MANAGEMENT OBJECTIVES

Clarifications:

- The Resource Goal may be a pre-dam goal, but we are working within the constraints imposed by the Preferred Alternative and the ROD.
- Objectives will look at capabilities of post-dam resource constraints. Objectives are goals.
- Protocol: In the Appendix where Dave Garrett lists all of the objectives, information needs and management actions in the Annual Plan, we will specify all the information needs that were completed that year, citing the appropriate report.
- RFP information needs to be specifically reflective of these objectives and information needs.
- Section 1205: ...to determine the effects of Glen Canyon Dam and other measures taken by the Secretary pursuant to this title on downstream resources...

Definitions:

- The "Colorado River ecosystem" is defined as: "The Colorado River mainstem corridor and interacting resources in associated riparian and terrace zones, located primarily from the forebay of Glen Canyon Dam (GCD) to the western boundary of Grand Canyon National Park, a distance of approximately 293 river miles." *(GCMRC FY99 Annual Monitoring and Research Plan, Final Draft dated 12/15/98)* AMWG needs to accept a definition that includes Lake Powell study area.
  -replace "Colorado riverine corridor" with "Colorado River ecosystem" where it appears in the MO document
- "LCR": GCMRC cannot go up any tributaries except the LCR 13 miles (with funds from the AMP) just below the Blue Springs area. (There are biological issues in the area of the estuary at the mouth of Pete's Creek but only in less than 300 yards there.)
- "Current" encompasses seasonality too.
- "Dam Operations" is defined as:
  (AMWG must define this for us at its next meeting.) As defined in the Environmental Impact Statement? Relate to daily. These MO's relate to monthly and yearly operations.

DRAFT

GLEN CANYON DAM MANAGEMENT OBJECTIVES

March 27, 1998

PURPOSE

The purpose for developing Management Objectives is to define measurable standards of desired future resource conditions which will serve as objectives to be achieved by all stakeholders in the Glen Canyon Dam Adaptive Management process. These Management Objectives are framed within the Preferred Alternative and implemented by specific dam operating criteria and other actions taken by the Secretary to protect, mitigate adverse impacts to, and improve the values for which the Glen Canyon National Recreation Area and Grand Canyon National Park were established.

Information Needs define the specific scientific understanding required to obtain specified Management Objectives.

Management Objectives and Information Needs specified by stakeholders are the basis for development and implementation of annual monitoring and research programs. Research plans are developed annually and must address specified Adaptive Management Work Group (AMWG) Information Needs.

BACKGROUND

The Glen Canyon Dam Final Environmental Impact Statement states that an Adaptive Management Program (AMP) will be initiated following the issuance of a Record of Decision by the Secretary of the Interior. The concept of adaptive management is based on the recognized need for operational flexibility to respond to future monitoring and research findings and varying resource conditions. The AMP will monitor the effect of the operating criteria adopted by the Secretary as a result of the Environmental Impact Statement process and determine if the anticipated results (Management Objectives) in the Preferred Alternative of the Environmental Impact Statement and the Record of Decision are being reached. If it is found that the objectives are not being reached, the AMP will develop proposals for modifications to the Glen Canyon Dam Operations and/or the exercise of other authorities under existing laws to achieve the anticipated results (Management Objectives).

Principals which guided the design of the AMP include:

- Monitoring and research programs should be designed by qualified researchers in direct response to objectives and information needs of the AMWG.

- A process is required to coordinate and communicate AMWG information needs to researchers and to develop recommendations for decision making.

The Adaptive Management Work Group recognized the desirability of beginning the process of clarifying and consolidating the management objectives of organizations that participate in the AMP in order to clearly identify management needs to researchers. Initiating this process facilitates and expedites monitoring and research designs.

PROCESS

The procedure selected for development and approval of (Stakeholder) Management Objectives and Information Needs is as follows:

Defining Goals, Objectives and Information Needs. Defining terms were developed by Stakeholders as a guide to articulation of Goals, Objectives, Information Needs and Management Actions as follows:

TERM	DESCRIPTORS
Goals	- Directional Statement - Qualitative - Rarely Attained - Generic
Objectives	- Defines desired Future Resource Condition - Quantifiable - Has Target Dates - Has Timelines - Concise - Within Legal Boundaries
Information Needs	- Uses Information Collection Process - Results in Product, Outcome, Report, Model, Data - Incorporates Data Collection, Analysis, Synthesis, etc. - Accomplishment associated with Management Objective
Management Actions	- A Management Activity - Has Timeline - Has Target Date - Concise - Within Legal Boundary

Development of Objectives, Information Needs and Management Actions. The Management Objectives are initially designed to be in accord with the Environmental Impact Statement: these objectives do not define the ideal desired future resource condition. Rather, they describe, clarify and detail the resource impacts described in the EIS for the preferred alternative. Under the operating criteria signed by the Secretary, the GCMRC will monitor the resources and periodically inform the TWG and AMWG regarding the condition of the resources. If the operation of Glen Canyon Dam under the criteria fail to meet these objectives the AMWG will either recommend operational changes to the Secretary or modify the management objectives.

(Delete this paragraph now?) Initial development of Objectives, Information Needs and Management Actions can and usually does occur by individual stakeholders. However, discussion and agreement on Management Objectives, Information Needs, and Management Actions to be included in the Adaptive Management Program must occur in an open forum of the Technical Work Group (TWG). Final approval of Management Objectives, Information Needs and Management Actions to be used in developing Grand Canyon Monitoring and Research Center (GCMRC) monitoring and research plans is by the Adaptive Management Work Group (AMWG).

The following draft Management Objectives, Information Needs and Management Actions are still in development and will not be approved by the AMWG until July, 1998. They are being designed to guide GCMRC program planning through the period FY1999-2003.

The GCMRC and TWG will report annually on progress related to individual Management Objectives, Information Needs, and Management Actions, and will revise Information Needs and Management Actions as needed.

ECOSYSTEM ASSESSMENTS

MO 1: Conceptual models will be developed to represent the Adaptive Management Program area. These conceptual models will be used to: (1) guide monitoring and research planning, (2) more clearly define critical attributes and linkages within and between resource categories, (3) promote improved understanding of key factors that derive changes in the systems, (4) make qualitative assessments of resource change resulting from alternative dam operations, and (5) provide information to stakeholders and managers regarding the potential impacts of alternative dam operations on Lake Powell and the Colorado River ecosystem and associated resources. Completion of these conceptual models in FY99 will provide important tools for organizing the GCMRC's understanding of the Lake Powell and Colorado River ecosystems and the effects of dam operations.

