO is intended to include all shorelines (eddies and channel margins) between 25,000 cfs and the highest level of potential dam effects on pre-dam sand bars (about 125,000 cfs or pre-dam alluvium (pda) terrace of Hereford et al. 1998). The highest level will be determined through discussions with sedimentological, cultural, recreational, and riparian workers on how best to constrain this boundary and in how many areas it should be monitored.

NOTE: Coarse sediment is important to the ecosystem, as is fine sediment. There is an MO on rapids navigability under the recreation goal that indirectly addresses debris flows, as well as an MO on trout spawning habitat under the trout goal.

Information Need: consult with various researchers to determine how best to break out sub-reaches from the three broader fine sediment reaches as described above. The riparian group suggested developing a table that has various resource concerns on the X-axis and various processes on the Y-axis. The recreation group suggested developing a table that has river miles (-15 to 278) on the X-axis and various resources on the Y-axis (those resource areas impacted by sedimentological processes).

Goal 9. Maintain or improve the quality of recreational experiences for users of the Colorado River ecosystem, within the framework of GCDAMP ecosystem goals.

MO #	Perform some action	On some element	On some attribute	At some place	From the current level	To the target level	Comments
9.1	Maintain	Visitor	Physical access	Mainstem	Information Need. Obtain from current GLCA and GRCA management plans. Use 10-year average distributed by season of user-days, number of people, and distribution.	Information Need	The target level should be within the capacity of the CRE to absorb visitor impacts. The target level should consider GLCA and GRCA Management Plans
			Physical safety (other than whitewater boating)		Information Need. Use average of NPS incident reports from Myers et al. for period 1988-92. ⁽²⁵⁾ Include data and conclusions from other reports re: accident rates during interim and experimental flows and BHBF. Brown and Hahn (1987) did the baseline study in 1985-6 for GCES I, and collected data at medium and high flows. Jalbert and Mitchell (1992) collected data in 90-91 during the "experimental flows," primarily at low flows; and Jalbert (1997) again in 1996 during the BHBF. Also Underhill and Borkan (1987).	Metric is river-related deaths or injuries. The target is to minimize river-related injuries and deaths. Information Need: To correlate flows, equipment type, and guide experience to NPS river incident reports related to wading anglers, river travel in the flatwater reaches above the Paria River and below Separation Canyon, and trails to and along the river, to determine flow-related risk. The stage of Lake Mead should be included in the correlation for the reach below Separation Canyon.	
9.2	Maintain or improve	Recreational opportunities	Quality and quantity	Glen Canyon	Information Need GLCA data: number and variety of recreational activities.	Information Need	NPS studies underway. The target level should be within the capacity of the CRE to absorb visitor impacts. The target level should consider GLCA and GRCA Management Plans. Management action: a non-native fishing policy for concessions contracts needs to be developed.
				Grand Canyon	Information Need. GRCA data: number and variety of recreational activities.	Information Need	

Goal 9. Maintain or improve the quality of recreational experiences for users of the Colorado River ecosystem, within the framework of GCDAMP ecosystem goals.

MO #	Perform some action	On some element	On some attribute	At some place	From the current level	To the target level	Comments
9.3	Increase	Camping beaches	Size	Mainstem	Information Need From Kaplinski et al. in prep.	800 m ² (Stewart et al. 2000)	The target level should be within the capacity of the CRE to absorb visitor impacts. The target level should consider GLCA and GRCA Management Plans. Metric for Quality includes parameters for vegetation, sanitation, and shade. Metric for Distribution is number of campsites required per identified reach.
			Quality	Mainstem	Information Need	Information Need Metric needs to be a “quality index.” That includes parameters for open sand area, < 8 degrees slope, mooring, wind protection, ant colonies, degree of human impact (fire rings, trail erosion, litter, sanitation), vegetation encroachment, and shade. Also, need to assess and quantify the processes causing changes in beach quality and size (e.g., river flows, wind, tributary runoff, vegetation encroachment, human, other.)	
			Distribution	Critical reaches	Information Need	Minimum 21 +/- 5 beaches per critical reach above maximum ROD flows (25,000 cfs) capable of accommodating 16-36 people. Also, consider NPS river travel model.	
				Non-critical reaches	Information Need	Information Need: Suggest an average of one beach capable of accommodating 16-36 people every 2.0 river miles (Grand Canyon River Guides, personal comm.)	

