BONYTAIL (*Gila elegans*)
RECOVERY GOALS

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RECOVERY GOALS
Amendment and Supplement to the Bonytail Chub Recovery Plan

U.S. Fish and Wildlife Service
Mountain-Prairie Region (6)
Denver, Colorado

Approved: Ralph O. Morgenweck
Regional Director, Region 6, U.S. Fish and Wildlife Service

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DISCLAIMER PAGE

These recovery goals amend and supplement the 1990 Bonytail Chub Recovery Plan. Recovery plans delineate reasonable actions that are believed to be required to recover and/or protect listed species. The U.S. Fish and Wildlife Service publishes these plans, which may be prepared with the assistance of recovery teams, contractors, State agencies, and others. Attainment of the objectives and provision of any necessary funds are subject to priorities, budgetary, and other constraints affecting the parties involved. Recovery plans do not necessarily represent the views nor the official positions or approval of any individuals or agencies involved in the plan formulation, other than the U.S. Fish and Wildlife Service. Recovery plans represent the official position of the U.S. Fish and Wildlife Service **only** after they have been signed by the Regional Director or Director as **approved**. Approved recovery plans are subject to modification as dictated by new findings, changes in species status, and the completion of recovery tasks.

CITATION FOR THESE RECOVERY GOALS

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EXECUTIVE SUMMARY

This document amends and supplements the Bonytail Chub Recovery Plan of 1990. The purpose of this document is to describe site-specific management actions/tasks; provide objective, measurable recovery criteria; and provide an estimate of the time to achieve recovery of the endangered bonytail (*Gila elegans*), according to Section 4(f)(1) of the Endangered Species Act of 1973, as amended. Recovery or conservation programs that include the bonytail will direct research, management, and monitoring activities and determine costs associated with recovery.

Current Species Status: The bonytail is listed as endangered under the Endangered Species Act of 1973, as amended. The species is endemic to the Colorado River Basin of the southwestern United States. Adults attain a maximum size of about 550 mm total length (TL) and 1.1 kg in weight. An unknown, but small number of wild adults exist in Lake Mohave on the mainstem Colorado River of the Lower Colorado River Basin (i.e., downstream of Glen Canyon Dam, Arizona), and there are small numbers of wild individuals in the Green River and upper Colorado River subbasins of the Upper Colorado River Basin.

Habitat Requirements and Limiting Factors: The bonytail was historically common to abundant in warm-water reaches of larger rivers from Mexico to Wyoming. Little is known about the specific habitat requirements of bonytail because the species was extirpated from most of its historic range prior to extensive fishery surveys. The bonytail is considered adapted to mainstem rivers where it has been observed in pools and eddies. Similar to other closely related *Gila* spp., bonytail in rivers probably spawn in spring over rocky substrates; spawning in reservoirs has been observed over rocky shoals and shorelines. It is hypothesized, based on available distribution data, that flooded bottomland habitats are important growth and conditioning areas for bonytail, particularly as nursery habitats for young. Threats to the species include streamflow regulation, habitat modification, competition with and predation by nonnative fish species, hybridization, and pesticides and pollutants.

Recovery Objective: Downlisting and Delisting.

Recovery Criteria: Objective, measurable criteria for recovery of bonytail in the Colorado River Basin are presented for each of two recovery units (i.e., the upper basin, including the Green River and upper Colorado River subbasins; and the lower basin, including the mainstem and its tributaries from Lake Mead downstream to the southerly International Boundary with Mexico) because of different recovery or conservation programs and to address unique threats and site-specific management actions/tasks necessary to minimize or remove those threats. Recovery of the species is considered necessary in both the upper and lower basins because of the present status of populations and existing information on bonytail biology. Self-sustaining populations will need to be established through augmentation. Without viable wild populations, there are many uncertainties associated with recovery of bonytail. The bonytail was listed prior to the 1996 distinct population segment (DPS) policy, and the U.S. Fish and Wildlife Service

(Service) may conduct an evaluation to designate DPSs in a future rule-making process. These recovery goals are based on the best available scientific information, and are structured to attain a balance between reasonably achievable criteria and ensuring the viability of the species beyond delisting. These recovery criteria will need to be reevaluated and revised after self-sustaining populations are established and there is improved understanding of bonytail biology.

Downlisting can occur if, over a 5-year period: (1) genetically and demographically viable, self-sustaining populations are maintained in the Green River subbasin and upper Colorado River subbasin such that — (a) the trend in adult (age 4+; ≥250 mm total length) point estimates for each of the two populations does not decline significantly, and (b) mean estimated recruitment of age-3 (150–249 mm TL) naturally produced fish equals or exceeds mean annual adult mortality for each of the two populations, and (c) each point estimate for each of the two populations exceeds 4,400 adults (4,400 is the estimated minimum viable population [MVP] needed to ensure long-term genetic and demographic viability); and (2) a genetic refuge is maintained in a suitable location (e.g., Lake Mohave, Lake Havasu) in the lower basin recovery unit; and (3) two genetically and demographically viable, self-sustaining populations are maintained in the lower basin recovery unit (e.g., mainstem and/or tributaries) such that — (a) the trend in adult point estimates for each population does not decline significantly, and (b) mean estimated recruitment of age-3 naturally produced fish equals or exceeds mean annual adult mortality for each population, and (c) each point estimate for each population exceeds 4,400 adults; and (4) when certain site-specific management tasks to minimize or remove threats have been identified, developed, and implemented.

Delisting can occur if, over a 3-year period beyond downlisting: (1) genetically and demographically viable, self-sustaining populations are maintained in the Green River subbasin and upper Colorado River subbasin such that — (a) the trend in adult point estimates for each of the two populations does not decline significantly, and (b) mean estimated recruitment of age-3 naturally produced fish equals or exceeds mean annual adult mortality for each of the two populations, and (c) each point estimate for each of the two populations exceeds 4,400 adults; and (2) a genetic refuge is maintained in the lower basin recovery unit; and (3) two genetically and demographically viable, self-sustaining populations are maintained in the lower basin recovery unit such that — (a) the trend in adult point estimates for each population does not decline significantly, and (b) mean estimated recruitment of age-3 naturally produced fish equals or exceeds mean annual adult mortality for each population, and (c) each point estimate for each population exceeds 4,400 adults; and (4) when certain site-specific management tasks to minimize or remove threats have been finalized and implemented, and necessary levels of protection are attained.

Conservation plans will go into effect at delisting to provide for long-term management and protection of the species, and to provide reasonable assurances that recovered bonytail populations will be maintained without the need for relisting. Elements of those plans could include (but are not limited to) provision of flows for maintenance of habitat conditions required for all life stages, regulation and/or control of nonnative fishes, minimization of the risk of hazardous-materials spills, and monitoring of populations and habitats. Signed agreements

among State agencies, Federal agencies, American Indian tribes, and other interested parties must be in place to implement the conservation plans before delisting can occur.

Management Actions Needed:

1. Reestablish populations with hatchery-produced fish.
2. Identify genetic variability of bonytail and maintain a genetic refuge in a suitable location in the lower basin.
3. Provide and legally protect habitat (including flow regimes necessary to restore and maintain required environmental conditions) necessary to provide adequate habitat and sufficient range for all life stages to support recovered populations.
4. Provide passage over barriers within occupied habitat to allow unimpeded movement and, potentially, range expansion.
5. Investigate options for providing appropriate water temperatures in the Gunnison River.
6. Minimize entrainment of subadults and adults at diversion/out-take structures.
7. Investigate habitat requirements for all life stages and provide those habitats.
8. Ensure adequate protection from overutilization.
9. Ensure adequate protection from diseases and parasites.
10. Regulate nonnative fish releases and escapement into the main river, floodplain, and tributaries.
11. Control problematic nonnative fishes as needed.
12. Minimize the risk of increased hybridization among *Gila* spp.
13. Minimize the risk of hazardous-materials spills in critical habitat.
14. Remediate water-quality problems.
15. Provide for the long-term management and protection of populations and their habitats beyond delisting (i.e., conservation plans).

Estimated Time to Achieve Recovery: Wild bonytail are rare. Therefore, use of hatchery fish (progeny of cultured brood stock) will be necessary to establish new populations. Time to achieve recovery of the bonytail cannot be accurately estimated until self-sustaining populations are established through augmentation and habitat enhancement. The rate at which populations become established will depend on survival of stocked fish in the wild, integration of stocked fish with rare wild stocks, reproductive success, and recruitment. Response of the species to ongoing management activities will need to be assessed through monitoring, and strategies for recovery and estimates of time to achieve recovery will be reevaluated periodically. Based on current information and associated uncertainties, it is estimated that self-sustaining populations of bonytail will become established over the next 15 years. During this time, population dynamics and responses to management actions will be evaluated.

For bonytail populations to be self-sustaining, adults must reproduce and recruitment of young fish into the adult population must occur at a rate to maintain the population at a minimum of 4,400 adults. When this occurs, the definition of a "self-sustaining" population is met, and the "clock" starts on the downlisting and delisting process.

Once self-sustaining populations have been established, reliable population estimates, based on a multiple mark-recapture model, are needed for all populations over a 5-year monitoring period for downlisting and over a 3-year monitoring period beyond downlisting in order to achieve delisting. The accuracy and precision of each point estimate will be assessed by the Service in cooperation with the respective recovery or conservation programs, and in consultation with investigators conducting the point estimates and with qualified statisticians and population ecologists. Self-sustaining populations and first reliable point estimates for all populations are expected by 2015. If those estimates are acceptable to the Service and all recovery criteria are met, downlisting could be proposed in 2020 and delisting could be proposed in 2023.

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1.0 INTRODUCTION

1.1 Background

The bonytail *(Gila elegans)* is a large cyprinid fish endemic to the Colorado River Basin (Valdez and Clemmer 1982). Adults attain a maximum size of about 550 mm total length (TL; Bozek et al. 1984) and 1.1 kg in weight (Vanicek 1967). The bonytail is currently listed as "endangered" under the Endangered Species Act of 1973, as amended (ESA; 16 U.S.C. 1531 *et. seq.*), under a final rule published on April 23, 1980 (45 FR 27710). A recovery plan was approved on September 4, 1990 (U.S. Fish and Wildlife Service 1990a). The final rule for determination of critical habitat was published on March 21, 1994 (59 FR 13374), and the final designation became effective on April 20, 1994.

"Bonytail" is the accepted common name for *Gila elegans* (Robins et al. 1991). The synonym "bonytail chub" was used when the species was listed in 1980 and is an often-used common name (Valdez and Clemmer 1982).

The bonytail is a member of a unique assemblage of fishes native to the Colorado River Basin consisting of 35 species with 74% level of endemism (Miller 1959). It is one of four mainstem, big-river fishes currently listed as endangered under the ESA; others are the humpback chub (*Gila cypha*), Colorado pikeminnow (*Ptychocheilus lucius*, formerly Colorado squawfish; Nelson et al. 1998), and razorback sucker (*Xyrauchen texanus*). The native fish assemblage of the Colorado River is jeopardized by large mainstem dams, water diversions, habitat modification, and nonnative fish species, and degraded water quality (Miller 1961; Minckley and Deacon 1991).

1.2 Purpose and Scope

This document amends and supplements the Bonytail Chub Recovery Plan of 1990 (Recovery Plan; U.S. Fish and Wildlife Service 1990a). The purpose and scope are to assimilate current information on the life history of the species and status of populations to develop recovery goals associated with the five listing factors that [as specified under Section 4(f)(1) of the ESA] identify site-specific management actions necessary to minimize or remove threats; establish objective, measurable recovery criteria; and provide estimates of the time and costs required to achieve recovery. In developing the recovery goals, the full body of available information pertinent to issues related to species life history and conservation was considered. However, it is not the intent of this document to provide a comprehensive treatise of infomation on bonytail; a synopsis of the life history that includes a description of habitat requirements is provided in Appendix A. Additional and more detailed information can be found in literature cited in this document and in reports and publications referenced in those citations.

These recovery goals were developed as an amendment and supplement to the Recovery Plan to focus on the requirements of Section 4(f)(1)(B) of the ESA, which requires that the Secretary of the Interior incorporate into each plan site-specific management actions; objective, measurable

criteria; and estimates of the time and costs to carry out those measures needed to achieve the plan's goal and to achieve intermediate steps toward that goal. The Recovery Plan did not contain those key requirements of the ESA; therefore, these recovery goals take precedence over the Recovery Plan. Recovery or conservation programs that include the bonytail (see section 1.3) will direct research, management, and monitoring activities and determine costs associated with recovery. The recovery goals are not intended to include specifics on design of management strategies nor are they intended to prescribe ways that management strategies should be implemented. Those details (and associated costs) need to be developed by the respective recovery or conservation programs in their implementation plans.

An important aspect in development of these recovery goals was to attain a balance between reasonably achievable criteria and ensuring the viability and security of the species beyond delisting. Reasonably achievable criteria considered demographic and genetic requirements of self-sustainability. These recovery goals are intended to be used by the U.S. Fish and Wildlife Service (Service) in rule-making processes to downlist and/or delist the bonytail. The Service intends to review, and revise as needed, these recovery goals at least once every 5 years from the date they are made public through a Notice of Availability published in the *Federal Register*, or as necessary when sufficient new information warrants a change in the recovery criteria. Review of these recovery goals will be part of the review of listed species as required by Section 4(c)(2)(A) of the ESA, *"The Secretary shall ... conduct, at least once every five years, a review of all species..."*.

1.3 Recovery or Conservation Programs

Three of the five major endangered-species recovery or conservation programs of the Colorado River Basin include the bonytail (highlighted in Box 1). These are the Upper Colorado River Endangered Fish Recovery Program (UCRRP), the Native Fish Work Group (NFWG), and the Lower Colorado River Multi-Species Conservation Program (MSCP). The UCRRP is a recovery program that was initiated under a Cooperative Agreement signed by the Secretary of the Interior on January 22, 1988, as a coordinated effort of State and Federal agencies, water users, energy distributors, and environmental groups to recover the four endangered fishes in the upper basin downstream to Glen Canyon Dam, excluding the San Juan River (U.S. Department of the Interior 1987; Wydoski and Hamill 1991; Evans 1993). It functions under the general principles of adaptive management (see section 5.1.2) and consists of seven program elements, including instream flow protection; habitat restoration; reduction of

<u>Box 1. Recovery or Conservation Programs</u>

1. ***Upper Colorado River Endangered Fish Recovery Program (UCRRP)***
2. San Juan River Basin Recovery Implementation Program (SJRRIP)
3. Glen Canyon Dam Adaptive Management Program (GCDAMP)
4. ***Native Fish Work Group (NFWG)***
5. ***Lower Colorado River Multi-Species Conservation Program (MSCP)***

nonnative fish and sportfish impacts; propagation and genetics management; research, monitoring, and data management; information and education; and program management. As stated in the governing document of the UCRRP (U.S. Department of the Interior 1987), the goal is to recover the endangered fishes while water development proceeds in compliance with State and Federal laws, including the ESA, State water law, interstate compacts, and Federal trust responsibilities to American Indian tribes. Funding for the UCRRP will continue through 2011 under legislation passed in October 2000 (P.L. 106-392); Congress will review the UCRRP to determine if funding should be authorized beyond 2011. The NFWG is a conservation program coordinating efforts of State and Federal agency biologists, as well as university staffs and volunteers, to conserve and protect the genetic pool of bonytail and razorback sucker primarily in Lake Mohave (Burke and Mueller 1993).

The MSCP is a conservation program under development that was initiated in response to the designation of critical habitat for the four endangered "big river" fishes in 1994, and the listing of the southwestern willow flycatcher (*Empidonax traillii extimus*) as endangered in 1995 (SAIC/Jones & Stokes 2002). In response, representatives from the U.S. Departments of the Interior and Energy; several American Indian tribes; water, power, and wildlife resource management agencies from the three lower basin States; and a significant number of agricultural, municipal, and industrial providers of Colorado River water and power resources have formed a regional partnership that is developing a multi-species conservation program aimed at protecting sensitive, threatened, and endangered species of fish, wildlife, and their habitat. The partnership has formed a 27-member steering committee, which has been designated by the Service as an Ecosystem Conservation and Recovery Implementation Team under the ESA. The MSCP planning area comprises the historic floodplain of the Colorado River from Lake Mead to the southerly International Boundary with Mexico and areas to elevations up to and including the full pool elevations of Lakes Mead, Mohave, and Havasu (SAIC/Jones & Stokes 2002). The bonytail is one of 56 species proposed for coverage by the MSCP, and it is one of the six focus species.

2.0 THE RECOVERY PROCESS

2.1 Definition of Recovery

Understanding the Service's strategy for recovery of the bonytail, as provided in the ESA and implementing regulations, first requires an understanding of the meaning of "recover" and "conserve". The ESA does not specifically define recover, and the term "recovery" is used with respect to recovery plans *"...for the conservation and survival..."* of listed species. An endangered species, as defined in Section 3(6) of the ESA, means *"any species which is in danger of extinction throughout all or a significant portion of its range."* A threatened species is defined in Section 3(19) of the ESA as *"any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range."* According to Service policy (U.S. Fish and Wildlife Service 1990b), *"Recovery is the process by which the decline of an endangered or threatened species is arrested or reversed, and threats to its survival are neutralized, so that its long-term survival in nature can be ensured. The goal of*

this process is the maintenance of secure, self-sustaining wild populations of species with the minimum necessary investment of resources." The ESA's implementing regulations (50 CFR § 402.02) further define recovery as *"...improvement in the status of listed species to the point at which listing is no longer appropriate under the criteria set out in section 4(a)(1) of the Act."* The policy and regulations use the word recovery in a narrow ESA sense, giving it meaning that is different from returning a species to its normal position or condition.

The definition provided for recovery in the implementing regulations and the definition provided for conserve in the ESA have essentially the same meaning. Section 3(3) of the ESA states: *"The terms "conserve," "conserving," and "conservation" mean to use and the use of all methods and procedures which are necessary to bring any endangered species or threatened species to the point at which the measures provided pursuant to this Act are no longer necessary."* Hence, recovery and conserve both mean to bring a species to the point at which it no longer needs the protection of the ESA, because the species is no longer in danger of extinction throughout all or a significant portion of its range. This definition of recovery falls far short of requiring that a species must be restored to its historic range and abundance before it can be considered recovered or delisted. It also falls short of requiring the restoration of a species to all the remaining suitable habitat, unless this is necessary to sufficiently reduce the species' susceptibility to threats to a level at which the species is no longer threatened or endangered.