BIOLOGICAL RESOURCES

A. AQUATIC RESOURCES

Goal: To protect and enhance native fish populations in Glen and Grand Canyons, as well as recreationally-important cold water sportfish populations in Glen Canyon, and the aquatic foodbase upon which they depend.

Definition: Aquatic resources include invertebrates, algae, macrophytes, and fish, with specific concerns for Threatened and Endangered Species. Of specific concern are plant and animal matter contributing to the primary food base.

MANAGEMENT OBJECTIVES, STAKEHOLDER INFORMATION NEEDS, MANAGEMENT ACTIONS

A.1 - Aquatic Food Base

MO 1: Maintain and enhance the aquatic food base in the Colorado River ecosystem to support desired populations of native and non-native fish. At a minimum, maintain continuously inundated areas for *Cladophora* and aquatic invertebrates at or above 5,000 cfs discharge levels from Glen Canyon Dam.

SIN 1.1.

RSIN 1.1 Determine status and trends in species composition and population structure of ecologically important food web organisms originating from aquatic and riparian sources and the influence of ecologically significant processes.

SIN 1.2. Define food base character, structure and requirements for maintaining target populations

SIN 1.3. Determine system changes to maintain/enhance food base

SIN 1.4. Define impacts of alternative operating criteria on the Colorado River ecosystem aquatic food base

SIN 1.5. Determine the species composition and the distribution of aquatic algae and macrophytes in the Colorado River ecosystem

SIN 1.6. Determine the species composition and density of macroinvertebrates in the Colorado River ecosystem

NSIN 1.7 Identify and characterize the available aquatic habitat of the Colorado River and significant tributaries, such as the LCR (riffle, run, pool, backwater, etc.)

NSIN 1.8 Develop a comprehensive aquatic habitat map (with GIS) for the river corridor at various water levels.

NSIN 1.9 Quantify and evaluate changes in river habitat caused by dam operations over time

NSIN 1.10 Determine the effect of sediment exposure time on benthic community mortality

NSIN 1.11 Effects of sediment removal and transport on hyporheic communities

NSIN 1.12 Effects of selenium on benthic/hyporheic communities

A.2 - Trout

MQ 2: In the Colorado River downstream of Glen Canyon Dam to the confluence of the Paria river, sufficient ecological conditions (such as habitat, foodbase and temperature) should be maintained, which in conjunction with management by Arizona Game and Fish will produce a healthy self-sustaining population of at least 100,000 Age II+ rainbow trout that achieve 18 inches in length by Age III with a mean annual relative weight (Wr) of at least 0.90.

SIN 2.1. Determine ecosystem requirements, population character and structure to maintain reproduced populations of Age II plus fish at 100,000 population levels in Glen Canyon

SIN 2.2. Determine changes in rainbow trout population size, character and structure in Glen Canyon

SIN 2.3. Evaluate harvested and field sampled rainbow trout to determine the contribution of naturally reproduced fish to the population in Glen Canyon

SIN 2.4. Determine the availability and quality of spawning substrates in the Glen Canyon reach, necessary to sustain the rainbow trout fishery

SIN 2.5. Determine the growth and condition of rainbow trout in Glen Canyon

SIN 2.6. Define criteria for sustaining a healthy rainbow trout population in Glen Canyon, RSIN: determine the impact of current levels of selenium on trout biology and ecology

A.3 - Native Fish:[1]

MO 3: Enhance the Little Colorado River population of humpback chub above 1987 levels determined by April/May hoop-net monitoring in the lower 1,200 meters of the Little Colorado River. (Focused at fish >200mm, and should include a fish health assessment.)

MO 4: Maintain levels of recruitment of humpback chub in the mainstem and Little Colorado River, as indexed by size frequency distributions and presence and strength of year-classes. (Focused at young-of-year and juvenile fish, and should include a fish health assessment.)

(3/4 relates to both MO's #3 & #4)

SIN 3/4.1. Determine adult humpback chub populations and evaluate population health and reproductive success

SIN 3/4.2. Determine levels of recruitment of humpback chub in the mainstem and the LCR

SIN3/4. 3. Determine quantity and quality of backwater and near shore habitat in mainstem

SIN 3/4.4. Determine and identify surrogate native or non-native fishes for evaluation of health factors for humpback chub

SIN 3/4.5. Develop a habitat suitability and availability index, which may include backwaters and near shore habitat, using existing data for humpback chub

SIN 3/4.6. Evaluate impacts of sampling methods and recreation use on humpback chub populations

[1] Note that Critical Habitat has been designated in GC for both razorback sucker and humpback chub. As Critical Habitat for razorback sucker, GC may have a role in recovery as a reintroduction site. Such actions would need to be guided by the recovery plan (now in prep) or regional implementation plans.

MO 5: Protect humpback chub spawning population and habitat in the Little Colorado River (RPA 2).

MA 5.1. Develop a management plan for the Little Colorado River. (RPA 2).

MO 6: Evaluate through monitoring and research the effectiveness of the Reasonable and Prudent Alternative specified by the Fish and Wildlife Service to remove jeopardy for the Humpback Chub in the Colorado River ecosystem as follows (RPA 1.A):

MA 6.1 Evaluate and implement, as appropriate, a selective withdrawal program for Lake Powell waters (RPA 1.B).

SIN 6.1. Determine a set of possible temperature changes in the mainstem Colorado River resulting from implementing selective withdrawal (RPA 1.B.i).

SIN 6.2. Determine the anticipated effects on native populations which may result from implementation of temperature changes from a selective withdrawal structure. Determine the range of temperatures for successful larval fish development and recruitment and the relationship between larval/juvenile growth and temperature (RPA 1.B.ii).

SIN 6.3. Assess the temperature induced interactions between native and non-native fish competitors and predators. Assess the effects of temperature, including seasonality and degree, on *Cladophora* and associated diatoms, *Gammarus,* aquatic insects, and fish parasites and disease (RPA 1.B.iii and 1.B.iv).

SIN 6.4. Evaluate effects of withdrawing water on the heat budget of Lake Powell, effects of potentially warmer inflow into Lake Mead, and the concomitant effects on the biota within both reservoirs. Evaluate the temperature profiles along with heat budget for both reservoirs Evaluate effects of reservoir withdrawal level on fine particulate organic matter and important plant nutrients to understand the relationship between withdrawal level and reservoir and downstream resources (RPA 1.B.v and 1.B.vi).