Goal 9. Maintain or improve the quality of recreational experiences for users of the Colorado River ecosystem, within the framework of GCDAMP ecosystem goals.

MO #	Perform some action	On some element	On some attribute	At some place	From the current level	To the target level	Comments
9.4	Improve	Rapids	Navigability	Mainstem	Information Need	Information Need See incident rates/flow level during the late 1980s and Interim Flow period.	The target level to be developed from NPS on-river accident rates. See Myers et al. ⁽²⁵⁾ The target should address navigability across the range of flows allowed within the ROD. The metric is the number of accidents per rapid at each flow. See also Brown and Hahn (1987), and Jalbert and Mitchell (1992).
			Whitewater boating safety		Information Need	Metric is river-related deaths or injuries. The target is to minimize river-related injuries and deaths. IN: To correlate flows, equipment type, and guide experience to NPS river incident reports, to determine flow-related risk.	
9.5	Maintain or enhance	Experience	Wilderness	CRE in Grand Canyon National Park	Information Need	Information Need See GRCA data on use levels and distribution.	See Bishop, et al. (1986) for flow-related wilderness. The target level should consider GRCA and GLCA Management Plans (in progress).
				CRE below GCD in Glen Canyon NRA	Information Need	Information Need See GLCA data on use levels and distribution.	

Goal 10. Maintain power production capacity and energy generation, and increase where feasible and advisable, within the framework of GCDAMP ecosystem goals.

MO #	Perform some action	On some element	On some attribute	At some place	From the current level	To the target level	Comments
10.1	Maintain or increase	Power	Marketable capacity and energy	GCD	Current practices	Information Need	Constrained by the ROD
10.2	Maintain	Power	Existing emergency criteria for WAPA system	GCD	Current practices	Information Need	Constrained by the ROD
10.3	Maintain	Power	Existing emergency criteria for WSCC system	GCD	Current practices	Information Need	Constrained by the ROD
10.4	Maintain	Power	Regulation	GCD	Current practices	Information Need Determine if the current regulation scheme, or additional regulation schemes, will cause problems for the ecosystem.	

Goal 11. Preserve, protect, manage, and treat cultural resources for the inspiration and benefit of past, present and future generations.

MO #	Perform some action	On some element	On some attribute	At some place	From the current level	To the target level	Comments
11.1	Preserve	Register-eligible properties	National Register integrity	Area of Potential Effect	Information Need (at least 264 properties)	100% of Register-eligible properties	The target is to preserve register-eligible properties (e.g., TCPs and prehistoric and historic sites) via protection, management, and/or treatment (e.g., data recovery) for the purpose of federal agency compliance with NHPA, as well as AMP and AMWG compliance with GCPA.
11.2	Manage	Traditionally important resources	Resource integrity	CRE	Information Need (obtained through ethnographic studies, polls, interviews, surveys, and literature)	Information Need Long-term trend indicates stable or improving for each identified resource.	The target is to manage (based on current cultural values) other traditionally important resources that are not sufficiently addressed under other MOs. Specifically, this MO addresses resources not considered Register-eligible.
11.3	Protect and maintain	Traditional cultural resources	Physical access	CRE	Information Need	Information Need	See USBR ⁽³⁴⁾ The target is to provide meaningful tribal consultation on AMP activities that might restrict or block physical access by Native American traditional practitioners. See AIRFA and EO 13007.

Goal 12. Maintain a high quality monitoring, research, and adaptive management program.

MO #	Perform some action	On some element	On some attribute	At some place	From the current level	To the target level	Comments
12.1	Maintain or attain	Socio-economic data	Hydropower	N/A	EIS	Information Need	The target level is adequate socioeconomic data for making recommendations to the Secretary.
			Air quality	N/A	EIS	Information Need	
			Wilderness	N/A	EIS	Information Need	
			Recreation	N/A	EIS and Stewart (1999)	Information Need	
			Non-use values	N/A	Non-use study accompanying the EIS.	Information Need	
			Tribal & spiritual values	N/A	EIS	Information Need	
12.2	Integrate and synthesize	Cultural and environmental data	Interdisciplinary information	CRE	Not readily available and not completely synthesized or integrated	Readily accessible by georeferencing using GIS, databases, etc.	The target is adequate cultural and environmental data for making recommendations to the Secretary.
12.3	Attain and maintain	Monitoring and research program	Natural, cultural, and recreational resources	CRE	GCMRC Strategic Plan 1998-2002	Updated GCMRC Strategic Plan	The target is implementation of a GCMRC Strategic Plan that has been agreed to by the AMWG after review by the SAB, the PA signatories, and the TWG, and that will subsequently be reviewed on a periodic basis.

