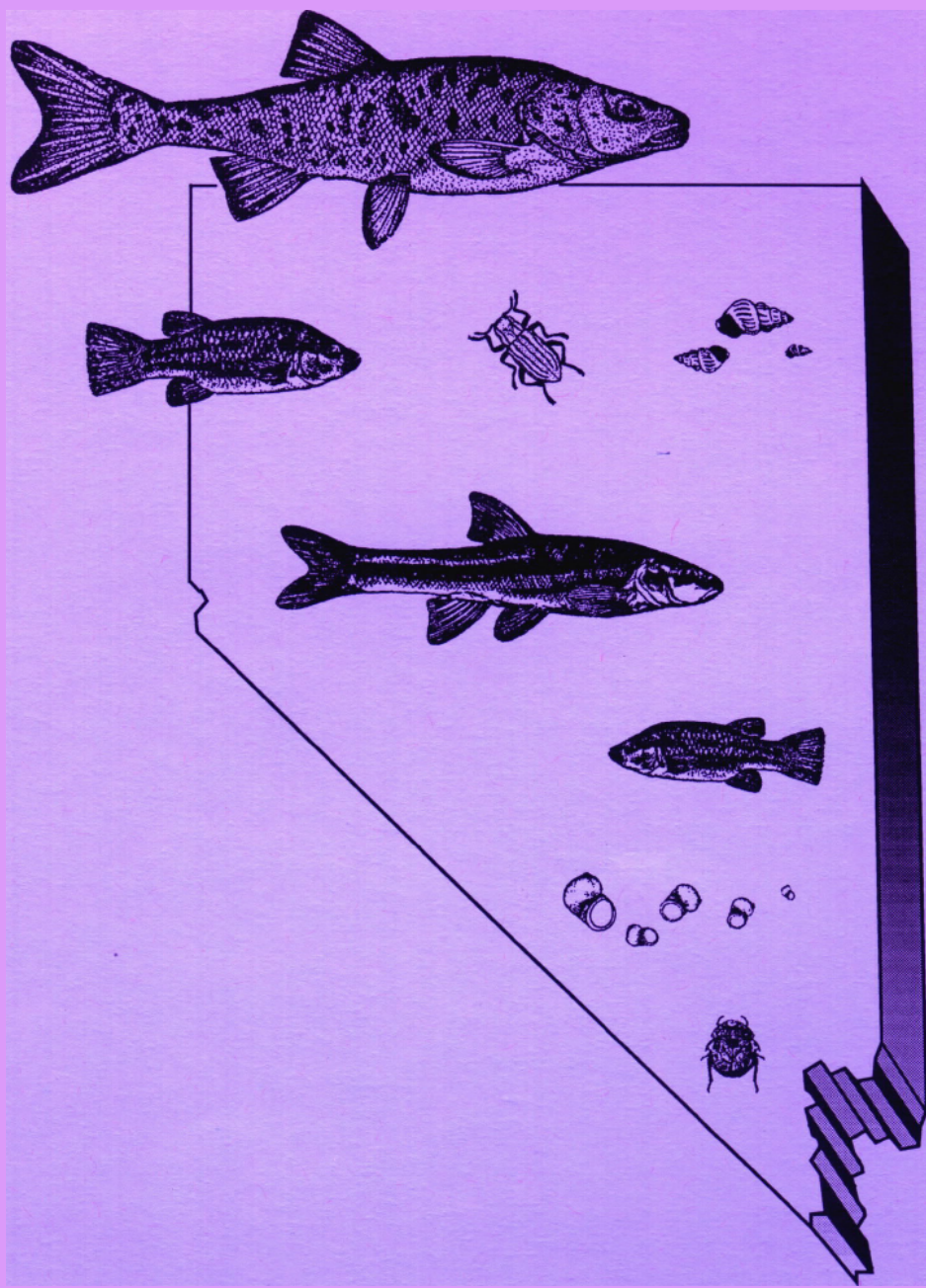


Recovery Plan for the Aquatic and Riparian Species of Pahrnagat Valley


*Region 1
Portland, Oregon*



RECOVERY PLAN
FOR THE
AQUATIC AND RIPARIAN
SPECIES OF
PAHRANAGAT VALLEY

U.S. Fish and Wildlife Service
Region 1
Portland, Oregon

Approved:



Regional Director, U.S. Fish and Wildlife Service

Date:

5/26/98

This plan covers the following federally listed species in Pahrnagat Valley: Pahrnagat roundtail chub, White River springfish and Hiko White River springfish.

DISCLAIMER

Recovery plans delineate reasonable actions that are believed to be required to recover and protect listed species. Plans are published by the U.S. Fish and Wildlife Service, sometimes prepared with the assistance of recovery teams, contractors, State agencies, and others. This document was prepared by the U.S. Fish and Wildlife Service, Reno Fish and Wildlife Office, Reno, Nevada. Objectives will be attained and any necessary funds made available subject to budgetary and other constraints affecting the parties involved, as well as the need to address other priorities. Recovery plans do not necessarily represent the views, official positions, nor approval of any individuals or agencies involved in the plan formulation, other than the U.S. Fish and Wildlife Service. They 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.

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Executive Summary of the Recovery Plan for Aquatic and Riparian Species of Pahrnagat Valley

Current Status: The Pahrnagat Valley in Lincoln County, Nevada, supports three native, endangered species. The Pahrnagat roundtail chub is found in approximately 3.5 kilometers (2.2 miles) of the Pahrnagat Creek and 2.5 kilometers (1.6 miles) of the main ditch, but historically occurred in over 30 kilometers (18.4 miles) of the creek. The White River springfish occupies the spring pool of Ash Spring in considerable numbers, but historically occurred in the spring pool and throughout its outflow. Hiko White River springfish are present in Hiko Spring and in Crystal Spring and its outflow. The population in Hiko Spring is stable, but the Crystal Spring population is in danger of extirpation.

Habitat Requirements and Limiting Factors: The Pahrnagat roundtail chub requires cool water to withstand warm summer temperatures. The two springfish species need waters with stable environmental parameters (especially stable vegetative cover and freedom from nonnative fishes). Primary threats to all three species include nonnative species introductions, habitat alteration, and disease.

Recovery Objective: Delisting for all three species

Recovery Criteria: The Pahrnagat roundtail chub may be considered for reclassification from endangered to threatened when:

- 1) Pahrnagat Creek/Ditch contains adequate cool water pools, for chub to persist through the summer months;
- 2) a self-sustaining Pahrnagat roundtail chub population (comprising three or more age-classes, a stable or increasing population size, and documented reproduction and recruitment) is present in a combined total of approximately 75 percent of either 6.8 kilometers (4.7 miles) of the Crystal Spring outflow stream through its confluence during the winter months with the Ash Springs outflow stream, or 10 kilometers (6.2 miles) of Pahrnagat Creek/Ditch below the confluence for three complete

generations (or a minimum of 15 consecutive years); and

3) impacts to the species and its habitat have been reduced or modified to a point where they no longer represent a threat of extinction or irreversible population decline.

The Pahrnagat roundtail chub may be considered for delisting provided that all reclassification criteria have been met and when:

1) a minimum year round in-stream flow of 1.75 cubic feet per second is present, at the point where Pahrnagat Ditch starts, to sustain a Pahrnagat roundtail chub population;

2) the riparian corridor along the outflow stream of Crystal Spring has been enhanced;

3) all impacts to its habitat have been reduced or modified sufficiently for both the species and land uses to coexist; and

4) a Pahrnagat roundtail chub population as defined in the downlisting criteria inhabits both approximately 75 percent of both the 6.8 kilometers (4.7 miles) of the Crystal Spring outflow stream through its confluence during the winter months with the Ash Springs outflow stream, and approximately 75 percent of the 10 kilometers (6.2 miles) of Pahrnagat Creek/Ditch from the beginning of Crystal and Ash Springs outflows to Upper Pahrnagat Lake.

The White River springfish may be considered for delisting when:

1) a self-sustaining White River springfish population (comprising three or more age-classes, a stable or increasing population size, and documented reproduction and recruitment) is present in the spring pools of Ash Spring for three complete generations (or a minimum of 6 consecutive years); and

2) impacts to the species and its habitat have been reduced or modified to a

point where they no longer represent a threat of extinction or irreversible population decline.

The Hiko White River springfish may be considered for delisting when:

1) a self-sustaining Hiko White River springfish population (comprising three or more age-classes, a stable or increasing population size, and documented reproduction and recruitment) is present in the spring pools of Hiko and Crystal Springs for three complete generations (or a minimum of 6 consecutive years); and

2) impacts to the species and its habitat have been reduced or modified to a point where they no longer represent a threat of extinction or irreversible population decline.

Actions Needed:

1. Maintain and enhance aquatic and riparian habitats in Pahrnagat Valley.
2. Develop and implement monitoring plans.
3. Provide public information and education.
4. Establish and maintain populations at Dexter National Fish Hatchery, Key Pittman Wildlife Management Area, and Pahrnagat National Wildlife Refuge.

Estimated Cost for the first five years of recovery (\$1,000's):

<u>Year</u>	<u>Total</u>
1998	152
1999	102
2000	126
2001	105
2002	85

The total estimated cost for recovering the native listed species is \$ 892,00. Additional costs for a pipeline can not be determined at this time.

Date of Recovery: Delisting of the native listed fishes could be initiated in 2015, if recovery criteria are met.

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Recovery Plan for the Aquatic and Riparian Species of Pahrnagat Valley

Part I. INTRODUCTION

A. Brief Overview

Pahrnagat Valley is located in south-central Lincoln County, Nevada, approximately 148 kilometers (92 miles) north of Las Vegas, Nevada (Figure 1). It provides habitat for three fish species that have been listed as endangered, one bird species listed as endangered, and one bird species that has been listed as threatened pursuant to the Endangered Species Act of 1973, as amended (Endangered Species Act). It also provides known or potential habitat for 22 other species (1 fish, 2 snails, 2 aquatic beetles, 12 mammals, and 5 birds, Table 2) that are currently of special concern though not presently candidates for listing under the Endangered Species Act.

A recovery plan for the Pahrnagat roundtail chub (*Gila robusta jordani*) was prepared in 1985. This revised plan will update the information on Pahrnagat roundtail chub life history, abundance and distribution, food habits, population dynamics, species interactions, and recovery actions. This plan will also specify life history parameters, species interactions, and recovery actions for both the White River springfish (*Crenichthys baileyi baileyi*) and the Hiko White River springfish (*Crenichthys baileyi grandis*). In keeping with current Fish and Wildlife Service policy, this plan is designed to maintain ecosystem integrity as well as recover the three listed species.

The Pahrnagat roundtail chub was listed as an endangered species by the U.S. Fish and Wildlife Service on October 13, 1970 (35 Federal Register 16047) and has a recovery priority of 3 indicating a high degree of threat, but a high recovery potential. Though the historical range of Pahrnagat roundtail chub was all major waters in the Pahrnagat Valley, the historical population size is uncertain. Only a few Pahrnagat roundtail chub were captured from Hiko Spring, Crystal Spring, Ash Springs, and the Pahrnagat Creek during intensive investigations conducted

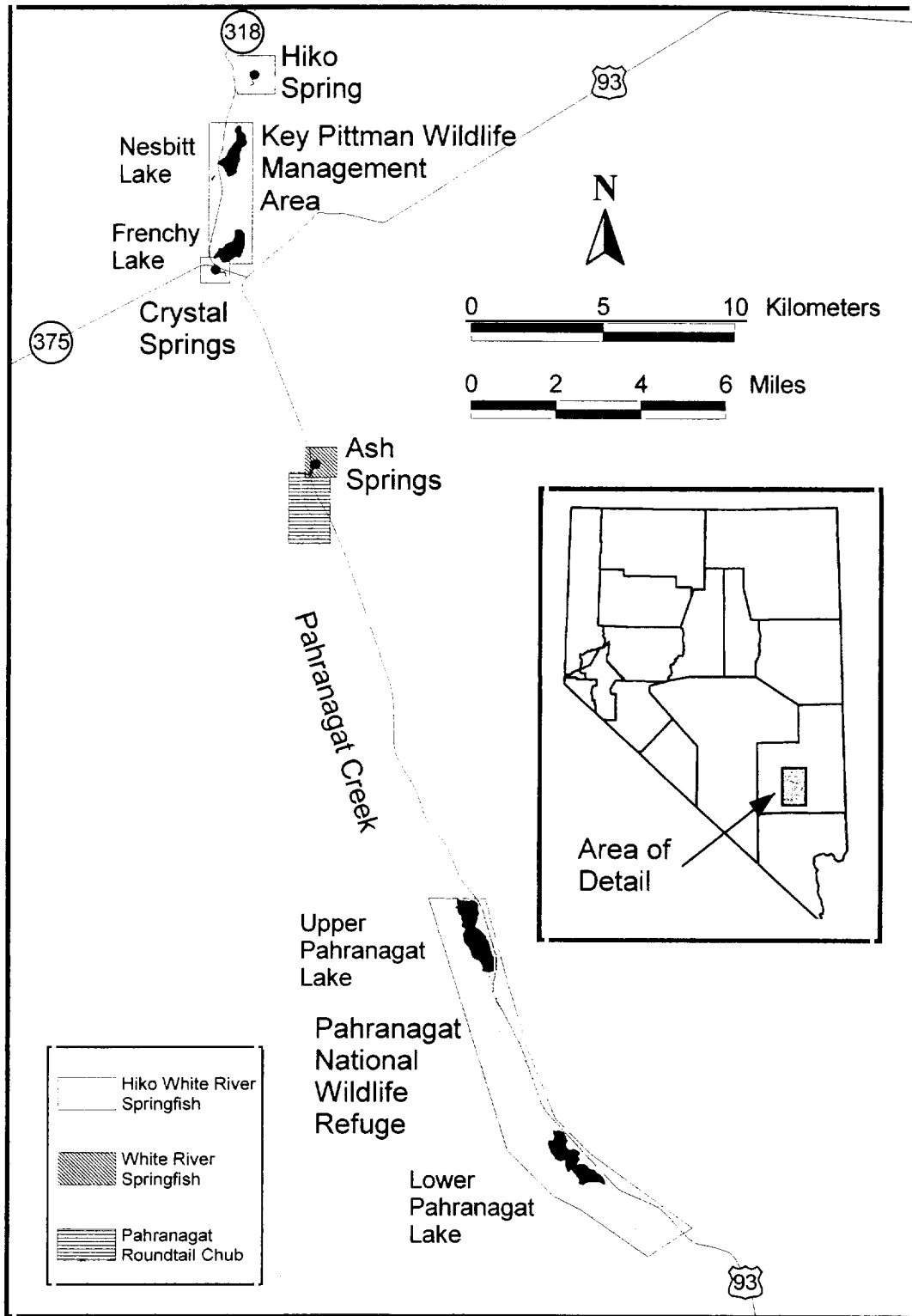


Figure 1. Present distribution of the Pahranaagat roundtail chub, Hiko White River springfish, and the White River springfish in the Pahranaagat Valley.

prior to 1950 (Tanner 1950, La Rivers 1962). Currently, this fish is restricted to approximately 3.5 kilometers (2.2 miles) of the Pahranaagat Creek, and 2.5 kilometers (1.6 miles) of irrigation ditch, and the population is estimated to contain 150 to 260 adults (Figure 1). A survey done in 1865, showed the waterway found in the valley to be a creek and the creek extended through the valley (DOI 1865). It is named Pahranaagat Creek by the United States Geological Survey-Geographic Names Information System. Since then it has been used and altered extensively for irrigation with many changes occurring to the natural waterway. The remaining portion of the waterway (16.5 kilometers, 10.2 miles) will be referred to as the Pahranaagat Ditch to reflect local customs and concerns.

Two other fishes endemic to Pahranaagat Valley, the White River springfish and the Hiko White River springfish, were listed as endangered species with respective critical habitats on September 27, 1985 (50 Federal Register 39123). Both of these species have recovery priorities of 3C indicating a high degree of threat and conflict with other resource uses, but a high recovery potential. White River springfish are restricted to the spring pool at Ash Springs, where the population has ranged from approximately 1,200 to 9,800 in the past 10 years. Hiko White River springfish occupy the pools of Hiko and Crystal Springs (Figure 1) and have been introduced into Blue Link Spring in Mineral County, Nevada (Tuttle et al. 1990). Fewer than 125 Hiko White River springfish occur in Crystal Spring, but the populations at Hiko and Blue Link Springs contained approximately 5,500 and 12,000 fish, respectively, when last surveyed in 1995.

Pahranaagat Valley is an important overwintering area for threatened bald eagles (*Haliaeetus leucocephalus*) in Nevada (60 Federal Register 36000). In 1986, three bald eagles wintered in Pahranaagat Valley (U.S. Fish and Wildlife Service 1986a). Recently, up to twelve bald eagles have been observed in the valley during the winter months (Chris Shonemen, Fish and Wildlife Service, pers. comm.). Pahranaagat Valley is an important component of the recommended bald eagle recovery strategy, which provides for well distributed populations and habitats, gene flow between subpopulations, decreased risk of catastrophic events, and different management strategies (U.S. Fish and Wildlife Service 1986a). A recovery plan exists for this wide-ranging species, so it will not be addressed further in this document.

The Southwestern willow flycatcher (*Empidonax traillii extimus*) was listed as endangered with critical habitat in 1995 (60 Federal Register 10694). Currently, the only known occurrence of this species in the Valley has been on the Pahrnat National Wildlife Refuge. The recovery plan for this wide ranging species has not yet been completed. Since recovery needs are not known at this time, this species will not be covered in this plan, though it is likely that recovery tasks that enhance riparian corridors will also benefit the Southwestern willow flycatcher. Critical habitat was designated in 1997 (62 Federal Register 39129). No critical habitat has been designated in Nevada.

The extirpation of two fishes, Pahrnat spinedace and White River desert sucker, and decline of the three fishes covered by this plan has been attributed to habitat alteration and nonnative species introductions. The recovery of the remaining fishes will require cooperation from private landowners, enhancing the compatibility of existing uses and the quality of fish habitat, and removal or control of nonnative aquatic species.

B. Species Description

Pahrnat roundtail chub - Pahrnat roundtail chub are taxonomically aligned with the roundtail chub (*Gila robusta*) complex of the Colorado River drainage (Miller 1946, Minckley 1973, Smith 1978). Tanner (1950) originally granted the Pahrnat roundtail chub specific recognition; later authors, however, recognized its similarity to other roundtail chub and redefined it as a subspecies (La Rivers 1962, Hubbs et al. 1974). Research conducted recently determined the Pahrnat roundtail chub is a distinct subspecies (DeMarais 1993). Pahrnat roundtail chub are most similar to roundtail chub in the Colorado River and its larger tributaries, but have more scales in, above, and below the lateral line; are less elongate; and are greenish in color with black blotches (Tanner 1950, La Rivers 1962). Pahrnat roundtail chub are elongate fish with a narrow caudal peduncle (the area from the base of the anal fin to tip of the fin at the end of the tail) and a deeply incised caudal fin (at the end of the tail). They obtain a total length of approximately 25 centimeters (10 inches).

White River springfishes - The common name of the species *Crenichthys baileyi*

is the same as that of the endangered subspecies (*C. b. baileyi*) found in Ash Springs - White River springfish. In order to avoid confusion in this section of the recovery plan, the species will be referred to as "White River springfish" and the subspecies as "Ash Springs White River springfish."

White River springfish were originally described as a subspecies of *Cyprinodon macularius*, although the fish was later considered to be a distinct species (Gilbert 1893, Jordan and Evermann 1896). The genus *Crenichthys* was erected in 1932 with the description of Railroad Valley springfish (*C. nevadae*) and White River springfish were then associated with the new genus (Hubbs 1932, Sumner and Sargent 1940, La Rivers 1962). The genus *Crenichthys* is closely allied with the killifish genus *Empetrichthys*, and was originally assigned the common name of "killifish." In 1980, the common name of the genus *Crenichthys* was changed to "springfish" in deference to selection of the genus' scientific name based on the fishes' occupation of spring habitats (Hubbs 1932; Bailey, et al. 1970; Robins, et al. 1980; Williams and Wilde 1981). Williams and Wilde (1981) further refined White River springfish taxonomy by describing five subspecies based on significant morphological differences among populations from isolated springs along the pluvial (caused by the action of rain) White River, Nevada (Table 1).

Table 1: The five subspecies of White River springfishes, *Crenichthys baileyi*.

Common Name	Scientific Name
Preston White River springfish	<i>Crenichthys baileyi albivallis</i>
Moorman White River springfish	<i>Crenichthys baileyi thermophilus</i>
Hiko White River springfish	<i>Crenichthys baileyi grandis</i>
White River springfish (Ash Spring)	<i>Crenichthys baileyi baileyi</i>
Moapa White River springfish	<i>Crenichthys baileyi moapae</i>

White River springfish are small (average 30 millimeters (1.2 in total length), deep-bodied fish that are generally olivaceous dorso-laterally and silver ventrally with two lateral rows of dark spots on the sides (La Rivers 1962). Breeding males exhibit more intense coloration than females, with mid-dorsal markings becoming

very dark (almost black) and contrasting with light, sometimes yellow, sides (Kopec 1949). The two rows of lateral dark spots differentiate White River springfish from Railroad Valley springfish, which have only one row of lateral spots (Hubbs and Miller 1941).

Ash Springs White River springfish are moderately sized with many characteristics intermediate between the larger bodied Preston White River springfish and Hiko White River springfish, and the smaller bodied Moorman White River springfish. Specific physical characteristics and the measurement of these characteristics that distinguish Ash Springs White River springfish from the other subspecies include a longer head and greater least bony interorbital (eye socket measurement) width than Preston White River springfish, longer anal to caudal length than Moorman White River springfish, and fewer fin rays than Hiko White River springfish and Moapa White River springfish (Williams and Wilde 1981). The Ash Springs White River springfish that inhabit the outflow stream below Ash Springs exhibit some integration of the meristic (measurement of distinct physical characteristics) and color characteristics attributed to Hiko White River springfish. (Williams and Wilde 1981).

Hiko White River springfish differ from the other subspecies by their larger size (adults average longer than 40 millimeters, 1.6 inches) and deeper coloration. The males are more yellow in color over the ventral surface of head and body, and become deep orange toward the caudal fin (Williams and Wilde 1981). Hiko White River springfish have longer heads than Preston White River springfish, and more dorsal and anal fin rays than Moorman White River springfish and Ash Springs White River springfish (Williams and Wilde 1981).

C. Associated Native Species of Concern

There are several species within the Pahranaagat Valley that, though not presently candidates for listing, are of concern to the Fish and Wildlife Service. Six of these species occur in the same habitats occupied by the endangered species of Pahranaagat Valley. Although actions recommended by this recovery plan may not directly benefit all species of concern found in Pahranaagat Valley, several may prevent future habitat disturbances that may adversely affect these species.

Consideration of these species of concern during Pahrnagat Valley recovery activities could promote the conservation of these species and alleviate the need to list them as threatened or endangered in the future. The following discussion addresses specific species in Table 2 that would benefit from recovery actions for the fishes.

In addition to the endangered fishes, three other native fishes historically occurred in Pahrnagat Valley: Pahrnagat spinedace (*Lepidomeda altivelis*), White River desert sucker (*Catostomus clarki intermedius*), Pahrnagat speckled dace (*Rhinichthys osculus velifer*). Pahrnagat spinedace are now extinct and the White River desert sucker has been extirpated from Pahrnagat Valley, although other populations persist in the White River Valley (La Rivers 1962, Minckley and Deacon 1968, Courtenay et al. 1985). These fishes had occupied the outflow stream from Ash Springs and the Pahrnagat Ditch (La Rivers 1962).

Pahrnagat speckled dace are currently the predominant native fish found in Pahrnagat Valley. This fish occurs in the outflows of Crystal and Ash Springs, two unnamed springs across the valley from Ash Springs, and a large portion of the Pahrnagat Ditch (Tuttle et al. 1990). Pahrnagat speckled dace are common and their populations appear to be relatively stable, although some populations experience seasonal fluctuations (Tuttle et al. 1990). Speckled dace can reproduce throughout the year and will proliferate under favorable conditions (Tuttle et al. 1990).

A distinctive form of speckled dace was thought to occur in Cottonwood North and L Springs on the Pahrnagat National Wildlife Refuge. Because both populations were at precariously low numbers, presumably due to limiting habitat conditions, Nevada Division of Wildlife (NDOW) personnel transplanted 24 fish (13 from Cottonwood North, 11 from L spring) into Maynard Spring in February 1991 (Jim Heinrich, NDOW, pers. comm.). The population in Maynard Spring is doing well, although the other two populations remain extremely small. Research recently completed indicates this species is merely another morphological type of Pahrnagat speckled dace (Oakey 1996).

Table 2. Species of concern that occur in Pahrnagat Valley or habitats occupied by the endangered species in Pahrnagat Valley.

Common Name	Scientific Name	Status*
Pahrnagat roundtail chub	<i>Gila robusta jordani</i>	Endangered
(Ash Springs) White River springfish	<i>Crenichthys baileyi baileyi</i>	Endangered
Hiko White River springfish	<i>Crenichthys baileyi grandis</i>	Endangered
Pahrnagat speckled dace	<i>Rhinichthys osculus velifer</i>	SC
Southwestern willow flycatcher	<i>Empidonax traillii extimus</i>	Endangered
pygmy rabbit	<i>Brachylagus idahoensis</i>	SC
spotted bat	<i>Euderma maculatum</i>	SC
Allen's big-eared bat	<i>Idionycteris phyllotis</i>	SC
Desert Valley kangaroo mouse	<i>Microdipodops megacephalus albiventer</i>	SC
Pahrnagat Valley montane vole	<i>Microtus montanus fucusus</i>	SC
small-footed myotis	<i>Myotis ciliolabrum</i>	SC
long-eared myotis	<i>Myotis evotis</i>	SC
fringed myotis	<i>Myotis thysanodes</i>	SC
long-legged myotis	<i>Myotis volans</i>	SC
Yuma myotis	<i>Myotis yumanensis</i>	SC
big free-tailed bat	<i>Nyctinomops macrotis</i>	SC
pale Townsend's big-eared bat	<i>Plecotus townsendii pallescens</i>	SC
bald eagle	<i>Haliaeetus leucocephalus</i>	Threatened
western burrowing owl	<i>Athene cunicularia hypugea</i>	SC
ferruginous hawk	<i>Buteo regalis</i>	SC
black tern	<i>Chlidonias niger</i>	SC
least bittern	<i>Ixobrychus exilis hesperis</i>	SC
white-faced ibis	<i>Plegadis chihi</i>	SC
Pahrnagat pebblesnail	<i>Fluminicola merriami</i>	SC
Amargosa naucorid	<i>Pelocoris shoshone shoshone</i>	SC
Moapa warm spring riffle beetle	<i>Stenelmis calida moapa</i>	SC
Grated tryonia	<i>Tryonia clathrata</i>	SC
undescribed riffle beetle	<i>Stenelmis sp.</i>	SC

* SC = Species of concern to the Fish and Wildlife Service that are not presently listed nor identified as candidates for listing.

Pahranagat montane voles were captured during 1993 in the vicinity of Upper Pahranagat Lake and the North Marsh on the Pahranagat National Wildlife Refuge (Cris Tomlinson, NDOW, *in litt.*, 1993). Prior to this effort, the last recorded occurrence of this mammal in Pahranagat Valley was in 1935, when 24 Pahranagat montane vole skulls were collected from owl pellets 4 miles south of Alamo, near Upper Pahranagat Lake (Hall 1981). Pahranagat montane voles were not captured near Maynard, L, Cottonwood, or Ash Springs in 1993, but skulls were found in owl pellets collected near Maynard, L, and Lone Tree Springs (Cris Tomlinson, *in litt.*, 1993; Chris Schoneman, Fish and Wildlife Service, *in litt.*, 1993). Pahranagat montane voles captured on the Pahranagat National Wildlife Refuge were in areas of dense cover provided by wildrye (*Leymus triticoides*), salt grass (*Distichlis spicata*), and alkali sacaton (*Sporobolus airoides*) (Cris Tomlinson, *in litt.*, 1993). Montane vole growth rates and reproductive age vary in response to local environmental conditions; consequently, in fluctuating environments age distributions may remain unstable and population densities may shift (Negus et al. 1992). Although voles primarily inhabit marshy meadows, young voles need shrub cover to disperse. Maintaining and enhancing the riparian corridor along the Pahranagat Ditch and near the springs may safeguard Pahranagat montane vole habitat and dispersal routes in the valley.

The Moapa Warm Springs riffle beetle occur in the swift, shallow water on gravel, vegetation, and particularly bare tree roots of warm springs. The Moapa Warm Springs riffle beetle was recently elevated to full species level (Schmude 1992). Though it was once thought to occur at both Hiko and Ash Springs, it has not been collected at Ash Springs in the last 40 years. The original collection at Ash and Hiko Springs is thought to have been misidentified and, Moapa Warm Springs riffle beetle is now considered endemic to the Warm Springs area in Clark County, Nevada (Schmude 1992).

An undescribed species of riffle beetle (*Stenelmis* sp.) was collected in Pahranagat Valley in 1991. The riffle beetle was found in the spring heads of Ash Springs, but was not found in the outflow stream despite extensive sampling (Schmude and Brown 1991). The new species may be endemic to warm springs in southern Nevada, if not restricted to Ash Springs. The habitat of this riffle beetle in Ash Springs would be preserved secondarily due to maintenance of Ash Springs White

River springfish habitat.

Amargosa naucorids are oval shaped, flattened bugs with front legs that form pincers. The middle and back legs are modified for swimming. Many naucorid species have fully developed flight wings, but flight is rarely observed. Colors are variable and range from a blackish brown to yellow brown and even gray or green. Body size is approximately 8-9 millimeters (0.31-0.35 inch) long and 5 millimeters (0.2 inch) wide. The Amargosa naucorid is consistently smaller and has different coloration than the one other *Pelocoris shoshone* subspecies (*Pelocoris shoshone amargosus*) found in the Amargosa River system in southwestern Nevada and Death Valley, California (La Rivers 1956, Usinger 1956).

Naucorids eat various aquatic organisms including dragonfly, midge, and mosquito larvae; water boatmen; and mollusks. They carry a small air bubble under water with them to maximize diving time. In the Pahranaagat area, Amargosa naucorids typically live among aquatic plants in pools and lower velocity stream reaches, often under overhanging banks associated with marshy habitats. Current population status is unknown.

The springs in Pahranaagat Valley also provide habitat for two mollusk species that only occur in portions of the White River drainage. Grated tryonia shells are cone-shaped and less than 5 millimeters (0.2 inch) long (Landye 1973). Prominent ridges run the length of the shells, and finer growth lines can be seen between the ridges. Grated tryonia are members of the family Hydrobiidae. This snail occurs most often in detritus and algae. In 1973, they were considered rare to common in spring systems in the Pahranaagat Valley. They also occur in spring systems to the north in the White River valley and south in Moapa Valley. Declines have been associated with the introduction of *Melanooides turberculatum*, and habitat modification may also be a threat. The grated tryonia snail was proposed for listing as threatened (41 Federal Register 62876) but the proposal was withdrawn because it was not finalized within 2 years, as required by the Act. However, current population size and status is unknown.

Pahranaagat pebblesnail (*Pyrgulopsis merriami*) shells are cone-shaped, but broad

and are less than 3 millimeters (0.12 inch) long and 3 millimeters (1.2 inches) wide (Landeye 1973). They are also known as turban snails. The operculum (lid) is amber in color. Pahranaagat pebblesnails are members of the Family Hydrobiidae. In 1973, these snails were collected from Ash, Crystal, and Hiko Springs and estimated to be abundant in number (Landeye 1973). They were found primarily on rocks and submergent vegetation in the upper 60-70 meters (197-230 feet) of the spring sources (Landeye 1973). In a recent survey, this snail was found to be in Ash Spring and common in Hot Creek, Moormon, and Moon River in the White River Valley in Nye County, Nevada (Hershler, 1995). It was not found in either Crystal or Hiko Springs.

A new undescribed species of pebblesnail was found in Crystal and Hiko Springs (Hershler 1995). They were found to be abundant in both springs. Currently, a description of this snail is under preparation.

D. Distribution and Population Status

During the late Pleistocene-early Holocene wet periods, the White River of southeastern Nevada flowed southward from its headwater tributaries in northern White River Valley, through Pahranaagat Valley into Kane Springs Wash, southeastward through Arrow Canyon into Moapa Valley, where it joined the pluvial Carpenter River (now referred to as Meadow Valley Wash), and emptied into the Virgin River above its confluence with the Colorado River (Courtenay et al. 1985, Hubbs and Miller 1948, Smith 1978, Williams and Wilde 1981). Surface flows in this system are now confined to the headwater tributaries of the White River; outflow streams from springs in White River, Pahranaagat, and Moapa Valleys; and the Muddy (Moapa) River (Courtenay et al. 1985). As the White River system desiccated 10,000 years ago, the native fishes of the system were isolated into disjunct waters and differentiated into a variety of species and subspecies (Courtenay et al. 1985, Williams and Wilde 1981).

Pahranaagat roundtail chub - It is uncertain how abundant Pahranaagat roundtail chub were historically, because the species was not collected prior to alteration of the aquatic habitats of Pahranaagat Valley (Townley 1973). It has been reported that the fish were used for aquaculture and sold to restaurants in the vicinity,

which indicates they may have been more abundant than currently (Ferris 1991). The species existed in waters from Crystal, Hiko, and Ash Springs and in the Pahranaagat Creek and Ditch based upon collections made in the 1940s (Tanner 1950). The amount of historically occupied habitat is estimated to have totaled approximately 30 kilometers (18.6 miles) of stream, including the three springs and their outflows, the Pahranaagat Ditch, and Maynard Lake at the southern end of the valley. In 1950, Tanner (Tanner 1950) reported the Pahranaagat roundtail chub to be scarce and in danger of extinction. Following the introduction of nonnative fishes, concern was expressed repeatedly for the next 2 decades over the low number of Pahranaagat roundtail chub in the system (Deacon et al. 1979, Deacon 1979, Minckley and Deacon 1968, Hubbs and Miller 1948).

Hardy (1982) reported that 37 to 45 adult Pahranaagat roundtail chub inhabited approximately 2.3 kilometers (1.4 miles) of the Pahranaagat Creek in 1982. In 1986, the National Fisheries Research Center-Reno Substation was contracted to do a 3-year study on the life history and habitat requirements of the Pahranaagat roundtail chub. Pahranaagat roundtail chub were found to inhabit 6.0 kilometers (3.8 miles) of both the ditch, and creek, including Ash Springs though not contiguously (Tuttle et al. 1990). Depending upon season, adult population estimates ranged from 150 to 260 adults during the period 1986 through 1989 (Figure 2). Juvenile Pahranaagat roundtail chub counts ranged from 24 in the winter to 405 juveniles in the summer. More recent counts (Stein et al 1997) show adult numbers ranging from 94 in winter to 306 in summer and juveniles ranging from 18 in winter to 505 in summer.

White River springfish - White River springfish are found throughout the Ash Springs pool with infrequent occurrences in the outflow stream (Tuttle et al. 1990). Historically, White River springfish inhabited Ash Springs and its outflow stream and were considered common in these areas (Table 3). With the introductions of mosquitofish (*Gambusia affinis*) in 1963, and convict cichlid (*Cichlasoma nigrofasciatum*), shortfin molly (*Poecilia mexicana*) and sailfin molly (*Poecilia latipinna*) in 1964, White River springfish experienced a population decline (Table 3). Additionally, Ash Springs is a very popular recreation area, primarily for swimming purposes. From 1986 through 1989, the pool was drained annually and algal growth was removed, keeping White River

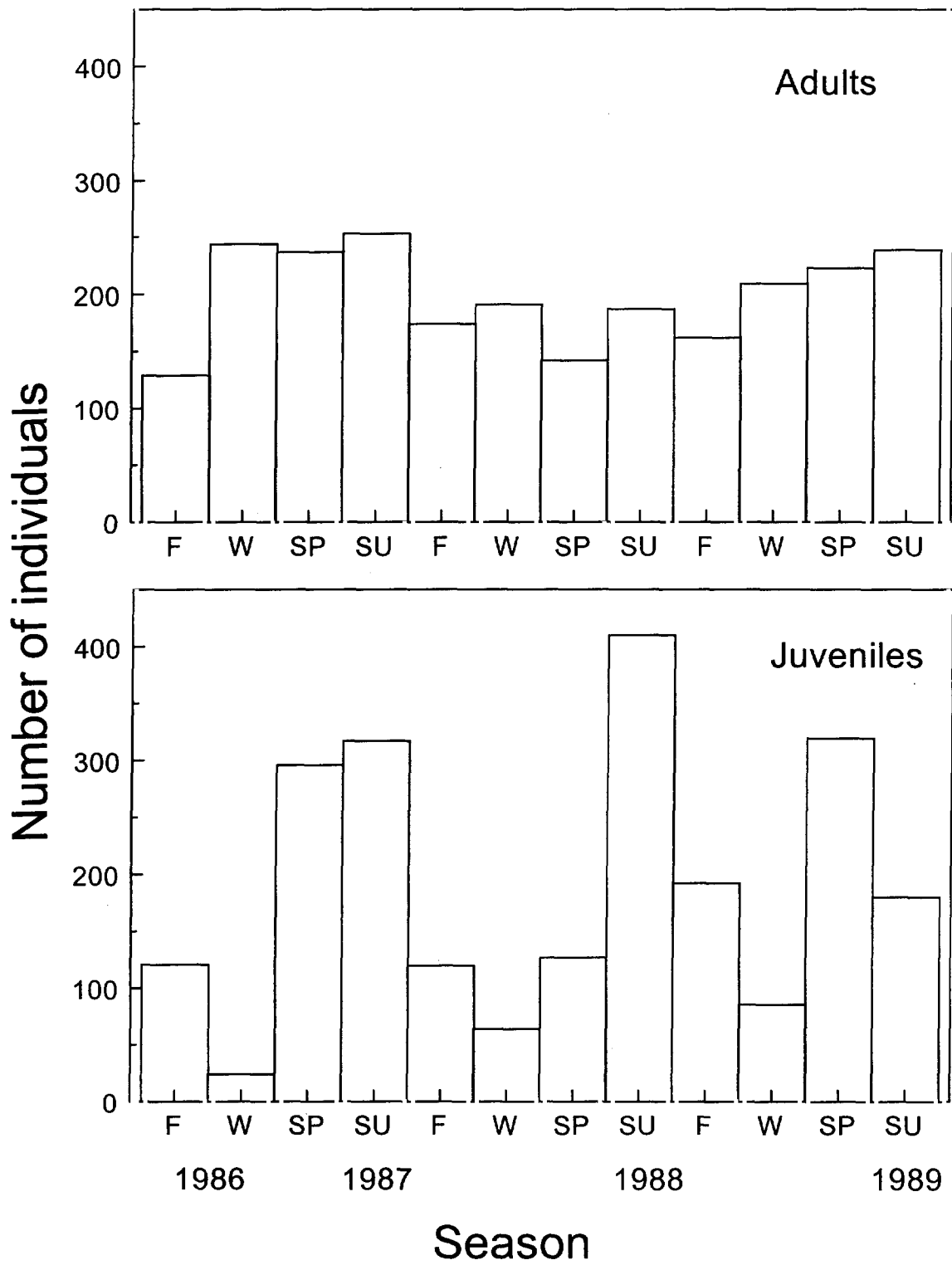


Figure 2. Seasonal numbers of adult and juvenile Pahrnagat roundtail chub in the Pahrnagat Creek.

springfish numbers low (Table 3). In recent years, the habitat manipulations stopped though the swimming continued primarily in the northern and southern ends of the spring pool, allowing White River springfish to establish a stable to increasing population (Table 3). Swimming does not appear to impact the White River springfish as much as previously thought as long as areas with little or no swimming are provided. Nonnatives continue to impact the White River springfish population in the spring.

Hiko White River springfish

Hiko Spring - Hiko White River springfish were common in Hiko Spring and its outflow stream until 1963, when the outflow stream was modified for irrigation and mosquitofish were introduced (Courtenay et al. 1985). Shortfin mollies and largemouth bass (*Micropterus salmoides*) were first observed in Hiko Spring in February 1965, after which the Hiko White River springfish population again declined (Table 3, Courtenay et al. 1985). By 1967 Hiko White River springfish had been extirpated from Hiko Spring and its outflow stream (Minckley and Deacon 1968, Deacon 1979, Williams and Wilde 1981, Courtenay et al. 1985).

Hiko White River springfish collected from Crystal Spring were spawned at the University of Nevada, Las Vegas, and the resultant progeny were released into Hiko Spring in 1984. Convict cichlids had also been introduced into Hiko Spring by 1984 (Courtenay et al. 1985). Despite the presence of nonnative fishes, Hiko White River springfish reestablished a population at Hiko Spring and continued to increase. Though no data are currently available, this may indicate that if nonnative fish populations are low and habitat manipulation is minimal, native fishes are able to dominate. In 1990, the population was estimated to contain approximately 12,000 individuals. In June 1994, however, Fish and Wildlife Service personnel visiting Hiko Spring observed relatively few Hiko White River springfish and noted that algae were being removed from the spring pool (Donna Withers, Fish and Wildlife Service, pers. comm.).

Table 3. Population estimates for Hiko White River and White River springfish populations in Pahranaagat Valley Springs. An empty box indicates no data.

Year	Hiko White River Springfish			White River Springfish	Source
	Hiko	Crystal	Blue Link	Ash	
1949	common	common		common	1
1963		62*		10	2
1965	2*	11.25*		2.6	3
1966	.67*	12.5*		1	3
1980	extirpated	12*		1	3
1983	extirpated	1*		5	3
1984	70**		274 stocked		4
1985			2,885		4
1986	7,784	265	3,907	1,241	5,6
1987	5,749	181	11,053	1,705	7,6
1988	4,367	354			7,8
1989	5,174	8	8,918	357	8
1990	12,175		***	common	9
1991	6,690	60	150**	6,400	9,10
1992	7,450	30	2,755	7,450	10,11
1993	5,480	38	9,460	7,200	12
1994	11,342	68	5,531	46,275	13

* Estimated number of fish per trap hour

** Number of fish reintroduced into these spring systems.

*** A significant portion of the population was lost during this year.

1. La Rivers 1962

2. Deacon et al. 1964

3. Courtenay et al. 1985

4. John Elliot (NDOW), pers. comm.

5. Withers 1986

6. Tuttle et al. 1990

7. NDOW 1988

8. Sjoberg 1989

9. Heinrich 1991a

10. Heinrich 1991b

11. Heinrich 1993

12. Heinrich 1994

13. Heinrich 1995

Crystal Spring - Even though Crystal Spring and its outflow stream were modified by the ditches of Native Americans prior to the arrival of the first European settlers in 1866, Hiko White River springfish remained abundant into the 1960s (Courtenay et al. 1985). In 1959, largemouth bass were released into Crystal Spring by the Nevada Division of Wildlife (then Nevada Fish and Game) (Courtenay et al. 1985). Largemouth bass moved out of the spring pool into the outflow channel, but did not reproduce and were not present in Crystal Spring or its outflow streams by 1961. Convict cichlids and shortfin mollies colonized Crystal Spring by invading from Ash Springs, and were very abundant in Crystal Spring by the 1970s (Courtenay and Deacon 1982). The Hiko White River springfish population declined sharply following the introduction of convict cichlids and shortfin mollies (Table 3). As the nonnative species proliferated, Hiko White River springfish numbers fell to a precariously low level due to predation and competition with the nonnative species. Hiko White River springfish continue to be very rare in Crystal Spring (Table 3).

Blue Link Spring - Due to the serious threats facing the Hiko White River springfish populations, a refugium was created in 1984 by the Nevada Division of Wildlife, at Blue Link Spring in Mineral County, Nevada. To protect the spring and its associated reservoir, 4.7 hectares (ha, 11.6 acres) of public land managed by the Bureau of Land Management (BLM) were withdrawn from surface entry and mining (58 Federal Register 31655). A total of 264 fish from Hiko Spring were released, quickly established a population, and remained abundant until 1990 (Table 3). A significant portion of the population was lost in 1990 when water flow into the reservoir decreased, either due to valve failure or vandalism, and the water cooled to a level lethal to Hiko White River springfish. Following repair of the spring box water supply valves, the population was supplemented with an additional 150 fish from Hiko Spring. The fish recolonized the spring and the population has recovered to numbers comparable to pre-1990 levels (Table 3).

E. Habitat Description

Pahranagat Valley - Pahranagat Valley is approximately 65 kilometers (40 miles) long and 11 kilometers (7 miles) wide. Its northern boundary is the constricted section of the valley about 16 kilometers (10 miles) north of Hiko,

Nevada, and its southern boundary is a similarly constricted point in the valley immediately south of Maynard Lake, which is believed to have been dry since 1940 (U. S. Department of Agriculture (USDA) 1940). Pahrnagat Valley extends over approximately 142,449 hectares (352,000 acres), and includes 4,850 hectares (12,000 acres) of private lands, 538 hectares (1,330 acres) of State land, 2,180 hectares (5,400 acres) of Fish and Wildlife Service land, and 134,882 hectares (333,300 acres) of public lands administered by the Bureau of Land Management. All habitat for the listed species occurs in waters surrounded by private lands except for 0.04 hectare (0.1 acre) at the spring source of Ash Springs, which is managed by the Bureau of Land Management.

The climate of the valley represents a transitional zone between the Mohave and Great Basin deserts and is characterized by light precipitation (annual average 17.5 centimeters [7 inches]) and little snow in most years, low humidity, and a large number of sunny days. The summers are long, hot, and dry; and the winters are short and dry. Strong winds, common throughout most of the year, are more intense during the spring. The effectiveness of the limited rainfall is greatly diminished by the high rates of evaporation (USDA 1944). Average air temperature in the valley is 15 degrees Celsius (59.2 degrees Fahrenheit) with a maximum monthly average temperature of 29 degrees Celsius (84.5 degrees Fahrenheit) and a minimum monthly average temperature of 0.4 degrees Celsius (32.7 degrees Fahrenheit).

Valley elevations vary from 1,160 meters (3,800 feet) at Hiko to 915 meters (3,000 feet) at the Pahrnagat Lakes. The soil characteristics of Pahrnagat Valley are common to most soils that have developed in the dry intermountain west (USDA 1940, 1944). Except for the dark-colored bottom-land soils, Pahrnagat Valley soils are deficient in organic matter, humus, and nitrogen; and they normally have a light gray or light grayish-brown color (USDA 1940). They are very rich in mineral compounds, such as carbonates of lime and magnesium, and sodium and potassium salts (USDA 1940, 1944).

The plant community of Pahrnagat Valley is typical of the Mojave Desert and is dominated by the creosote bush (*Larrea tridentata*) - burroweed (*Ambrosia dumosa*) vegetation association (Kanim 1986). Livestock grazing is a principal

land use in Pahranaagat Valley, and pastures with a variety of grasses and legumes have been established in the valley bottom.

The surface water of Pahranaagat Valley comes from several springs, which produce dependable flows totaling 37,000 cubic meters (48,470 cubic yards) annually (USDA 1940, 1944). The majority of Pahranaagat Valley's water comes from Hiko Spring, Crystal Spring, and Ash Springs, with several smaller springs and seeps supplying additional surface water. The total spring flow is more than would be expected from the limited rainfall on this small tributary watershed, and much of this water originates at more distant points (USDA 1940, 1944). Several valleys to the north and east of Pahranaagat Valley, including Coal Valley, Garden Valley, Pahroc Valley, Dry Lake Valley, and Delmar Valley, all contribute to the spring flows in Pahranaagat Valley. These valleys receive considerably more aggregate rainfall than Pahranaagat Valley, but lack streams and have very few springs that discharge the water (USDA 1940, 1944). Pahranaagat Valley has no external surface drainage because a natural barrier created by overlapping alluvial fans at the south end of the valley blocks surface drainage. Maynard Lake and its associated marshes formed from this captured spring water (USDA 1940).

The Pahranaagat Ditch/Creek floodplain, which is used for agriculture, is fairly flat with an average gradient of 6 meters per kilometers (20 feet per mile) (USDA 1940). The floodplain is bordered by alluvial fans, which slope down from the adjacent mountain ranges (USDA 1940). In places, these alluvial fans have an even slope and merge almost imperceptibly with the floodplain, while in other places distinct bluffs occur (USDA 1940).

Water rights in Pahranaagat Valley were established by court decree on October 14, 1929, and have been adjudicated by the State of Nevada for Lincoln County at the rate of 0.0305 meters per second (0.1 foot per second) per 40 hectares (100 acres). Four irrigation ditch systems distribute water on a timed rotation to the farmers and ranchers of Pahranaagat Valley during the irrigation season of March 15 to October 15 (Lincoln County Conservation District (LCCD) 1980). Water right owners receive the total ditch flow to their property on a set rotation frequency (approximately every 17 days) for a specific length of time based on the percentage of the total ditch flow represented by their water right (LCCD 1980).

Hiko Spring - Hiko Spring is the northernmost and the third largest spring in Pahranaagat Valley (Garside and Schilling 1979). The outflow stream from Hiko Spring was probably first redirected and impounded in 1865 to provide water for the silver stamp mills in the area, and secondarily created Nesbitt and Frenchy Lakes (Courtenay et al. 1985). Previously referred to as Hatch and Shutt's Lakes, these lakes are now part of Nevada Division of Wildlife's Key Pittman Wildlife Management Area. Today, the water from Hiko Spring is used for agricultural and municipal purposes. Previously diverted into concrete ditches, the entire outflow stream is now captured in underground pipes, which transport the water to nearby agricultural lands. The only surface water remaining is an impoundment at the spring source and a small marsh created by seepage from the spring pool.

Hiko Spring maintains a temperature of 27 degrees Celsius (81 degrees Fahrenheit), although a maximum temperature of 32 degrees Celsius (90 degrees Fahrenheit) was recorded in 1934 (Table 4). The water issues from a contact between alluvium and dolomite (Garside and Shilling 1979), with a mean flow of 0.167 cubic meters per second (5.9 cubic feet per second) (Table 4). The water issuing from the spring source is generally of good quality, although safe drinking water standards were exceeded during the 1930s and 1940s (Table 4). In 1934, potassium concentrations were three times the safe drinking level, and in 1943 and 1944 boron levels rose above levels considered harmful to humans (American Public Health Association et al. 1985). Additionally, a high concentration of sodium in the spring water during 1940-42 may have harmed soil permeability (American Public Health Association et al. 1985). The water is slightly basic with a pH of 8 (Table 4).

Crystal Spring - Crystal Spring, located 27 kilometers (17 miles) northwest of Alamo, Lincoln County, Nevada, is the second largest of the spring systems in the valley. Crystal Spring has been the most intensely disturbed by habitat alterations. It consists of at least two individual springs; one flows from an orifice in limestone bedrock and the other from a contact between alluvium and bedrock (Garside and Shilling 1979). The Pahranaagat Indians modified this spring for agricultural use before the first European settlement was established. The alteration was a ditch 2.4 meters wide (8 feet), 1.8 meters (6 feet) deep, extending for several kilometers. The spring has since been altered continually for

Table 4. Water quality parameters for Hiko Spring. Values are in milligrams per liter unless otherwise noted. Temp=Temperature, SiO₂= Silica, Ca=Calcium, Mg=Magnesium, Na=Sodium, K=Potassium, HCO₃= Bicarbonate, SO₄=Sulfate, Cl=Chloride, F=Fluoride, NO₃=Nitrate, B=Boron, TDS=Total Dissolved Solids, Cond=Conductivity.

Year	Temp (°C)	Flow (m ³ per second)	SiO ₂	Ca	Mg	Na	K	HCO ₃	SO ₄	Cl	F	NO ₃	B	TDS	Cond μmhos	pH	*
1912	32	0.034	35	52	34	22	22	272	36	11		0.8		315			1
1915		0.255		52	24	22		272	36	11					596		2
1934	32	0.178	35	52	24	22	60	272	36	11				315			3
1936		0.186															2
1940-42		0.185		84	23	249		610	251	60					1824		2
1943		0.181		46.5	24.6	23.5		274.2	29.8	9.8			2.3		512		2
1944				46.5	24.6	23.5		274.5	29.7	9.7			.21				1
1944				48	23.2	29.9		280	36	11			.21	430			4
1962	27	0.186	33	46.4	23	29	7.2	260	36	11	0.5	1.2	0.1			8	1
1963	27	0.152	33	44	23.4	28.9	7.0	259.8	36	11	0.6	1.24	0.1		494	8	2
1966	27	0.151															1

* Source References

1. Garside and Schilling 1979
3. USDA 1940

2. Eakin 1963
4. USDA 1944

agricultural uses (Courtenay et al. 1985). In the 1880s all the spring outflows were further modified to provide additional water for agricultural use. The water level in Crystal Spring is controlled by a gate that directs flow into either of the two outflows. The main outflow (the historical headwaters of the Pahranaagat Creek) continues for approximately 900 meters (0.6 mile) before flowing into a concrete irrigation channel, with five diversion boxes and seven outlet concrete channels (four to the east and three to the west). The riparian corridor along the main concrete channel is minimal. Farther downstream, the water flows back into an earthen channel. Portions of this channel have previously been trenched, but most areas appear to have been undisturbed for several years. Flow in this channel is periodically interrupted by agricultural diversions, however these diversions do not commonly cause desiccation of the entire flow. The last portion of the Crystal Spring outflow is an earthen irrigation ditch extending 5.8 kilometers (3.6 miles) and averaging 1 meter (3.3 feet) in width. This portion connects to the Ash Springs outflow; however, for much of the year only the upper 4.8 kilometers (3.0 miles) of the ditch contains water. The smaller outflow, created to provide water for nearby agriculture, conveys water intermittently, and thus offers little habitat for the springfish. Crystal Spring impoundment allows for diversion of the entire spring flow into either the natural channel or the earthen irrigation ditch. The water level in the spring pool is lowered significantly when the natural channel is used, and it fluctuates throughout the irrigation season.

Crystal Spring discharge varied between 0.169 cubic meters per second (5.9 cubic feet per second) in 1912 to 0.31 cubic meter per second (10.9 cubic feet per second) in 1989 (Table 5). Water temperature, which was warmer for the earlier part of this century, has cooled by several degrees in recent years (Table 5). Overall water quality is good with a few exceptions. As in Hiko Spring, the potassium concentration exceeded safe drinking water standards in 1934. In 1936, chloride concentration was 69 milligrams per liter (1 milligram per liter = 1 part per million), which may be damaging to plant growth (APHA 1985).

Table 5. Water quality parameters for Crystal springs. Values are in milligrams per liter unless otherwise noted. Temp=Temperature, SiO₂= Silica, Ca=Calcium, Mg=Magnesium, Na=Sodium, K=Potassium, HCO₃= Bicarbonate, SO₄=Sulfate, Cl=Chloride, F=Fluoride, NO₃=Nitrate, B=Boron, TDS=Total Dissolved Solids, Cond=Conductivity.

Year	Temp (°C)	Flow (m ³ per sec)	SiO ₂	Ca	Mg	Na	K	HCO ₃	SO ₄	Cl	F	NO ₃	B	TDS	Cond	pH	Source*
1912	32	0.169	26	53	23	19	5	261	37	11				306			1
1915		0.198		53	22.9	19		261	37	11					577		2
1934	32	0.310	26	53	23	19	50	261	37	11				306			3
1935				55	23	37		26.4	13	7							1
1936		0.282		55	23	37		273.3	13	69					671		2
1940 -42		0.274															2
1943		0.269		45	24.2	20.8		268.4	28.1	8.9			.05		488		2
1944				45	24	21		262	28	8.9			.05				1
1944				46	24	25		268	34	9			.05	406			4
1962	28	0.283	31	46	22.2	23.9	5.5	242	34	9.9	2.9	0.6	.04			7.2	1
1963	27		29.5	45	23.3	23	5.2	267	27	8.1	0.6	1.2	.45	286		8.2	1
1963	27.5	0.335	31	46	22.9	23.5	5.3	257.1	30.5	9.1	1.7	0.93	1.1	277	481	7.6	2
1986	26.6	0.476													499	7.0	5
1989	26-28	0.31															6

*Source References

1. Garside and Schilling 1979
4. USDA 1944

2. Eakin 1963
5. Baugh et al. 1986

3. USDA 1940
6. Tuttle et al. 1990

The pH of Crystal Spring varies between neutral (7.0) to slightly basic (8.2) (Table 5). The dissolved oxygen levels in Crystal Spring ranges from 1.3 to 6.4 milligrams per liter depending on the season (Tuttle et al. 1990). The main channel of the outflow has a much greater dissolved oxygen concentration (6.5 to 15.7 milligrams per liter) than the created irrigation ditch (3.6 to 5.9 milligrams per liter) (Tuttle et al. 1990).

Dense vegetation, consisting mostly of the nonnative aquatic weed watercress (*Nasturtium officinale*), lines the sand and silt bottom of the spring pools. The main outflow has a maximum depth of 1.5 meters (5 feet), width between 10 and 30 meters (33 and 100 feet), and extends approximately 900 meters (0.6 mile) before discharging into a concrete irrigation ditch (Tuttle et al. 1990). This reach is also characterized by dense aquatic vegetation and silty substrate. The southern ditch off of the spring pool is much shallower and narrower, has very little vegetation, and has a silt substrate.

Ash Springs - Ash Springs is the southernmost, largest, and warmest of the three spring systems. Located 14.5 kilometers (9 mile) north of Alamo, Nevada, Ash Springs may have been the least altered historically, because it was the home of the Ash Ute Indians who were hunters rather than cultivators (Courtenay et al. 1985). It later became an important source of water for travelers.

Ash Springs consists of at least seven springs which issue from a contact between alluvium and bedrock (Garside and Shilling 1979). The springs have a common outflow stream, which has been impounded by construction of U. S. Highway 93, and now forms a large pool. The spring pool provides good stream flow when the gate controlling the water level is open. Ash Springs was historically a stream with continuous flow before it was modified into the existing deep convoluted pool. Below the highway, the outflow stream flows southwest to join the outflow stream from Crystal Spring. From this point on, the stream is referred to as the Pahranaagat Ditch.

Ash Springs water temperatures range from 31 - 36 degrees Celsius (88 - 97 degrees Fahrenheit), and mean discharge is 0.56 cubic meter per second (19.8 cubic feet per second) (Table 6, Tuttle et al. 1990). The overall water quality for

this site is excellent with only one recorded incident of elevated potassium level in 1934 (Table 6). Dissolved oxygen concentrations fluctuate between 1.8 and 5.1 milligrams per liter seasonally (Tuttle et al. 1990). The pH level has changed from slightly acidic (6.4) in 1935 to slightly basic (8.1), where it has remained for the past 3 decades (Table 6).

Ash Springs now form a large, convoluted pool, 0.4 kilometer (0.2 mile) long and 0.5 - 2.0 meters (1.6 - 6.6 feet) deep (Tuttle et al. 1990). The bottom consists of sand and silt with locally dense submergent vegetation and algal mats. A thick canopy of willow (*Salix* sp.) and ash trees (*Fraxinus* sp.) border the eastern bank while the west side is more sparsely vegetated with willow, ash, and grasses.

Pahranagat Creek/Ditch - Pahranagat Ditch begins at the confluence of the outflow streams from Crystal and Ash Springs, though this only occurs in the winter months; and flows south and empties into Upper and Lower Pahranagat Lake. In May 1858, the White Mountain Expedition described a large stream that was waist deep and several yards wide with fish measuring up to a foot in length, indicating that the stream probably did not dry up later in the summer like so many of the other basin streams (Stott 1984). At the time of the expedition, Johnson found the valley had been successfully settled and irrigated by the Indians. It was not until the spring of 1866 that all the irrigable land within the Pahranagat Valley had been claimed (Townley 1973).

Today, approximately 90 percent of Pahranagat Creek has either been converted to irrigation ditches or is dewatered during the irrigation season (Kanim 1986; Tuttle et al. 1990). The creek follows its historical channel for 3.5 kilometers (2.2 miles) and is then diverted into a concrete irrigation ditch (Tuttle et al. 1990). Although the ditch channel is intact 5.6 kilometers (3.5 miles) beyond this diversion, it contains water only during the winter months. During the irrigation season, leakage from the highland irrigation ditch and a water right supplies a small quantity of water to the ditch at the diversion.

Table 6. Water quality parameters for Ash Springs. Values are in milligrams per liter unless otherwise noted. Temp=Temperature, SiO₂=Silica, Ca=Calcium, Mg=Magnesium, Na=Sodium, K=Potassium, HCO₃=Bicarbonate, SO₄=Sulfate, Cl=Chloride, F=Fluoride, NO₃=Nitrate, B=Boron, TDS=Total Dissolved Solids, Cond=Conductivity.

Year	Temp (°C)	Flow (m ³ per sec)	SiO ₂	Ca	Mg	Na	K	HCO ₃	SO ₄	Cl	F	NO ₃	B	TDS	Cond	pH	Source*
1912	32		34	49	13	59		259	46	11				303			1
1915		0.566		49	12.9	45.1	14	258.6	46.1	11					626		2
1934	32	0.598	34	49	13	59	75	259	46	11				303			3
1935				54	10	47		264	41	14						6.4	1
1936		0.548		54	10	47.2		264.1	40.8	14					614		2
1940-42		0.440		57.6	24.2	34.3		312.3	43.2	12					693		2
1943		0.491		45.7	18.7	25.4		253.4	26.4	9.8					477		2
1944				45	18	21		256	44	10			0.4				1
1944				46	19	31		256	35	11				398			4
1962	31	0.548	31	39	18	32	6.8	231	34	9.7	0.5	1.3	0.1	286		8.1	1
1963	31	0.504	31	39	18.2	32	6.6	231.2	34.1	9.9	0.6	1.24	1.1		443		2
1980	30	0.44							37			1.3			468.2	8.1	5
1986	31	0.54										1.27					6
1989	31-36	0.56															7

*Source References

1. Garside and Shilling 1979
6. Kanim 1986

2. Eakin 1963
7. Tuttle et al. 1990

3. USDA 1940

4. USDA 1944

5. Hardy 1982

The ditch channel is intact 10.8 kilometers (6.7 miles) north of the Pahrnagat National Wildlife Refuge and conveys water into Upper Pahrnagat Lake. During the irrigation season, this stretch of Pahrnagat Ditch contains water primarily from agricultural runoff and seepage. During the winter months, the Pahrnagat National Wildlife Refuge receives the entire volume of water discharged from Crystal and Ash Springs, except for small amounts needed for stock water and flushing salt and alkali from the agriculture fields. The Upper and Lower Pahrnagat Lakes, previously named Johnson and Rush Lakes block the continued flow of the Pahrnagat Ditch/Creek. Only in unusually wet years did water flow into Maynard Lake (Courtenay et al. 1985).

Water temperature in Pahrnagat Creek/Ditch varies between 18 degrees and 32 degrees Celsius (64 to 90 degrees Fahrenheit), depending on the relative amounts of water contributed by Crystal and Ash Springs, which varies depending on the season. Since Crystal Spring water is substantially cooler than the Ash Springs water, it provides both cooler water and food sources when it reaches the Creek primarily during the winter months (Table 7). On rare occasions, Crystal Spring water will reach the creek and ditch during the irrigation months but this only happens if excess water runs off the fields or an upstream irrigation user does not use the water. Water volume in Pahrnagat Creek/Ditch fluctuates between 0.35 and 0.94 cubic meter per second (12.4 to 33.2 cubic feet per second) seasonally, depending on the flow received from Crystal Spring (Table 7). The dissolved oxygen content of the river water is relatively constant at 5.0 to 7.6 milligrams per liter, even though the water from Crystal Spring may vary from 1.1 to 10.7 milligrams per liter.

Water quality in Pahrnagat Creek/Ditch is good near its headwaters, but progressively worsens downstream (Table 7). Much of this degradation is attributable to concentrations of total phosphorus and suspended solids. Crystal and Ash Springs produce 48.5 kilograms (107 pounds) of suspended solids, but this value increases to 1,692 kilograms (3,730 pounds) by the time the water has moved through the irrigation system (USGS 1980). The water quality deterioration is attributed primarily to reuse of waters and flushing of soils (USGS 1980).

The upper portion of Pahranaagat Creek has a well-developed border of ash trees interspersed with cottonwood (*Populus fremontii*), California grape (*Vitis californica*), and willow (Kanim 1986, Tuttle et al. 1990). The pastures that line the river have been planted with a variety of different forage species. Riparian vegetation provides complete cover along the upper portion, approximately 4.5 kilometers (2.8 miles) of the Pahranaagat Ditch, but is essentially absent downstream in some areas. Herbaceous plant species such as Yerba mansa (*Anemopsis californica*), western niterwort (*Nitrophila occidentalis*), and spike rush (*Eleocharis parishii*) are common along the stream edge (Deacon et al. 1980).

Stream bottom substrates vary by reach, ranging from gravel upstream near the Crystal Spring/Ash Springs confluence to sand, silt, and clay downstream (Tuttle et al. 1990, Kanim 1986). The distribution of aquatic macrophytes in Pahranaagat Creek/Ditch varies from small, isolated beds of marsh pennywort (*Hydrocotyle verticellata*) and water cress (*Rorippa nasturtium-aquaticum*) in the upstream reaches, to 100 percent cover by pondweed (*Potamogeton* sp.), water cress, and spiny water nymph (*Najas marina*) downstream (Deacon et al. 1980). Extensive mats of the algae *Chara zeylanica*, *Spirogyra* sp., and *Compsopogon coeruleus* are found in lower river reaches (Deacon et al. 1980). Benthic invertebrates in upstream riffles are dominated by caddisflies, midges, and riffle beetle larvae. Downstream, the introduced snail, *Melanooides tuberculatus*, is predominant although Pahranaagat pebblesnail, and other invertebrates of the Coenagrionidae and Chironomidae families are present.

Table 7. Water quality parameters for certain areas in the Pahranaagat Valley. Values are in milligrams per liter unless otherwise noted. Temp=Temperature, SiO₂= Silica, Ca=Calcium, Mg=Magnesium, Na=Sodium, K=Potassium, HCO₃= Bicarbonate, SO₄=Sulfate, Cl=Chloride, F=Fluoride, NO₃=Nitrate, B=Boron, TDS=Total Dissolved Solids, Cond=Conductivity.

Area	Year	Temp (°C)	Flow (m ³ /sec)	Ca	Mg	Na	HCO ₃	SO ₄	Cl	TDS	pH	DO	Cd	Source*
Main Outflow	1989	18-32	0.56-0.87									5.0-7.6		1
Crystal Fork		5-24	0.00-0.31									1.1-10.7		1
Pahranaagat Lake	1934			18	139	813	802	1088	254	3023				2
Pahranaagat Ditch	1986	16	0.35-0.94								8.1	4.6-6.5	488	3
Upper Lake	1944			28	51	163	305	140	30	741				4
Upper Lake	1944			40	45	173	431	189	57				1207	5
Lower Lake	1921			18	139	813	803	1086	254				4647	5
Lower Lake	1944			20	106	470	546	436	106	1756				4
Lower Lake	1944			33	62.3	333	628	332	97				1826	5

*Source References

1. Tuttle et al. 1990
4. USDA 1944

2. USDA 1940
5. Eakin 1963

3. Kanim 1986

F. Critical Habitats

Critical habitat, as defined by section 3 of the Act, includes: 1) The specific areas, within the geographical area occupied by a species at the time of its listing under the Act, that contain those physical or biological features essential to the conservation of the species and that may require special management considerations or protection; and 2) specific areas, outside the geographical area occupied by the species at the time it is listed, that are determined to be essential for the conservation of the species. Section 7 of the Act requires all federal agencies to consult with the Fish and Wildlife Service when any activity funded or carried out by that agency may affect designated critical habitat. No critical habitat has been designated for the Pahranaagat roundtail chub.

Hiko White River springfish critical habitat includes the two springs historically occupied by Hiko White River springfish along with their outflows and surrounding land areas for a distance of 15 meters (50 feet) from these springs, as follows: 1) Hiko Spring and its associated outflows - T. 4 S., R. 60 E., SW $\frac{1}{4}$ of NE $\frac{1}{4}$ Sec. 14 and NW $\frac{1}{4}$ of SE $\frac{1}{4}$ Sec. 14; and 2) Crystal Spring and its associated outflows - T. 5 S., R. 60 E., NE $\frac{1}{4}$ Sec. 10, NE $\frac{1}{4}$ of SE $\frac{1}{4}$ Sec. 10, SW $\frac{1}{4}$ of NW $\frac{1}{4}$ Sec. 11, and NW $\frac{1}{4}$ of SW $\frac{1}{4}$ Sec 11 (50 Federal Register 39123). Constituent elements for all Hiko White River springfish critical habitats include warm water springs and their outflows and surrounding land areas that provide vegetation for cover and habitat for insects and other invertebrates on which the species feeds.

The areas designated as critical habitat for Hiko White River springfish do not include all habitats historically or currently occupied by the species, most notably Crystal Spring outflow downstream from the designated critical habitat (Hubbs and Miller 1948, Courtenay et al. 1985). No critical habitat is designated for the introduced population at Blue Link Spring.

White River springfish critical habitat includes Ash Springs, its outflow, and surrounding land areas for a distance of 15 meters (50 feet) from these areas within T. 6 S., R. 60 E., E $\frac{1}{2}$ of E $\frac{1}{2}$ Sec. 1, and T. 6 S., R. 61 E., NW $\frac{1}{4}$ of NW $\frac{1}{4}$ Sec. 6 (50 Federal Register 39123). Constituent elements for all White River springfish critical habitats include warm water springs and their outflows and

surrounding land areas that provide vegetation for cover and habitat for insects and other invertebrates on which the species feeds. The areas designated as White River springfish critical habitat includes all habitats historically and currently occupied by the White River Springfish (Hubbs and Miller 1948, Courtenay et al. 1985).

G. Life History and Habitat Requirements

Pahranagat Roundtail Chub

Habitat Use - Adult (greater than 100 millimeters [4 inches] total length) and juvenile Pahranagat roundtail chub (25 to 100 millimeters [1 - 4 inches] total length) in the Pahranagat Creek typically inhabit pools below a riffle, but adults were also found in deeper pools, closer to the stream bottom, and in faster water (Tuttle et al. 1990). Larval Pahranagat roundtail chub occur in slack water, near the water surface, and along the creek's edge. During all seasons, adult Pahranagat roundtail chub occurred in water depths ranging from 0.4 to 1.4 meters (1.3 to 4.6 feet) deep, with a mean of 0.8 meter (2.6 feet), and water velocities ranging from 0.00 to 0.80 meter per second (0.0 to 2.6 feet per second), with a mean of 0.32 meter per second (1.04 feet per second). Pahranagat roundtail chub juveniles occupied areas with water velocities of 0.00 to 0.60 meter per second (0.0 to 2.0 feet per second), with a mean of 0.20 meter per second (0.7 foot per second). Larval Pahranagat roundtail chub occurred in essentially still water (0.00 to 0.30 meter per second [0.0 to 1 foot per second]), with a mean of 0.06 meter per second (0.2 foot per second). Habitat use among the three life stages varies, indicating juvenile and larval Pahranagat roundtail chub function as ecologically separate entities (Tuttle et al. 1990).

Adult Pahranagat roundtail chub occupy deeper and slower water in summer than in spring or winter. This shift is partially attributable to reduced summer water flow, but may also be part of a behavioral response to increased metabolic demands associated with warmer water. Summer water temperatures (29.2 to 32.2 degrees Celsius, 85 to 90 degrees Fahrenheit) in the Pahranagat Creek are very stressful for fish and potentially lethal. Along with inhabiting areas of lower

water velocity during the summer, Pahrana gat roundtail chub also reduce their active metabolism. During the summer season, Pahrana gat roundtail chub tail beats were only 75 percent of those counted during the winter. This reduction suggests that the Pahrana gat roundtail chub may move into slower water during the summer to reduce energy expenditures (Tuttle et al. 1990).

Foraging Behavior - The patchy distribution of Pahrana gat roundtail chub in the Pahrana gat Creek/Ditch suggests that this fish requires specific foraging habitat (Tuttle et al. 1990). Pahrana gat roundtail chub typically congregate in pools below a portion of the river that is typically narrow and has increased water velocity. Fallen trees or branches are common to these areas, and increase water turbulence. The distinctive hydraulic conditions that Pahrana gat roundtail chub occupy probably provide optimum opportunities for encountering food items with minimal energy expenditure. Pahrana gat roundtail chub generally enter slightly faster water velocities when striking at a food item (Tuttle et al. 1990).

During the winter of the study, Pahrana gat roundtail chub congregate at the confluence of Crystal Springs and Pahrana gat Creek to forage because ostracods (seed shrimps) and other invertebrates are abundant in the cooler water. During the summer, chub congregate in the occasional pockets of cool water created by irrigation runoff from adjacent pastures and forage on food items carried by the runoff.

Foraging Rate - Pahrana gat roundtail chub forage primarily on drifting invertebrates and secondarily, though infrequently, by pecking at substrate. The species rarely preys on other fish, although a Pahrana gat roundtail chub was observed to successfully consume a mosquitofish (Tuttle et al. 1990). Rates of adult drift feeding vary, with more food consumed in the winter than in summer. The lower food consumption rate during the summer corresponds to a reduced availability of food items during the summer. The summer appears to be a period of austerity for adults, characterized by high metabolic demands due to warmer water temperatures and low food availability.

There is no relationship between feeding rate and relative food item abundance for two size classes of adult Pahrana gat roundtail chub, although there is a

relationship between feeding rate and water temperature for larger adults (Tuttle et al. 1990). Large Pahrnagat roundtail chub may feed more selectively with increasing water temperatures, preferring bigger and energetically more efficient prey items. During winter, retrieval of smaller prey items in cooler water requires the expenditure of less metabolic energy.

Reproductive Biology - Pahrnagat roundtail chub have been observed spawning at three sites in the Pahrnagat Creek, all approximately 3.2 kilometers (2.0 miles) to 3.5 kilometers (2.2 miles) below Ash Springs. Adult Pahrnagat roundtail chub begin to congregate in mid-January, although spawning generally does not start until late January. Peak daytime spawning activity generally occurs during early to mid-February, and although congregations persist through March, spawning usually does not occur after mid-February. In May 1988 spawning congregations appeared on two of the spawning sites, but no spawning activity was observed, and no larvae were produced.

Male and female Pahrnagat roundtail chub are readily distinguishable by their reproductive behavior, which is similar to other cyprinids. The persistent and insistent behavior of a fish in the spawning congregation suggests that it is a male. Females are fewer in number and receive substantial attention in the form of male pursuit. When the female is ready to spawn, she swims down to the gravel bottom where she is attended by a group of 2 to 10 males. The spawning group vibrates violently for 3 to 6 seconds. The female generally swims away and is pursued by males until ready to spawn again. It is believed that females only appear on the spawning site when prepared to spawn, which occurs intermittently over several days.

Spawning occurs in relatively fast water in gravel-covered pool bottoms at water depths ranging from 0.58 to 1.04 meters (1.9 to 3.4 feet), and water velocity ranging from 0.08 to 0.54 meter per second (0.25 to 1.2 feet second). Water temperatures during the spawning months range from 17.0 to 24.5 degrees Celsius (63 to 76 degrees Fahrenheit), and dissolved oxygen concentrations from 5.2 to 6.3 milligrams per liter (parts per million).

Pahrnagat roundtail chub eggs are broadcast over gravel substrates and

apparently fall into the cracks. Convict cichlids and speckled dace have been observed picking at the spawning beds, presumably in search of eggs. Larvae reach "swim-up" stage approximately 28 days after eggs are deposited in the gravel bed. It takes 28 - 53 days for all larvae to leave the spawning beds, with peak emigration occurring on the 30th day. Larval emigration generally occurs between 6:00 p.m. and midnight, with the majority of emigration occurring between 7:00 and 8:00 p.m.

White River Springfishes

Very little information is available on the life history and habitat requirements of White River springfish and Hiko White River springfish. However, research has been conducted on other *Crenichthys* subspecies. Because of the relatedness between the subspecies, it is assumed that White River springfish and Hiko White River springfish have similar life histories and comparable habitat needs. For this discussion, White River and Hiko White River springfishes are divided into three age classes: 1) adult greater than 35 millimeters (1.4 inches) total length, 2) juvenile 10 to 35 millimeters (0.4 to 1.4 inches) total length, and 3) larvae less than 10 millimeters (0.4 inch) total length.

Habitat Use - Adult White River springfish are found at varying depths, from 0.4 to 1.7 meters (1.3 to 5.6 feet), but prefer deeper water (1.1 meters, 3.6 feet). Juvenile White River springfish will also use all depths, but generally occur in shallower (0.64 meter, 2.1 feet) water and are more vertically dispersed. Larval White River springfish restrict their movement to the top of the water column (0 to 0.6 meter deep, 0 to 2 feet) and are found most frequently at 0.35 meter (1.1 feet). All age classes of White River springfish are present in areas of calm water (Tuttle et al. 1990).

Food Habits - White River springfish are feeding generalists (Deacon and Minckley 1974, Williams and Williams 1982, Wilde 1989). An examination of the stomach contents of Moormon White River springfish indicate that invertebrates, especially amphipods (small crustaceans), are the most important items in their diet (Wilde 1989). Williams and Williams (1982) found Preston White River springfish to be predominantly herbivorous (plant-eating), ingesting

filamentous algae, vascular plants, and diatoms, although some individuals consumed large quantities of midges and caddisfly larvae. Differences in diet probably result from differences in habitat that dictate food item availability. Wilde (1989) noted a shift in diet to herbivory in the winter when invertebrates were not abundant. Springfish forage along the substrate and in plants, as evidenced by the ingestion of bottom-dwelling invertebrates, plant fragments, and detritus. They are active only during the daytime, with peaks occurring in the morning and afternoon.

Generally, small fish need to consume a large percentage of their body weight in food every day to meet their metabolic demands. These metabolic demands will vary directly with water temperature of the occupied habitat (Bond 1979). Moormon White River springfish inhabiting a warm-water (35.5 - 37 degrees Celsius, 96 - 99 degrees Fahrenheit) spring have respiratory rates four or more times greater than Preston White River springfish from a cool-water (21 degrees Celsius, 70 degrees Fahrenheit) spring (Sumner and Sargent 1940). Additionally, springfish from a warm-water spring were able to survive in a cool-water spring, but the converse does not hold true (Sumner and Sargent 1940).

White River springfish and Hiko White River springfish are uniquely adapted for surviving in environments of extreme temperatures and low dissolved oxygen content (Hubbs and Hettler 1964). The ability of springfish to adaptively thermoregulate by moving in and out of areas of extreme temperatures, which would be lethal under extended exposure, and to live in water with a broad range of temperatures, has enabled them to survive in areas deemed too hostile for other fish species (Hubbs and Hettler 1964).

Reproductive Biology - Deacon and Minckley (1974) defined springfish spawning as asynchronous, i.e. individual females will spawn at different times of the year. Most females average two spawning periods a year, while the spawning season of the entire population extends over a long period of time each year. Moapa White River springfish spawn year-round with peak spawning activity from April through August (Scoppettone et al. 1987). The period of spawning activity may be regulated by the primary productivity (production of food) in the spring system (Schoenherr 1981).

Kopec (1949) reported the spawning behavior of Moapa White River springfish held in aquaria. The male began courting the female at a 45° angle with his head down, from a distance of 2.5 to 7.6 centimeters (1 - 3 inches) directly ahead of the female, allowing her to witness his intense colors and markings. The male then approached the female and attempted to corner her in dense vegetation. Soon they formed an S-shaped clasp with both fish vibrating very quickly as they laid on their sides. As the anal fin of the male folded under the female's ovipositor, insuring a direct pathway for fertilization, one egg was deposited. The egg then fell onto and adhered tightly to nearby vegetation. Spawning females deposited 10 to 17, 1.9 millimeter-diameter (.07 inch) eggs. Larval springfish were hatched after a 5-7 day incubation period.

H. Reasons for Listing and Current Threats

The Pahrnat roundtail chub was listed as endangered in 1970 under the Endangered Species Preservation Act of 1966, a precursor of the Endangered Species Act (35 Federal Register 16047). This previous act did not require a published summary of the factors affecting the species and the reasons for its listing. However, it is probable that the species was granted endangered status because it had been extirpated from two of three historically occupied spring systems, and was considered to be extremely rare. Degradation of the riparian habitat due to grazing, crop production in adjacent habitat, and loss of riverine canopy was believed to be contributing to the declining Pahrnat roundtail chub population. Though these activities may have contributed to decline of the fishes in the past, recent field visits suggest that the previous activities and recovery of the listed fishes are not mutually exclusive. However, improvements in the current habitat conditions, while maintaining current land use practices, will be needed before the fish can be recovered.

White River springfish and Hiko White River springfish were listed as endangered species with critical habitat in 1985. At that time, the one known population of the White River springfish and the single remaining population of the Hiko White River springfish were threatened by habitat alteration and the presence of nonnative species, which compete and prey upon the springfishes (50 Federal Register 39123).

Populations of both subspecies of springfish continue to face threats to their existence from: continued presence of nonnative species, diseases not previously found in native fish populations, habitat manipulation, and loss of genetic material exchange between populations.

Nonnative Introductions - Research has presented evidence that nonnative species find it difficult or impossible to successfully invade and establish populations in environments with an existing large, diverse fauna (Deacon and Minckley 1974). In ecosystems simplified or modified by disturbance, nonnative species may and do, become established. Generally, species that succeed when introduced into faunally saturated areas are those with a wide spectrum of tolerances (Courtenay and Taylor 1986). However, when only one or a few fish species occupy a habitat, such as in most desert waters, nonnative species typically establish readily, with deleterious results to native fish communities (Minckley et. al. 1991). A reduction in size of individual native fish populations, a rapid, apparent niche segregation of the native fish, extinction of the native fish, or a combination of the first two outcomes are common results of nonnative species invasions.

In the Pahranaagat Valley habitat overlap between Pahranaagat roundtail chub and shortfin molly occurs primarily during the Pahranaagat roundtail chub larval stage (Tuttle et al. 1990). Convict cichlids were believed to be the more formidable threat to larval Pahranaagat roundtail chub based on gut analysis and observations of them picking at gravel spawning beds of adult Pahranaagat roundtail chub. In laboratory experiments using a castostomid (sucker) larvae as a substitute for the endangered Pahranaagat roundtail chub, shortfin mollies were discovered to be extremely effective larval predators (Scoppettone 1993). Mollies are now considered a greater threat to larval Pahranaagat roundtail chub than cichlids because of their tendency for greater spatial overlap (Tuttle et al. 1990). Fortunately, Pahranaagat roundtail chub reproduction occurs in late winter when populations of nonnatives are depressed and in reaches of river with the smallest nonnative populations.

The greatest spatial overlap between native and introduced fishes is between springfish (both subspecies) and shortfin molly, followed by springfish and

convict cichlids (Tuttle et al. 1990). Both springfish species larvae overlapped most with adult mollies. Mollies and cichlids are thermophilic (warm temperature loving), like the springfish, and are abundant in the areas occupied by springfish. In laboratory experiments, both the convict cichlid and shortfin molly were found to be extremely adept at larval predation. Competition for food between springfish and shortfin molly is minimal, although both forage at or near the bottom, because of the molly's tendency towards herbivory. The greatest competition for food resources occurs between cichlids and springfish as they are both omnivorous and thermophilic.

Recent experiments, using the Moapa White River springfish as a substitute for the two listed species, clarified behavioral relationships between the springfish, the shortfin molly, and the convict cichlid. Springfish are more aggressive amongst themselves in the presence of shortfin molly, which increased mortality among springfish (Scoppettone unpublished data). Mollies were also observed preying upon newly laid springfish eggs. Springfish were most often the target of aggressive cichlid attacks, resulting in significant springfish mortality. When springfish were confined with both nonnative species, the aforementioned practices became more intense. Experimental reproductive data confirmed severely reduced larval production and recruitment for springfish cohabiting with convict cichlids and shortfin mollies.

In addition to direct effects such as predation and mortality, nonnative fish have introduced fish parasites including tapeworms (*Bothriocephalus acheilognathi*), nematodes (*Contracaecum spp.*), and anchor worms (*Lernaea spp.*) into desert ecosystems which negatively affect the native fish populations (Deacon and Minckley 1974). Anchor worm infestations cause tissue damage, blood loss, and expose fish to secondary infections. Heavy infestations may cause reduced longevity, reduced fecundity, and even direct mortality. For example, a significant increase in the incidence of *Lernaea* was documented in Ash Springs in 1964 after the release of shortfin molly, sailfin molly, and convict cichlid (Deacon 1979). This increase in parasitism resulted in a dramatic decline in abundance of the native fish population. The effect of the other parasites on the native fish populations in the Pahrnagat Valley are currently unknown. Tapeworms may cause fish to become listless, lose weight, or become sterile;

severe infections may cause the abdomen to become distended and block the intestine (USFWS 1986b). Nematodes may encyst in fish muscle tissue.

Negative impacts to the listed fish species from nonnative species other than fishes include predation by bullfrog (*Rana catesbeiana*) and crayfish (*Procambarus clarkii*). A nonnative snail species, *Melanooides tuberculatum*, is abundant in the spring systems, but its impact on the fishes is unknown.

Habitat Changes - The use of the Pahrnagat Valley ecosystem to provide water for irrigation purposes has continued for well over a century. Loss of water and associated alteration of the stream channel and adjacent habitat to provide water for irrigation from the lower part of the Ditch appear to have been at least a partial factor in the decline of Pahrnagat roundtail chub and its habitat. Nonnative species have been responsible for the decline and extirpation of numerous native, desert fishes, the impacts from water fluctuation and springhead manipulation have been less severe and are more easily rectified than have the impacts of nonnative fish (Courtenay and Deacon 1982, Deacon et al. 1979, Deacon and Minckley 1974). In Pahrnagat Valley, preliminary evidence suggest that areas that have been disturbed by algae removal, water level fluctuation, and recreational activities, are more apt to be predominated by nonnative fishes, whereas native fish are more common in areas with few or no disturbances.

Though many of the habitat modifications occurring in the Valley appear to adversely affect native fish populations, these impacts could be managed to lessen the impact to the fish with minimal changes on how the water is used. Several potential impacts to the species, such as the loss of juvenile chub, which may occur in the concrete-sided irrigation channels, and the cleaning of springheads to remove algae, which may be removing a springfish food source and spawning habitat, should be corrected to enhance habitat conditions. One possible solution would be screening the irrigation channels or the capture and removal of the juveniles from the channels. Screens may significantly reduce the impact to the fish without affecting land use. An alternative for cleaning out all the algae in the springhead may be to clean out a portion of the spring for swimming and aesthetics and to leave a portion of the algae for food and spawning material. Structures that impound the springheads pose substantial drops for waters entering

the main outflows, and springfish in these outflows become stranded when the gates open. These fish are unable to return to the springheads and are lost to the population. Designing a structure that retains the water but allows the fish to move freely back and forth during irrigation may be a possible alternative. In addition, these disturbances may contribute to nonnative, aquatic species impacts upon native species. If all the measures previously discussed were employed, the nonnative fishes numbers could be reduced as the native fish numbers increased. Portions of the spring pools are used as swimming holes, and native fishes are not found in these areas when swimming occurs; however, nonnative fishes are typically abundant in these areas. Swimming does not necessarily preclude recovery for springfish as long as areas are designated solely for springfish to occupy. Though habitat manipulations in the springs are most detrimental to the springfishes and juvenile Pahrnagat roundtail chub, various measures, such as weirs or other devices that keep the fish in safe nonthreatening habitat, could be employed to minimize or eliminate the impacts without affecting the use of the water. The Fish and Wildlife Service foresees working with the landowner(s) to develop methods to maintain land-use activities and enhance chub and springfish habitat.

When listing the chub it was thought that agricultural activity in the Valley resulted in the conversion of riparian habitat to pastures for grazing and crop production and had significant impacts on the chub. It was also believed that agricultural water use generated a sparse riparian corridor along both the irrigation channel and the seasonally dewatered creek. Recently, the Fish and Wildlife Service has toured much of the dewatered creek and found that most of the riparian corridor appears to be potentially suitable habitat for the fish species covered in this plan. Additional riparian habitat may be created with further habitat improvements. The falling debris from the riparian overstory provides the drift-feeding Pahrnagat roundtail chub an important component of its food base. The riparian overstory also shades the Ditch/Creek; without this shade, the temperatures in the Ditch/Creek may approach lethal levels. The most important limiting factor for adult Pahrnagat roundtail chub population is a lack of cool water areas for the adults to use during summer. With the cooperation of a private landowner, the Fish and Wildlife Service has begun to study whether a diversion of artificial pools in the lower Ditch provides suitable habitat for the chub to live.

Interviews with the oldest residents of the Valley indicates that the overstory that exists today has been relatively stable and consistent since 1901 (Shelley Wadsworth, Lincoln County Public Lands Commission, written communication, 1997).

Research has shown that grazing alters the macroinvertebrate community in waters adjacent to, and downstream of, grazed areas by decreasing taxa diversity (Rinne 1988). Additionally, further problems may arise in the form of increased ammonia and nitrites concentrations from cattle having unrestricted access to water (Taylor et al. 1987). By restricting access to the creek, accompanied with off-site watering, or some type of temporary barrier along the creek (i.e. cut logs), these impacts would be minimized if not eliminated. The Fish and Wildlife Service anticipates working with the landowner to develop strategies to maintain adjacent land-use activities and improve chub habitat.

I. Conservation Efforts

Numerous conservation efforts have been undertaken for the benefit of the listed species in the Pahranaagat Valley. Pahranaagat roundtail chub were established at the Dexter National Fish Hatchery in New Mexico in 1986 to prevent extinction by a catastrophic event. Prior to the listing of both subspecies of springfish, a Hiko White River springfish population was established at Blue Link Spring expressly for the conservation of this subspecies (see section D).

In addition to being protected by the provisions of the Endangered Species Act, all three species are protected by the State of Nevada, which prohibits taking of protected species without a valid State collecting permit (Nevada Administrative Code 503.065). The Nevada Division of Wildlife has received funding from the Fish and Wildlife Service through section 6 of the Endangered Species Act to monitor the population status of all three species, and to develop conservation easement agreements between the State and private landowners.

The Bureau of Land Management completed an Ash Springs Coordinated Resource Management Plan for the White River springfish and the Pahranaagat roundtail chub in 1989. This plan allows the Bureau of Land Management to

manage the recreational activities at the spring sources and provide protection for the area.

In 1986, the Fish and Wildlife Service prepared a draft environmental assessment on habitat protection for the Pahrnagat roundtail chub, White River springfish, and Hiko White River springfish (USFWS 1986c). This document provides alternatives for identifying the most feasible and effective means for conserving the Pahrnagat roundtail chub, White River springfish, Hiko White River springfish, and their habitats.

A recovery plan for the Pahrnagat roundtail chub was prepared in 1985 by the Fish and Wildlife Service. The primary objective of the plan was to improve the status of the Pahrnagat roundtail chub so it could be removed from the list of Threatened and Endangered Wildlife (USFWS 1985). The plan identified priority research and recovery needs for the Pahrnagat roundtail chub including development of a captive breeding population and studies to determine habitat preferences, population dynamics, and biological effects of altered habitat. The recovery plan provided guidance for Federal agencies wishing to fund or perform recovery actions identified in the plan. In the years immediately following publication of the 1985 recovery plan, much effort was directed toward establishing the captive population at Dexter National Fish Hatchery and identifying the ecology of the Pahrnagat roundtail chub. The Fish and Wildlife Service's National Fisheries Research Center-Reno completed many research tasks specified in the 1985 plan, including Pahrnagat roundtail chub life history, abundance and distribution, food habits, habitat use, movement patterns, population dynamics, and inter- and intraspecific interactions (Tuttle et al. 1990). This research also provided information on White River and Hiko White River springfishes.

The Fish and Wildlife Service has been involved with the landowners and County government on finding solutions for recovery of the listed species that are compatible with local custom, culture, livelihoods, and land uses. The Fish and Wildlife Service is working with local government to develop a county-wide Habitat Conservation Plan (HCP) that would provide protection for these three listed species as well as five others. Habitat Conservation Plans are designed to

protect species while allowing certain types of development and agricultural activities. Habitat Conservation Plans need to take into consideration the recovery needs of the listed species and must be designed to ensure they do not preclude recovery. They are one important tool for fostering cooperative conservation efforts, documenting obligations of the involved parties, and committing the involved parties to those obligations through a binding agreement.

Additionally, the Fish and Wildlife Service is currently working with a private landowner to develop a Habitat Conservation Plan for Ash Spring. This Habitat Conservation Plan would provide protection for the White River springfish and the Pahranaagat roundtail chub while contributing to the economic development of Lincoln County. Lastly, the Fish and Wildlife Service is working with another private landowner to collect data on whether areas on the downstream part of the ditch provide suitable habitat in terms of water quantity, quality and temperature.

J. Recovery Strategies

Cooperation and support from the local landowners is vital in recovering the endangered fishes and the ecosystem upon which they depend. Approximately 98 percent of the riparian ecosystem is privately owned. Recovery of these fish will include current custom and culture. The cooperation of individual landowners and communication from the Fish and Wildlife Service are essential to accomplish most of the tasks necessary for recovery. Obtaining private landowner approval will be pursued on an individual basis as well as with the utilization of a working group. This group will be composed of Fish and Wildlife Service, State, county, and town officials, irrigation users, ranchers, and private landowners, as appropriate.

Utilization of habitats currently unoccupied within the Pahranaagat Valley and associated spring systems will be vital to the recovery of the listed species occurring in Pahranaagat Valley. Currently, the Fish and Wildlife Service is working with cooperative landowners on gathering the data needed to determine which currently unoccupied areas may be most suitable for recovery and survival of the listed species. Equally important for recovery of listed species is the removal or reduction of nonnative species. The Fish and Wildlife Service is

currently working with the Nevada Division of Wildlife and several private landowners to eradicate nonnative species. A cooperative valley-wide effort to improve habitat for these species would minimize impacts to individual landowners.

Additionally, the populations of Hiko White River springfish and Pahranaagat roundtail chub at Blue Link Spring and Dexter National Fish Hatchery, respectively, should be maintained and managed as refugia populations. These populations are needed to prevent the loss of the species due to the close proximity of all occupied habitats, and the resultant potential for a catastrophic event which may adversely affect all natural populations. Additionally, these refugia populations may be used to increase gene flow (heterozygosity) within the species. Gene flow is important for the overall health and perpetuity of any species. Although these refugia populations are not essential to meet the recovery criteria of the species, they may help prevent extinction and improve the species overall health while moving toward recovery. Each refugium population should be maintained until the species is fully recovered and post-recovery monitoring indicates they are no longer needed. The Nevada Division of Wildlife and the Fish and Wildlife Service are presently pursuing an additional site for the Pahranaagat roundtail chub on State or Federal land, which will be used as the refugium instead of Dexter National Fish Hatchery.

K. Landowner Concerns

The Fish and Wildlife Service has been very involved with the Lincoln County Public Lands Commission and private landowners about their concerns with recovering the listed species in the Valley. Various concerns have been expressed and will be presented in this section. Most of the concerns expressed have been about ensuring and respecting private property rights, water rights, and agreements made by the Fish and Wildlife Service. The Fish and Wildlife Service is strongly committed to working cooperatively with individuals or groups of individuals to develop strategies to maintain existing adjacent land-use activities in the course of improving chub and springfish habitat. One avenue to enhance this cooperative effort would be a memorandum of understanding between the Fish and Wildlife Service and a landowner(s). The memorandum of

understanding would state the responsibilities, planned activities, and applicable restrictions that would apply to the Fish and Wildlife Service and the landowner.

Another concern expressed was that the Fish and Wildlife Service might be “taking” a certain amount of acreage of land on either side of the Ditch to recover the fishes. This type of action is not a part of the recovery plan, nor does the Fish and Wildlife Service believe it necessary to recover the fishes. Certain habitat enhancements could be done on individual properties such as deepening (cleaning) the Ditch, adding additional riparian vegetation to the Ditch’s banks, fencing portions of the Creek and Ditch to limit livestock usage without stopping it, and offering offsite water for livestock. These alternatives would not be implemented without permission from the landowner. Recently, the Fish and Wildlife Service has discussed these alternatives with landowners.

Lastly, private landowners expressed concern about access to private lands. The Fish and Wildlife Service will not enter lands illegally and will not access private land for recovery activities without the express permission of the landowner. The Fish and Wildlife Service will request appropriate permission either in writing or verbally from the landowner and will do so at time interval determined by the landowner.

Part II. Recovery

A. Objective and Criteria

The objective of this Recovery Plan is to recover and maintain the aquatic and riparian habitats of the Pahranaagat Valley so that the three endangered fish species may be removed from the Federal list of endangered and threatened species. This Recovery Plan also addresses the research and habitat needs of several unlisted species of concern to the Fish and Wildlife Service. Because this Plan addresses an ecosystem, actions taken to improve the status of the native fishes should also improve the status and condition of other endemic species and the entire aquatic ecosystem. All recovery criteria are subject to revision on the basis of new information (including research specified as recovery tasks). If recovery actions are undertaken as scheduled, all species could be recovered by 2015.

The Pahranaagat roundtail chub may be considered for reclassification from endangered to threatened when:

- 1) Pahranaagat Creek/Ditch contains adequate cool water pools, for chub to persist through the summer months;

- 2) a self-sustaining Pahranaagat roundtail chub population (comprising three or more age-classes, a stable or increasing population size, and documented reproduction and recruitment) is present in a combined total of approximately 75 percent of either 6.8 kilometers (4.7 miles) of the Crystal Spring outflow stream through its confluence during the winter months with the Ash Springs outflow stream, or 10 kilometers (6.2 miles) of Pahranaagat Creek/Ditch below the confluence for three complete generations (or a minimum of 15 consecutive years); and

- 3) impacts to the species and its habitat have been reduced or modified to a point where they no longer represent a threat of extinction or irreversible population decline.

The Pahranaagat roundtail chub may be considered for delisting provided that all

reclassification criteria have been met and when:

- 1) a minimum year round in-stream flow of 1.75 cubic feet per second is present, at the point where Pahranaagat Ditch starts, to sustain a Pahranaagat roundtail chub population;
- 2) the riparian corridor along the outflow stream of Crystal Spring has been enhanced;
- 3) all impacts to its habitat have been neutralized or reduced sufficiently for both the species and land uses to coexist; and
- 4) a Pahranaagat roundtail chub population as defined in the downlisting criteria inhabits both approximately 75 percent of both the 6.8 kilometers (4.7 miles) of the Crystal Spring outflow stream through its confluence during the winter months with the Ash Springs outflow stream, and approximately 75 percent of the 10 kilometers (6.2 miles) of Pahranaagat Creek/Ditch from the beginning of Crystal and Ash Springs outflows to Upper Pahranaagat Lake.

The White River springfish may be considered for delisting when:

- 1) a self-sustaining White River springfish population (comprising three or more age-classes, a stable or increasing population size, and documented reproduction and recruitment) is present in the spring pools of Ash Spring for three complete generations (or a minimum of 6 consecutive years); and
- 2) impacts to the species and its habitat have been reduced or modified to a point where they no longer represent a threat of extinction or irreversible population decline.

The Hiko White River springfish may be considered for delisting when:

- 1) a self-sustaining Hiko White River springfish population (comprising three or more age-classes, a stable or increasing population size, and documented reproduction and recruitment) is present in the spring pools of Hiko and

Crystal Springs for three complete generations (or a minimum of 6 consecutive years); and

2) impacts to the species and its habitat have been reduced or modified to a point where they no longer represent a threat of extinction or irreversible population decline.

The probability of survival will be determined at the time reclassification or delisting is proposed by evaluating monitoring data on reproduction and recruitment, verifying the modification or elimination of the impacts, and examining the potential for development of new or recurring threats. Prior to implementation of any task in this Plan, the lead Federal agency must comply with all applicable provisions of the National Environmental Policy Act and Endangered Species Act. All necessary Federal, State, and local permits or authorizations will be obtained. Recovery activities on private land will depend on obtaining the cooperation and permission of the landowners. The Fish and Wildlife Service will not enter private lands illegally.

These recovery criteria were designed to provide a basis for consideration of delisting, but not for automatic delisting. Completion of tasks 122-123 will minimize or eliminate impacts incurred by nonnative species and habitat changes, whereas; task 21 will provide the data needed to document recovery of the listed species. Before delisting may occur, the Fish and Wildlife Service must determine that the following five listing factors are no longer present or continue to adversely affect the listed species: 1) the present or threatened destruction, modification, or curtailment of the species' habitat or range; 2) over utilization for commercial, recreational, scientific, or educational purposes; 3) disease or predation; 4) inadequacy of existing regulatory mechanisms; and 5) other human-made or natural factors affecting the continued existence of the species (50 CFR 424.11). The final decision regarding delisting would be made only after a thorough review of all relevant information by the Fish and Wildlife Service. It is the goal of the Fish and Wildlife Service to achieve recovery as quickly as possible while minimizing social and economic impacts.

Although not necessary for their recovery, the existing refugia population of

Pahranagat roundtail chub at Dexter National Fish Hatchery should be moved to State or Federal land in the Valley and the Hiko White River springfish at Blue Link Spring should be managed and maintained into the future. These populations occur outside the Pahranagat Valley and may prevent the extinction of the Pahranagat roundtail chub and the Hiko White River springfish should unforeseen catastrophic events severely affect or eliminate their populations in Pahranagat Valley.

B. Narrative Outline of Recovery Actions

1. Maintain, and enhance aquatic and riparian habitats in the Pahranagat Valley

11. Develop and implement conservation agreements

Implementation plans will be developed and presented to landowners and local governing bodies before conservation agreements with landowners are signed. The Fish and Wildlife Service strongly supports open communication with landowners and local government, including the details of all implementation plans and conservation agreements.

Conservation agreements are an important method for achieving reclassification and delisting and should be negotiated with willing private landowners. Such agreements could include permission to access habitat for management activities, collecting data, creating pools to determine juvenile chub survival in the lower creek/ditch, habitat improvement activities such as deepening and cleaning of the creek/ditch, providing fencing to allow additional riparian growth, eradicating nonnative species, installing of weirs to prevent Pahranagat roundtail chub from being washed out of irrigation ditches, and other measures, as appropriate.

These agreements will clearly establish the limits of any conservation

actions and ensure that they do not infringe on the landowner's land and water rights. The Fish and Wildlife Service will not attempt to use a landowner's property for any other purpose than that stated in the agreement. Nor does the Fish and Wildlife Service expect any landowner to significantly alter their current land use practices or attempt to use their water for any other purpose than as established by existing water rights.

12. Establish a working group with local landowners, private interest groups, and county representatives

The working group would be able to identify recovery strategies that benefit the native species and minimize or eliminate the effects of those tasks on the economic base and private citizens in the area. Input from the working group would be an asset in developing an outreach program designed to acquaint local citizens with the endangered species in the area. The working group should be established as soon as possible. The working group would help elicit cooperation and support from all local landowners for the implementation of recovery tasks. This cooperation and support is vital for recovery to take place since over 98 percent of the endangered species habitat occurs on or adjacent to private land.

13. Enhance aquatic and riparian habitats in the Pahranaagat Valley

131. Identify and control factors limiting native species abundance and distribution

Several factors have already been identified as limiting native fish populations. Nonnative species are seriously impact native fishes through predation and competition for resources. Wherever feasible, all nonnative species should be removed from native fish habitats. