Glen Canyon Dam
Adaptive Management Work Group

Ad Hoc Committee on Strategic Planning

Report to AMWG, _____ 2001

Strategic Plan Update

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 ecosystem 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 ecosystem 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. Management actions, including changes in dam operations, will be tried that attempt to return ecosystem patterns and processes to their range of natural variability. When this is not appropriate, or beyond the range of operational or legal flexibility of the dam, 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, ~~and~~ remove jeopardy from humpback chub and razorback sucker, and prevent adverse modification to its 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

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. Linkages: See the numbers of fish desired under Goals 2, 3, and 4.

1.1 (1 and 3)	Maintain or attain	~~Algae and periphyton~~ 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	~~17.5~~x +/- y g/m^2 (Cobble)~~(27)~~ ~~2.7~~ a +/- b g/m^2 (Pool) ~~(27)~~ (To be provided from Shannon et al.)	~~150 g/m^2(27)~~ x +/- y g/m^2 (Cobble) a +/- b g/m^2 (Pool) (Need to resolve differences between data from Shannon et al. and AGFD.)	Also see McKinney et al. 1999(22) The small group suggested the target should be the average of 1996 and 1997 data which they believe represents the best biomass estimates for the period in which data is available, and because they appeared to be good years to support the desired species.
			Composition		~~49.60% *Cladophora*~~ ~~33.10% Chlorophyta~~ ~~9.10% *Fontinalis*~~ ~~3.35% Chromophyta~~ ~~2.40% Rhodophyta~~ ~~2.50% Cyanobacteria~~ ~~(27)~~	~~Obtain from literature~~ Information Need	~~Metric is % of algal species that support upright diatoms~~ 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.
					River Mile / % Algae / % Macro-phytes POOLS IN / IN IN / IN IN / IN COBBLES IN / IN IN / IN IN / IN		
			~~Production~~		~~Information Need~~	~~Information Need~~	~~Metric is g/m^2/time of *Cladophora*~~

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
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. Linkages: See the numbers of fish desired under Goals 2, 3, and 4.							
1.2 (2)	Maintain or attain	Benthic invertebrates	Biomass	Mainstem from Glen Canyon Dam to Paria River	~~5.0~~ x +/- y g/m^2 (Cobble)[27] ~~1.0~~a +/- b g/m^2 (Pool)[27]	~~5000 g/m^2[27]~~ x +/- y g/m^2 (Cobble) a +/- b g/m^2 (Pool)	Also see McKinney et al. 1999[22]
			Composition		~~0.4% Worms~~ ~~3.6% *Gammarus*~~ ~~5.5% Oligochaetes~~ ~~0.1% Simulium~~ ~~28.8% Midges~~ ~~3.8% Miscellaneous~~ ~~57.7% Gastropoda~~ ~~(Cobble)[27]~~ ~~1.0% Worms~~ ~~0.9% Gammarus~~ ~~35.7% Oligochaete~~ ~~22.3% Midges~~ ~~(Pool)[27]~~ Cobble: % Tubificids % *Gammarus* % Chironomids % Gastropods % Other Pool: % Tubificids % *Gammarus* % Chironomids % Gastropods % Other (Data to be filled in by Joe Shannon and AGFD.)	Information Need	Metric is relative % of species.
			~~Production~~		~~Information Need~~	~~Information Need~~	~~Metric is g/m^2/time~~

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

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. Linkages: See the numbers of fish desired under Goals 2, 3, and 4.

~~1.3 (3)~~	~~Maintain or attain~~	~~Aquatic macrophytes~~	~~Biomass~~	~~Mainstem from Glen Canyon Dam to Paria River~~	~~Information Need~~	~~Information Need~~	
			~~Composition~~		~~Information Need~~	~~Information Need~~	
			~~Production~~		~~Information Need~~	~~Information Need~~	~~Metric is g/m^2/time~~
1.~~3~~4 (4 and 6)	Maintain or attain	Primary producers: algae on hard substrates ~~and,~~ rooted macrophytes on soft substrates, and diatoms	Biomass	Mainstem below the Paria River on cobble bars identified by specific sampling sites	River Mile ~~RM~~ / g/m^2	50 g/m$^{2(27)}$	
					COBBLE		
					2		
					61		
					68		
					127		
					205		
			Composition		River Mile ~~RM~~ / % Algae / % Macro-phytes	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		
					68		
					127		
					205		