The phrase "throughout all or a significant portion of its range" is used in both definitions of endangered and threatened. Neither "significant" nor "range" are defined in the ESA or implementing regulations. Hence, the ESA provides the Service with latitude to use its discretion, based on the best scientific information available, to develop recovery goals and implement recovery plans designed to conserve and recover species. The ESA clearly does not use the term significant in a statistical sense. Significance cannot be reliably and safely applied in any strictly quantitative framework, because of the great variety of organisms, habitats, and threats that must be evaluated for protection under the ESA.

Given that the ESA is intended to avoid species extinction, the Service avoids the pitfalls of a purely quantitative approach by instead viewing significant in the context of a species' long-term survival needs. The term becomes logical, meaningful, and useful if applied in this context. A significant portion of the range is that area that is important or necessary for maintaining a viable, self-sustaining, and evolving population or populations, in order for a taxon to persist into the foreseeable future. That "significant portion" may constitute a large portion of the historic range of a species or a relatively small portion of the historic range. Other parts of a species' range (regardless of whether it is historical, current, or potential range) may not be significant to its long-term survival, regardless of its geographic extent. Therefore, a species extirpated from such areas does not necessarily mean it is threatened or endangered, regardless of the geographic extent of those areas.

Implicit in the ESA definitions of threatened and endangered and in the principles of conservation biology is the need to consider genetics, demographics, population redundancy, and threats (as identified by the listing factors). The ESA is mandated to recover species to the point that they are "not likely" to be in danger of extinction for the foreseeable future throughout all or

a significant portion of their range. The Service believes that the "not likely" standard is exceeded by the requirement of the recovery goals to maintain multiple widespread populations that are independently viable, because it is unlikely that future singular threats will endanger widely separated multiple populations. Viable populations have sufficient numbers of individuals to counter the effects of deleterious gene mutations as a result of inbreeding, and to counter the effects of deaths exceeding births and recruitment failure for periods of time. Thus, the conservation biology principle of redundancy is satisfied by the required multiple genetically and demographically viable, self-sustaining populations (section 3.1.3). Furthermore, the principle of resiliency is satisfied with sufficiently large populations to persist through normal population variations, as well as through unexpected catastrophic events (section 3.1.4).

The principles of recovery and conservation as defined in the ESA, implementing regulations, and Service policy demonstrate the strong relationship between the delisting criteria used for recovery and the five listing factors in Section 4(a)(1) of the ESA. These five listing factors must be addressed in any reclassification of a species [ESA Section 4(c)(2)(B); section 4.0 of this document], and are:

> "*(A) The present or threatened destruction, modification, or curtailment of its habitat or range;*
> *(B) overutilization for commercial, recreational, scientific, or educational purposes;*
> *(C) disease or predation;*
> *(D) the inadequacy of existing regulatory mechanisms; and*
> *(E) other natural or manmade factors affecting its continued existence.*"

Recovery is based on reduction or removal of threats and improvement of the status of a species during the period in which it is listed, and not just from the time a listed species is proposed for reclassification. Environmental conditions and the structure of populations change over time, and threats recognized at listing or in subsequent recovery plans may no longer be directly applicable when reclassification is considered. Management actions and tasks conducted by recovery or conservation programs for listed species are expected to minimize or remove threats and improve the species' status.

When delisting a species, the Service must determine that the five listing factors no longer apply, e.g., the habitat is no longer threatened with destruction or modification, the current abundance and range is adequate, and the habitat needed to sustain recovered populations is present. Therefore, the recovery goals (section 5.0) include management actions and tasks, as well as downlisting and delisting criteria, presented by "recovery factor". These recovery factors were derived from the five listing factors and state the conditions under which threats are minimized or removed.

Recovery is achieved when management actions and associated tasks have been implemented and/or completed to allow genetically and demographically viable, self-sustaining populations to thrive under minimal ongoing management and investment of resources. Achievement of recovery does not mandate returning a species to all or a significant portion of its historic range, nor does it mandate establishing populations in all possible habitats, or everywhere the species

can be established or reestablished. Removing a species from protection of the ESA remands the primary management responsibility of that species to the States, who may choose to further expand its range and populations. The standard of establishing and protecting viable, self-sustaining populations is applied to the recovery of bonytail, and was used in developing recovery goals for the other three endangered fishes of the Colorado River Basin (U.S. Fish and Wildlife Service 2002a, 2002b, 2002c). This approach is consistent with recovery of other vertebrate species, such as the bald eagle (*Haliaeetus leucocephalus*; 64 FR 36453), peregrine falcon (*Falco peregrinus*; 64 FR 46541), desert tortoise (*Gopherus agassizii*; Berry 1999), Pacific salmon (*Oncorhynchus spp.*; Allendorf et al. 1997), and southern sea otter (*Enhydra lutris nereis*; Ralls et al. 1996).

2.2 Recovery Units

Recovery of bonytail in the Colorado River Basin is considered necessary in both the upper and lower basins because of the present status of populations and existing information on bonytail biology. For the purpose of these recovery goals, the upper and lower basins are divided at Glen Canyon Dam, Arizona. Separate objective, measurable recovery criteria were developed for each of two recovery units (i.e., the upper basin, including the Green River and upper Colorado River subbasins; and the lower basin, including the mainstem and its tributaries from Lake Mead downstream to the southerly International Boundary with Mexico) to address unique threats and site-specific management actions necessary to minimize or remove those threats. The recovery units encompass three management areas under different and separate recovery or conservation programs (i.e., UCRRP, NFWG, and MSCP; see section 1.3 for description of geographic coverage by each of the programs). Designation of the recovery units is consistent with goals established by these programs. For example, the governing document for the UCRRP (U.S. Department of the Interior 1987) states: "*Since the recovery plans* [for the Colorado pikeminnow, humpback chub, and bonytail; razorback sucker was not federally listed in 1987, but was included in the UCRRP] *refer to species recovery in both the upper and lower basins, these goals* [recovery/management goals in the original recovery plans] *also apply to both basins, until revised for the upper basin, through implementation of this recovery program. However, the goal of this program for the three endangered species is recovery and delisting in the upper basin. In general, this would be accomplished when the habitat necessary to maintain self-sustaining populations has been determined and provisions are in place to maintain and protect that habitat and these species. The Implementation Committee will be expected to revise these goals for the upper basin as the program develops. Attainment of these goals will result in recovery and delisting of the listed species in the upper basin."* Parties to the UCRRP agreed that the four endangered species could be downlisted and delisted separately in the upper basin. However, the document also states: "*... this program can not, and does not in anyway, diminish or detract from or add to the Secretary's ultimate responsibility for administering the Endangered Species Act."*

The bonytail was listed prior to the 1996 distinct population segment (DPS) policy, and the Service may conduct an evaluation to designate DPSs in a future rule-making process. In the Policy Regarding the Recognition of Distinct Vertebrate Population (61 FR 4721–4725), the

U.S. Fish and Wildlife Service and the National Marine Fisheries Service clarified their interpretation of the phrase *"distinct population segment of any species of vertebrate fish or wildlife"* for the purposes of listing, delisting, and reclassifying species under the ESA. Designation of DPSs is a separate listing process that is different from recovery plans/goals, and is accomplished by a rule-making process. A DPS is a segment of the population and includes a part of the range of a species or subspecies. Like all listings, the DPS is described geographically, but it is important to retain the purpose of the ESA *"...to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved..."*. The elements considered for designation of DPSs are: *"1) Discreteness of the population segment in relation to the remainder of the species to which it belongs; 2) The significance of the population segment to the species to which it belongs; and 3) The population segment's conservation status in relation to the Act's standards for listing (i.e., is the population segment, when treated as if it were a species, endangered or threatened?)."*

Species listed prior to the DPS policy may be reconsidered for DPS designation at the time of reclassification or at the 5-year status review. The DPS policy states: *"Any DPS of a vertebrate taxon that was listed prior to implementation of this policy will be reevaluated on a case-by-case basis as recommendations are made to change the listing status for that distinct population segment. The appropriate application of the policy will also be considered in the 5-year reviews of the status of listed species required by section 4(c)(2) of the Act."* Section 4(c)(2)(A) of the ESA requires a review of listed species *"at least once every five years"*. If DPSs are designated, these recovery criteria will need to be reevaluated.

2.3 Development of Recovery Goals

Development of recovery goals for the bonytail followed a specific process. First, current data on the life history of the species were assimilated (Appendix A; section 3.0). Second, the assimilated data were used to evaluate population viability and self-sustainability (section 3.0). Third, past and existing threats were identified according to the five listing factors (section 4.0). Finally, site-specific management actions were identified to minimize or remove threats, and objective, measurable recovery criteria were developed based on the five factors (section 5.0). The process of developing the recovery goals was interactive and iterative, and the recovery goals are the product of considerable input from stakeholders and scientists from throughout the Colorado River Basin and from rigorous peer review. Input from biologists and managers throughout the basin was received through meetings with the Colorado River Fishes Recovery Team; Biology, Management, and Implementation committees of the UCRRP; Colorado River Fish and Wildlife Council; American Indian tribes; State game and fish agencies; water and power interests; and appropriate Federal agencies. Input was also received through independent reviews of previous drafts (see acknowledgments). Development of these recovery goals paralleled similar efforts by the Colorado Division of Wildlife and benefitted from exchange of information with the principal author (Nesler 2000).

The process of downlisting and delisting described in this document is consistent with provisions specified under Section 4(b), Basis For Determinations, and Section 4(f)(1), Recovery Plans, of

the ESA. Under Section 4(b), the Secretary of the Interior shall determine if a species is endangered or threatened "*...solely on the basis of the best scientific and commercial data available...*". Specifically, under Section 4(f)(1)(B), each recovery plan must incorporate (i) "*a description of such site-specific management actions as may be necessary to achieve the plan's goal for conservation and survival of the species*"; (ii) "*objective, measurable criteria which, when met, would result in a determination, in accordance with the provisions of this section, that the species be removed from the list*"; and (iii) "*estimates of the time required and cost to carry out those measures needed to achieve the plan's goal and to achieve intermediate steps toward that goal.*" Objective, measurable recovery criteria identify downlisting and delisting requirements for each management action, and define viable, self-sustaining populations consisting of target numbers of adults and subadults for wild populations. Under Section 4(c)(2)(B) of the ESA, each determination of reclassification of a species shall be made in accordance with provisions of Sections 4(a) and 4(b).

3.0 POPULATION VIABILITY AND SELF-SUSTAINABILITY

Population viability and self-sustainability are the cornerstones to defining a recovered species. Factors that determine population viability and self-sustainability are demographics (size and age structure of populations), population redundancy (number and distribution of populations), habitat carrying capacity (resource limitations), and genetic considerations (inbreeding and genetic viability). This section discusses the development of genetic and demographic viability standards for achieving the primary objective of the Recovery Plan: "*... to prevent extinction of the bonytail chub.*" "*Once the immediate threat of extinction is removed and essential information regarding factors that limit survival of bonytail chub is obtained, quantitative goals for downlisting and delisting will be addressed...*" Guidelines for population viability and self-sustainability are stated in Box 2 (Franklin 1980; Soulé 1980; Shaffer 1987; Allen et al. 1992).

Box 2. Guidelines for Population Viability and Self-Sustainability

- A viable, self-sustaining population has negligible probability of extinction over a 100- to 200-year period.
- A population should be sufficiently large to survive historically observed environmental variation.
- A population should be sufficiently large to maintain long-term genetic diversity and viability.
- Multiple demographically viable (redundant) populations greatly reduce the probability of extinction if the populations are independent in their susceptibility to catastrophic events.
- A viable, self-sustaining population must have positive recruitment potential sufficient to replace adult mortality near carrying capacity, and on average, exceed adult mortality when the population is below carrying capacity.
- Carrying capacity is not expected to be the same for different populations because physical habitat, water quality, and biological components are likely to vary.

3.1 Demographic Viability

3.1.1 Demographic characteristics, environmental uncertainty, and catastrophic events

Demographic or population viability refers to the persistence of a species over time, as affected by uncertainties in population dynamics. A viable, self-sustaining population has negligible probability of extinction over a 100- to 200-year time frame (Franklin 1980; Soulé 1980). Population viability can be affected by demographic characteristics, environmental uncertainty, and catastrophic events (Shaffer 1987; Allen et al. 1992). Demographic characteristics relate to random changes in birth and death rates, primarily reflecting differences at the population level. Persistence time for a population faced only with demographic variability increases geometrically as the population increases, and only populations with individuals that number in the "10s to 100s" are vulnerable to extinction due simply to demographic variability (Shaffer 1987). Hence, demographic viability is generally considered to be an issue only with severely depleted populations (Goodman 1987; Allen et al. 1992), such as the bonytail. Few wild bonytail remain, and evidence of natural reproduction has not been reported since the late 1960's (Vanicek 1967; Vanicek and Kramer 1969).

Population persistence decreases linearly with environmental uncertainty (Shaffer 1987), which is also a major factor in the decline of the bonytail. Environmental uncertainty results from changes in environmental factors such as variability in food supply; weather; population dynamics of predators, competitors, and parasites; and in the case of riverine fishes, variability in seasonal flow characteristics. Many of these environmental factors may be highly correlated to population demographics, such as reproductive success, survival, and recruitment. Population sizes necessary for persistence under environmental variability reflect the resulting variability in birth and death rates (Allen et al. 1992). Specifically linking environmental variability to birth and death rates is difficult (Ewens et al. 1987), and use of a demographic model for bonytail is limited because of the lack of reliable empirical data on these life-history parameters. Population viability analyses (PVA; Gilpin 1993; Soulé 1987; Shaffer 1987) were considered but not employed because of a lack of conclusive data on state and rate variables for the species.

As an alternative to demographic models, the concept of carrying capacity can be used to approximate population sizes and potential. Populations can be viewed as having some potential with respect to resource limitations or theoretical carrying capacity. The variance (V) in potential growth rate (r), without limitations of carrying capacity, has to be sizably greater than r ($V > 2r$) before the population is susceptible to extinction, otherwise the population tends toward the carrying capacity (Roughgarden 1979). This is difficult to ascertain for the bonytail because historic population sizes are not well known and wild populations do not currently exist.

Catastrophic events are rare incidents that may cause sizable mortality in one or more age groups. A catastrophe is an event that would, with a single act, eliminate one or more ages of bonytail in a reach of river. This may include such factors as dramatic and extensive alteration of riverine habitat, invasion of nonnative fishes as highly successful predators or competitors, or spills of toxic substances. Abundance and distribution of bonytail were greatly reduced by the

1930's as a result of land-use practices, degraded water quality, and nonnative fishes (Dill 1944; Miller 1961). Further reduction and extirpation from many regions of the Colorado River Basin followed construction of mainstem dams. The specific cause or causes are unknown, but it is believed that extirpation of the species is linked to human-caused modifications of environmental conditions critical to specific life-history needs of the species (Valdez and Clemmer 1982). Although bonytail are long-lived fishes (40+ years), persistent reproductive and recruitment failure have depleted and extirpated wild populations. It is unclear if the characteristic chronology of razorback sucker extirpations of 40–50 years following dam construction in lower basin reservoirs (i.e., Mead, Mohave, Havasu; Minckley et al. 1991) is similar for the bonytail; i.e., fish that were produced prior to habitat inundation and fragmentation reached maximum longevity with little or no recruitment to replace adult mortality.

3.1.2 Existing populations of bonytail

Currently no self-sustaining populations of bonytail exist in the wild, and very few individuals have been caught throughout the basin. Captures of wild adult bonytail have occurred in Lakes Powell, Mohave, and Havasu, and in rivers of the Upper Colorado River Basin (Table 1; Figure 1; Appendix A). Of the 34 adult bonytail captured in Lake Mohave between 1976 and 1988 (Minckley et al. 1989), 11 were used as the original brood stock (Hamman 1981, 1982, 1985). Progeny of these fish have been released into several locations in upper and lower basin habitats, with variable survival rates. Approximately 130,000 hatchery-produced F_1 and F_2 fish were released into Lake Mohave between 1981 and 1987 as part of an effort by the Service to prevent extinction and promote eventual recovery of the species. Younger bonytail of adult size and spawning ability have been collected from the reservoir in the 1990's along with the old adults of the founder population. It is unknown whether these younger adults are from the original stockings or a result of natural reproduction. Releases of hatchery-reared adults into riverine reaches in the upper basin have resulted in low survival (Chart and Cranney 1991), with no evidence of reproduction or recruitment. Recent releases into repatriated, predator-free riverside ponds near Parker, Arizona, have produced up to three year classes (Pacey and Marsh 1998; personal communication, C. Minckley, U.S. Fish and Wildlife Service). Since 1977, only 11 wild adults have been reported from the upper basin (Valdez et al. 1994), but no upper basin fish have been transferred to hatchery facilities.

3.1.3 Populations of bonytail as redundant units

Maintaining several populations with relatively independent susceptibility to threats is an important consideration in the long-term viability of a species (Shaffer 1987; Goodman 1987). These redundant populations provide security in case of a catastrophic event or repeated year-class failure. The positive effect of relatively independent populations can be demonstrated by the following examples. Consider that a single population has a probability of extinction from a catastrophic event of 10% in 200 years. If two populations are independent, the probability of both going extinct is 1% (0.1^2). For three populations, the probability reduces to 0.1% (0.1^3). Even with an extinction probability of 25% for one population, the probability of extinction for two and three populations is 6.3% and 1.6%, respectively (Casagrandi and Gatto 1999).

Table 1. Documented captures of wild bonytail from the Colorado River Basin.