SIN 6.5. Evaluate when to release warmer temperature water, what seasonal pattern of releases to use to avoid establishment of permanent backwater areas, and how best to use floods, to limit expansion or invasion of non-native fish species. (RPA 1B)

SIN 6.6. Determine the effects of water temperature on reproductive success, growth, and survivorship of Grand Canyon fishes (RPA 1.C.i).

SIN 6.7. Determine origins of fish food resources, energy pathways, and nutrient sources important to their production, and the effects of Glen Canyon Dam operations on these resources (RPA 1.C.vi).

SIN 6.8. Determine the effects of dam operations, including modifications to regulate water temperatures, on the parasites and disease organisms of endangered and native fishes in Grand Canyon. using various flow and temperature scenarios to determine cause and effect relationships between dam operations and responses of the community of endangered and native fishes endemic to the Grand Canyon (RPA 1.C.vii).

MO 7: Establish a second spawning aggregation of humpback chub downstream of Glen Canyon Dam (RPA 4).

SIN 7.1. Develop criteria for self sustaining populations of humpback chub

SIN 7.2. Assess feasibility of second population including other current aggregations

MO 8: Evaluate through monitoring and research the effectiveness of the Reasonable and Prudent Alternative specified by the Fish and Wildlife Service to remove jeopardy for the Razorback Sucker in the Colorado River ecosystem as follows:

SIN 8.? To be added.

MO 9: Help ensure the continued existence of the razorback sucker.

SIN 9.1 Investigate opportunities to establish razorback suckers in the Grand Canyon, including development of spawning and rearing areas that would function like flooded river bottom lands. (RPA 3)

MO 10: Verify the status of populations of flannelmouth sucker, bluehead sucker, and speckled dace in the mainstem Colorado River and its tributaries, and manage for healthy, self-sustaining populations.

SIN 10.1 Determine population dynamics, distribution, and other life history traits of native fish species.

Comments from Norm Henderson re: Fish (FMS and other natives):

NSIN 1. Establish whether Flannelmouth Suckers/native fish are actually spawning in the mainstem Colorado River within Glen Canyon under current conditions. If spawning occurs, do any eggs hatch or larvae survive? Determine the current and past (before Glen Canyon Dam) importance of mainstem Glen Canyon spawning habitat (in relationship to tributary spawning)

NSIN 2. Determine the origin of adult Flannelmouth Suckers/native fish that are attempting to spawn in the mainstem Colorado River within Glen Canyon? Are the old pre-dam adults? Are the post-dam adults from the tributaries, i.e., Paria River, that find certain mainstem habitat factors preferable? Are they mainstem adults from the Grand Canyon?

NSIN 3. Determine the location of all spawning beds within Glen Canyon (related to flows) and summarize the important characteristics. Determine the relative importance of Glen Canyon habitat in relationship to other mainstem habitat within Grand Canyon and upstream of Lake Powell

NSIN 4. Specifically determine the cause(s) for mainstem spawning failure within Glen Canyon:

a. Eggs not deposited, or if deposited not viable because of low water temperature or fluctuating flows, i.e., drying of spawning beds or removal of eggs by strong currents

b. Fertile eggs deposited and hatch but larvae can't grow because of limited or no nursery habitat for food and shelter (again, due to cold temperatures and fluctuating flows)

c. Eggs laid and hatch and some survive and move downstream to warmer water and return much later to spawn

NSIN 5. Describe the specific role of flow levels and fluctuations on reproduction and survival of eggs, larvae, young-of-year, and adults. Specifically, determine the availability of moderate near-shore habitat that might be used by larvae, young-of-year, or adults

NSIN 6. Describe the relative importance of various tributaries to flannelmouth survival (spawning, recruitment, predation)

NSIN 7. What is the food source in the mainstem now? Is there a sufficient food base for adequate growth and a healthy population in the mainstem? What was historic food source?

NSIN 8. Determine the optimal habitat conditions for flannelmouth sucker reproductions, survival, recruitment, etc., i.e., temperature, flow, food, shelter. What habitat factors in the mainstem attract adult Flannelmouth suckers to spawn? What is the attraction over tributaries, i.e., Paria River?

NSIN 9. Determine the fidelity of Flannelmouth suckers to certain areas and spawning beds

NSIN 10. Determine if possible the current and historic use of Flannelmouth sucker habitat for spawning, foraging, cover, etc., within the Colorado River and Paria Rivers as well as other tributaries

NSIN 11. Develop a Flannelmouth sucker conceptual model for the Colorado River ecosystem, i.e., food, habitat, predation

NSIN 12 What habitat modifications could be made to improve Flannelmouth sucker population levels and overall health, i.e., substrate modification, nursery habitat establishment (warm backwaters), flow modification, etc.

NSIN 13. Assess the influence of non-native fish on native fish species

NSIN 14. Determine the effect of current selenium levels discharged from Glen Canyon Dam on native fish species

MO 11: Verify the status of and manage for healthy, self sustaining populations of flannelmouth sucker in Glen Canyon, based upon the capability of the habitat to support those fishes. (Focused at young-of-year, juvenile, and adults to determine size frequency distributions, densities [via catch rates], and assessment of fish health.)

SIN 10/11.1. Determine historic and current character and structure of species populations

SIN 10/11.2. Determine historic and current ecosystem requirements (habitat, spacing, food source, interdependencies, etc.) of species

SIN 10/11.3. Determine and define impacts of alternative flow regimes on species population character and structure

SIN 10/11.4. Determine requirements to maintain/enhance self-sustaining populations of species

MO 12: Attain riverine conditions that support all life stages of endangered and native fish species.

NSIN 12.0 Design experimental flows and studies to include high steady flows in the spring and low steady flows in the summer and fall during low water years (RPA 1.A). Improve the mean for determining the definition of a "low water year" that would initiate research flows in a given year.

SIN 12.1 Determine humpback chub life history schedule for populations downstream of Glen Canyon Dam (RPA 1.C.v).