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.~~4~~5 (5)	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]	~~Obtain from literature~~To be provided based on 1996-97 data.	
			Composition		~~0.4% Worm~~ ~~7.1% *Gammarus*~~ ~~8.2% Oligochaete~~ ~~4.3% Simulium~~ ~~55.4% Chironomid~~ ~~3.6% Miscellaneous~~ ~~21.0% Gastropod~~ ~~(Cobble)~~[27] ~~0.4% Worm~~ ~~1.1% *Gammarus*~~ ~~30.1% Oligochaete~~ ~~14.3% Simulium~~ ~~48.9% Chironomid~~ ~~1.2% Miscellaneous~~ ~~4.0% Gastropod~~ ~~(Pool)~~[27] Cobble: % Tubificids % *Gammarus* % Chironomids % Gastropods % Other Pool: % Tubificids % *Gammarus* % Chironomids % Gastropods % Other	Obtain from literature	Metric is relative % of species.
			~~Production~~		~~Information Need~~	~~Information Need~~	~~Metric is g/m^2/time~~

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
			~~Distribution~~		~~20 Worms~~ ~~500 *Gammarus*~~ ~~120 Oligochaetes~~ ~~10 Simulium~~ ~~2150 Midges~~ ~~20 Miscellaneous~~ ~~1580 Gastropod~~ ~~(Cobble at Mile 2)~~[~~27~~]	~~Information Need~~	
1.~~5~~6 (7)	Maintain or attain	Foodbase drift: Diptera *Gammarus* Other Bugs CPOM FPOM DOC	Abundance	Mainstem below GCD	~~0.024 g/m^3/s (Plants)~~ ~~0.056 g/m^3/s (Detritus)~~ ~~0.001 g/m^3/s (Inverts)~~ River Mile / AFDW: 2 / 61 / 68 / 127 / 205 /	~~Obtain from literature~~To be provided based on 1996-97 data.)	
			~~Composition~~		~~29.2% (Plants)~~ ~~69.3% (Detritus)~~ ~~1.1% (CPOM inverts)~~ ~~0.4% (FPOM inverts)~~	~~Obtain from literature~~	

Goal 2. Maintain or attain viable populations of existing native fish, ~~and~~ remove jeopardy from humpback chub and razorback sucker, and prevent adverse modification to its 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 (8)	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.)~~LCR and mainstem within 3 miles of LCR~~	~~8096~~ 4330-4811 individuals [3;~~36~~] 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_e.
				Eight mainstem aggregations~~Mainstem except within 3 miles of the LCR~~	Information Need ?? Confidence interval with a mean of 225 individuals??~~225 individuals~~ [3;~~36~~]	Information Need	
2.2 (9)	Maintain or attain	Humpback chub (51 mm to 150 mm)	Year class strength~~Abundance~~	LCR aggregation~~LCR and mainstem within 3 miles of LCR~~	Information Need. Consider using a CPUE index for different year classes, at some place in the LCR at some time during the year.~~Obtain from literature~~	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~~Mainstem except within 3 miles of the LCR~~	Information Need~~0-74 captures/trip~~ [9]	Information Need	

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

MO #	Perform some action	On some element	On some attribute	At some place	From the current level	To the target level	Comments
2.3 (new)	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	Target is viable populations and removal of jeopardy.
				8 mainstem aggregations	Information Need	Information Need	
2.~~4~~3 (10)	Establish	Humpback chub	Spawning aggregation~~Populations~~	CRE downstream of GCD	One spawning aggregation in the LCR	A second spawning aggregation	The target is removal of jeopardy.
2.~~5~~4 (11)	Attain	Humpback chub	Condition	LCR aggregation~~LCR and mainstem within 3 miles of LCR~~	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~~Mainstem except within 3 miles of the LCR~~	Information Need	Information Need	
			Disease and other parasites~~Health~~	LCR aggregation~~LCR and mainstem within 3 miles of LCR~~	Information Need	Information Need	
				8 mainstem aggregations~~Mainstem except within 3 miles of the LCR~~	Information Need	Information Need	