Location	Number	Years	Citation
Gunnison River, near Delta, Colorado	1	1889	Jordan (1891)
Green River	5	1889	Jordan (1891)
Grand Canyon	16	1940's	Miller (1944)
Green River, Hideout Canyon, Utah	unknown	1959	Gaufin et al. (1960)
Green River, Dinosaur Natl. Monument, Colorado	2	1962	Banks (1964)
Green River, Dinosaur Natl. Monument, Colorado	67 adults	1964–66	Vanicek and Kramer (1969)
Lower Yampa & Green Rivers, Colorado and Utah	36	1967–1973	Holden and Stalnaker (1975)
Lake Mohave	19 adults	1974–1984	Bozek et al. (1984)
Lake Mohave	34 adults	1976–1988	Minckley et al. (1989)
Lake Powell, Wahweap Bay, Utah	1 adult	1977	Gustaveson et al. (1985)
Lower Yampa River	1 adult	1979	Holden and Crist (1981)
Green River, Coal Creek Rapid, Gray Canyon, Utah	1 adult	1982–1985	Tyus et al. (1982, 1987)
Lake Powell, Wahweap Bay, Utah	1 adult	1985	Personal communication, Randy Radant, Utah Division of Wildlife Resources
Colorado River, Black Rocks, Colorado	1 adult	1984	Kaeding et al. (1986)
Green River, Gray Canyon, Utah	2 adults	1985	Moretti et al. (1989)
Colorado-Green confluence, Utah	1 adult	1986	Valdez and Williams (1993)
Colorado River, Cataract Canyon, Utah	3 adults	1985, 1988	Valdez and Williams (1993)
Lake Mohave	16	1988–1989	U.S. Fish and Wildlife Service (1990a)
Lake Havasu	unknown	circa 1990	U.S. Fish and Wildlife Service (1990a)
Lake Mohave, Tequila Cove	1	2002	Personal communication, C. Minckley, U.S. Fish and Wildlife Service

Figure 1. Recent distribution of wild bonytail in the Colorado River Basin.

An important aspect of recovery for bonytail is the establishment of several viable populations that are independently susceptible to catastrophic events. Maintenance of these populations would constitute sufficient redundancy as protection against threats and catastrophic events. If one population is severely depleted or eliminated by a catastrophe, other viable, self-sustaining populations will provide a source of fish and genetic material for restarting an extirpated population.

3.1.4 Bonytail as a metapopulation

The metapopulation concept is a natural phenomenon that should be considered when evaluating species persistence. A metapopulation is defined as a network of populations or subpopulations that have some degree of intermittent or regular gene flow among geographically separate units occupying habitat patches (Meffe and Carroll 1994). Populations that make up a metapopulation exist along a continuum of connectedness, with no clear break points, from totally isolated units to those that experience regular and high gene flow (Ehrlich and Murphy 1987; Harrison et al. 1988). Connectedness among units of a metapopulation may vary seasonally or annually (U.S. Fish and Wildlife Service 1995), and the best way to identify population units is that they have some ecological and evolutionary significance (Hanski and Gilpin 1997). Under metapopulation dynamics, habitat patches that become unoccupied due to local extirpations may become repopulated by dispersing individuals from other subpopulations. Metapopulations depend on the ability of individuals to disperse and repopulate empty patches in a manner timely enough to ensure that sufficient numbers of patches always contain viable subpopulations. The role of metapopulations in bonytail population dynamics can only be determined after populations become established.

3.2 Carrying Capacity

Carrying capacity is the theoretical size of a population that can be sustained by the existing environment, and is determined by population demographics and resource limitations (i.e., limiting factors), including habitat. Functional carrying capacity is the population at its equilibrium state in the presence of resource limitations, and is determined as the level where births equal deaths, or lambda (λ) is equal to 1.0 (Begon et al. 1990). Potential carrying capacity is the maximum possible population size with resource limitations minimized or removed.

Carrying capacity of newly established populations of bonytail is not expected to be the same for different populations because physical habitat (e.g., river channel, flow, and cover), chemical constituents (water quality), and biological components (e.g., food and predators) are likely to vary among river reaches. Hence, the same or even similar numbers and densities of fish in new populations should not be expected for recovery. Carrying capacity, as a function of recovery, must be considered on its own merits for recovery of each population. Only a few bonytail currently exist in the wild, and carrying capacity cannot be determined at this time; therefore, demographic recovery criteria may need to be modified as populations are established and information on carrying capacity is developed.

3.3 Genetic Viability

Genetic viability describes the pool of genetic diversity adequate to allow a population of animals to survive environmental pressures that may exceed the limits of developmental plasticity (Frankel 1983). Genetically viable populations maintain 90% of the genetic diversity present in the ancestral (pre-disturbance) population for 200 years (Soulé 1980; Soulé and Wilcox 1980; Soulé and Simberloff 1986). Genetic variability consists of within-population genetic diversity and genetic variation found among linked populations or stocks (Meffe 1986; Meffe and Carroll 1994). The risk with bonytail is that numbers of wild individuals are so low that erosion of genetic variability may have already occurred. This loss in genetic variability can result in increased extinction probabilities and lead the population to "extinction vortices" (Gilpin and Soulé 1986). Genetic concepts that were considered are summarized in Box 3.

<u>Box 3. Genetics Concepts and Considerations</u>

- Genetic viability describes the pool of genetic diversity adequate to allow a population of animals to survive environmental pressures that may exceed the limits of developmental plasticity.
- Genetic variability consists of within-population genetic diversity and genetic variation found among linked populations.
- Genetic effective population size (N_e) is the number of individuals contributing genes to the next generation.
- Rate of inbreeding is an index of the amount of genetic exchange among closely related individuals and is of particular importance because it may result in offspring that are sterile or inviable after one to several generations.
- N_e of at least 50 adults avoids inbreeding depression and is necessary for conservation of genetic diversity in the short-term; N_e of 500 is needed to avoid serious long-term genetic drift; N_e of 1,000 provides a conservative estimate beyond which significant additional genetic variation is not expected.
- Minimum viable population (MVP) is defined as a population that is sufficiently abundant and well adapted to its environment for long-term persistence without significant artificial demographic or genetic manipulations.

Historic genetic diversity of the bonytail remains unknown because of the few wild specimens left today and the small amount of material available from historic collections. Genetic analyses have been performed on hatchery-propagated progeny of wild adults from Lake Mohave. Twenty-four F_2 individuals, naturally produced in earthen ponds at Dexter National Fish Hatchery, were examined electrophoretically for soluble gene products of 45 loci (Minckley et al. 1989). Six polymorphic loci were identified, and electromorphic distribution at each locus agreed with Hardy-Weinberg expectations. Although these bonytail had a lower mean level of heterozygosity than arroyo chub (*Gila orcutti*), direct-count heterozygosity for bonytail was comparable to mean values reported for other western North American cyprinids. Minckley et

al. (1989) concluded that allozyme variation expressed by these hatchery-produced bonytail suggested a genetically variable stock suitable for reintroduction into appropriate wild habitats. Similar results were reported by Rosenfeld and Wilkinson (1989), who electrophoretically examined 23 gene loci using tissues from 24 hatchery specimens derived from six females and five males from Lake Mohave. These studies suggest that despite the low numbers of bonytail in the wild, hatchery brood stocks contain sufficient genetic variability for starting new populations in the wild. Recent genetic analysis of the founder population of bonytail from Lake Mohave (N = 10, 3.48–8.48 effective mated pairs; Hedrick et al. 2000) showed that using 30 pairs of existing F1 parents (60 individuals) provides a ratio of effective number of founders in the future broodstock to maximum possible genetic variation of 89.3% to 97.1%. Increasing the number to 150 pairs only slightly increases the effective number of founders with ratios of 97.6% to 99.4%. Inclusion of additional wild individuals into the future broodstock would significantly increase the effective number of founders. For example, one additional wild fish would increase the number of effective founders to 4.5–9.5 effective mated pairs.

3.3.1 Genetic effective population size

One way to judge genetic viability is through consideration of "genetic effective population size" (N_e), which is the number of individuals contributing genes to the next generation (Crow and Kimura 1970; Gilpin and Soulé 1986; Soulé 1987; Allendorf et al. 1997). N_e was derived in order to gauge the number of adults needed in a population to maintain genetic viability. The concept of N_e was defined by Wright (1931) as the size of an ideal population whose genetic composition is influenced by random processes in the same way as the real population. Low heterozygosity is the dynamic result of low N_e, and N_e likely differs by species (Meffe 1986). The concept of N_e was used to determine if wild populations are at risk genetically, but lack of genetic structural characterization with functional relationships for bonytail precludes a specific determination of N_e at this time. In the absence of this information, N_e for bonytail was derived from principles in conservation genetics by using the "50/500 rule" (Franklin 1980). It has been suggested that a minimum genetic effective population size of 50 is required to avoid inbreeding depression (Soulé 1980), and a minimum genetic effective population size of 500 is required to reduce long-term genetic drift (Franklin 1980). Lynch (1996) suggested an N_e of 1,000 as the number of adults beyond which significant additional genetic variation is not expected. An N_e of 500 is commonly used for fishes (Waples 1990; Bartley et al. 1992; Allendorf et al. 1997) and other vertebrate species (Mace and Lande 1991; Ralls et al. 1996). Wild populations afford the long-term genetic variation needed to maintain the species over time. No wild, self-sustaining populations of bonytail exist that provide sorting of alleles to maintain natural genetic variability. Where recovery relies on artificially reared select individuals, it is necessary to start populations with large numbers of individuals to ensure genetic variability. Without wild populations, genetic viability is not assured, therefore, bonytail require an N_e of 1,000, representing the number of adults beyond which significant additional genetic variation is not expected (Lynch 1996). Recent research by fish geneticists support use of the 50/500 rule (Reiman and Allendorf 2001). An important consideration to genetic viability is maintaining natural connectedness and potential for gene flow among populations, regardless of size (Reiman and Dunham 2000).

It is important to note that the number of individuals in a population required to achieve a genetic effective population size may be several times greater than the genetic effective population size (Frankel and Soulé 1981). Sex ratio and proportion of breeding individuals in the population are two important considerations in deriving the number of individuals necessary to support N_e. A 1:1 male to female ratio is used as the effective sex ratio for bonytail based on a consensus decision of biologists (Lentsch et al. 1998). With a 1:1 sex ratio, an N_e of 1,000 adults would consist of 500 males and 500 females. If all adults in a population breed every year and contribute genes to the following generation, some minimum number of adults (N_g) would equal N_e. However, as with most populations, it is believed that not all bonytail spawn every year or contribute genes to the following generation, and hence, N_g is not equal to N_e. It is important to determine a ratio of genetic effective population size (N_e) to minimum population size (N_g), or N_e/N_g.

For various fish species (rainbow trout [*Oncorhynchus mykiss*], chinook salmon *[O. tshawytscha*], white seabass [*Atractoscion nobilis*]), the ratio N_e/N_g varies from 0.013 to 0.90 (Table 2; Bartley et al. 1992; Avise 1994; Hedrick et al. 1995; Allendorf et al. 1997) for an overall average of about 0.30, which is the ratio reported for chinook salmon (McElhany et al. 2000), and other Pacific salmon species (Waples et al. 1990a, 1990b). This overall average ratio for fishes of 0.30 was used to determine the number of adult bonytail needed to support an N_e of 1,000. Mace and Lande (1991) reported that the genetic effective population size is typically 20–50% of the actual population size.

Table 2. Estimates of effective/actual population size (N_e/N_g) ratios for various fish species.

Species	N_e/N_g	Reference
Sea bass (*Atractoscion nobilis*)	0.27–0.40	Bartley et al. (1992)
Coho salmon (*Oncorhynchus kisutch*)	0.24	Simon et al. (1986)
Rainbow trout (*Oncorhynchus mykiss*)	0.90	Bartley et al. (1992)
Chinook salmon (*Oncorhynchus tshawytscha*)	0.013–0.043	Bartley et al. (1992)
Chinook salmon (*Oncorhynchus tshawytscha*)	0.30	McElhany et al. (2000)

Using an N_e of 1,000, a 1:1 sex ratio, and an N_e/N_g ratio of 0.30, an estimated N_g of 3,333 was derived as the estimated number of adult bonytail necessary to maintain a genetic effective population size in the wild. This approach does not imply that established populations should be allowed to decrease to this level; the estimate of 3,333 is used as a gauge to evaluate genetic viability of isolated populations.

A conservative approach for determining N_g was used in order to account for unknowns in genetic diversity of the species. At best, using hatchery stocks with reduced diversity will result in populations with less than the necessary genetic diversity for their environment, similar to a

founder effect (Simberloff and Wilson 1970). It may take several generations following reintroductions for allele shifts to produce a gene pool most suitable to the environment.

3.3.2 Minimum viable population

Genetic effective population size provides a gauge for genetic viability but does not necessarily account for demographic viability. The concept of a minimum viable population (MVP) is defined as a population that is sufficiently abundant and well adapted to its environment for long-term persistence without significant artificial demographic or genetic manipulations (Shaffer 1981; Soulé 1986, 1987; Soulé and Simberloff 1986;). Meffe and Carroll (1994) define an MVP as *"the smallest isolated population size that has a specified percent chance of remaining extant for a specified period of time in the face of foreseeable demographic, genetic, and environmental stochasticities, plus natural catastrophes."* Use of MVP does not mean that populations should be allowed to drop to these levels, but is used to assess their genetic and demographic viability. It must be recognized that some populations of any wild animal species may be below an MVP, as dictated by carrying capacity. It cannot be expected that every population will exceed an MVP; linkages to other populations help to keep smaller populations viable. As stated by Thomas (1990), *"There is no single 'magic' population size that guarantees the persistence of animal populations."* Thomas (1990) also stated that MVPs are rarely lower than a few 100 individuals and often correspond to an actual population count of about 1,000.

A minimum viable population size of 4,400 was derived by adding 30% to the N_g of 3,333 to account for an estimate of the average annual mortality of adult bonytail (3,333 x 1.30 = 4,333 or about 4,400; Box 4). An average annual adult mortality factor was added to buffer against an event that may result in recruitment failure for a year. The concept of adding a mortality factor to a genetically viable population as demographic security is taken from recovery criteria established for the southern sea otter, in which the estimated mortality from exposure to simulated oil spills was added to the estimate of N_g, based on an N_e of 500 (Ralls et al. 1996).

Box 4. Computation of Minimum Viable Population (MVP)

$$N_g = N_e/(N_e/N_g)$$

where: N_e = genetic effective population size, 1,000

N_e/N_g = proportion of adults contributing genes to next generation; ~0.30 for most fish

therefore: $N_g = 1{,}000/0.30$

$N_g = 3{,}333$

hence: MVP = 3,333 x 1.30 = 4,333 (rounded to 4,400)

where: 1.30 compensates for annual adult mortality of 30%

4.0 THREATS TO BONYTAIL BY LISTING FACTOR

The bonytail was designated as an endangered species under a final rule published April 23, 1980 (45 FR 27710–27713). Reasons for decline of the species were identified as *"...the physical and chemical alteration of their habitat and introduction of exotic fishes..."*. The Bonytail Chub Recovery Plan (U.S. Fish and Wildlife Service 1990a) further stated that *"The decline of the bonytail chub has been attributed to stream alteration caused by construction of dams, flow depletion from irrigation and other uses, hybridization with other Gila, and the introduction of nonnative fish species."* Hence, the primary threats to bonytail populations are streamflow regulation and habitat modification (including cold-water dam releases, habitat loss, and blockage of migration corridors); competition with and predation by nonnative fish species; hybridization; and pesticides and pollutants (Box 5). These five threats are associated with the five listing factors (see section 2.1), and a summary of each is presented in the following sections. Site-specific management actions and objective, measurable criteria associated with five recovery factors to minimize or remove threats are provided in section 5.0.

<u>Box 5. Primary Threats To Bonytail</u>

- Streamflow regulation.
- Habitat modification.
- Predation by nonnative fish species.
- Hybridization.
- Pesticides and pollutants.

4.1 Listing Factor (A): The Present or Threatened Destruction, Modification, or Curtailment of Its Habitat or Range

It is believed that bonytail once inhabited the larger rivers of the Colorado River Basin from Wyoming and Colorado to northwestern Mexico. The historic abundance and distribution of the species were never accurately documented, but a precipitous decline occurred in known populations concurrent with extensive habitat alterations. These alterations led to a loss of the contiguous complement of habitats used by the various life history phases of the species. Hence, streamflow regulation and associated habitat modification are identified as primary threats to the bonytail. Regulation of streamflows in the Colorado River Basin is manifested as reservoir inundation of riverine habitats and changes in flow patterns, sediment loads, and water temperatures. For example, streamflow regulation has generally reduced the magnitude of spring peak flows and increased the magnitude of summer–winter base flows. Since 1950, annual peak flows of the Colorado River in historic upper Colorado River habitats have decreased by 29–38% (Van Steeter and Pitlick 1998). Flows of the Green River at Jensen, Utah, have decreased by 13–35% during spring and increased by 10–140% during summer through winter due to regulation by Flaming Gorge Dam (Muth et al. 2000); the largest number of wild bonytail were collected in the early and mid-1960's upstream of Jensen (Vanicek and Kramer 1969; Table 1).

The bonytail was reported in decline following a period of dam construction throughout the Colorado River Basin. Starting with Hoover Dam in 1935, numerous dams were constructed that fragmented and inundated riverine habitat; released cold, clear waters; altered ecological

processes; affected seasonal availability of habitat; and blocked fish passage. Reservoirs formed by these dams were stocked with a variety of nonnative fishes for recreational fisheries, and these fishes preyed upon and competed with the native fishes. In the 1960's, major dams were also constructed in the upper basin, primarily through the Colorado River Storage Project (CRSP) Act, including Flaming Gorge Dam (1962) on the Green River, Navajo Dam (1962) on the San Juan River, the Aspinall Units (1963) on the Gunnison River, and Glen Canyon Dam (1963) on the Colorado River. The decline of the species throughout the basin is attributed largely to extensive habitat loss, modification, and fragmentation, and blocked fish passage associated with dam construction and operations. Following the dams of the CRSP, fewer and smaller dams were constructed on tributaries, including McPhee Dam (1985) on the Dolores River and Taylor Draw Dam (1987) on the White River. Dams have not been constructed within suspected historic habitat of bonytail since 1987, and the threat of dam construction has been minimized considerably. Although bonytail have been reported historically from lower basin reservoirs, such as Lake Mead, Lake Mohave, and Lake Havasu, numbers have declined in these environments because of lack of reproduction and recruitment sufficient to replace old and dying adults. These reservoirs became sinks for bonytail that once inhabited local riverine regions.

Cold-water releases have eliminated most native fishes from river reaches immediately downstream of dams, except for small numbers of flannelmouth sucker (*Catostomus latipinnis*), bluehead sucker *(C. discobolus*), and speckled dace (*Rhinichthys osculus*) that remain in some tailwaters. River temperatures have been modified from seasonal lows of near freezing and highs of nearly 30°C to relatively constant dam releases of about 4–13°C. Depending on dam elevation, time of year, and river volume, river temperatures may not equilibrate with atmospheric temperatures for nearly 400 km downstream (as in the Colorado River below Glen Canyon Dam). These cold releases have caused reproductive failure and slowed growth of the warm-water native fishes. Penstock modifications on Flaming Gorge Dam in 1976 (Holden and Selby 1979; Holden and Crist 1981) allowed for warmed releases down the Green River beginning in 1978. These warmed releases have provided more suitable water temperatures for several species of native fishes in Lodore Canyon (Bestgen and Crist 2000) and may allow for expansion of bonytail when reproduction and recruitment of the species are restored.

Other aspects of habitat alteration throughout the Colorado River Basin may be important for recovery as more is learned about this endangered species. Historically, the Colorado River Basin was a continuous series of habitats, and the only physical barriers to movement were natural rapids and swift turbulent flows, which were probably only seasonal impediments to fish movement. Since 1905, numerous human-made dams have been constructed throughout the Colorado River Basin, fragmenting habitat and blocking migration corridors. In the lower basin, 14 major dams have inundated habitat, altered water quality, restricted fish movement, and otherwise altered habitats through the Colorado, Gila, Salt, and Verde rivers since completion of Hoover Dam in 1935; other dams on the Colorado River include Davis, Parker, Palo Verde Diversion, Imperial, and Laguna. Glen Canyon Dam approximately divides the lower from the upper basin and also is a barrier to fish movement.

Six barriers are identified in the upper basin upstream of Glen Canyon Dam within historic habitat of bonytail (Burdick and Kaeding 1990; Table 3). Four of these barriers are classified as

Table 3. Existing dams and diversion structures within historic bonytail habitat.

River	Structure	Current Status	Access to Suitable Habitat
Upper Colorado River	Grand Valley Diversion	Year-around passage completed in 1998	Passage adds 5 km additional habitat up to Price-Stubb Diversion
Upper Colorado River	Price-Stubb Diversion	Environmental Assessment to remove or modify in progress	Passage would add about 9 km additional habitat up to Government Highline Diversion
Upper Colorado River	Government Highline Diversion	No formal passage proposal	Passage would add 5 km additional habitat
Gunnison River	Redlands Diversion	Fishway installed in 1996; successfully passing fish	Passage adds 50 km additional habitat
Green River	Tusher Wash Diversion	Passage may be difficult at very low flows	Previously occupied habitat both up and downstream
Yampa River	Craig Diversion	Structure modified in 1992; successfully passing fish	Previously occupied habitat downstream

medium or high-head structures that are partial or seasonal barriers to fish movement or that have been modified to allow passage. The Price-Stubb Diversion presently defines the upper-most distribution of stocked bonytail in the upper Colorado River; a second structure, the Government Highline Diversion, is immediately upstream. Passage by these diversions could allow the species to expand its range by about 22 km (Osmundson 1999). The Redlands Fishway on the lower Gunnison River has allowed Colorado pikeminnow, razorback sucker, and other native fishes to regain access to about 40 km of the Gunnison River. A diversion structure on the Yampa River near Craig, Colorado, was recently replaced, in part, to allow unassisted fish passage (Masslich 1993). Modification of these dams and diversions could allow for considerable range expansion and increases in populations. Further, water withdrawn at diversion structures can entrain native fishes and isolate them in canal systems where their survival is potentially low. Diversion structures should be screened (as needed) to minimize or prevent entrainment of at least subadult and adult bonytail.

Maintenance of streamflow is important to the ecological integrity of large western rivers (Tyus 1992; Collier et al. 1996; Poff et al. 1997; Schmidt et al. 1998). Life histories of many aquatic species, especially fish, are often specifically tied to flow magnitude, frequency, and timing, such that disruption of historic flows can jeopardize native species. The importance of flow management to the endangered fishes of the Colorado River is recognized (Tyus 1992; Stanford 1994). Enhancing natural temporal and spatial habitat complexity through flow and temperature management is the basis for benefitting the endangered fishes (Osmundson et al. 2000b).

Flow recommendations have been developed for some river systems in the Upper Colorado River Basin that identify and describe flows with the necessary magnitude, frequency, duration, and timing to benefit the endangered fish species (e.g., Modde and Smith 1995; Osmundson et al. 1995; U.S. Department of the Interior 1995; Holden 1999; Modde et al. 1999; McAda 2000

[under revision]; Muth et al. 2000). These flows were designed to enhance habitat complexity (e.g., suitable spawning areas, inundation of floodplain areas) and to restore and maintain ecological processes (e.g., sediment transport, food production) that are believed to be important to the life history of these endangered fishes. Spring peak flows are important to the dynamic sediment processes that maintain in-channel habitat complexity, and prevent vegetation encroachment and channel narrowing. For example, cobble and gravel deposits used for spawning are relatively permanent features formed at high flows. Lower peak flows in subsequent years result in deposition of fine sediments over cobble and gravel deposits. Peak flows, whose timing coincides with the natural runoff cycle, are needed to ensure that suitable sites, cleansed of fine sediments, are available during the spawning period. Conversely, low and relatively stable base flows in summer, fall, and winter provide stable, warm, and productive nursery habitats for young fish.

Flows necessary to restore and maintain required habitats of the native Colorado River fishes mimic the natural hydrograph and include spring peak flows and summer–winter base flows. Little is known about the specific habitat requirements of bonytail because the species was extirpated from most of its historic range prior to extensive fishery surveys (see Appendix A for details on habitat requirements). The bonytail is considered adapted to mainstem rivers where it has been observed in pools and eddies. Similar to other closely related *Gila* spp., bonytail in rivers probably spawn in spring over rocky substrates; spawning in reservoirs has been observed over rocky shoals and shorelines. It is hypothesized, based on available distribution data, that flooded bottomland habitats, inundated by spring peak flows, are important growth and conditioning areas for bonytail, particularly as nursery habitats for young. Although, little is known about the life history of bonytail, the last reported concentrations of the species in the upper basin occurred in or upstream of alluvial river reaches with significant floodplain habitat. Biologists in the lower basin have successfully introduced bonytail into repatriated riverside habitats (i.e., flooded bottomlands) and obtained a biological response of reproduction and recruitment. Hatchery personnel at Dexter National Fish Hatchery have reported natural reproduction by bonytail in earthen ponds. Appropriating flooded bottomland habitats that are relatively free of predators may provide an opportunity for successful reproduction and recruitment to start new populations in the wild.

Flow recommendations have been developed that specifically consider flow-habitat relationships within historic habitat of bonytail (see section 3.1.2; Table 1) in the upper Colorado River (Osmundson et al. 1995; McAda 2000), Gunnison River (McAda 2000), Yampa River (Modde and Smith 1995; Modde et al. 1999; U.S. Fish and Wildlife Service 2000), and Green River (Muth et al. 2000). These flow recommendations will be evaluated and revised (as necessary) as part of an adaptive-management process, and flow regimes to benefit the endangered fishes will be implemented through multi-party agreements or by other means (see section 4.4).

4.2 Listing Factor (B): Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

Overutilization of bonytail for commercial, recreational, scientific, or educational purposes is not considered a threat to the species, either presently or historically. This factor will be reevaluated and, if necessary, actions to ensure adequate protection will be identified before downlisting and attained before delisting.

Bonytail have no commercial or recreational value and are not sought by commercial fishermen or anglers. Some fish may be incidentally caught when recreational angling for other sympatric species, but the number of native fish harmed or killed is believed to be insignificant based on creel surveys by the Colorado Division of Wildlife (personal communication, T. Nesler, Colorado Division of Wildlife). All angler access points near occupied habitat are posted with signs advising anglers to release any endangered fish unharmed.

Collection of bonytail for scientific or educational purposes is regulated by the Service under Section 10(a) of the ESA. Scientific collecting permits are issued to investigators conducting legitimate scientific research, and "take" permits are issued where a reasonable loss of fish is expected. Permits to collect bonytail for educational purposes are normally not requested but are regulated by the same provisions of the ESA.

4.3 Listing Factor (C): Disease or Predation

4.3.1 Diseases and parasites

Diseases and parasites currently are not considered singly significant in the decline of the bonytail (see section A.12 for expanded discussion of parasites), but these factors will be reevaluated and, if necessary, actions will be identified to minimize adverse effects before downlisting. Adequate protection from deleterious diseases and parasites will be attained before delisting.

4.3.2 Nonnative fishes

A large number of nonnative fishes are found in historic and currently occupied habitat of bonytail. Many of these are considered predators, competitors, and vectors of parasites and diseases (Tyus et al. 1982; Lentsch et al. 1996; Pacey and Marsh1999). Many researchers believe that nonnative species are a major cause for lack of recruitment in the native fishes, including bonytail (McAda and Wydoski 1980; Minckley 1991; Tyus 1987). There are numerous reports of predation of native fish eggs and larvae by common carp (*Cyprinus carpio*), channel catfish (*Ictalurus punctatus*), smallmouth bass (*Micropterus dolomeiui*), largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*), green sunfish (*Lepomis cyanellus*), and redear sunfish (*Lepomis microlophus*; Jonez and Sumner 1954; Langhorst 1989; Marsh and Langhorst 1988). Marsh and Langhorst (1988) found that larval razorback sucker in Lake Mohave grew better in the absence of predators, and Marsh and Brooks (1989) reported that

channel catfish and flathead catfish (*Pylodictis olivaris*) were major predators of newly stocked razorback sucker in the Gila River. Juvenile razorback sucker (average 171 mm TL) stocked in isolated coves along the Colorado River in California suffered extensive predation by channel catfish and largemouth bass (Langhorst 1989). Similar results are reported for bonytail in isolated riverside ponds along the lower Colorado River near Parker, Arizona (personal communication, C. Minckley, U.S. Fish and Wildlife Service).

Similar effects of predation on native fishes are reported from the Upper Colorado River Basin. Lentsch et al. (1996) identified six species of nonnative fishes as existing threats, including red shiner (*Cyprinella lutrensis*), common carp, sand shiner (*Notropis stramineus*), fathead minnow (*Pimephales promelas*), channel catfish, and green sunfish. Small forms, such as adult red shiner, are known predators of larval native fish (Ruppert et al. 1993). Large predators, such as walleye (*Stizostedion vitreum*) and northern pike (*Esox lucius*) also pose a threat to subadult and adult native fishes (Tyus and Beard 1990).

A Strategic Plan for Nonnative Fish Control was developed for the Upper Colorado River Basin (Tyus and Saunders 1996) and implemented by the UCRRP in 1997. Some activities include mechanical removal of nonnative fishes through intensive sampling, and modification of habitats used as residential or nursery areas by nonnative fishes. Preliminary results of the control program are inconclusive as to the beneficial effects for native fishes. Data from a 7-year research period on the San Juan River suggest that efforts to date were effective in reducing density of large channel catfish, but efforts were not effective in reducing overall abundance of channel catfish in the river (Holden 1999). A positive population response by native fishes to this channel catfish reduction has not been reported (personal communication, San Juan River Basin Recovery Implementation Program, Biology Committee). A strategic control program has also been recommended for Grand Canyon (Valdez et al. 1999b), and a Science Plan is being developed for implementation of nonnative fish removal starting in 2003 (GCMRC 2002).

Removal of nonnative fishes from isolated habitats has become one of the major management actions in recovering the native fishes in the lower basin. Efforts to restore the gene pool of fishes in Lake Mohave by capturing and rearing larvae have identified predation by nonnative fishes as a major cause of mortality of young fish (Marsh 1987, 1994; Mueller 1995; Mueller et al. 1998). These studies have found increased survival and growth of razorback sucker and bonytail under predator-free environments (Mueller et al. 2000).

Control of the release and escapement of nonnative fishes into the main river, floodplain, and tributaries is also a necessary management action to stop the introduction of new fish species into occupied habitats and to thwart periodic escapement of highly predaceous nonnatives from riverside features. Agreements have been signed among the Service and the States of Colorado, Utah, and Wyoming to review and regulate all stockings within the Upper Colorado River Basin (U.S. Fish and Wildlife Service 1996) in order to reduce the introduction and expansion of nonnative fishes. A Memorandum of Agreement implementing these procedures was signed on September 5, 1996, by the Service and the States and remains in effect through the life of the UCRRP. This agreement regulates releases of nonnative fishes within the 50-year floodplain of the river, and provides security against State or Federal endorsed programs introducing new

species into the system or increasing the numbers or distribution of existing species. The agreement also allows the States to regulate and restrict stocking of privately owned ponds. These procedures will also reduce the likelihood of new parasites and diseases being introduced through nonnative fish stockings. Similar procedures need to be developed and implemented in the lower basin.

Annual flooding of the river can inundate riverside ponds potentially containing large numbers of green sunfish, black bullhead, largemouth bass, and other nonnative fishes that may escape to the river during high flows (Valdez and Wick 1983). Riverside features determined to be problematic must be either isolated from high river floods, designed to drain annually with the rise and fall of the river, or treated with piscicidal compounds to eradicate nonnative fishes. The Colorado Division of Wildlife is to prepare a Colorado River Fisheries Management Plan (Plan) that will implement a more detailed nonnative fish control effort. The Plan is to be reviewed and approved by the Colorado Wildlife Commission and UCRRP. The Plan will be finalized and implemented by the dates specified in the Recovery Implementation Program Recovery Action Plan (RIPRAP) of the UCRRP. One aspect of the Plan will be pond reclamation, which can include complete removal of nonnative fish, screening ponds to prevent escapement to the river, and/or reshaping ponds so that they no longer support year-round habitation by nonnative fish.

Another aspect of nonnative fish control in the Colorado River Basin is removal of bag and possession limits on nonnative fishes in designated critical habitat. For example, the State of Colorado has removed bag and possession limits on all nonnative, warm-water sport fishes within critical-habitat reaches of the Colorado and Yampa rivers. Colorado also has agreed to close river reaches to angling where and when angling mortality is determined to be significant to native fishes. The State of Arizona has implemented a similar measure of removing bag and possession limits of nonnative species within designated critical habitat.

Three management actions are identified to reduce the threat of nonnative fishes: high spring flows, nonnative fish control strategies, and stocking agreements. There is documented evidence that high flows temporarily disadvantage nonnative fishes in several ways, including displacement from sheltered habitats, disruption of spawning activities, increased mortality in high mainstem currents, and physical downstream transport of individuals. Studies from the Upper Colorado River (McAda and Kaeding 1989), Green River (Valdez 1990), Yampa River (Muth and Nesler 1993), and Lower Colorado River through Grand Canyon (Hoffnagle et al. 1999; Valdez et al. 2001) showed reductions in densities of small-bodied species of fish (e.g., fathead minnow, red shiner, sand shiner, plains killifish [*Fundulus zebrinus*]) following high flows. On the San Juan River, no evidence exists to support the hypothesis that high flows even temporarily disadvantage nonnatives and promote endangered fish reproduction and recruitment (Holden 1999). Strong year classes of native species (e.g., Colorado pikeminnow [McAda and Ryel 1999], humpback chub [Gorman 1994]) have consistently occurred following high runoff years, and have been attributed to cleansing of spawning gravels and short-term reduction in nonnative fishes. Hence, even a short-term reduction in nonnative fishes could allow increased survival and recruitment of native forms (Tyus and Saunders 1996). Flow recommendations include the provision of high flows, which provide these unsuitable conditions for nonnative fishes and may at least temporarily reduce numbers of these predators and competitors.

Active control programs should be implemented or continued (as needed) for problematic nonnative fishes in bonytail nursery habitats (potentially flooded bottomlands), northern pike in the Yampa and middle Green rivers, and channel catfish and flathead catfish in river reaches where bonytail become reestablished. Guidance is not provided in this document with regard to target reduction levels because such criteria may be premature and unreasonable to achieve, or may be easily achieved and exceeded. Little is known with respect to responses by nonnative fish populations to overt control measures, and these must be evaluated as part of nonnative fish control programs. Another unknown aspect of nonnative fish control is the need to maintain control measures indefinitely or periodically over time. These decisions will have to be made from information gained through these control programs during the downlist monitoring period.

4.4 Listing Factor (D): The Inadequacy of Existing Regulatory Mechanisms

Implementation of regulatory mechanisms are necessary for recovery of the bonytail and to ensure long-term conservation of the species. Regulatory mechanisms affect many aspects of legal protection, such as habitat and flow protection, regulation and/or control of nonnative fishes, regulation of hazardous-materials spills, and angling regulations. Flow regimes to benefit bonytail populations must be identified, implemented, evaluated, and revised (as necessary) before downlisting can occur (existing flow recommendations are described in section 4.1). By the time of delisting, legal protection of habitat (including flows) necessary to provide adequate habitat and sufficient range for all life stages of bonytail to support recovered populations must be accomplished through various means including instream-flow appropriations, legal agreements, contracts, operating criteria, and/or other means. Additionally, certain States may issue policies that also afford flow protection. As examples, the State of Utah has instituted a policy that subordinates all future water-rights appropriations for the Green River from Flaming Gorge Dam to the Duchesne River confluence for the summer and autumn periods to provide flows to benefit the endangered fish; actions proposed under this policy would not affect pre-existing water rights (Utah Division of Water Rights 1994). Also, the State of Colorado has established two instream-flow rights on the Colorado River under its state instream-flow law.

Before delisting, the primary regulatory mechanism for protection of bonytail is through Section 7(a)(2) of the ESA, as administered by the Service. *"Each Federal agency shall, in consultation with and with the assistance of the Secretary, insure that any action authorized, funded, or carried out by such agency... is not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of habitat of such species which is determined by the Secretary, after consultation as appropriate with affected States, to be critical..."* In the Upper Colorado River Basin, the UCRRP provides a mechanism for dealing with Section 7 consultations in a unified manner. There are currently no formal recovery programs in the lower basin, and Section 7 consultations are addressed on a case-by-case basis. The NFWG is an ad hoc group of dedicated volunteers and agency biologists focused on protecting and augmenting the genetic diversity of current native fish populations in Lake Mohave. The goal of the MSCP is to provide a comprehensive mechanism for ensuring regulatory compliance under both Sections 7 and 10 of the ESA for all participating Federal and non-Federal MSCP agencies and entities. Similarly, the MSCP is intended, and is being

structured, to provide environmental compliance pursuant to the California Endangered Species Act and California Environmental Quality Act (CEQA). None of the recovery or conservation programs in the Colorado River Basin are regulatory mechanisms that provide permanent, long-term protection for the species after delisting.