SIN 12.2 Develop and implement a program to evaluate effects of factors limiting overwintering survival of young-of-year humpback chubs in the Grand Canyon (Fall 97, RPM 1). The program shall evaluate the implications of high flows, habitat restrictions, predation, reduced sediment loads, and cold water temperatures. (Fall 97 Test Flow T&C 1). This is to include specific hypotheses as follows:

SIN 12.2a test flows do not significantly reduce densities of young-of-year humpback chub; and (Fall 97 Test Flow T&C2)

SIN 12.2b test flows do not significantly affect/alter nearshore habitats used by native fishes (Fall 97 Test Flow T&C 2)

SIN 12.3 Quantify to the extent possible the effects of spring high steady flows and summer and fall low steady flows on endangered and native fish (RPA 1.a).

SIN 12.4 Determine relationships among tributary hydrology, reproductive success of fishes, and the abundance of fishes in mainstem rearing habitats (RPA 1.c.ii).

SIN 12.5 Determine the effects of mainstem hydrology on the number of nearshore rearing habitats, environmental conditions in these habitats, and their successful utilization by fishes (RPA 1.C.iii).

SIN 12.6 Assess biotic interactions between native and non-native fishes, particularly those that occur in nearshore rearing habitats affected by dam operations (RPA 1.C.iv).

SIN 12.7 Determine the effects of future test flows(i.e., 25,000 cfs and greater) from October through February on young-of-year humpback chub recruitment and over-wintering survival.

MA 12.1 Limit future test flows (i.e., 25,000 cfs and greater) from October through February until a program has been designed and implemented to evaluate and assess factors determining young-of-year humpback chub recruitment and over-wintering survival.

MO 13: Maintain sufficient rearing habitat for native fish to complete critical life stages.

SIN 13.? To be added.

MO 14: Maintain sediment-dependent native fish nearshore habitats. (Terms & Conditions 2).

SIN 14.1 Use studies associated with the proposed test flow that include determination of effects on physical habitat used by young fishes, food base, and direct effect on larval, juvenile, and adult native and non-native fishes to develop methods to detect changes in numbers of humpback chub or their habitat. (1996 BHBF HBC RPM 3)

SIN 14.2 Develop a method to determine the number of humpback chubs suspected to be lost during special flows and the relationship of this loss to the Grand Canyon population. (T&C 2)

SIN 14.3 Develop a strategy to sustain notable year classes of humpback chubs that are susceptible to being transported downstream into unfavorable habitats. (T&C 2)

SIN 14.4 Acquire an understanding of the frequency of HBC year classes in the system susceptible to being transported downstream into unfavorable habitats and impact of flows on that year class. (T&C 2)

SIN 14.5 Determine impacts of flows on young humpback chubs during study flows, and develop methods of detecting changes in numbers, to assist in establishing levels of incidental take. (RPM)

SIN 14.6 Develop biological criteria governing the implementation of special flows that will assure that the level of incidental take of HBC is not exceeded. (RPM)

MA 14.1 Conduct BHBFs during periods that avoid concentrations of young-of-year

humpback chub (1996 BHBF, HBC RPM 1)

MA 14.2 A report of the results of the monitoring, including complete and accurate records of all incidental take that occurred during the course of the project, will be submitted to the Service the same date that a draft and final is submitted to Reclamation. Progress reports provided to Reclamation will also be provided to the Service. This report will also describe how the terms and conditions of all reasonable and prudent measures in this incidental take statement were implemented, including any deviations from the test flow and explanation for need to change. (1996 BHBF T&C 2)

SIN 14.7. Using monitoring and research programs evaluate all test flows in RPA and potential impacts to threatened and endangered fisheries

SIN 14.8. Determine the benefits and impacts of installing selective withdrawal for thermal modification in the mainstem of the Colorado River downstream of Glen Canyon Dam

A.4 - Native / Non-Native Fish Interactions

MO 15: Minimize, to the extent possible, competitive and predatory interactions between native and non-native fishes.

SIN 15.1. Define areas and conditions of current and future existing and potential interactions

SIN 15.2. Determine key attributes associated with competitive and predatory interactions

SIN 15.3. Determine methods for minimizing competitive and predatory interactions with or without isolation

SIN 15.4. Determine the species composition, relative abundance, and size class structure of non-native fishes in the Colorado River ecosystem and important tributaries

SIN 15.5. Identify existing and potential sources of interaction (predatory, competitive) between extant non-native fishes and native fishes of the Colorado River ecosystem and important tributaries

SIN 15.6. Evaluate the effects of various flow regimes, including beach/habitat

building flows, habitat maintenance flows, and endangered fish research flows on the distribution and abundance of native and non-native fishes in the Colorado River ecosystem and important tributaries

B. TERRESTRIAL and RIPARIAN RESOURCES

Goal: To maintain a diversity of terrestrial and riparian species, including where possible existing remnants of native communities, associated with ongoing natural evolutionary and ecological processes giving priority to native species (i.e., those occurring not directly because of man).

Definition: Terrestrial and riparian resources include, among other things: vegetation, insects, amphibians, reptiles, avifauna, and mammals. Riparian and terrestrial vegetation includes both native and non-native plant species, and include natural species; balanced successional stages; unique plants and threatened and endangered plants.

MANAGEMENT OBJECTIVES, STAKEHOLDER INFORMATION NEEDS, MANAGEMENT ACTIONS

B.0 - General Terrestrial Resources

MO 16: Protect, restore, and enhance survival of native and special status species (federal, tribal, and state designations). Ensure that the required habitat for these species is preserved.

SIN 16.1. Define and specify ecology of native faunal components, especially threatened and endangered species; including evolutionary and environmental changes, natural range of variation, linkages, interdependencies, and requirements

SIN 16.2. Determine species population to detect departures from natural range of variation

SIN 16.3. Determine changes, declines in special status species and characterize ecosystem changes to benefit species

NSIN 16.4 Identify and characterize riparian wildlife habitat types along the river corridor

NSIN 16.5 Develop a comprehensive wildlife habitat map (using remote sensing and GIS) for the river corridor for high priority species (mammals, amphibians, reptiles, birds)

NSIN 16.6 Evaluate/monitor leopard frog populations within Glen Canyon. Determine

effects of dam operations on these populations (flooding, desiccation, loss of habitat)

NSIN 16.7 Determine feasibility of establishing other populations of leopard frogs within the river corridor

NSIN 16.8 Identify and evaluate other sensitive amphibian and aquatic reptilian species, i.e., red spotted toads, Woodhouses toads, canyon tree frogs

MO 17: Maintain a natural age-class distribution of wildlife species throughout the majority of natural range in Glen and Grand Canyons, emphasizing the need to recruit into breeding age classes.