Goal 12. Maintain a high quality monitoring, research, and adaptive management program.

MO #	Perform some action	On some element	On some attribute	At some place	From the current level	To the target level	Comments
12.4	Attain and maintain	AMP composed of all stakeholders	That acknowledges uncertainty and uses experimentation, monitoring & research	N/A	An ongoing AMP program with a Strategic Plan in development	Updated AMP Strategic Plan	The target is implementation of an AMP Strategic Plan that describes the processes for science-based collaborative resources management.
			Participation		<p><u>For calendar year 2000:</u> Average TWG attendance = 92 % Average AMWG attendance = 95 % Participation on TWG and AMWG ad hoc groups = 35 % This last number was the number of TWG or AMWG members who volunteered to be on ad hoc groups divided by the total number of TWG and AMWG members.</p>	100% attendance by all representatives at AMWG and TWG meetings plus active participation in Ad Hoc Committees.	The target is to have all AMWG and TWG members actively involved with AMP deliberations and activities, and their input recognized and valued.

Goal 12. Maintain a high quality monitoring, research, and adaptive management program.

MO #	Perform some action	On some element	On some attribute	At some place	From the current level	To the target level	Comments
12.5	Attain and maintain	AMP	Effective tribal consultation (i.e., inclusion of tribal values and perspectives into the AMP)	CRE	Current participation at TWG, AMWG, and PA meetings	Effective dialogue between tribes and AMWG members on all AMP actions	See USBR ⁽³²⁾ The target is to achieve, at a minimum, effective, legally mandated government-to-government consultation. To achieve this MO it is important to provide adequate funding, but funding alone is not a sufficient indicator of successful achievement.
12.6	Attain and maintain	Management activities, research, and long-term monitoring activities	Tribal participation	AMP	Information Need	Information need	The target is a set of activities that provides meaningful tribal participation and meets each tribe's interests to ensure that tribal values are incorporated in the scientific activities of the adaptive management program, and that tribal interpretations of monitoring and research data are considered. <u>Linkage:</u> Vision/Mission statement, particularly the mention of federal trust responsibilities.

Goal 12. Maintain a high quality monitoring, research, and adaptive management program.

MO #	Perform some action	On some element	On some attribute	At some place	From the current level	To the target level	Comments
12.7	Conduct	Experimental flows	Flow dynamics	Mainstem	1996 BHBF 1997 HMF 2000 LSSF test	Information Need To be proposed by the Experimental Flows Ad Hoc Group.	See GCMRC, ⁽⁶⁾ Webb et al. ⁽³⁷⁾ and Topping et al. ⁽³¹⁾ The target level is the experiments needed to gain critical understanding of ecosystem function under different dam operations, e.g., BHBFs, HMFs, biological opinion flows, and financial exception criteria flows.
12.8	Conduct	Management experiments	Other management actions	CRE	Check dams Translocation of KAS Fishing regulations	Information Need At a minimum, one management action to address native v. non-native fish interaction and one to address vegetation encroachment on beaches in the next five years.	The target level is the experiments needed to gain critical understanding of ecosystem function under different management alternatives outside of dam operations.
12.9	Build	AMP	Public support	N/A	Information Need	Information Need A public outreach plan adopted by the AMWG. Propose to have BOR, NPS, and USGS public affairs people develop the plan.	Metric should include GCMRC and BOR web pages; GCD programs and tours; AMWG Outreach Committee; publications; various AMWG member activities. The purpose is adequate public support for AMP experiments and adaptive management, and a diverse funding base.

Goal 12. Maintain a high quality monitoring, research, and adaptive management program.