In addition to Federal protection under the ESA, bonytail are protected by all basin States under categories such as "endangered", "threatened", or "sensitive". This protection prohibits intentional take and keeping or harming in any way any fish captured incidentally, and may need to remain in place after the species is Federally delisted. However, the States do not address the major problem of habitat destruction, and especially streamflow modification. Most States have instream-flow laws that allow "beneficial use" of water left in streams for wildlife, but these laws typically only provide for flow that is the minimum amount necessary to maintain the fishery. With some States, there is also an inherent conflict between management of nonnative sport fish and recovery of endangered fishes. Where valued sport fisheries occur, there is an ongoing dilemma between public demands for maintenance and expansion of fisheries and management actions to conserve and recover endangered fish. There is no immediate solution to the dilemma, but predation by nonnative fishes is clearly identified as a cause for the decline of many of the native Colorado River fishes, and long-term agreements between States and the Service are essential.

After removal from the list of species protected by the ESA, the bonytail and its habitat will continue to receive consideration and some protection through the following Federal laws and related State statutes, and will need the provisions to protect habitat previously discussed. The National Environmental Policy Act (NEPA; 42 U.S.C. 4321–4370d) requires Federal agencies to evaluate the potential effects of their proposed actions on the quality of the human environment and requires the preparation of an environmental impact statement whenever projects may result in significant impacts. Federal agencies must identify adverse environmental impacts of their proposed actions and develop alternatives that undergo the scrutiny of other public and private organizations as a part of their decision-making process. Recovery actions identified for bonytail are linked to federal actions, which must undergo review under NEPA.

Section 101(a) of the Federal Water Pollution Control Act (i.e., Clean Water Act; 33 U.S.C. 1251–13287) states that the objective of this law is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters and provide the means to assure that *"...protection and propagation of fish, shellfish, and wildlife..."*. This statute contributes in a significant way to the protection of the bonytail and its food supply through provisions for water quality standards, protection from the discharge of harmful pollutants, contaminants [Section 303(c), Section 304(a), and Section 402] and discharge of dredge or fill material into all waters, including certain wetlands (Section 404).

The Organic Act (16 USC 1, as amended) provides for management of National Park Service areas in such a manner *"...to promote and regulate the use of the...national parks...which purpose is to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations."* The National Park Service is the

largest single jurisdictional land owner in reaches with critical and other occupied habitats for the four Colorado River endangered fishes (Maddux et al. 1993).

The Fish and Wildlife Coordination Act (16 U.S.C. 661–666c) requires that Federal agencies sponsoring, funding, or permitting activities related to water resource development projects request review of these actions by the Service and the State natural resource management agency. These comments must be given equal consideration with other project purposes. Also, the Federal Land Policy and Management Act (43 U.S.C. 1701–1784) requires that public lands be managed to protect the quality of scientific, ecological, and environmental qualities and preserve and protect certain lands in their natural conditions to provide food and habitat for fish and wildlife.

The need for conservation plans and agreements was identified to provide reasonable assurances that recovered bonytail populations will be maintained. These plans are to be implemented after delisting and are intended to assure that relisting does not become necessary. They would be developed to ensure long-term management and protection of the species, and should include (but not limited to) provision of flows for maintenance of habitat conditions required for all life stages, regulation and/or control of nonnative fishes, minimization of the risk of hazardous-materials spills, and monitoring of populations and habitats. Signed agreements among State agencies, Federal agencies, American Indian tribes, and other interested parties must be in place to implement the conservation plans before delisting can occur.

4.5 Listing Factor (E): Other Natural or Manmade Factors Affecting Its Continued Existence

4.5.1 Hybridization

Intergrades among the Colorado River *Gila* have been reported by several investigators (Holden and Stalnaker 1970; Valdez and Clemmer 1982; Kaeding et al. 1990; Douglas et al. 1989, 1998). The presence of intergrades in the wild suggests hybridization among bonytail, roundtail chub, and humpback chub; hybridization has been demonstrated under hatchery conditions (Hamman 1981). Some have suggested that hybridization is the result of a breakdown in reproductive isolating mechanisms caused by habitat and streamflow changes in the basin (Valdez and Clemmer 1982), while others (Dowling and DeMarais 1993) hypothesize that introgressive hybridization has played a significant role in generating the great morphological diversity in the genus *Gila* and providing additional genetic variability. The effect of hybridization on the *Gila* species is unclear, and the factors that lead to increased hybridization of bonytail are not evaluated, because there are no reproducing populations in the wild. Current levels of hybridization are not considered singly significant in the decline of the bonytail, but these factors will be reevaluated at downlisting and any necessary protection will be implemented at delisting. A discussion of hybridization in bonytail is presented in section A.3.

4.5.2 Pesticides and pollutants

The potential role of pesticides and pollutants in suppressing populations of *Gila* were discussed by Wick et al. (1981). Over 16% of young roundtail chub from the Yampa and Colorado rivers in 1981 showed spinal deformities (i.e., lordosis), hypothesized to be related to high pesticide levels from local agricultural applications (Haynes and Muth 1981). Other pollutants in the system include petroleum products, heavy metals (e.g., mercury, lead, zinc, copper), nonmetalics (i.e., selenium), and radionucleides. Although these elements are concentrated in some regions of the basin, no tissue analyses have been conducted for bonytail to determine current levels of bioaccumulation. Selenium has been identified as a potential problem for razorback sucker and Colorado pikeminnow (Osmundson et al. 2000a).

Potential spills of hazardous materials threaten all endangered fishes. The Denver and Rio Grande Western railroad tracks parallel the Colorado River at Black Rocks and upper Westwater Canyon with the risk of derailment and spills of materials into the river, although no known derailments have occurred in these areas. The susceptibility of stocked bonytail to toxic substances is illustrated by a large, but unquantified loss of humpback chub in Westwater Canyon in the 1980's as a result of a large ash flow following a range wildfire high in the watershed (personal communication, J. Cresto, U.S. Bureau of Land Management). Ash and large amounts of sediment washed down Westwater Creek during a sudden thunderstorm. The potential for spills of petroleum products also exists for repatriated bonytail in Yampa Canyon. For example, numerous petroleum-product pipelines cross or parallel the Yampa River upstream of Yampa Canyon, most of which lack emergency shut-off valves. One pipe ruptured in the late 1980's releasing refined oil into the Yampa River, but the effects of this spill were not documented.

All States have hazardous-materials spills emergency-response plans that provide a quick cleanup response to accidental spills (see section 4.4). These responses may not be sufficiently rapid to minimize deleterious effects to fishes. Quick response may, therefore, be inadequate to protect the species and preventive measures must be incorporated into these plans. These preventive measures may include reduced speed of railway traffic near occupied habitats, such as upper Colorado River; safety shut-off valves on petroleum-products lines in or near the floodplain; and filtration systems in case of accidental spills of hazardous materials at bridge crossings above occupied habitats. Identifying and implementing the most reasonable and prudent preventive measures will require a comprehensive review of existing State and Federal hazardous-materials spills emergency-response plans. These preventive measures must be implemented before delisting.

Another cause of degraded water quality is the Atlas Mills tailings pile located on the north bank of the Colorado River near Moab, Utah. In 1998, the Service determined in a final biological opinion that this pile *"...is likely to jeopardize the continued existence of..."* the Colorado pikeminnow and razorback sucker. This biological opinion was withdrawn on February 8, 2001, because of refusal by the Nuclear Regulatory Commission to reinitiate consultation. Section 3405 of the Floyd D. Spence National Defense Authorization Act for Fiscal Year 2001 (P.L. 106-398) requires that the Atlas Mills tailings site be transferred to the Department of Energy for

remediation. Congress authorized $300 million for clean-up of the Atlas Mills tailings pile. Remediation is outside of the purview of the UCRRP.

There are two significant threats to endangered fish posed by the Atlas Mills tailings pile. The first is from toxic discharges of pollutants, particularly ammonia, through groundwater to the Colorado River. The second is the risk of catastrophic pile failure, that could bury important nursery areas and destroy other fish habitat. To address the threats posed by the discharge of toxic pollution, whether tailings are reclaimed on site or removed to another location, the groundwater must be cleaned up to the extent necessary to prevent the discharge of ammonia, uranium, and other toxic pollutants into the Colorado River and meet the State of Utah surface-water and groundwater quality standards for fish and wildlife. To assess whether such clean-up has occurred, groundwater-system compliance and measuring points must be established.

5.0 RECOVERY GOALS

The following are site-specific management actions and objective, measurable recovery criteria for the bonytail presented by the two recovery units, i.e., the upper basin (including Green River and upper Colorado River) and the lower basin (including the mainstem and its tributaries from Lake Mead downstream to the southerly International Boundary with Mexico). The bonytail was listed prior to the 1996 DPS policy, and the Service may conduct an evaluation to designate DPSs in a future rule-making process. Steps for downlisting and delisting presented in this section are consistent with provisions specified under Section 4(a)(1), Section 4(b), Section 4(c)(2)(B), and Section 4(f)(1) of the ESA (see section 2.0 of this document). The five recovery factors (i.e., Factor A, Factor B, etc.) were derived from the five listing factors (see section 2.1) and state the conditions under which threats are minimized or removed. For each recovery factor, management actions and tasks are identified that minimize or remove threats to the bonytail. Under objective, measurable recovery criteria, demographic criteria and recovery factor criteria are presented for downlisting and delisting. Generally, for each downlisting criterion there is a corresponding delisting criterion. Reclassification can be considered when appropriate recovery criteria are met.

Anthropogenic changes in the lower basin have extensively modified the riverine ecosystem, including native-fish habitats. Therefore, recovery goals in the lower basin are based on a limited amount of habitat and taking aggressive actions (e.g., stocking large numbers of adults) that allow for the establishment and maintenance of populations in riverine and/or repatriated habitats (e.g., riverside habitats, such as oxbows, depressions, bottomlands, that are connected where feasible to the mainstem Colorado River).

5.1 Requirements and Uncertainties Associated with Recovery Goals

5.1.1 Demographic criteria and monitoring

Demographic criteria that describe numbers of populations and individuals (adults and juveniles) for downlisting and delisting are presented for upper and lower basin recovery units. These

criteria require four genetically and demographically viable, self-sustaining populations (two in each recovery unit), based on requirements of no significant decline in numbers of adults for each population and recruitment equal to or exceeding adult mortality. In addition, a genetic refuge needs to be established and maintained in a suitable location in the lower basin recovery unit.

It is anticipated that self-sustaining populations of bonytail will be established over the next 15 years, during which time population dynamics and responses to management actions will be evaluated. A 5-year monitoring period is required for downlisting, and a 3-year monitoring period beyond downlisting is required for delisting. The downlist monitoring period begins with the first reliable estimates for all populations acceptable to the Service once self-sustaining populations have been established (i.e., progeny are recruiting) The downlist and delist monitoring periods are expected to be continuous, and reclassification cannot be considered until each population has been monitored for the required period of time. The total 8-year monitoring period is equivalent to approximately one generation time for bonytail, and is considered sufficient to determine if populations are stable, increasing, or decreasing. Generation time is equal to the mean adult age and is computed as the average age of attaining sexual maturity; i.e., $age_{sex\ maturity}$ plus (1/d), where d is equal to death rate (Seber 1982; Gilpin 1993). For bonytail, the age of attaining sexual maturity is 4 years and the adult survival rate is 0.70 (d=1-0.70); hence, generation time is 4 + [1/(1-0.70)] or approximately 8. No estimates of survival are available for wild bonytail. Lacking that information and following best professional judgement, a conservative estimate of average annual adult mortality (0.30) that was equal to the estimate for razorback sucker (the highest mortality rate of the four big river fishes) was applied to bonytail.

It is important to note that under Section 4(g)(1) of the ESA, *"The Secretary shall implement a system in cooperation with the States to monitor effectively for not less than five years the status of all species which have recovered to the point at which the measures provided pursuant to this Act are no longer necessary..."*. Hence, populations would be monitored for at least 5 additional years after delisting.

The Service considers a reliable estimate as one that is based on a multiple mark-recapture model. Direct enumeration of fish populations is not feasible in turbid rivers, and removal estimates are unreliable because of the difficulty of blocking reaches of large rivers to meet the model assumption of no migration. Instead, closed-population, multiple mark-recapture estimators (Otis et al. 1978; Burnham et al. 1987; Chao 1989; Osmundson and Burnham 1998) are recommended for deriving population point estimates and to guide development of sampling designs that conform to these models. The accuracy and precision of each point estimate will be assessed by the Service in cooperation with the respective recovery or conservation programs, and in consultation with investigators conducting the point estimates and with qualified statisticians and population ecologists. If, for example, an estimate is made that is considered unreliable (i.e., lacks precision and accuracy) because of poor sampling conditions or other causes, a determination will be made if an additional estimate is needed in the following year in order to accurately assess if downlisting or delisting criteria are met. Field sampling methodologies should be developed and refined to attain a balance between the need for accurate and precise population estimates while minimizing stress to fish from excessive handling.

Monitoring must be designed to determine if the demographic criteria are being met. At least three point estimates are needed for each of the four established bonytail populations to downlist, and at least two more estimates are needed to delist. In order to ensure no net loss in each population, the trend in adult (age 4+; ≥250 mm TL; Vanicek 1967) point estimates cannot decline significantly; i.e., slope is not significantly less than zero over the trend period ($p \leq 0.05$), requiring that the population is either stable or increasing during the monitoring period. Also, mean estimated recruitment of age-3 (150–249 mm TL; Vanicek 1967) naturally produced fish in each population must equal or exceed mean annual adult mortality (i.e., ≥30%). This criterion requires that each population is reproducing, recruiting, and self-sustaining. To meet the requirement of genetically and demographically viable populations, each point estimate for each population must exceed 4,400 adults (MVP; see section 3.3.2). In addition to the demographic criteria, adequate habitat and sufficient range are required to support recovered populations. Recovery goals allow for maintenance of populations within areas of designated critical habitat (59 FR 13374).

5.1.2 Recovery factor criteria

The recovery factor criteria are directly linked to management actions/tasks. Recovery factor criteria for downlisting generally call for identification, implementation, evaluation, and revision of management tasks. Corresponding criteria for delisting call for attainment of necessary and feasible levels of protection that minimize or remove threats. Reference to management actions and tasks in occupied habitat presupposes establishment of populations through augmentation.

Each of the five threats identified in section 4.0 (i.e., streamflow regulation, habitat modification, competition with and predation by nonnative fishes, hybridization, and pesticides and pollutants) is addressed in this section with appropriate management actions/tasks. Details of these and other management actions/tasks that contribute to recovery are or will be identified in the RIPRAP of the UCRRP, and in annual work plans of the NFWG and MSCP. These programs function under the general principles of adaptive management, and the plans are periodically revised. In the context of these programs, adaptive management is the process by which management actions are identified, implemented, evaluated, and revised based on results of research and monitoring.

Providing and legally protecting habitat are necessary elements in recovery of the bonytail. Habitat as used in these recovery goals is defined as the physical and biological components of the environment required for recovery of the species, including flow regimes necessary to restore and maintain those environmental conditions. Hence, identification, implementation, evaluation, and revision of adequate flow regimes through adaptive management are identified as criteria necessary for downlisting. By the time of delisting, flows (as well other habitat components) identified as necessary to the life history of the species must be provided and legally protected through various means, including instream-flow appropriations, legal agreements, contracts, operating criteria, and/or other means. As stated in the governing document of the UCRRP (U.S. Department of the Interior 1987), under this program legal protection of flows referenced in these recovery goals for upper basin rivers will be consistent with State and Federal laws related to the Colorado River system (sometimes referred to as “Law of the River”), including State water law,

interstate compacts, and Federal trust responsibilities to American Indian tribes. It is recognized that flow management alone is not sufficient to ensure self-sustaining populations of the endangered fishes, and that a combination of flow and non-flow management actions will be necessary for recovery. It is anticipated that flow management actions identified in these recovery goals can be achieved in balance with non-flow management actions to improve ecosystem conditions and enhance recovery and sustainability of the endangered fish populations. Population and demographic data collected through monitoring will be used to track progress toward meeting the habitat needs of the species.

Implementation of conservation plans is required in order to provide for the long-term management and protection of bonytail populations after delisting. These conservation plans will be developed and implemented through agreements among State agencies, Federal agencies, American Indian tribes, and other interested parties, and may include (but are not limited to) provision of flows for maintenance of habitat conditions required for all life stages, regulation and/or control of nonnative fishes, minimization of the risk of hazardous-materials spills, and monitoring of populations and habitats.

Use of hatchery fish (progeny of cultured broodstock) will be necessary to establish new populations of bonytail. Provisions and recommendations of the Policy Regarding Controlled Propagation of Species Listed Under the Endangered Species Act (65 FR 56916) should be used as guidelines for use of hatchery fish in recovery. The UCRRP has a genetics management plan (Czapla 1999) and is revising a facilities-needs plan based on revised State stocking plans. Similar plans need to be developed for the lower basin recovery unit.

5.1.3 Uncertainties

These recovery goals are based on the best available scientific information, and are structured to attain a balance between reasonably achievable criteria and ensuring the viability of the species beyond delisting. Without wild viable populations, considerable uncertainty exists regarding recovery of the bonytail. It is expected that research, management, and monitoring activities directed by the UCRRP, NFWG, and MSCP will fill information gaps and considerably narrow, if not eliminate, many of the uncertainties that affect recovery criteria. As self-sustaining populations are established and studied, additional data and improved understanding of bonytail biology will prompt future revision of these recovery goals. The Service intends to review, and revise as needed, these recovery goals at least once every 5 years from the date of their publication in the *Federal Register*, or as necessary when sufficient new information warrants a change in the recovery criteria. Review of these recovery goals will be part of the review of listed species as required by Section 4(c)(2)(A) of the ESA, "*The Secretary shall ... conduct, at least once every five years, a review of all species...*". Uncertainties associated with these recovery goals include:

- Demographic Viability. The metapopulation concept may apply to bonytail populations, but the role of metapopulations in bonytail population dynamics can only be determined after populations become established.
- Carrying Capacity. The carrying capacity for bonytail populations is unknown. Numbers of wild fish are too few to make any inferences on carrying capacity.