NSIN 17.0 Identify terrestrial species potentially affected by dam operations and determine effects on distribution, abundance, and population structure.

SIN 17.1. Determine species' natural ranges (pre and post dam)

SIN 17.2. Determine historic age class distribution (pre and post dam)

SIN 17.3. Assess natural range and age class disruption, changes, constraints, probable long-term viability implications to species; assess alternate habitat, ecology associations (specifically age class); and ecosystem associations

SIN 17.4. Determine impacts of alternative operating criteria on ecosystem and ecology requirements of species

MO ??: Manage and maintain aquatic and riparian habitat needed to ensure that viable populations of resident and migratory wildlife continue to exist and flourish.

B.1. - Avifauna

MO 18: Protect, restore, and enhance survival of native and special status avifauna.

SIN 18.1. Evaluate the viability of food chain(s) for native fauna, including the Peregrine Falcon, Southwestern Willow Flycatcher, and other special status species

SIN 18.2. *Determine peregrine falcon breeding sites in Glen Canyon and Grand Canyon (Colorado River 2)

SIN 18.3. *Study peregrine falcon population dynamics and determine their relationship to the changing riparian ecosystem for meeting life stage requirements (Colorado River 3)

SIN 18.4. *Determine eagle habitat utilization and foraging patterns and their relationship to dam operations and perform additional eagle monitoring where deemed feasible (Colorado River 4)

*(*Note: Are these tied to dam operations? GRCA does some of this already.)*

SIN 18.5. Define food chain associations, interdependencies, requirements, etc., for native species population targets.

SIN 18.6. Determine impacts of alternative operating criteria on food chain associations.

B.2 - Kanab Ambersnail

MO 19: Attain the Reasonable and Prudent Alternatives for sustainable populations of Kanab Ambersnail established by the U.S. Fish and Wildlife Service.

SIN 19.1 Determine specific habitat characteristics required by the KAS (T&C 3--p.41)

SIN 19.2 Conduct studies to determine special flow impacts on Kanab ambersnail to assure that the level of incidental take is not exceeded. (I. T. - p.40)

SIN 19.3 Complete a census of the population and characterize the habitat. Once habitat requirements are determined, other potential habitat sites within the Grand Canyon corridor will be surveyed to determine species presence and recovery potential. (Colorado River 5--p.43)

SIN 19.4 Survey KAS habitat before and after any flow greater than 25,000 cfs to determine population and its species response to disturbance and ability to recover (T&C 4, p.42; and RPM)

SIN 19.5 Determine Kanab Ambersnail life history schedule for populations in the Colorado River ecosystem (CRS)

NSIN 16.9 Evaluate and monitor KAS populations within the Colorado River ecosystem. Determine ecological characteristics susceptible to changes in dam operations, i.e., population size, habitat needs, life history

requirements

MA 19.1 Protect the habitat necessary for the survival of the existing population of Kanab ambersnail (Incidental Take--p.40)

MA 19.2 Do not allow high flows, or a controlled flood, to destroy more than 10% of the existing KAS occupied habitat in Grand Canyon. (Incidental Take--p.40)

MA 19.3 Develop agreed upon research protocol and conduct research in such a manner as to minimize disturbance to the KAS population and habitat. (T&C 3--p.41)

MA 19.4 Conduct a thorough investigation into KAS life cycle processes and requirements to determine their relationship to the riparian ecosystem and their susceptibility and response to disturbance. (Colorado River 5--p.43)

MA 19.5 Before another BHBF (45,000 cfs or greater), Reclamation will enter into informal consultation with the U.S. Fish and Wildlife Service and Arizona Game and Fish Department to:

MA 19.5a evaluate the test flow studies (RPM 2, 1996 BHBF);

MA 19.5b evaluate the establishment or discovery of a second population of Kanab ambersnail in Arizona (RPM 2, 1996 BHBF);

MA 19.5c evaluate incidental take (RPM 2, 1996 BHBF).

MA 19.6 Survey Kanab Ambersnail habitat before and after any flow greater than 25,000 cfs to determine the species' response to disturbance and ability to recover. (T&C 4--p.42)

MA 19.7 Continue coordination with the Interagency Kanab Ambersnail Working Group to establish or discover a second population of the Kanab ambersnail in Arizona. (Fall 97 Flow T&C 4)

MA 19.8 Monitoring of the project area and other areas that could be affected by the proposed action shall be done to ascertain take of individuals of the species and/or of its habitat that causes harm, harassment, or death to the species. This monitoring will be accomplished using the following protocol (Needs to be investigated):

MA 19.8.1a "A Draft Proposal to Assess, Mitigate and Monitor the impacts of an Experimental High Flow from Glen Canyon Dam on the Endangered Kanab Ambersnail at Vaseys Paradise, Grand Canyon, Arizona" (Stevens *et al.* 1995b).

MA 19.8.1b In order to more accurately determine elevation of river stage at the range of flow that will be experienced during the test flow, and for use in developing a stage discharge relationship for future flow, the placement of a stage recorder, such as a pressure transducer coupled to a recorder should be deployed, if possible, in the mainstem at an appropriate site near the Kanab ambersnail population. The U.S. Geologic Survey should be contacted regarding the possibility of changing the location of a stage recorder to be used in test flow studies to the Kanab ambersnail site.

MA 19.8.1c SALVAGE PROTOCOL. Kanab ambersnail specimens found dead, or taken as part of research activities, shall be collected and held as specified in the AGFD and NPS permit, with final deposition in a suitable museum collection such as at Northern Arizona University (1996 BHBF KAS T&C 1)

SIN 19.6 Determine changes in populations, health, and character of Ambersnail

MO 20: Ensure the existence of a second population of Kanab Ambersnail in Arizona.

NSIN 20.0 Determine genetic similarities and differences among populations of Kanab ambersnail

SIN 20.1 Investigate the transplant success of vegetation important to the Kanab ambersnail:

SIN 20.1a Investigate success of temporarily removing *Mimulus*, *Nastertium*, or other appropriate vegetation into a temporary holding facility, and replanting. (1996 BHBF CM 5a)

SIN 20.1b Investigate success of temporarily/permanently relocating *Mimulus*, *Nastertium*, or other appropriate vegetation. (1996 BHBF CM 5b)

MA 20.1.1 Minimize future take and support salvage and refugia population(s) of KAS (Fall 97 Test Flow CM 1)

MA 20.1.2 Provide logistical support to the Arizona Game and Fish Department's proposal to establish vegetation for the refugium population of the Kanab ambersnail at the Phoenix Zoo, and subsequent support for the transfer of ambersnails when permit and weather conditions permit. (Fall 97 Flow T&C 2)

B. 4 - Vegetation

MO 21: Encourage dynamic vegetative communities made up of diverse groups of native riparian and upland species (where affected by dam operations) at different stages of succession and at different elevations above the water line.