Goal 2. Maintain or attain viable populations of existing native fish, ~~and~~ remove jeopardy from humpback chub and razorback sucker, and prevent adverse modification to its 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 (12)~~	~~Maintain or attain~~	~~Humpback chub~~	~~Spawning~~	~~LCR and mainstem within 3 miles of LCR~~	~~Information Need~~	~~Information Need~~	~~See Gorman and Bramblett.[9]~~
				~~Mainstem except within 3 miles of the LCR~~	~~Information Need~~	~~Information Need~~	~~The target is viable populations and removal of jeopardy.~~
2.6 (13)	Reduce	~~Non-native~~Native fish	Mortality due to non-native fish predation as a % of overall mortality~~Predation on native fish~~	LCR~~CRE below GCD~~	Information Need	Information Need	The target is reduction of non-native fish predation so it does not impinge on native fish viability. Linkages: The native fish MOs in Goal 2 and Goal 3.
				Mainstem	Information Need	Information Need	
			~~Competition with native fish~~	~~CRE below GCD~~	~~Information Need~~	~~Information Need~~	
2.7 (14)	Attain	Razorback sucker	~~Populations~~Abundance	CRE below GCD	0 individuals [9]	Information Need	Target is derived from the capability of the habitat to support the species, and includes the removal of jeopardy.
2.8 (15)	Maintain	Flannelmouth sucker	Abundance ~~and distribution~~	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 (16)	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.

NOTE FOR GOAL 4: The purpose of this goal is recreation. It is limited by MO 2.6.

MO #	Perform some action	On some element	On some attribute	At some place	From the current level	To the target level	Comments
~~This goal is self-explanatory and does not need a separate qualitative target.~~ Linkages: See Issue Paper B (trout).							
4.1 (17)	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 ~~– 250,000~~ Age II+ individuals	~~An upper threshold level of population abundance should be developed that triggers some action to reduce abundance so population densities do not drive the other suite of RBT indicators below acceptable levels.~~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	
			~~Electrofishing CPUE~~		~~Information Need~~	~~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.
~~4.2 new~~	~~Maintain or attain~~	~~Rainbow trout~~	Natural recruitment		100%	100%	This MO restates and measures the goal.

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.

NOTE FOR GOAL 4: The purpose of this goal is recreation. It is limited by MO 2.6.

MO #	Perform some action	On some element	On some attribute	At some place	From the current level	To the target level	Comments
4.2~~3~~ new	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.	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 (24)	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. 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 (25)	Maintain	Kanab ambersnail	Habitat	~~Above some stage level at~~ Vasey's Paradise ~~(stage level is an Information Need)~~	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 ~~ten~~x-year running average greater than or equal to ~~50~~y% of the total area of occupied habitat measured at Vasey's in March 1996, with a minimal level TBD.	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.

NOTE FOR GOAL 6: This goal is intended to help achieve the biological, cultural, and recreational goals.

MO #	Perform some action	On some element	On some attribute	At some place	From the current level	To the target level	Comments
The target is an achievable and appropriate mix of ~~these~~ 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. ~~The Old High Water Zone is a high priority because of the threat of losing it. One way of maintaining it is through high flows, which may have a negative effect on marshes and New High Water Zones.~~ ~~Considering the legal and regulatory mandates of the NPS to protect natural landscapes and native species and communities, considering regenerative capabilities, and recognizing the dynamic and successional nature of these communities, the other three zones would be a lower priority.~~							
6.1 (29)	Maintain	Marsh community	Abundance	CRE below GCD and above Lake Mead's dynamic water level	1215 patches (4.6 ha)[7]	For a ~~10~~x-year running average of ~~1000~~ y or more marsh patches >/= 10 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 a ~~10~~x-year running average area equal to +/- ~~50~~y% of the area defined by aerial imaging in 2000.	