- Genetic Viability. A conservative N_e of 1,000 was used because of the absence of wild, self-sustaining populations to provide sorting of alleles to maintain natural genetic variability. Without wild populations, genetic viability is uncertain and not assured.
- Hybridization—Hybridization of bonytail with other *Gila* species is identified as a primary threat in the Bonytail Chub Recovery Plan. Crosses among bonytail, humpback chub, and roundtail chub have been successfully performed in a hatchery, and there is a risk of hybridization for the species in the wild. However, the factors that would lead to increased risk of hybridization are not currently known. Hence, this will need to be evaluated as fish are released into the wild and populations become established in proximity or sympatry with the other *Gila* spp.
- Flow and Temperature Recommendations. Flow and temperature recommendations have been developed that specifically consider flow-habitat relationships in habitats occupied by bonytail. However, it is uncertain to what extent these recommendations can be met and what flow regimes will be necessary to meet the life history needs of the bonytail. Streamflow reduction and modification from dams and water withdrawal systems have reduced spatial and temporal variability in flow regimes, reduced available habitat, and changed ecosystem function and structure. A paradigm in river management suggests that the ecological integrity of river ecosystems is linked to their natural dynamic character (Stanford et al. 1996; Poff et al. 1997), and restoring a more natural flow regime is the cornerstone of river restoration. This paradigm and the response by endangered fishes of the Colorado River Basin is largely untested, and as these flow regimes to benefit the endangered fishes are implemented, it is important to be aware of associated uncertainties and plan for management of unanticipated results. Response of bonytail to flows will need to be monitored in order to identify and provide flow regimes that are necessary to restore and maintain adequate habitat and sufficient range for all life stages.
- Nonnative Fish Response. Uncertainty exists regarding the responses of nonnative fishes to active control measures and to flow regimes to benefit the endangered fishes. Many of these nonnative fishes, both warm-water and cold-water, prey on and compete with native fishes. There are indications that high spring flows have a negative effect on nonnative fishes, but the overall response of nonnative fish populations to flow recommendations is uncertain. Long-term response by nonnative fishes to mechanical removal is also an uncertainty. It is unknown if reduction in numbers of nonnatives will result in lower population numbers, altered age structure, or opening of niches for new or existing nonnative fishes. It is also unknown if reduction in nonnative fishes will result in increased numbers of native fishes.
- Efficacy of Monitoring Programs. The precision and reliability of long-term monitoring programs to accurately measure the response of bonytail to management actions is an uncertainty. Mark-recapture estimates of established populations may reflect high variability because of population variability and/or sampling variability. This variability in estimates may exceed the level of population response to a management action, masking measurement of short-term

responses and cause-effect relationships. Demographic criteria proposed in this document attempt to account for this variability and set numbers that are measurable under current conditions.

- Establishing Self-Sustaining Populations. Hatchery fish will be used to establish new populations. The survival, recruitment, and reproductive success of these fish in the wild is uncertain. This uncertainty is greater in rivers or river reaches that have been extensively modified.
- Response to Management Actions. Response by bonytail populations to management actions is also uncertain. Management actions, such as repatriation of riverine habitats in the lower basin, regulation of escapement of nonnative fishes, control of parasites, control of nonnative fishes, and minimization of risk to hazardous-materials spills, may vary in their effectiveness to benefit bonytail. Tasks and recovery criteria associated with each of these management actions are intended to provide some measure of success before reclassification can occur.

5.2 Site-Specific Management Actions and Tasks by Recovery Factor

5.2.1 Upper basin recovery unit

5.2.1.1 Factor A.—Adequate habitat and range for recovered populations provided

Management Action A-1.—Provide flows necessary for all life stages of bonytail to support recovered populations, based on demographic criteria.

Task A-1.1.—Identify, implement, evaluate, and revise (as necessary through adaptive management) flow regimes to benefit bonytail populations in the Green River and upper Colorado River subbasins (see section 4.1 for discussion of existing flow recommendations to benefit the endangered fishes and for discussion of suspected bonytail flow-habitat requirements; see Appendix A for a synopsis of bonytail life history).

Task A-1.2.—Provide flows regimes (as determined under Task A-1.1) that are necessary for all life stages of bonytail to support recovered populations in the Green River and upper Colorado River subbasins.

Management Action A-2.—Provide passage for bonytail within occupied habitat to allow adequate movement and, potentially, range expansion.

Task A-2.1.—Continue to provide fish passage over Redlands Diversion and Grand Valley Diversion to allow adequate movement of bonytail in the upper Colorado River and Gunnison River (see section 4.1 for a discussion on barriers to fish passage).

Task A-2.2.—Modify Price-Stubb Dam and Government Highline Dam to allow adequate movement of bonytail in the upper Colorado River.

Management Action A-3.—Investigate options for providing appropriate water temperatures in the Gunnison River that would allow for range expansion of bonytail.

Task A-3.1.—Investigate the feasibility of modifying releases from Aspinall Unit dams to increase water temperatures in the Gunnison River that would allow for upstream range expansion of bonytail in the Gunnison River (see section 4.1 for discussion on warm-water releases).

Task A-3.2.—Modify releases from Aspinall Unit dams to increase water temperatures in the Gunnison River, if determined feasible and necessary to achieve demographic criteria for the upper Colorado River subbasin (see section 5.3.2.1.2).

Management Action A-4.—Minimize entrainment of subadult and adult bonytail in diversion canals.

Task A-4.1.—Identify measures (e.g., screens, baffles) to minimize entrainment of subadult and adult bonytail at problematic diversion structures, such as the Green River Canal, Grand Valley Irrigation Canal, Government Highline Diversion Project, and the Redlands Canal Company Diversion (see section 4.1 for discussion on entrainment).

Task A-4.2.—Install devices and/or implement other measures (as determined under Task A-4.1) to minimize entrainment.

Management Action A-5.—Investigate habitat requirements for all life stages of bonytail (including importance of floodplain habitats) and provide those habitats necessary to support recovered populations, based on demographic criteria.

Task A-5.1.—Identify habitats that are necessary for the establishment and maintenance of bonytail populations in the Green River and upper Colorado River subbasins (see Appendix A).

Task A-5.2.—Provide habitats (as determined under Task A-5.1) for all life stages of bonytail that are necessary to support recovered populations in the Green River and upper Colorado River subbasins.

5.2.1.2 Factor B.—Protection from overutilization for commercial, recreational, scientific, or educational purposes

Management Action B-1.—Protect bonytail populations from overutilization for commercial, recreational, scientific, or educational purposes.

Task B-1.1.—Reevaluate and, if necessary, identify actions to ensure adequate protection from overutilization of bonytail for commercial, recreational, scientific, or educational purposes; not currently identified as an existing threat (see section 4.2).

Task B-1.2.—Implement identified actions (as determined under Task B-1.1) to ensure adequate protection of bonytail populations from overutilization for commercial, recreational, scientific, or educational purposes.

5.2.1.3 Factor C.—Adequate protection from diseases and predation

Management Action C-1.—Minimize adverse effects of diseases and parasites on bonytail populations.

Task C-1.1.—Reevaluate and, if necessary, identify actions to minimize adverse effects of diseases and parasites on bonytail populations; not currently identified as an existing threat (see sections 4.3.1 and A.12 for discussion of diseases and parasites).

Task C-1.2.—Implement identified actions (as determined under Task C-1.1) to ensure adequate protection of bonytail populations from deleterious diseases and parasites.

Management Action C-2.—Regulate nonnative fish releases and escapement into the main river, floodplain, and tributaries.

Task C-2.1.—Develop, implement, evaluate, and revise (as necessary through adaptive management) procedures for stocking nonnative fish species in the Upper Colorado River Basin to minimize negative interactions between nonnative fishes and bonytail (see sections 4.3.2 and A.8 for discussion of effects of nonnative fishes).

Task C-2.2—Finalize and implement procedures (as determined under Task C-2.1) for stocking nonnative fish species in the Upper Colorado River Basin to minimize negative interactions between nonnative fishes and bonytail.

Management Action C-3.—Control problematic nonnative fishes as needed.

Task C-3.1.—Develop control programs for small-bodied nonnative fishes (e.g., cyprinids and centrarchids) in nursery habitats in river reaches occupied by young bonytail to identify levels of control that will minimize negative interactions. (see sections 4.3.2 and A.8 for discussion of effects of nonnative fishes).

Task C-3.2.—Implement identified levels (as determined under Task C-3.1) of nonnative fish control in nursery habitats in river reaches occupied by young bonytail.

Task C-3.3.—Develop channel catfish control programs in river reaches occupied by bonytail to identify levels of control that will minimize negative interactions.

Task C-3.4.—Implement identified levels (as determined under Task C-3.3) of channel catfish control in river reaches occupied by bonytail.

Task C-3.5.—Develop northern pike control programs in reaches of the Yampa and middle Green rivers occupied by bonytail to identify levels of control that will minimize negative interactions.

Task C-3.6.—Implement identified levels (as determined under Task C-3.5) of northern pike control in reaches of the Yampa and middle Green rivers occupied by bonytail.

5.2.1.4 Factor D.—Adequate existing regulatory mechanisms

Management Action D-1.—Legally protect habitat (see definition of habitat in section 5.1.2) necessary to provide adequate habitat and sufficient range for all life stages of bonytail to support recovered populations, based on demographic criteria.

Task D-1.1.—Determine mechanisms for legal protection of adequate habitat through instream-flow rights, contracts, agreements, or other means (see section 4.4 for discussion of regulatory mechanisms).

Task D-1.2.—Implement mechanisms for legal protection of habitat (as determined under Task D-1.1) that are necessary to provide adequate habitat and sufficient range for all life stages of bonytail to support recovered populations.

Management Action D-2.—Provide for the long-term management and protection of bonytail populations and their habitats.

Task D-2.1.—Identify elements needed for the development of conservation plans that are necessary to provide for the long-term management and protection of

bonytail populations; elements of these plans may include (but are not limited to) provision of flows for maintenance of habitat conditions required for all life stages of bonytail, regulation and/or control of nonnative fishes, minimization of the risk of hazardous-materials spills, and monitoring of populations and habitats (see section 4.4 for discussion of need for conservation plans).

Task D-2.2.—Develop and implement conservation plans and execute agreements among State agencies, Federal agencies, American Indian tribes, and other interested parties to provide reasonable assurances that conditions needed for recovered bonytail populations will be maintained.

5.2.1.5 Factor E.—Other natural or manmade factors for which protection has been provided

Management Action E-1.—Minimize the threat of hybridization among *Gila* species in river reaches occupied by bonytail.

Task E-1.1.—Evaluate and, if necessary, identify actions to minimize the risk of hybridization to bonytail; not currently identified as an existing threat (see sections 4.5.1 and A.3 for discussion of hybridization).

Task E-1.2.—Implement identified action (as determined under task E-1.1) to ensure adequate protection of bonytail populations from hybridization.

Management Action E-2.—Minimize the risk of hazardous-materials spills in critical habitat.

Task E-2.1.—Review and recommend modifications to State and Federal hazardous-materials spills emergency-response plans to ensure adequate protection for bonytail populations from hazardous-materials spills, including prevention and quick response to hazardous-materials spills (see section 4.5.2 for discussion of hazardous-materials spills).

Task E-2.2.—Implement State and Federal emergency-response plans that contain the necessary preventive measures (as determined under Task E-2.1) for hazardous-materials spills.

Task E-2.3.—Identify locations of all petroleum-product pipelines within the 100-year floodplain of critical habitat and assess the need for emergency shut-off valves to minimize the potential for spills.

Task E-2.4.—Install emergency shut-off valves (as determined under Task E-2.3) on petroleum-product pipelines within the 100-year floodplain of critical habitat.

Management Action E-3.—Minimize threats from degraded water quality on bonytail.

Task E-3.1.— Identify actions to remediate groundwater contamination from the Atlas Mills tailings pile located near Moab, Utah, in order to restore water quality of the Colorado River in the vicinity of the pile in accordance with the State of Utah and Environmental Protection Agency (EPA) water-quality standards for fish and wildlife (see section 4.5.2 for discussion of groundwater contamination).

Task E-3.2.— Implement actions (as determined under Task E-3.1) to remediate groundwater contamination from the Atlas Mills tailings pile.

5.2.2 Lower basin recovery unit

5.2.2.1 Factor A.—Adequate habitat and range for recovered populations provided

Management Action A-1.—Provide flows necessary for all life stages of bonytail to support recovered populations, based on demographic criteria.

Task A-1.1.—Identify, implement, evaluate, and revise (as necessary through adaptive management) flow regimes that are necessary for the establishment and maintenance of bonytail populations in the mainstem and/or tributaries.

Task A-1.2.—Provide flow regimes (as determined under Task A-1.1) that are necessary for all life stages of bonytail to support recovered populations in the mainstem and/or tributaries.

Management Action A-2.—Minimize entrainment of subadult and adult bonytail in diversion/out-take structures.

Task A-2.1.—Identify measures (e.g., screens, baffles) to minimize entrainment of subadult and adult bonytail at problematic diversion and/or out-take structures (see section 4.1 for discussion on entrainment).

Task A-2.2.—Install devices and/or implement other measures (as determined under Task A-2.1) to minimize entrainment.

Management Action A-3.—Investigate habitat requirements for all life stages of bonytail (including importance of floodplain habitats) and provide those habitats necessary to support recovered populations, based on demographic criteria.

Task A-3.1.—Identify habitats that are necessary for the establishment and maintenance of bonytail populations in the mainstem and/or tributaries (see Appendix A).

Task A-3.2.—Provide habitats (as determined under Task A-3.1) for all life stages of bonytail that are necessary to support recovered populations in the mainstem and/or tributaries.

5.2.2.2 Factor B.—Protection from overutilization for commercial, recreational, scientific, or educational purposes

Management Action B-1.—Protect bonytail populations from overutilization for commercial, recreational, scientific, or educational purposes.

Task B-1.1.—Reevaluate and, if necessary, identify actions to ensure adequate protection from overutilization of bonytail for commercial, recreational, scientific, or educational purposes; not currently identified as an existing threat (see section 4.2).

Task B-1.2.—Implement identified actions (as determined under Task B-1.1) to ensure adequate protection of bonytail from overutilization for commercial, recreational, scientific, or educational purposes.

5.2.2.3 Factor C.—Adequate protection from diseases and predation

Management Action C-1.—Minimize adverse effects of diseases and parasites on bonytail populations.

Task C-1.1.—Reevaluate and, if necessary, identify actions to minimize adverse effects of diseases and parasites on bonytail populations; not currently identified as an existing threat (see sections 4.3.1 and A.12 for discussion of diseases and parasites).

Task C-1.2.—Implement identified actions (as determined under Task C-1.1) to ensure adequate protection of bonytail populations from deleterious diseases and parasites.

Management Action C-2.—Regulate nonnative fish releases and escapement into the mainstem, floodplain, and tributaries.

Task C-2.1.—Develop, implement, evaluate, and revise (as necessary through adaptive management) procedures for stocking and to minimize escapement of nonnative fish species into the mainstem, floodplain, and tributaries to minimize negative interactions between nonnative fishes and bonytail (see sections 4.3.2 and A.8 for discussion of effects of nonnative fishes).

Task C-2.2.—Finalize and implement procedures (as determined under Task C-2.1) for stocking and to minimize escapement of nonnative fish species

into the mainstem, floodplain, and tributaries to minimize negative interaction between nonnative fishes and bonytail.

Management Action C-3.—Control problematic nonnative fishes as needed.

Task C-3.1.—Develop control programs for problematic nonnative fishes in the mainstem, floodplain, and tributaries to identify levels of control that will minimize negative interactions between nonnative fishes and bonytail.

Task C-3.2.—Implement identified levels (as determined under Task C-3.1) of nonnative fish control in the mainstem, floodplain, and tributaries.

5.2.2.4 Factor D.—Adequate existing regulatory mechanisms

Management Action D-1.—Legally protect habitat (see definition of habitat in section 5.1.2) necessary to provide adequate habitat and sufficient range for all life stages of Colorado pikeminnow to support recovered populations, based on demographic criteria.

Task D-1.1.—Determine mechanisms for legal protection of habitat through instream-flow rights, contracts, agreements, or other means (see section 4.4 for discussion of regulatory mechanisms).

Task D-1.2.—Implement mechanisms for legal protection of habitat (as determined under Task D-1.1) that are necessary to provide adequate habitat and sufficient range for all life stages of bonytail to support recovered populations.

Management Action D-2.—Provide for the long-term management and protection of bonytail populations and their habitats.

Task D-2.1.—Identify elements needed for the development of conservation plans that are necessary to provide for the long-term management and protection of bonytail populations; elements of these plans may include (but are not limited to) maintenance of genetic diversity in Lakes Mohave or Havasu, provision of flows for maintenance of adequate habitat conditions for all life stages of bonytail, regulation and/or control of nonnative fishes, and monitoring of populations and habitats (see section 4.4 for discussion of need for conservation plans).

Task D-2.2.—Develop and implement conservation plans and execute agreements among State agencies, Federal agencies, American Indian tribes, and other interested parties to provide reasonable assurances that conditions needed for recovered bonytail populations will be maintained.

5.2.2.5 Factor E.—Other natural or manmade factors for which protection has been provided

Management Action E-1.—Minimize the threat of hybridization among *Gila* species in river reaches occupied by bonytail.

Task E-1.—Evaluate and, if necessary, identify actions to minimize the risk of hybridization to bonytail; not currently identified as an existing threat (see sections 4.5.1 and A.3 for discussion of hybridization).

Task E-2.—Implement identified action (as determined under task E-1) to ensure adequate protection of bonytail populations from hybridization.

5.3 Objective, Measurable Recovery Criteria

5.3.1 Downlist criteria

5.3.1.1 Demographic criteria for downlisting (population demographics in both recovery units must be met in order to achieve downlisting)

5.3.1.1.1 Upper basin recovery unit

Green River Subbasin

1. A self-sustaining population is maintained over a 5-year period, starting with the first point estimate acceptable to the Service, such that:

   a. the trend in adult (age 4+; ≥250 mm TL) point estimates does not decline significantly, and

   b. mean estimated recruitment of age-3 (150–249 mm TL) naturally produced fish equals or exceeds mean annual adult mortality, and

   c. each point estimate exceeds 4,400 adults (Note: 4,400 is the estimated MVP number; see section 3.3.2).

Upper Colorado River Subbasin

2. A self-sustaining population is maintained over a 5-year period, starting with the first point estimate acceptable to the Service, such that:

   a. the trend in adult (age 4+; ≥250 mm TL) point estimates does not decline significantly, and

b. mean estimated recruitment of age-3 (150–249 mm TL) naturally produced fish equals or exceeds mean annual adult mortality, and

c. each point estimate exceeds 4,400 adults (MVP).

5.3.1.1.2 Lower basin recovery unit

1. Genetic variability of bonytail identified and a genetic refuge (e.g., in Lake Mohave, Lake Havasu, or other suitable locations) is maintained over a 5-year period.