NSIN 21.0 Determine distribution and abundance of native and non-native riparian vegetation, including federal-, state- and tribal-listed sensitive species, old high water zone, new high water zone, and nearshore marshes

NSIN 21.1 Comprehensively evaluate (identify and quantify) the OHWZ (above 150,000 cfs) and NHWZ (between 45,000 and 150,000 cfs) vegetation types (communities) within the Colorado River ecosystem

a. Develop a comprehensive vegetation map for the Colorado River ecosystem

b. Determine populations dynamics and changes due to dam operations

c. Determine habitat requirements and reproductive biology of principal species

NSIN 21.2 Comprehensively monitor (change in extent or abundance) the OHWZ and NHWZ plant communities. Link monitoring to site specific studies to determine species diversity

NSIN 21.3 Determine the effects of current and proposed dam operations on these communities

NSIN 21.4 Determine the ecology of the principal woody species (reproduction, establishment) within the OHWZ. Quantify the effects of dam operations on this ecology

MO 22: Understand species composition and abundance within riparian and upland communities affected by dam operations.

SIN 22.1 Determine historical natural composition of riparian and upland communities

SIN 22.2 Characterize normal range of variation and ecology of species

SIN 22.3 Determine impacts of operating criteria on the succession processes of natural vegetation communities

SIN 22.4 Evaluate impacts of dam operations on establishment of and impacts from exotic plant species

SIN 22.5 Evaluate impacts to vegetation communities of alternate aspects of operating criteria

MO 23: Emphasize the perpetuation of plant communities and any special status species (federal, tribal, and state designations) to ensure their continued existence within the system.

SIN 23.1 Determine historic and current distributions, range of variation and ecology of T&E and special status species

SIN 23.2 Establish ecosystem requirements of special status species and determine probable impacts of proposed flow regimes

SIN 23.3 Determine population changes in special status species

C. GIS

MO 1: (no Management Objective)

NSIN 1.1 Develop a comprehensive GIS base map for topography, geology and soils for the Colorado River ecosystem.

NSIN 1.2 Develop an integrated data/GIS structure for the storage and retrieval of all GCMRC studies.

CULTURAL RESOURCES

Goal: To preserve cultural resource in situ wherever possible, and develop~~where appropriate~~, knowledge of the resource ~~that can be maintained~~for future generations.

Definition: Cultural resources include prehistoric and historic archaeological sites, structures and properties of interest to all Americans. Of particular importance are traditional cultural properties, sacred sites, collection areas, and other resources that are important to Native Americans in maintaining their cultural heritage, lifeways, and practices. Cultural resources are nonrenewable and irretrievable if lost.

MANAGEMENT OBJECTIVES, STAKEHOLDER INFORMATION NEEDS, MANAGEMENT ACTIONS

MO 1: Conserve *in situ* all the downstream cultural resources and take into account Native American cultural resource concerns in the Colorado River ecosystem.

SIN 1.1 Monitor cultural sites potentially impacted by Glen Canyon Dam operations to determine present condition and rate of change to assess: types of degradation, threats; rates of degradation; define immediacy of threats to resources; protection methodologies; protection, monitoring and research costs

SIN 1.2 Develop data systems to assess variable risk of damage/loss of differing resources/sites from preferred and alternative strategies and operating criteria

SIN 1.3 Characterize all cultural resource sites as to the specific associated management/research needs, i.e.; preservation, stabilization, documentation, etc.; under alternative operating criteria

SIN 1.4 Preservation, stabilization and/or documentation of cultural resources as impacted by sediment resources associated with alternative operating criteria

SIN 1.5 Preservation, stabilization of flood terraces holding cultural resources

SIN 1.6 Evaluate flood terrace stability necessary to maintain cultural resources and terraces at pre-dam conditions

SIN 1.7 Evaluate methodology for correlating recreational sites use and cultural resource impacts.

MO 2: If *in situ* conservation is not possible, design mitigative strategies that integrate the full consideration of the values of all concerned tribes with a scientific approach.

SIN 2.1 Characterize through scientific study and data development all assumed historical and current values, including scientific values, of resources to tribal nations and to general public

SIN 2.2 Develop research designs and costs associated with data recovery

MO 3: Protect, and maintain physical access to and use of traditional cultural properties and other cultural resources, where such access and use may be impacted by dam operations.

RSIN 3.1 Characterize historic and current traditional cultural associations of all sites associated with impacts of dam operating criteria

R-MO 4: Maintain and integrate all appropriate cultural data recovered from monitoring, remedial, and mitigative action and incorporate these data into the evolving research designs and mitigative strategies for understanding the human occupation and use of the Colorado River ecosystem.

NSIN 4.1 Develop evolving research designs and/or other methods including synthesis of existing available data and GIS for understanding human occupation and use.

SOCIO-ECONOMIC
(HYDROPOWER)

Goal: To maximize the value of long term firm power and energy generation within the criteria and operating plans established by the Secretary under Section 1804 of the Grand Canyon Protection Act.

Definition: A product of the Glen Canyon Power plant is electrical generation. The facility contributes significant power to rural electrical associations, public municipalities, irrigation districts and Federal and State facilities in the Southwestern and Rocky Mountain areas of the United States.

MANAGEMENT OBJECTIVES, STAKEHOLDER INFORMATION NEEDS, MANAGEMENT ACTIONS

MO 1: Maximize the value of long-term power and energy generation within the criteria and operating plans established by the Secretary under Section 1804 of the Grand Canyon Protection Act[2].

SIN 1.1 Continue to monitor the amount of revenues collected from the generation of electrical power at the Glen Canyon Power plant.

SIN 1.2 Continue to account for the financial/economic cost of the operational changes at Glen Canyon Dam due to the ROD including rate impacts to CRSP long-term firm electrical customers.

RSIN 1.3 Calculate the financial costs of research flows so that these costs can be declared "non-reimbursable" (as defined by Section 1804 of the Grand Canyon Protection Act)

RSIN 1.4 Monitor any difficulties in operating an integrated electrical system, including regulating a load control area
(Recommendation: Dave Garrett will clarify this with Clayton Palmer)

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[2]The data needed to measure and evaluate power production is already routinely collected by the USBR and WAPA (no data gathering is required of GCMRC).

PHYSICAL

WATER RESOURCES

Goal: To operate Glen Canyon Dam for water flows and water quality consistent with existing law and policy.

Definition: Water resources include all aspects of water quantity and quality. The "Law of the River" guides water releases from Glen Canyon Dam. Although of more recent concern, water quality as it relates to changes over time is of specific concern.

MANAGEMENT OBJECTIVES, STAKEHOLDER INFORMATION NEEDS, MANAGEMENT ACTIONS

MO 1: The Secretary shall Operate Glen Canyon Dam in a manner fully consistent with the Record of Decision and subject to the "Law of the River," including but not limited to the following: Grand Canyon Protection Act of 1992, the Colorado River Compact, the Upper Colorado River Basin Compact, the Water Treaty of 1944 with Mexico, the decree of the Supreme Court in Arizona vs. California, and the provisions of the Colorado River Storage Project Act of 1956, and the Colorado River Basin Project Act of 1968 that govern allocation, appropriation, development, and exportation of the waters of the Colorado River Basin.

SIN 1.1 Annually collect and report Glen Canyon Dam flow release information.

MO 2: Maintain water quality at levels appropriate to support physical, biotic, and human resource needs of various ecosystems downstream of Glen Canyon Dam as mandated by the Grand Canyon Protection Act and incorporated into the Record of Decision.

SIN 2.1 Monitor water quality, composition and temperature and compare to applicable standards.

SIN 2.1a Quantify current selenium levels in water discharged from Glen Canyon Dam. Determine how selenium concentrations are affected by dam operations.

SIN 2.1b Determine/quantify the dynamics of major cations, anions and nitrate/phosphate ratios resulting from dam operations.

SIN 2.2 Evaluate feasibility of short term or long term changes of water temperature through selective withdrawal.

SEDIMENT RESOURCES

Goal: To maintain a range of sediment deposits over the long-term, including an annually flooded bare-sediment (unvegetated) active zone, a less frequently flooded vegetated zone, terraces (within the 45,000 cfs river stage), and backwater channels. Managing sediment resources will be on a reach-scale basis. Should significant and localized adverse impacts occur, site-specific mitigation would be considered.

Definition: Sediment resources include a broad array of material, ranging from suspended fines to coarse gravels. Primary interest relates to both material in suspension, which affects benthic capability, as well as stored sediment in beaches and channel margins, which affects recreation.

MANAGEMENT OBJECTIVES, STAKEHOLDER INFORMATION NEEDS, MANAGEMENT ACTIONS

MO 1: Maintain a long-term balance of river-stored sand to support maintenance flow (in years of low reservoir storage), beach/habitat-building flow (in years of high reservoir storage), and unscheduled flood flows. Maintain system dynamics and disturbance by annually (in years which Lake Powell water storage is low) redistributing sand stored in the river channel and eddies to areas inundated by river flows between 20,000 cfs and maximum power plant capacity.

SIN 1.1 Define historical and current (character and structure) levels of river stored sediment in system and associated flow regimes

SIN 1.2 Define minimal levels of river stored sediments necessary to maintain long term sandbar, backwater, instream sediment deposits

SIN 1.3 Develop procedures to monitor and predict impacts of alternative operating criteria (flow regimes) on river stored sediment, and impacts in select reaches

RSIN 1.4 Measure and model sediment contributions from all contributing sources, including tributary and high terrace sources

SIN 1.5 Evaluate the geology/geomorphology within Glen Canyon to: (1) determine historical changes in size and extent of beaches, sandbars and backwaters, (2) quantify sediment (size class and quantity) input from side channels, (3) understand bed morphology dynamics, (4) evaluate high terrace erosion and contribute to river sediment.

MO 2: As a minimum for each reach, maintain the number and average size (area and thickness) of sandbars and backwaters between the stages associated with flows of 8,000 and 45,000 cfs that existed during the 1990/91 research flows.

SIN 2.1 Characterize sandbar/backwater baselines and character and structure in 1990/91

SIN 2.2 Working with various resource agencies and specialists, select most appropriate flow levels/regimes to determine baseline for comparisons for all resources

SIN 2.3 Monitor future changes in sediment and define balances (channel, banks, bars) and hydraulic processes necessary to maintain 1990/91 sandbar levels

SIN 2.4 Evaluation of flow regime impacts on terrace and cultural resources

SIN 2.5 Evaluate historical sandbar/backwater change, and develop methods for predefining beach and sandbar change under operating criteria

SIN 2.6 Determine implications of dam operating criteria on beach and sandbar and backwater character and structure, including suitability of camping beaches

SIN 1.7 Comprehensively quantify the extent and location of existing sandbars, beaches and backwaters along the Colorado River corridor

SIN 2.8 Assess the effects and use of the spillways on bed morphology in the front of the dam and its effects on power production and biota

MO 3: Periodically increase the average size of sandbars above the 20,000 cfs river stage and number and average size of backwaters to the amounts measured during the high period of 1990/91 or the 1996 test of the beach/habitat-building flow in as many years as reservoir and downstream conditions allow.

SIN 3.1 Define 1996 and 1990/91 backwater ecosystems and associated flow regimes

SIN 3.2 Define historical variation in backwater number and character

SIN 3.3 Define changes between 1990/91 and 1996 in sediment and backwater resources character and structure associated with dam operating criteria

SIN 3.4 Define all linkages, associations, interdependencies, etc., of physical sediment resource and backwater resources to biotic entities

SIN 3.5 Define processes necessary to maintain backwaters at 1990/91 or 1996 levels

MO 4: Maintain system dynamics and disturbance by redistributing sand stored in the river channel and eddies to areas inundated by river flows up to 45,000 cfs in as many years as possible when BHBF hydrologic and resource criteria are met.

SIN 4.1 Define character and structure of all beaches and backwaters in system after 1996 test flows

SIN 4.2 Develop methodologies to define future flow regimes to maximize benefit to sediment and backwater character and structure

SIN 4.3 Develop an assessment of dam operation impacts on range of variation in sediment and other resources within Colorado River ecosystem and the associated processes that created these ranges

Norm Henderson's Comments for Sediment Information Needs:

NSIN 1. Quantify the available sediment in the river channel within the Glen Canyon reach to build beaches within Marble Canyon

NSIN 2. Determine the relative importance of high terrace erosion to beach building within the Glen Canyon reach

NSIN 3. Quantify the sediment inputs within the Glen Canyon reach from unregulated side channels

NSIN 4. Assess the impact of current and anticipated dam operations on the high terraces within Glen Canyon. Define the relative importance of natural erosion of high terraces as compared to that experienced due to current dam operations

NSIN 5. Develop an understanding of bed morphology dynamics within Glen Canyon

NSIN 6. Determine the relative importance of sediment grain size within Glen Canyon compared to downstream reaches

NSIN 7. Summarize the historical changes in river banks and sandbars within the Glen Canyon reach and determine long term changes in size

NSIN 8. Comprehensively quantify the extent and location of existing sandbars and beaches along the river corridor

RECREATION

Goal: To provide quality recreation experiences that do not adversely affect natural or cultural resources within the river corridor.

Definition: Recreation resources include sport fishing, white water rafting, boating, hiking, sightseeing, photography, and hunting.

MANAGEMENT OBJECTIVES, STAKEHOLDER INFORMATION NEEDS, MANAGEMENT ACTIONS

MO 1: Provide quality recreation experiences consistent with other resource objectives.

SIN 1.1 Determine criteria and aspects that are important to or detract from recreational experience

SIN 1.2 Determine the impacts of scientific study on recreational experience

SIN 1.3 Characterize procedures to mitigate those aspects of flows that detract from recreational character of river

SIN 1.4 Determine angler satisfaction, use and harvest

SIN 1.5 Determine potential impacts of increased heavy metals on sport fishing

MA 1.1 Utilize approaches for monitoring and research that are appropriate to maintain or improve the character of the recreational experience as defined in NPS management plans for those areas.

MA 1.2 Ensure water release strategies and communications systems that support and enhance the full range of river recreation experiences allowed under NPS management plans for those areas.

MO 2: Maintain flows and sediment processes that create an adequate quantity, distribution and variety of beaches for camping, as long as such flows are consistent with management of natural recreation and cultural resource values (other natural resource values).

SIN 2.1 Determine adequate beach quantity, quality, character and structure for camping throughout system

SIN 2.2 Evaluate impacts of operating criteria on establishing and maintaining adequate beaches and distribution of other resources, quality, character and structure

SIN 2.3 Develop methodology to evaluate distribution, quantity and quality changes in all campable beaches through time

SIN 2.4 Develop systems models to predict flow regimes for building and maintaining beaches

MO 3: Maintain flows that minimize impacts to navigability by authorized water craft and for boaters, waders, and campers in the riverine corridor.

SIN 3.1 Determine if operating criteria maintains safe and adequate powercraft navigability in Glen Canyon and upper Lake Mead

SIN 3.2 Evaluate effects of operating criteria on recreation safety

SIN 3.3 Determine if operating criteria maintains whitewater raft navigation in Grand Canyon

SIN 3.4 Define ecosystem and other resource impacts of flow regimes required to maintain navigation

SIN 3.5 Develop methodology to evaluate potential conflicts of day rafting and other resources (e.g., bank degradation, sport fishing, bird watching, etc.)

MO 4: Maintain flows and habitat suitable for quality cold water fishery opportunities in Glen Canyon.

SIN 4.1 Determine flow regimes necessary to maintain fish populations of 100,000 adult Trout (age class II plus)

MO 5: Maintain flows and habitat suitable for waterfowl sport hunting and wildlife viewing opportunities in Glen Canyon.

SIN 5.1 Define pattern of waterfowl hunting use and satisfaction and other wildlife use and conflicts to other uses

LAKE POWELL

Goal: To understand impacts of Dam operations and where possible minimize these impacts, consistent with other resource objectives.

Definition: The Lake Powell program includes natural, biological and cultural resources impacted by operation of Glen Canyon Dam.

MANAGEMENT OBJECTIVES, STAKEHOLDER INFORMATION NEEDS, MANAGEMENT ACTIONS

The protocol for Lake Powell Management Objectives and Information Needs are related to Upstream Effects Only. (Downstream effects are included under the specific resource sections.)

Lake Powell Water Quality

MO 1: Prevent unacceptable effects on the water quality (physical, chemical, biological) of Lake Powell due to dam operations and ensure that fully informed AMWG decisions are possible both now and in the future.

Physical/Chemical (Limnology)

SIN 1.1 Determine the effect of current dam operations on reservoir water quality, including but not limited to the following:

a. Determine near-dam hydrogen sulfide levels (and other hazardous chemical constituents) within the hypolimnion occurring under current dam operating criteria.

b. Determine the dynamics of lake stratification and advective flows and their effects on chemical constituents

c. Determine/quantify the dynamics of major cations, anions, and nitrate/phosphate ratios resulting from dam operations

d. Determine the effects of dam operations on the physical/chemical dynamics of Lake Powell side channels and embayments

e. Quantify/model the heat budget for Lake Powell to determine near-term and long-term (monthly/weekly and annual summaries respectively) effects of a selective withdrawal system

f. Determine the effect of current dam operations on reservoir levels of selenium.

Biological

SIN 1.1 Determine the impacts of dam operations and resulting water quality on primary and secondary productivity of Lake Powell, including:

a. algae (phytoplankton, periphyton)
b. Macrophytes
c. zooplankton
d. macroinvertebrates

SIN 1.2 Describe and quantify the effects of elevated levels of selenium on the primary productivity of Lake Powell

Lake Powell Aquatic Ecosystem (Fishery)

Definition:

MO 2: Protect Lake Powell aquatic ecosystem from unacceptable impacts due to dam operations and subsequent effects, including but not limited to: temperature, reservoir surface elevations, elevated selenium levels, advective flow patterns, predator/prey relationships, and fish movements.

SIN 2.1 Determine the effects of water temperature caused by dam operations

SIN 2.2 Determine the effects of fluctuations in the reservoir surface elevations caused by dam operations

SIN 2.3 Determine the effects of elevated selenium levels caused by dam operations

SIN 2.4 Determine the effects of advective flow patterns on Lake Powell aquatic ecosystem caused by dam operations

SIN 2.5 Determine the effects of predator/prey relationships caused by dam operations

SIN 2.6 Determine the effects of fish movements caused by dam operations