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

NOTE FOR GOAL 6: This goal is intended to help achieve the biological, cultural, and recreational goals.

MO #	Perform some action	On some element	On some attribute	At some place	From the current level	To the target level	Comments
6.2 (30)	Maintain	New high water zone community	Patch number and distribution	CRE below GCD and above Lake Mead's dynamic water level	Information Need	Information Need	~~Target is to ensure that NHWZ vegetation is not eliminated from any reaches where it already occurs. Metric is number of miles per reach.~~ In all river reaches where it was documented by aerial ~~imaging~~ photography in ~~2000~~1984,~~.~~ the target is to allow for scouring of some NHWZ vegetation due to periodic high flows, and to allow its return through successional processes.
			Composition		Information Need	~~For no loss of native plant or animal species.~~ Species are assumed still to be present when they have been detected by monitoring within the last 10 years.	Target is to allow no loss of native plant or animal species.
			Area		Information Need	For a ~~10~~x-year running average area equal to +/- ~~50~~y% of the area defined by aerial imaging in 2000. ~~In any given year, the vegetated area should not be less than the area measured in 1983 or 25% of the area measured in 2000 (whichever is less).~~	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.

NOTE FOR GOAL 6: This goal is intended to help achieve the biological, cultural, and recreational goals.

MO #	Perform some action	On some element	On some attribute	At some place	From the current level	To the target level	Comments
6.3 (31)	Maintain	Old high water zone community	Abundance	CRE below GCD and above Lake Mead's dynamic water level	In 1992, there was an estimated 1,870 acres of OHWZ vegetation (Stevens 1992). ~~Information Need~~	Information Need	Target is no loss of area.
			Composition		Information Need	Information Need	
			Distribution		Information Need	Information Need	
6.4 (32)	Maintain	Sand Beach community	Abundance	CRE below GCD and above Lake Mead's dynamic water level	Information Need	Information Need	See Kearsley[15] and Stevens et al.[29]
			Composition		Information Need	Information Need	
			Distribution		Information Need	Information Need	
~~6.4 (33)~~	~~Maintain~~	~~Culturally important species~~	~~Abundance~~	~~CRE below GCD~~	~~157 species (Plants)[21;30]~~	~~Information Need~~	
			~~Distribution~~		~~Information Need~~	~~Information Need~~	
6.5 (34)	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 dynamic water level	95+ species (Plants)[28] 3 species (Birds)[28]	No new non-native species. Invasive non-native species cover </= x% of total riparian area. Targets are species-specific. ~~Range to be determined~~ (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 ~~No new non-native species. Invasive non-native species cover </= x% of total riparian area or less.~~	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.

NOTE FOR GOAL 6: This goal is intended to help achieve the biological, cultural, and recreational goals.

MO #	Perform some action	On some element	On some attribute	At some place	From the current level	To the target level	Comments
6.67 new	Maintain	Spring and wetland	Habitat occupied by rare and endemic species	CRE below GCD ~~at some stage level (Information Need)~~ and above Lake Mead's dynamic water level	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.
6.76 (27)	Maintain	Southwest willow flycatcher	Riparian habitat	CRE below GCD, ~~and especially from Separation to Lake Mead~~ and above Lake Mead's dynamic water level	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 NHWZ should be dominated primarily by willows and/or tamarisk at least 4 meters high and in patches at least 20 meters wide. This MO provides specificity for other MOs under this goal. Lake Mead water levels are an important factor, but are outside the control of the AMP.~~ The ~~D~~definition~~s~~ 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.

NOTE FOR GOAL 7: The phrase, "to achieve GCDAMP ecosystem goals," indicates that this goal is a method to achieve certain other goals. In this case, "ecosystem goals" includes biological goals, recreational goals, and the cultural goal.