2. Two self-sustaining populations (e.g., mainstem and/or tributaries) are maintained over a 5-year period, starting with the first point estimate acceptable to the Service, such that for each population:

   a. the trend in adult (age 4+; ≥250 mm TL) point estimates does not decline significantly, and

   b. mean estimated recruitment of age-3 (150–249 mm TL) naturally produced fish equals or exceeds mean annual adult mortality, and

   c. each point estimate exceeds 4,400 adults (MVP).

5.3.1.2 Recovery factor criteria for downlisting (recovery factor criteria in both recovery units must be met in order to achieve downlisting)

5.3.1.2.1 Upper basin recovery unit

Factor A.—Adequate habitat and range for recovered populations provided.

1. Flow regimes to benefit bonytail populations in the Green River and upper Colorado River subbasins identified, implemented, evaluated, and revised (Task A-1.1), such that:

   a. Adequate spawning habitat and appropriate spawning cues (e.g., flow patterns and water temperatures) are available to maintain self-sustaining populations, as reflected by downlisting demographic criteria in section 5.3.1.1.1.

   b. Adequate nursery habitat is available to maintain self-sustaining populations, as reflected by downlisting demographic criteria in section 5.3.1.1.1.

   c. Adequate juvenile and adult habitat (e.g., cover, resting, and feeding areas) are available to maintain self-sustaining populations,

as reflected by downlisting demographic criteria in section 5.3.1.1.1.

2. Passage over Redlands Diversion and Grand Valley Diversion continued to allow adequate movement of bonytail in the upper Colorado River and Gunnison River (Task A-2.1).

3. Modification of Price-Stubb Dam and Government Highline Dam initiated to allow adequate movement of bonytail in the upper Colorado River and Gunnison River (Task A-2.2).

4. Investigations initiated on the feasibility of modifying releases from Aspinall Unit dams to increase water temperatures in the Gunnison River that would allow for upstream range expansion of bonytail (Task A-3.1).

5. Measures identified to minimize entrainment of subadult and adult bonytail at problematic diversion structures (Task A-4.1).

6. Habitats identified that are necessary for the establishment and maintenance of bonytail populations in the Green River and upper Colorado River subbasins (Task A-5.1).

Factor B.—Protection from overutilization for commercial, recreational, scientific, or educational purposes.

7. Overutilization of bonytail for commercial, recreational, scientific, or educational purposes reevaluated and, if necessary, actions identified to ensure adequate protection (Task B-1.1).

Factor C.—Adequate protection from diseases and predation.

8. Effects of diseases and parasites on bonytail populations reevaluated and, if necessary, actions identified to ensure adequate protection (Task C-1.1).

9. Procedures developed, implemented, evaluated, and revised for stocking nonnative fish species in the Upper Colorado River Basin to minimize negative interactions between nonnative fishes and bonytail (Task C-2.1).

10. Control programs for small-bodied nonnative fishes in nursery habitats in river reaches occupied by young bonytail developed and implemented to identify levels of control that will minimize predation (Task C-3.1).

11. Channel catfish control programs in river reaches occupied by bonytail developed and implemented to identify levels of control that will minimize predation (Task C-3.3)

12. Northern pike control programs in reaches of the Yampa and middle Green rivers occupied by bonytail developed and implemented to identify levels of control that will minimize negative interactions (Task C-3.5).

Factor D.—Adequate existing regulatory mechanisms.

13. Mechanisms determined for legal protection of adequate habitat (Task D-1.1).

14. Elements of conservation plans identified that are necessary to provide for the long-term management and protection of bonytail populations (Task D-2.1).

Factor E.—Other natural or manmade factors for which protection has been provided.

15. Risk of hybridization to bonytail populations evaluated and, if necessary, actions identified to minimize the risk (Task E-1.1).

16. State and Federal hazardous-materials spills emergency-response plans reviewed and modified to ensure adequate protection for bonytail populations from hazardous-materials spills (Task E-2.1).

17. Locations of all petroleum-product pipelines within the 100-year floodplain of critical habitat identified and the need for emergency shut-off valves assessed (Task E-2.3).

18. Actions identified for remediation of groundwater contamination at the Atlas Mills tailings pile located near Moab, Utah (Task E-3.1).

5.3.1.2.2 Lower basin recovery unit

Factor A.—Adequate habitat and range for recovered populations provided.

1. Flow regimes that are necessary for the establishment and maintenance of bonytail populations in the mainstem and/or tributaries identified, implemented, evaluated, and revised (Task A-1.1), such that:

    a. Adequate spawning habitat and appropriate spawning cues (e.g., flow patterns and water temperatures) are available to maintain self-sustaining populations, as reflected by downlisting demographic criteria in section 5.3.1.1.2.

b. Adequate nursery habitat is available to maintain self-sustaining populations, as reflected by downlisting demographic criteria in section 5.3.1.1.2.

c. Adequate juvenile and adult habitat (e.g., cover, resting, and feeding areas) are available to maintain self-sustaining populations, as reflected by downlisting demographic criteria in section 5.3.1.1.2.

2. Measures identified to minimize entrainment of subadult and adult bonytail at problematic diversion and/or out-take structures (Task A-2.1).

3. Habitats identified that are necessary for the establishment and maintenance of bonytail populations in the mainstem and/or tributaries (Task A-3.1).

Factor B.—Protection from overutilization for commercial, recreational, scientific, or educational purposes.

4. Overutilization of bonytail for commercial, recreational, scientific or educational purposes reevaluated and, if necessary, actions identified to ensure adequate protection (Task B-1.1).

Factor C.—Adequate protection from diseases and predation.

5. Effects of diseases and parasites on bonytail populations reevaluated and, if necessary, actions identified to ensure adequate protection (Task C-1.1).

6. Procedures developed, implemented, evaluated, and revised for stocking and to minimize escapement of nonnative fish species into the mainstem, floodplain, and tributaries to minimize negative interactions between nonnative fishes and Colorado pikeminnow (Task C-2.1).

7. Control programs for problematic nonnative fishes in the mainstem, floodplain, and tributaries developed and implemented to identify levels of control that will minimize negative interactions between nonnative fishes and bonytail (Task C-3.1).

Factor D.—Adequate existing regulatory mechanisms.

8. Mechanisms determined for legal protection of adequate habitat (Task D-1.1).

9. Elements of conservation plans identified that are necessary to provide for the long-term management and protection of bonytail populations (Task D-2.1).

Factor E.—Other natural or manmade factors for which protection has been provided.

10. Risk of hybridization to bonytail populations evaluated and, if necessary, actions identified to minimize the risk (Task E-1.1).

5.3.2 Delist criteria

5.3.2.1 Demographic criteria for delisting (population demographics in both recovery units must be met in order to achieve delisting)

5.3.2.1.1 Upper basin recovery unit

Green River Subbasin

1. A self-sustaining population is maintained over a 3-year period beyond downlisting, starting with the first point estimate acceptable to the Service, such that:

    a. the trend in adult (age 4+; ≥250 mm TL) point estimates does not decline significantly, and

    b. mean estimated recruitment of age-3 (150–249 mm TL) naturally produced fish equals or exceeds mean annual adult mortality, and

    c. each point estimate exceeds 4,400 adults (MVP).

Upper Colorado River Subbasin

2. A self-sustaining population is maintained over a 3-year period beyond downlisting, starting with the first point estimate acceptable to the Service, such that:

    a. the trend in adult (age 4+; ≥250 mm TL) point estimates does not decline significantly, and

    b. mean estimated recruitment of age-3 (150–249 mm TL) naturally produced fish equals or exceeds mean annual adult mortality, and

    c. each point estimate exceeds 4,400 adults (MVP).

5.3.2.1.2 Lower basin recovery unit

1. A genetic refuge (e.g., in Lake Mohave, Lake Havasu, or other suitable locations) is maintained over a 3-year period beyond downlisting.

2. Two self-sustaining populations (e.g., mainstem and/or tributaries) are maintained over a 3-year period beyond downlisting, starting with the first point estimate acceptable to the Service, such that for each population:

   a. the trend in adult (age 4+; ≥250 mm TL) point estimates does not decline significantly, and

   b. mean estimated recruitment of age-3 (150–249 mm TL) naturally produced fish equals or exceeds mean annual adult mortality, and

   c. each point estimate exceeds 4,400 adults (MVP).

5.3.2.2 Recovery factor criteria for delisting (recovery factor criteria in both recovery units must be met in order to achieve delisting)

5.3.2.2.1 Upper basin recovery unit

Factor A.—Adequate habitat and range for recovered populations provided.

1. Flow regimes provided that are necessary for all life stages of bonytail to support recovered populations in the mainstem and/or tributaries (Task A-1.2), such that:

   a. Adequate spawning habitat and appropriate spawning cues (e.g., flow patterns and water temperatures) are available to maintain self-sustaining populations, as reflected by delisting demographic criteria in section 5.3.2.1.1.

   b. Adequate nursery habitat are available to maintain self-sustaining populations, as reflected by delisting demographic criteria in section 5.3.2.1.1.

   c. Adequate juvenile and adult habitat (e.g., cover, resting, and feeding areas) are available to maintain self-sustaining populations, as reflected by delisting demographic criteria in section 5.3.2.1.1.

2. Passage over Redlands Diversion and Grand Valley Diversion continued to allow adequate movement of bonytail in the upper Colorado River and Gunnison River (Task A-2.1).

3. Modification of Price-Stubb Dam and Government Highline Dam completed to allow adequate movement of bonytail in the upper Colorado River (Task A-2.2).

4. Releases from Aspinall Unit dams to increase water temperatures in the Gunnison River are modified, if determined feasible and necessary to achieve demographic criteria for the upper Colorado River subbasin (see section 5.3.2.1.1), to allow for upstream range expansion of bonytail (Task A-3.2).

5. Devices installed and/or measures implemented at problematic diversion structures to minimize entrainment of subadult and adult bonytail (Task A-4.2).

6. Habitats provided for all life stages of bonytail that are necessary to support recovered populations in the Green River and upper Colorado River subbasins (Task A-5.2).

Factor B.—Protection from overutilization for commercial, recreational, scientific, or educational purposes.

7. Adequate protection of bonytail populations from overutilization for commercial, recreational, scientific, or educational purposes attained (Task B-1.2).

Factor C.—Adequate protection from diseases and predation.

8. Adequate protection of bonytail populations from deleterious diseases and parasites attained (Task C-1.2).

9. Procedures finalized and implemented for stocking nonnative fish species in the Upper Colorado River Basin to minimize negative interactions between nonnative fishes and bonytail (Task C-2.2).

10. Identified levels of small-bodied nonnative fish control to minimize negative interactions attained in nursery habitats in river reaches occupied by young bonytail (Task C-3.2).

11. Identified levels of channel catfish control to minimize negative interactions attained in river reaches occupied by bonytail (Task C-3.4).

12. Identified levels of northern pike control to minimize negative interactions attained in reaches of the Yampa and middle Green rivers occupied by bonytail (Task C-3.6).

Factor D.—Adequate existing regulatory mechanisms.

13. Habitat necessary to provide adequate habitat and sufficient range for all life stages of bonytail to support recovered populations in the Green River and upper Colorado River subbasins is legally protected in perpetuity (Task D-1.2).

14. Conservation plans developed and implemented, and agreements among State agencies, Federal agencies, American Indian tribes, and other interested parties executed to provide reasonable assurances that conditions needed for recovered bonytail populations will be maintained (Task D-2.2).

Factor E.—Other natural or manmade factors for which protection has been provided.

15. Adequate protection of bonytail populations from hybridization attained (Task E-1.2).

16. State and Federal emergency-response plans implemented that contain the necessary preventive measures for hazardous-materials spills (Task E-2.2).

17. Emergency shut-off valves installed on all problematic petroleum-product pipelines within the 100-year floodplain of critical habitat (Task E-2.4).

18. Groundwater contamination remediated at the Atlas Mills tailings pile located near Moab, Utah, and water quality of the Colorado River in the vicinity of the pile restored in compliance with the State of Utah and EPA water-quality standards for fish and wildlife (Task E-3.2).

5.3.2.2.2 Lower basin recovery unit

Factor A.—Adequate habitat and range for recovered populations provided.

1. Flow regimes provided that are necessary for all life stages of Colorado pikeminnow to support recovered populations in the mainstem and/or tributaries (Task A-1.2), such that:

    a. Adequate spawning habitat and appropriate spawning cues (e.g., flow patterns and water temperatures) are available to maintain self-sustaining populations, as reflected by delisting demographic criteria in section 5.3.2.1.2.

b. Adequate nursery habitat are available to maintain self-sustaining populations, as reflected by delisting demographic criteria in section 5.3.2.1.2.

c. Adequate juvenile and adult habitat (e.g., cover, resting, and feeding areas) are available to maintain self-sustaining populations, as reflected by delisting demographic criteria in section 5.3.2.1.2.

2. Devices installed and/or measures implemented at problematic diversion and/or out-take structures to minimize entrainment of subadult and adult bonytail (Task A-2.2).

3. Habitats provided for all life stages of bonytail that are necessary to support recovered populations in the mainstem and/or tributaries (Task A-3.2).

Factor B.—Protection from overutilization for commercial, recreational, scientific, or educational purposes.

4. Adequate protection of bonytail from overutilization for commercial, recreational, scientific, or educational purposes attained (Task B-1.2).

Factor C.—Adequate protection from diseases and predation.

5. Adequate protection of bonytail populations from deleterious diseases and parasites attained (Task C-1.2).

6. Procedures finalized and implemented for stocking nonnative fish species in the mainstem, floodplain, and tributaries to minimize negative interactions between nonnative fishes and bonytail (Task C-2.2).

7. Identified levels of nonnative fish control to minimize negative interactions between nonnative fishes and bonytail attained in the mainstem, floodplain, and tributaries (Task C-3.2).

Factor D.—Adequate existing regulatory mechanisms.

8. Habitat necessary to provide adequate habitat and sufficient range for all life stages of bonytail to support recovered populations is legally protected in perpetuity (Task D-1.2).

9. Conservation plans developed and implemented, and agreements among State agencies, Federal agencies, American Indian tribes, and other

interested parties executed to provide reasonable assurances that conditions needed for recovered bonytail populations will be maintained (Task D-2.2).

Factor E.—Other natural or manmade factors which protection has been provided.

10. Adequate protection of bonytail populations from hybridization attained (Task E-1.2).

5.4 Estimated Time To Achieve Recovery of the Bonytail

Wild bonytail are rare. Therefore, use of hatchery fish (progeny of cultured brood stock) will be necessary to establish new populations. Time to achieve recovery of the bonytail cannot be accurately estimated until self-sustaining populations are established through augmentation and habitat enhancement. The rate at which populations become established will depend on survival of stocked fish in the wild, integration of stocked fish with rare wild stocks, reproductive success, and recruitment. Response of the species to ongoing management activities will need to be assessed through monitoring, and strategies for recovery and estimates of time to achieve recovery will be reevaluated periodically. Based on current information and associated uncertainties, it is estimated that self-sustaining populations of bonytail will become established over the next 15 years. During this time, population dynamics and responses to management actions will be evaluated.

For the bonytail population to be self-sustaining, adults must reproduce and recruitment of young fish into the adult population must occur at a rate to maintain the population at a minimum of 4,400 adults. When this occurs, the definition of a “self-sustaining” population is met, and the “clock” starts on the downlisting and delisting process.

Once self-sustaining populations have been established, estimated time to achieve recovery of the bonytail is 5 years for downlisting and an additional 3 years for delisting. Self-sustaining populations and first reliable point estimates for all populations are expected by 2015. If those estimates are acceptable to the Service and all recovery criteria are met, downlisting could be proposed in 2020 and delisting could be proposed in 2023 (Figure 2).

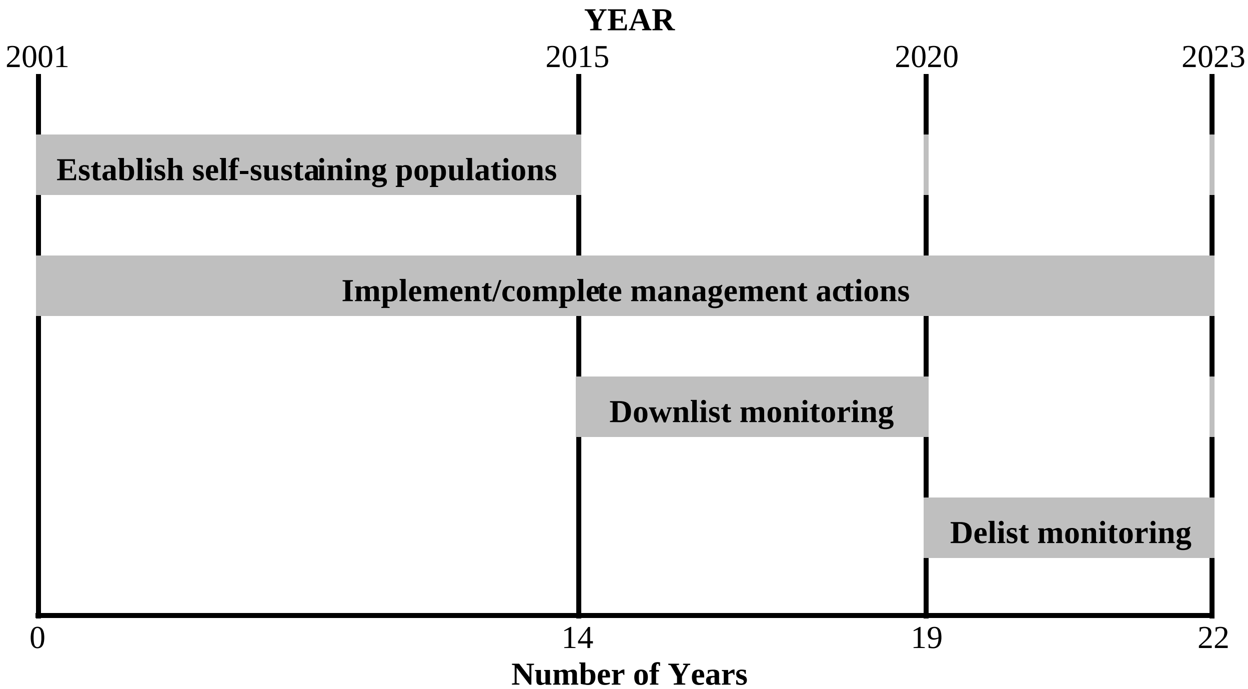

Figure 2. Estimated time to achieve recovery of the bonytail.

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APPENDIX A.

LIFE HISTORY OF THE BONYTAIL

Following is a synopsis of bonytail life history. This assimilation of information represents an overview of the best scientific information available for the species at this time. Additional and more detailed information can be found in literature cited in this document and in reports and publications referenced in those citations.

A.1 Species Description

The bonytail was originally collected and described from the Zuni River, New Mexico, of the Lower Colorado River Basin in 1853 by Baird and Girard of the Sitgreaves Expedition (Sitgreaves 1853; Girard 1856). It is commonly referred to as "bonytail chub", a name that has also been applied to other chubs of the Colorado River basin, including roundtail chub (*Gila robusta*) and humpback chub (*G. cypha*). The bonytail is a streamlined fish with a small head, slender body, and pencil-thin caudal peduncle. The head is flattened, the mouth is slightly overhung by the snout, and there is a small, smooth fleshy hump behind the head of adults; the hump is smaller than that of humpback chub. This species attains a maximum size of about 550 mm total length (TL; Bozek et al. 1994) and 1.1 kg in weight (Vanicek 1967). The color is dark gray above fading to a white belly, with yellow pigment at the base of the paired fins (pelvic and pectoral). Like the humpback chub, adult bonytail in spawning condition exhibit small pimple-like tubercles on the head and fins. There are usually 10 dorsal fin rays and 10 anal fin rays (Holden 1968). Caudal peduncle length divided by head length is 1.0 or more and head length divided by caudal peduncle depth is usually 5.0 or more (Minckley 1973). The body is mostly scaled with 75–88 along the lateral line. The scales are not as deeply embedded as in humpback chub, and they are present in small numbers on the nape, belly, and breast. Pharyngeal teeth formula is 2,5-4,2.

Bonytail are sometimes confused with the two sympatric species of Colorado River chubs—roundtail chub and humpback chub. This confusion occurs primarily with young fish that resemble the slender green and silvery young of the other species. The variability in dorsal and anal ray counts also precludes confident field identification where the three species coexist (Holden 1968). With adults, problems in identification may occur with species variants resulting from morphologic plasticity among the *Gila* complex (Douglas et al. 1998) and introgressive hybridization (Dowling and DeMarais 1993).

A.2 Distribution and Abundance

Bonytail were once widespread in the large rivers of the Colorado River Basin (Cope and Yarrow 1875; Jordan 1891; Jordan and Evermann 1896; Gilbert and Scofield 1898; Kirsch 1889; Chamberlain 1904). The species experienced a dramatic, but poorly documented, decline starting in about 1950, following construction of mainstem dams, introduction of nonnative fishes, poor land-use practices, and degraded water quality (Miller 1961; Ono et al. 1983).

Population trajectory over the past century and reasons for decline are unclear because lack of basin-wide fishery investigations precluded accurate distribution and abundance records. Also, interchangeable use of the name "bonytail" with two congeneric, sympatric species—humpback chub and roundtail chub—led to confusion in historic collections (Quartarone 1993). A photograph in Quartarone (1993) shows eight bonytail-like fish taken from the Colorado River near Moab, Utah, where none were otherwise reported.

Early collections of bonytail in the lower basin include 16 specimens from Grand Canyon (Miller 1944). The last large concentration of bonytail was seen in 1954 when about 500 adults were observed spawning over a gravel shelf in Lake Mohave, Arizona-Nevada (Jonez and Sumner 1954). Of the 34 adult bonytail captured in Lake Mohave between 1976 and 1988 (Minckley et al. 1989), 11 were used as the original brood stock (Hamman 1981, 1982, 1985). An additional 16 fish were collected from Lake Mohave in 1988–1989 (U.S. Fish and Wildlife Service 1990a).

The first record of bonytail from the upper basin was *"One specimen taken in the Gunnison at Delta; five in the Green River..."* in 1889 (Jordan 1891). There are also records of two fish collected in 1889 from an unknown location of the Green River (Bookstein et al. 1985). Ellis (1914) synonymized bonytail with roundtail chub *"...since intermediate forms and those agreeing with the descriptions of both species were taken from the same station in the Grand* [Colorado] *River at Grand Junction"*. This difficulty in segregating the species of Colorado River chubs persists today. Gaufin et al. (1960) and Smith (1960) reported bonytail from Hideout Canyon, Utah (upper Green River), before it was inundated by Flaming Gorge Reservoir, but the numbers and sizes are unknown because they were grouped with humpback chub and roundtail chub. Two bonytail *"...were observed washed up on the sandbars and banks near the ranger station..."* on the Green River in Dinosaur National Monument on September 9, 1962, following rotenone treatment (Banks 1964). "Bonytail chub" together with roundtail and humpback chub, were reported from the mouth of the Black's Fork River downstream through Flaming Gorge (Bosley 1960). This complex composed 7.3% of all fish taken in the Green River from Green River, Wyoming, to the Utah-Colorado state line (McDonald and Dotson 1960). Individuals were collected from the base of Flaming Gorge Dam in 1962 and from Little Hole (10 km below the dam) and are housed at the University of Michigan (personal communication, R. Miller, University of Michigan; Bookstein et al. 1985). Unknown numbers of bonytail were poisoned by the rotenone treatment of the Green River in Flaming Gorge in 1962 (Holden 1991).

Following closure of the Flaming Gorge Dam in 1963, bonytail were extirpated from about 105 km of the Green River between the dam and the Yampa River, primarily because of previous rotenone poisoning and cold-water releases from dam operations. Further downstream (below the Yampa River), bonytail outnumbered roundtails for the 1959, 1960, and 1961 year classes in the Green River in Dinosaur National Monument (Vanicek and Kramer 1969). But by the period 1967–1973, Holden and Stalnaker (1975) reported a scarcity of the species in the same area. Later, Joseph et al. (1977) reported catching two bonytail from the Green River below Jensen. Bonytail were seen in Lake Powell on the Colorado River soon after closure in 1962 (personal communication, K. Miller, Utah Division of Wildlife Resources) but are now rarely found in the Green River and Colorado River subbasins.

The last significant numbers of bonytail captured in the upper basin were in the Green River below the confluence of the Yampa River shortly after the closure of Flaming Gorge Dam; Vanicek and Kramer (1969) collected 67 bonytail > 200 mm TL during 1964–1966 in Dinosaur National Monument, Colorado. Holden and Stalnaker (1975) reported 36 bonytail during 1967–1973 from the lower Yampa River in Colorado, and the Green River between the confluence of the Yampa River and the confluence of the Colorado River, including Desolation/Gray Canyons, Utah. One bonytail (~330 mm TL) was caught by an angler at Antelope Canyon, near Wahweap Bay, Utah, on Lake Powell on September 4, 1977 (Gustaveson et al. 1985) and preserved by Utah Division of Wildlife Resources (UDWR). One adult bonytail was also captured in the lower Yampa River in 1979 (Holden and Crist 1981), and one adult was captured and released at Coal Creek Rapid in the Green River in Gray Canyon, Utah, in 1981 (Tyus et al. 1982). Kaeding et al. (1986) captured and released one adult bonytail (458 mm TL) in the Colorado River at Black Rocks, Colorado, on July 17, 1984. A fisherman brought a live bonytail (~380 mm TL) angled from Lake Powell near Wahweap Bay, Utah, to UDWR in 1985 (personal communication, R. Radant, Utah Division of Wildlife Resources). The fish died later in captivity and was identified by Mark Rosenfeld of the University of Utah (personal communication) as a bonytail; a taxidermy mount was made of this specimen and is on display at the University of Utah Natural History Museum. Two adult bonytail were captured, photographed, and released in Desolation/Gray Canyons in 1985 (Moretti et al. 1989). Also, four adult bonytail were reported from Cataract Canyon in 1985–1988 (Valdez 1990; Valdez and Williams 1993).

A.3 Hybridization

Intraspecific and interspecific morphological variation is extensive where humpback chub, roundtail chub, and bonytail occur sympatrically. This apparent introgressive hybridization has resulted in high phenotypic plasticity with morphologic intergrades present in all sympatric populations of Colorado River *Gila* (Holden and Stalnaker 1970; Smith et al. 1979; Valdez and Clemmer 1982; McElroy and Douglas 1995; Douglas et al. 1989, 1998; Kaeding et al. 1990). These intergrades suggest, to some, extensive hybridization with possible concomitant loss of genetic diversity and evolutionary adaptive traits (Valdez and Clemmer 1982; Rosenfeld and Wilkinson 1989). Dowling and DeMarais (1993) hypothesized that introgressive hybridization is part of the common evolutionary history of the Colorado River *Gila*, resulting in high phenotypic plasticity and adaptability to the rigorous physical habitats present in the Colorado River Basin. Evidence of intergrades was reported prior to extensive human alterations to the basin (Miller 1946).

The bonytail is part of a morphologically diverse group of western cyprinids that includes several congeneric species. This *Gila* complex consists of six forms that inhabit the Colorado River Basin, including the humpback chub, bonytail, roundtail chub, Virgin River chub *(G. robusta seminuda)*, Pahranagat roundtail chub *(G. r. jordani)*, and Gila chub *(G. intermedia)*. The humpback chub, bonytail, and roundtail chub are mainstem sympatric species with substantial evidence of introgressive hybridization (Dowling and DeMarais 1993), whereas the Virgin River chub, Pahranagat roundtail chub, and Gila chub are isolates and primarily lower Colorado River tributary inhabitants, although historic hybridization with other forms of *Gila* is evident.

Humpback chub and bonytail appear to be specialized derivatives of the roundtail chub complex, and may have arisen in response to special conditions in large erosive habitats (Smith et al. 1979; Minckley et al. 1989); a hypothesis that is supported by recent allozyme and mitochondrial DNA analysis (Dowling and DeMarais 1993).

Because only two of the three congeneric and sympatric species of the *Gila* complex are federally listed as endangered (i.e., humpback chub and bonytail), fish managers are compelled to distinguish these from the non-listed roundtail chub. Morphologic variation in these species has led to confusion in field identification, especially for young fish (Douglas et al. 1989, 1998). This confusion has precluded accurate assessment of life-history characteristics attributable to one species and definitive estimates of abundance (Chart and Lentsch 1999, 2000).

The effect of hybridization on the *Gila* species is unclear, and the factors that lead to increased hybridization of bonytail are unknown because there are no reproducing populations in the wild. Current levels of hybridization are not considered singly significant in the decline of the bonytail. The only population where hybridization of bonytail is suspected, based on morphological and morphometric examination of a limited number of specimens, is Cataract Canyon (Valdez 1990; McElroy and Douglas 1995). The incidence and potential effect of hybridization on bonytail will need to be evaluated as fish are released into the wild, and populations become established in proximity and/or sympatry with the other *Gila* species.

A.4 Habitat

Little is known about the specific habitat requirements of bonytail because the species was extirpated from most of its historic range prior to extensive fishery surveys. The bonytail is considered adapted to mainstem rivers where it has been observed in pools and eddies. Similar to other closely related *Gila* spp., bonytail in rivers probably spawn in spring over rocky substrates; spawning in reservoirs has been observed over rocky shoals and shorelines. It is hypothesized, based on available distribution data, that flooded bottomland habitats are important growth and conditioning areas for bonytail, particularly as nursery habitats for young. Flow recommendations have been developed that specifically consider flow-habitat relationships within historic habitat of bonytail in the upper basin, and were designed to enhance habitat complexity and to restore and maintain ecological processes (see section 4.1). The following is a description of observed habitat uses in various parts of the Colorado River Basin.

It has been suggested that the large fins and streamlined body of the bonytail is an adaptation to torrential flows (Miller 1946; Beckman 1963). Of five specimens captured recently in the upper basin, four were captured in deep, swift, rocky canyon regions (i.e., Yampa Canyon, Black Rocks, Cataract Canyon, and Coal Creek Rapid), but the fifth was taken in a reservoir (Lake Powell). Also, all fish taken from the lower basin since 1974 were caught in reservoirs. Specimens encountered in reservoirs are believed to be inhabiting their former habitats now inundated by these impoundments. Vanicek (1967) who handled numerous bonytail detected no difference in habitat selection from roundtail chub. These fish were generally found in pools and eddies in the absence of, although occasionally adjacent to, strong current and at varying depths generally over silt and silt-boulder substrates. No quantitative data are available for the habitat

of this species. It is hypothesized, based on historic and present distributions, that flooded bottomlands provide important nursery, growth, and conditioning habitats for bonytail. Adult bonytail captured in Cataract Canyon and Desolation/Gray Canyons were sympatric with humpback chub in shoreline eddies among emergent boulders and cobble, and adjacent to swift current (Valdez 1990).

A.5 Movement

Movement of 20 hatchery-reared bonytail released in Lake Mohave in 1996 and 1997 was monitored with the use of short-term telemetry (Marsh and Mueller 1999). Sonic tags were surgically implanted in the fish, and movement was monitored for 62 to 119 days. Cumulative distance traveled averaged 28.9 km and ranged from 19.9 to 33.0 km. Most fish were located in deep water adjacent to steep shorelines during daytime, and the fish moved to shallow shorelines at night. This movement information and capture observations corroborate that bonytail use shallow, gravel points along the lake shore.

A.6 Reproduction

Natural reproduction of bonytail was last documented in the Green River in Dinosaur National Monument for the year classes 1959, 1960, and 1961 (Vanicek and Kramer 1969). Ripe spawning fish were captured from mid-June to early July at a water temperature of 18°C. Spawning by bonytail and roundtail chub was believed to be spatially separated because ripe adults of both species were never captured in the same net.

Jonez and Sumner (1954) described the spawning act of bonytail in Lake Mohave. Approximately 500 bonytail were observed spawning over a gravel shelf up to 30 feet in depth. Each female had three to five male escorts, and adhesive eggs were broadcast over the gravel shelf. A gill net in the spawning area captured 42 males and 21 females ranging from about 280 to 350 mm (fork length); a 300-mm female contained an estimated 10,000 eggs. Vanicek (1967) reported wild bonytail of age groups V–VII in spawning condition. Hamman (1985) found that hatchery-reared bonytail began to sexually mature at age 2.

In a hatchery, adult bonytails (487–564 mm TL) yielded an average of 25,090 eggs per female (Hamman 1982). Incubation was shortest (99–174 h) and egg survival, hatching success, and fry survival were highest at 20–21°C, compared to 16–17°C and 12–13°C. Hamman (1982) found that eggs incubated at 16–17°C had only 55% survival, and those incubated at 12–13°C had only 4% survival. Survival at 20–21°C was 90%. Newly hatched fry averaged 6.8 mm TL. Over 83,500 hatchery-reared bonytail had been released by 1985 into the wild, all into Lake Mohave in the lower basin (Valdez 1985).

A.7 Survival

No estimates of survival are available for wild bonytail.

A.8 Predation

Nonnative fishes dominate the ichthyofauna of Colorado River Basin rivers, and certain species have been implicated as contributing to reductions in the distribution and abundance of native fishes (Carlson and Muth 1989). At least 67 species of nonnative fishes have been introduced into the Colorado River Basin during the last 100 years (Tyus et al. 1982; Carlson and Muth 1989; Minckley and Deacon 1991; Maddux et al. 1993; Tyus and Saunders 1996; Pacey and Marsh 1998). Tyus et al. (1982) reported that 42 nonnative fish species have become established in the upper basin, and Minckley (1985) reported that 37 nonnative fish species have become established in the lower basin. Many of these species were intentionally introduced as game or forage fishes, whereas others were unintentionally introduced with game species or passively as bait fish. Potential negative interactions (i.e., predation and competition) between nonnative and native fishes have been identified (e.g., Tyus and Beard 1990; Minckley 1991; Hawkins and Nesler 1991; Ruppert et al. 1993; Lentsch et al. 1996; Tyus and Saunders 1996; Pacey and Marsh 1998).

The threat of predation by nonnative fishes on the closely related humpback chub has been recognized in three populations. In Grand Canyon, brown trout (*Salmo trutta*), channel catfish (*Ictalurus punctatus*), black bullhead (*Ameiurus melas*), and rainbow trout (*Oncorhynchus mykiss*) have been identified as principal predators of juvenile humpback chub, with consumption estimates that suggest loss of complete year classes to predation (Marsh and Douglas 1997; Valdez and Ryel 1997). Marsh and Douglas (1997) documented predation on humpback chub in the LCR by rainbow trout, channel catfish, and black bullhead. Valdez and Ryel (1997) identified brown trout, rainbow trout, and channel catfish as known predators of humpback chub in Grand Canyon, and suggested that common carp (*Cyprinus carpio*) could be a significant predator of incubating humpback chub eggs in the LCR . In the upper basin, Chart and Lentsch (2000) identified channel catfish as the principal predator of humpback chub in Desolation/Gray Canyons. The UCRRP identified channel catfish as the principal predator of humpback chub in Yampa Canyon and is pursuing development and implementation of a control program.

A.9 Age and Growth

The only extensive study on age and growth of the bonytail is by Vanicek (1967). Of 67 bonytail aged by scales, the oldest and largest was 7 years old, 338 mm TL, and weighed 422 g. The age of putative bonytail captured in Cataract Canyon was not determined, but their length was comparable to the maximum length of 388 mm TL recorded by Vanicek and Kramer (1969) for a fish estimated to be 7 years old. Seven bonytail collected by Bozek et al. (1984) from Lake Mohave were 475–535 mm TL; the largest seen from Lake Havasu was 489 mm TL (Minckley 1973). Two bonytail from Lake Mohave were estimated to be 32 and 39 years old, based on otolith annuli (Ulmer 1983). Examination of otoliths from four bonytail from Lake Mohave indicated ages of 34, 40, 42, and 49 years (Rinne et al. 1986).

A.10 Length-Weight and Condition Factor

Vanicek (1967) reported a length-weight relationship of log W = -4.7899 + 2.860 (log L) for 67 bonytail greater than 200 mm TL collected from the Green River downstream of the Yampa River.

A.11 Diet

Little is known of the food habits of the bonytail. McDonald and Dotson (1960) reported that *"Colorado chub"* were largely omnivorous with a diet of terrestrial insects, plant matter, and fish. Several chubs were observed feeding on floating masses of debris washed by heavy rainfall. Vanicek (1967) reported that *"Colorado chubs"* fed mainly on terrestrial insects (mostly adult beetles and grasshoppers), plant debris, leaves, stems, and woody fragments.

A.12 Parasites

The only records of parasites from wild bonytail are from Hagen and Banks (1963) and Vanicek (1967). Both studies reported the anchor worm, *Lernea* sp., was commonly found attached to the base of fins or on gills of *"Colorado chubs"* in the Green River in Dinosaur National Monument.