MO #	Perform some action	On some element	On some attribute	At some place	From the current level	To the target level	Comments
12.10	Maintain or attain	Funding	Foundation and Corporate	N/A	\$0	Information Need	The target is adequate funding to meet the goal. Develop a plan identifying sources for obtaining foundation and corporate funding.
			Appropriated		\$75,000 (FY 2000)	\$1,010,000 USGS \$475,000 Tribal participation	
			State Agency		Information Need (obtain from AGFD)	Information Need	
			Power revenues		\$6.22M (for GCMRC) \$1.443M (for BOR)	\$7,850,000 indexed for CPI	
12.11	Maintain or attain	Participation	Externally-funded investigators	CRE	Information Need (obtain from NPS)	Information Need MAs: 1. Develop a brochure that indicates support that would be provided by GCMRC and NPS to researchers who bring their own funding to address issues related to AMP MOs and INs. 2. Get outside researchers engaged and obtain their data.	Current and target levels should include small and cost-shared projects in NPS, AGFD, etc. The target is contributions to meeting Information Needs by externally funded investigators. NOTE: Incentives could include donated office space, partial funding, letters of support, facilitated access, and logistical support.

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ADAPTIVE MANAGEMENT

Adaptive management is an iterative process, designed to experimentally compare selected management actions by evaluating alternative hypotheses about the ecosystem being managed. It consists of three parts: management actions, monitoring, and adaptation. Management actions are treated as experiments subject to modification. Monitoring is conducted to detect the effects of the management actions. Finally, management actions are refined based on the enhanced understanding about how the ecosystem responds.

AREA OF POTENTIAL EFFECT

The legal definition of Area of Potential Effect is the geographic area or areas within which an undertaking may cause changes in the character or use of historic properties, if any such properties exist (36 CFR 800.2(c)). The Programmatic Agreement signatories are currently (as of July 2001) re-evaluating the APE for the Adaptive Management Program and may change it from the current 256,000 cfs.

BIODIVERSITY

Biodiversity is “the variety of organisms considered at all levels, from genetic variants belonging to the same species through arrays of species to arrays of genera, families, and still higher taxonomic levels [including] ... the variety of ecosystems...”⁽³⁸⁾

BIOLOGICAL GOALS

Biological goals include Goal 1 (foodbase), Goal 2 (native fish), Goal 3 (extirpated species), Goal 5 (Kanab ambersnail), and Goal 6 (riparian and spring communities).

CAPACITY (GENERATING)

Generating capacity is a measure of the ability to generate electric power, usually expressed in MW (megawatts). The capacity of a hydropower plant is a function of head (reservoir elevation) and maximum water flow through the turbines.

COLORADO RIVER ECOSYSTEM

The Colorado River ecosystem is the Colorado River mainstem corridor and interacting resources in associated riparian and terrace zones, located primarily from the forebay of Glen Canyon Dam to the western boundary of Grand Canyon National Park. It includes the downstream inundation level to which dam operations impact physical, biological, recreational, cultural, and other resources. The scope of GCDAMP activities may include limited investigations into some tributaries (e.g., the Little Colorado and Paria Rivers).

CRITICAL REACHES

Critical reaches are where there are only very few, very small, or very high use campsites. These reaches are river mile (RM) 6 to 41, RM 75 to 114, RM 130 to 165, and perhaps RM 216 to 246.

CULTURAL GOAL

Cultural goal refers to Goal 11.

CULTURAL RESOURCES

Cultural resources includes, but is not necessarily limited to, any prehistoric or historic district, site, building, structure, landscape, or object included in, or eligible for inclusion in the National Register, including artifacts, records, and material remains related to such a property or resource. Properties of traditional religious and cultural importance to an Indian tribe are included in this definition under Section 101(d)(6)(A) of NHPA.

ECOSYSTEM

An ecosystem is “a community of organisms and their physical environment interacting as an ecological unit.”⁽²⁰⁾ An ecosystem consists of patterns and processes that are dynamic and occur within a particular range of temporal and spatial variability.

ECOSYSTEM MANAGEMENT

An ecosystem management approach differs from an issue-, species-, or resource-specific approach. Ecosystem management is a method for sustaining or restoring ecosystems and their functions and values. “It is goal driven, and it is based on a collaboratively developed vision of desired future conditions that integrates ecological,

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economic, and social factors. It is applied within a geographic framework defined primarily by ecological boundaries.”⁽¹¹⁾ Ecosystem management is a process that attempts to mimic appropriate ecosystem patterns (abundance and distribution of species and habitats) and ecosystem processes (drivers of ecosystem patterns). It includes managing for viable populations of all native species.

ECOSYSTEM PATTERNS

Ecosystem pattern is the abundance of species, biotic communities, and physical habitats, as well as their spatial and temporal distribution. This is a broader concept than “composition and structure.” Composition usually refers only to species presence or absence, and structure usually refers to the distribution of biotic communities.

ECOSYSTEM PROCESSES

Ecosystem processes are the abiotic (*i.e.*, non-living) and biotic (*i.e.*, living) functions, disturbances, or events that shape ecosystem patterns. There are physical processes (*e.g.*, fire, hydrologic, geomorphic, and climatic regimes; air chemistry, nutrient cycling), biological processes (*e.g.*, competition, predation, herbivory, parasitism, disease, migration, dispersal, gene flow, succession, recruitment, maturation), and anthropogenic processes (*e.g.*, habitat conversion, novel toxins, vandalism).

EMERGENCY EXCEPTION CRITERIA

Emergency exception criteria are operating criteria which allow the Western Area Power Administration to depart from ROD operating criteria in response to various emergency situations in accordance with their obligations to the North American Electric Reliability Council. These criteria also provide for exceptions to the ROD criteria during search and rescue situations, special studies and monitoring, and dam and powerplant maintenance.

EXTIRPATED SPECIES

An extirpated species is one that no longer occurs (*i.e.*, has become extinct) in a particular area. Examples from the CRE include roundtail chub, bonytail chub, and Colorado pikeminnow.

FINANCIAL EXCEPTION CRITERIA

Financial exception criteria would allow a temporary departure from ROD operating constraints on dam releases, as a response to a regional electricity market that is extraordinarily expensive. These criteria do not exist at this time. Similar criteria were in place during the period of Interim Flows (August 1991 to October 1996),

INVASIVE SPECIES

An invasive species is one that has invaded an area following changes in one or more ecosystem processes and has become dominant. Examples from the CRE include non-native species (*e.g.*, tamarisk) and native species (*e.g.*, willow).

MONITORING

Monitoring is the “collection and analysis of repeated observations or measurements to evaluate changes in condition and progress toward meeting a management objective.”⁽⁴⁾ Monitoring needs to produce data of sufficient statistical power to detect a trend if in fact it is occurring.⁽⁸⁾ Monitoring differs from inventorying, which is the measurement of environmental attributes at a given point in time to determine what is there. It also differs from research, which is the measurement of environmental attributes to test a specific hypothesis.

NATIVE SPECIES

A native species is one that occurred in an area before anthropogenic alterations to ecosystem patterns and/or processes. Examples from the CRE include humpback chub, razorback sucker, flannelmouth sucker, bluehead sucker, speckled dace, Colorado pikeminnow, bonytail, roundtail chub, river otter, Kanab ambersnail, Southwest willow flycatcher, brown-headed cowbird, netleaf hackberry, honey mesquite & catclaw acacia.

NON-NATIVE SPECIES

A non-native species is one that did not occur in an area before anthropogenic alterations to ecosystem patterns and/or processes. Non-natives are also known as introduced, exotic, or alien species. Many, but not all, non-native species can be categorized as an invasive species. Examples of non-native species in the CRE include *Gammarus*, rainbow trout, brown trout, common carp, red shiner, channel catfish, tamarisk, and camellthorn.

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to accomplish.

RANGE OF NATURAL VARIABILITY

The Range of Natural Variability is the spatial and temporal variation in ecosystem patterns and ecosystem processes under which the ecosystem has evolved. The range of natural variability for ecological processes is usually defined by their frequency (e.g., number/year), intensity (e.g., cubic feet per second), duration (e.g., number of days), magnitude (e.g., acres), seasonally, and rate of change. See Landres⁽¹⁸⁾ for a full discussion.

REASONABLE AND PRUDENT ALTERNATIVE

“Reasonable and prudent alternatives refer to alternative actions identified during formal consultation that can be implemented in a manner consistent with the intended purpose of the action, that can be implemented consistent with the scope of the Federal agency's legal authority and jurisdiction, that is economically and technologically feasible, and that the Director believes would avoid the likelihood of jeopardizing the continued existence of listed species or resulting in the destruction or adverse modification of critical habitat.”⁽⁵⁾

REASONABLE AND PRUDENT MEASURE

“Reasonable and prudent measures refer to those actions the Director believes necessary or appropriate to minimize the impacts, i.e., amount or extent of incidental take.”⁽⁵⁾

RECOVERY

Recovery is improvement in the status of a listed species to the point at which listing is no longer appropriate, under the criteria set out in section 4(a)(1) of the Endangered Species Act⁽⁵⁾.

RECREATIONAL GOALS

Recreational goals include Goal 4 (trout) and Goal 9 (recreation).

REGULATION

Western operates two load control areas that are tied to GCD. A load control area is a specific geographic areas assigned to an operator to regulate the moment-by-moment changes in electrical demand on the transmission lines in the area. Regulation is the adjustment in electrical generation within a load control area to meet minor changes in electrical use as reflected by electrical readings on transmission lines. Currently, GCD is committed to providing regulation up to plus or minus 1,000 cfs on an instantaneous basis to Western's load control area.

REGULATION FOR OTHERS

Regulation for others is that which can be made available for other electrical utilities, provided they have an electrical transmission link to GCD and that they are a control area operator or have contracted an agreement with their control area operator to receive this service.

REMOVAL OF JEOPARDY

To “jeopardize the continued existence of [a listed species] means to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species.”⁽⁵⁾ Removing (or avoiding) jeopardy is intended to be accomplished through the implementation of reasonable and prudent alternatives.

RIPARIAN ZONE

The riparian zone is the streamside area that is influenced by riverine processes, e.g., flood regime and distance to subsurface water.

SPRING COMMUNITY

Community of plants and animals that develops around springs and seeps.

TRIBAL CONSULTATION

Tribal consultation in the AMP is defined as the formal dialogue with designated governmental representatives and other AMWG members, through AMWG and TWG meetings, about trust assets, resources, and other tribal interests, that results in all the members of the AMWG understanding and appreciating tribal perspectives and the inclusion of

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tribal values within the AMP. Additionally, this consultation assists federal agencies in realizing their trust responsibility to tribal nations and fulfills the federal government's consultation requirements. Such consultation and the subsequent inclusion of tribal values can add to the knowledge base of the AMP, and tribal perspectives and values can temper the traditional western scientific approach used by the AMP, thus making it stronger.

TRIBAL PARTICIPATION

Tribal participation ensures that tribal values inform the interpretation of the quantity and quality of resources that results from a Western scientific approach to monitoring and research. Tribal participation is defined as a set of activities that may include one or more of the following: conducting and/or collaborating in resource projects awarded through the competitive process, participating in discussions with PIs regarding where and how they will conduct monitoring and research activities, and tribally relevant data analysis and information sharing.

VIABLE POPULATION

A population is considered viable when there is a high chance of persistence over a long timeframe without demographic or genetic augmentation. Population viability is not the same as "recovery" or "removal of jeopardy" for a species. However, the concept of population viability is an important consideration in determining recovery and removal of jeopardy.

Abbreviations

AFDW	ash-free dry weight
AGFD	Arizona Game and Fish Department
AIRFA	American Indian Religious Freedom Act
AMP	adaptive management program
AMWG	Glen Canyon Dam Adaptive Management Work Group
APE	Area of Potential Effect
BHBF	beach/habitat building flow
BO	biological opinion
BOR	Bureau of Reclamation
cfs	cubic feet per second
CPOM	coarse particulate organic matter
CPUE	catch per unit effort
CRE	Colorado River ecosystem
D50	median grain size
DO	dissolved oxygen
EO	Executive Order
FPOM	fine particulate organic matter
GCD	Glen Canyon Dam
GCMRC	Grand Canyon Monitoring and Research Center
GCPA	Grand Canyon Protection Act
GLCA	Glen Canyon National Recreation Area
GRCA	Grand Canyon National Park
HBC	Humpback chub
HMF	Habitat maintenance flow
KAS	Kanab ambersnail
LCR	Little Colorado River
LSSF	Low steady summer flow
MA	management action
MO	management objective
MSCP	Multi-Species Conservation Plan
Ne	effective population size
NHPA	National Historic Preservation Act
NHWZ	new high water zone
NPS	National Park Service
OHWZ	old high water zone
PI	principal investigator
popn	population
PVA	population viability analysis
RBT	Rainbow trout
Register	National Register of Historic Places
RM	river mile
RNV	range of natural variability
ROD	record of decision
RPA	reasonable and prudent alternative
SAB	Scientific Advisory Board (of GCMRC)
SWWF	Southwestern willow flycatcher
TBD	to be determined
USBR	United States Bureau of Reclamation
WACM	Western Area - Colorado and Missouri
WALC	Western Area - Lower Colorado
WAPA	Western Area Power Administration, Department of Energy
W _r	mean annual relative weight
WSCC	Western Systems Coordinating Council

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