MO #	Perform some action	On some element	On some attribute	At some place	From the current level	To the target level	Comments
7.1 (18)	Attain	Water	Temperature range	Mainstem	6.93-18.56 °C[17]	~~Use decision process~~ Information Need	Target may include several stations in the mainstem.
			Seasonal variability of temperature		Information Need	~~Use decision process~~ Information Need	
The target for MO 7.1 is a temperature range and pattern of seasonal variability based on the range of natural variability, the range of operational flexibility of the dam, the range of legal flexibility, and the range that optimizes conditions for the targeted resources. Targeted resources ~~are~~ may include foodbase, native fish, trout, and people (human health and safety – microorganisms and hypothermia). 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. Linkages: MO 13; Principles 4, 6, and 7; and the Vision-Mission statement.							
7.2 (19)	Maintain	Water	Quality	Mainstem	Information Need (for the specific water quality parameters to use).	Information Need ~~Obtain from literature and use decision process~~	Parameters may include nutrients, salinity, pH, DO, nitrogen, phosphorus, microbes, and others. Data available from NASQWAN.[35]
The target for MO 7.2 is water quality based on the range of natural variability, the range of operational flexibility of the dam, the range of legal flexibility, the legally-defined state water quality standards, and the range that optimizes conditions for the targeted resources. The targeted resources ~~are~~ may include foodbase, native fish, trout, Southwestern willow flycatcher, riparian and spring communities, the recreational experience, and cultural resources. Linkages: Goals 1-3, 8-10, and 12.							
7.3 (20)	Maintain	Flow dynamics	Power plant operations	Mainstem	ROD operating criteria	~~Current ROD~~ Dam operating criteria then in effect	See MO 50 for experimental flows.
			BHBF flows		Maximum 45,000 cfs (March to April)	~~Current ROD~~ Dam operating criteria then in effect	
			Habitat maintenance flows		ROD operating criteria	~~Current ROD~~ 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.

NOTE FOR GOAL 8: The phrase, "to achieve GCDAMP ecosystem goals," indicates that this goal is a method to achieve certain other goals. In this case, "ecosystem goals" includes biological goals, recreational goals, and the cultural goal.

MO #	Perform some action	On some element	On some attribute	At some place	From the current level	To the target level	Comments
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. Linkages: Recreational, biological, and cultural goals: 1-4, 7-10, and 12.							
8.1 (21)	Maintain or attain	Fine ~~S~~sediment	Abundance	Main channel ~~up to power plant capacity~~below 8,000 cfs	Information Need ~~329,000 m^3 (35 sites)~~[12;31]	Current volumes or higher (trend), including some timeframe based on tributary inputs and high flows timing (Information Need).	Metric is ~~area (m^2) and~~ volume (m^3) as a rolling average. Target level should consider spawning habitat for trout in Glen Canyon and sediment needed for BHBFs.
			Grain-size		Information Need ~~0.3-0.4 mm~~[12;31]	Current ~~volumes~~ level or ~~higher~~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] Target level should consider spawning habitat for trout in Glen Canyon and sediment needed for BHBFs.
			Distribution		Information Need Current level to be obtained from side scan sonar and video (Anima) and/or multi-beam.	Current ~~volumes~~ level or ~~higher~~more areally extensive (trend), including some timeframe based on tributary inputs and high flows timing (Information Need).	Metric is ~~# sandbars by reach~~patchiness and area (m^2) of sand on channel bottom. 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.

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MO #	Perform some action	On some element	On some attribute	At some place	From the current level	To the target level	Comments
8.2	Maintain or attain	Fine sediment	Abundance	Channel margins (not eddies) from 8,000 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. 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.	Also, see Kondolf. 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 number of sandbars by reach. 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.

NOTE FOR GOAL 8: The phrase, "to achieve GCDAMP ecosystem goals," indicates that this goal is a method to achieve certain other goals. In this case, "ecosystem goals" includes biological goals, recreational goals, and the cultural goal.

MO #	Perform some action	On some element	On some attribute	At some place	From the current level	To the target level	Comments
8.~~3~~2 (22)	Maintain or attain	Fine sediment	Abundance	Eddies up to 25,000 cfs	Information Need ~~289,120 m^3 (35 sites)[12; 31]~~	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 Target level should consider spawning habitat for trout in Glen Canyon and sediment needed for BHBFs.
			Grain-size		Information Need ~~0.15-0.18 mm[12; 31]~~	Information Need, including some timeframe based on tributary inputs and high flows timing	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 Target level should consider spawning habitat for trout in Glen Canyon and sediment needed for BHBFs.
8.~~4~~3 * (23)	Maintain or attain	Fine ~~S~~sediment	Abundance	Shorelines between 25,000 cfs and ~~maximum BHBF~~uppermost effects of a maximum dam release	Information Need ~~0.37m (Glen Canyon) 0.60m (Marble Canyon) 0.80m (Grand Canyon)[12]~~	Information Need	Metric is area (m^2) and volume (m^3) as a rolling average
			Grain-size		Information Need ~~0.15 – 0.18 mm[31]~~	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.

NOTE FOR GOAL 9: The phrase, "within the framework of GCDAMP ecosystem goals," is intended to indicate a hierarchy or order of precedence. That is, the accomplishment of this goal should be undertaken in such a way that the likelihood of achieving the biological goals and the cultural goal is not impaired.

MO #	Perform some action	On some element	On some attribute	At some place	From the current level	To the target level	Comments
9.1 (35)	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 ~~(subject to GLCA and GRCA river management plans in progress)~~	Target level should be within the capacity of the CRE to absorb visitor impacts. Target level should consider GLCA and GRCA Management Plans~~. See Myers et al.(25)~~
			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.~~No more river-related deaths. Minimum flows 10,000 cfs. Maximum flows 35,000 cfs. BHBF flows OK with adequate warning time (Stewart et al. 2000)~~	

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

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MO #	Perform some action	On some element	On some attribute	At some place	From the current level	To the target level	Comments
9.2 (36)	Maintain or improve	Recreational opportunities~~y spectrum~~	Quality and quantity	Glen Canyon	Information Need GLCA data: number and variety of recreational activities.	Information Need ~~GLCA Management Plan (in progress)~~	NPS studies underway. Target level should be within the capacity of the CRE to absorb visitor impacts. Target level should consider GLCA and GRCA Management Plans. ~~See Myers et al.~~[25] Management action: a non-native fishing policy for concessions contract needs to be developed.
				Grand Canyon	Information Need. GRCA data: number and variety of recreational activities.	Information Need ~~GRCA Management Plan (in progress – temporarily suspended)~~	

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

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MO #	Perform some action	On some element	On some attribute	At some place	From the current level	To the target level	Comments
9.3 (37)	Increase	Camping beaches	Size	Mainstem	Information Need From Kaplinski et al. in prep.	800 m^2 (Stewart et al. 2000)	Target level should be within the capacity of t he CRE to absorb visitor impacts. Target level should consider GLCA and GRCA Management Plans. ~~See Myers et al.(25).~~ 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 ~~21 +/- 5 beaches per critical reach above 10,000 cfs capable of accommodating 16-36 people (after Kearsley et al. 1999)~~	Minimum 21 +/- 5 beaches per critical reach above maximum ROD flows (25,000 cfs) capable of accommodating 16-36 people. ~~(after Kearsley et al. 1999)~~ 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.)	

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MO #	Perform some action	On some element	On some attribute	At some place	From the current level	To the target level	Comments
9.4 (38)	Improve	Rapids	Navigability	Mainstem	Information Need	Information Need See incident rates/flow level during the late 1980s and Interim Flow period. ~~Also use Haberline study for a reference.~~	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. 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 (39)	Maintain or enhance	Experience	Wilderness	Grand Canyon	Information Need	Information Need See GRCA data on use levels and distribution.	See Bishop, et al. (1986) for flow-related wilderness. Metric to include parameters for primitive character, unconfined experience, undeveloped natural and wild character, opportunities for solitude, sounds of nature and scenic beauty. Target level should consider GRCA Management Plans (in progress). ~~The NPS is probably responsible for monitoring this MO.~~

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

NOTE FOR GOAL 10: The phrase, "within the framework of GCDAMP ecosystem goals," is intended to indicate a hierarchy or order of precedence. That is, the accomplishment of this goal should be undertaken in such a way that the likelihood of achieving the biological goals, the recreational goals, and the cultural goal is not impaired.

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.	
~~10.1 (40)~~	~~Maintain or increase~~	~~Power~~	~~Generation flexibility~~	~~GCD~~	~~ROD and current operating practices~~ (33)	~~Information Need~~	

~~Target is to maintain current practices, as constrained by the ROD, for~~
~~? marketable capacity and energy,~~
~~? existing emergency criteria for the WAPA and WSCC systems, and~~
~~? regulation for WALC and WACM;~~

~~and to determine feasibility and advisability for~~
~~? financial exception criteria for the WAPA system, and~~
~~? regulation for other systems.~~

~~.~~

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 (41)	Preserve	Register-eligible properties	National Register integrity	Area of Potential Effect	Information Need (at least 264 properties)	100% of ~~extant historic~~Register-eligible properties	~~Target level should consider recreational impacts. See USBR[32] and Leap et al.[19]~~ Target is to preserve register-eligible properties via protection, management, and/or treatment (data recovery) for the purpose of federal agency compliance with NHPA, and AMP and AMWG compliance with GCPA.
11.2 (42)	Preserve	~~Other cultural~~ Traditionally important resources	Resource integrity~~Cultural values~~	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	~~Target level should consider recreational impacts.~~ Target is to preserve (stabilize or improve 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.

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
11.34 (44)	Protect and maintain	Traditional cultural resources	Physical access	CRE	Information Need	Information Need	See USBR[34] The target is designed to prevent ~~AMWG~~ the AMP from undertaking events that might restrict or block physical access by Native American religious practitioners, without meaningful consultation. 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 (46)	Maintain or attain	Socio-economic data	Hydropower	N/A	EIS~~Information Need~~	Information Need	~~The current level is how much socioeconomic data we have on the attributes~~. The target level is how much socioeconomic data is needed for adequate decision-making.
			Air quality	N/A	EIS~~Information Need~~	Information Need	
			Wilderness	N/A	EIS~~Information Need~~	Information Need	
			Recreation	N/A	EIS and Stewart (1999) ~~Information Need~~	Information Need	
			Non-use values	N/A	~~Information Need~~ Non-use study accompanying the EIS.	Information Need	
			Tribal & spiritual values	N/A	EIS~~Information Need~~	Information Need	
12~~1~~.2~~5~~ (45)	Integrate and synthesize	Cultural and environmental data ~~Information~~	Interdisciplinary information ~~Cultural and other resources~~	CRE	Not readily available and not completely synthesized or integrated~~Synthesis report~~ (30)	Readily accessible by georeferencing using GIS, databases, etc. ~~Information Need~~	Target is to ensure that data is able to be used both for increased understanding of the past and for ongoing interactions of humans within the CRE.
12.3~~2~~ (47)	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 a plan that has been completed, agreed to by the TWG and AMWG, and reviewed by the SAB, and that will subsequently be reviewed on a periodic basis.~~Current and target levels should include a planning document and an outside peer review document.~~

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.~~43~~ (48)	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~~Information Need~~	Updated AMP Strategic Plan ~~that describes the processes for science-based collaborative resources management.~~	The target is a Strategic Plan that describes the processes for science-based collaborative resources management.
			Participation		~~See meeting records.~~ For calendar year 2000: 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.	100% attendance by all representatives at AMWG and TWG meetings plus active participation in Ad Hoc Committees.	
12~~1~~.5~~3~~ (43)	Attain and maintain	AMP ~~resource monitoring and management actions~~	Effective ~~government-to-government~~ consultation* (i.e., inclusion of tribal values and perspectives into the AMP)	CRE	~~Existing level:~~ Current participation at TWG, AMWG, and PA meetings ~~$75,000 appropriated and $400,000 power revenues.~~	Effective dialogue between tribes and AMWG members on all AMP actions ~~100% of AMP actions~~	See USBR[32] 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.

*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 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.

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
12.64 (49)	Attain and maintain	Management activities, research, and long-term monitoring activities ~~Funding~~	Tribal participation*	AMP	Information Need ~~$75,000 (Appropriated) $400,000 (Power revenues)~~	Information need	The target is a set of activities consistent with the attached definition of tribal participation* that 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.~~level of funding adequate to meet each tribe's needs to participate in the Adaptive Management Program.~~ Linkage: Vision/Mission statement, particularly the mention of federal trust responsibilities.

* Definition of 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 activities, and tribally relevant data analysis and information sharing.

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~~5 (50)	Conduct	Experimental flows	Flow dynamics	Mainstem	1996 BHBF 1997 HMF 2000 LSSF test ~~Information Need~~	Information Need To be proposed by the Experimental Flows Ad hoc Group.	See GCMRC,[6] Webb et al.[37] and Topping et al.[31] 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.
12.~~8~~6 (51)	Conduct	Management experiments	Other management actions	CRE	Check dams Translocation of KAS ~~Information Need~~	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.	Target level is the experiments needed to gain critical understanding of ecosystem function under different management alternatives outside of dam operations.
12.~~9~~7 (52)	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 ~~target~~ 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~~8~~ (53)	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~~9~~ (54)	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.

Glossary

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 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).

BIOTIC COMMUNITY
A biotic community is a "group of organisms … that co-occur in the same habitat or area and interact through trophic and spatial relationships…."[20]

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).

CONCEPTUAL MODEL
A conceptual model is an "assessment of the dynamics of the more important compartments and fluxes of material or energy in a system [*i.e.*, patterns and processes], or of changes in a population."[20] A conceptual model is a heuristic tool to provide a framework for thinking about how an ecosystem functions and to discover gaps in our knowledge.

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.

CULTURALLY IMPORTANT SPECIES

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 GOALS

ECOSYSTEM INTEGRITY
Ecosystem integrity is "the ability to support and maintain a balanced, integrated, adaptive biological system having the full range of elements (genes, species, and assemblages) and processes (mutation, demography, biotic interactions, nutrient and energy dynamics, and metapopulation processes) expected in the natural habitat of a region."[13] Ecosystem integrity is related to ecosystem resilience (*i.e.*, the capacity to maintain characteristic patterns and processes) following a disturbance.

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, 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).

ELECTRICAL ENERGY
Electrical energy is the generation or use of electrical power over a period, usually expressed in megawatt-hours (MWh), kilowatt-hours (kWh), or gigawatt-hours (GWh).

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 river otter and razorback sucker.

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).

LEGAL FLEXIBILITY
Legal flexibility is that which is allowed by the statutes, judicial decrees, compacts, and treaties controlling operation of the dam.

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 prior to 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.

NATURALIZED SPECIES
A naturalized species is a non-native species that has become established in an area. See examples in the CRE listed under non-native species.

NON-NATIVE SPECIES
A non-native species is one that did not occur in an area prior to 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 camelthorn.

NON-USER GROUPS

OPERATIONAL FLEXIBILITY
Operational flexibility is the physical capability of the dam to release water.

PHYSICAL ACCESS

QUALITATIVE TARGET
An articulation of the purpose of one or more Management Objectives, in order to give a description in words of what the numerical target levels are intended 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).

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

RIVERINE ECOSYSTEM
The riverine ecosystem is any area typically inundated by the river.

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

USER GROUPS

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
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
KAS	Kanab ambersnail
LCR	Little Colorado River
MA	management action
MO	management objective
Ne	effective population size
NHPA	National Historic Properties Act
NHWZ	new high water zone
NPS	National Park Service
OHWZ	old high water zone
popn	population
PVA	population viability analysis
RBT	Rainbow trout
Register	National Historic Register
RNV	range of natural variability
ROD	record of decision
RPA	reasonable and prudent alternative
SWWF	Southwestern willow flycatcher
TBD	to be determined
WACM	Western Area - Colorado and Missouri
WALC	Western Area - Lower Colorado
WAPA	Western Area Power Administration, Department of Energy
Wr	mean annual relative weight
WSCC	Western Systems Coordinating Council

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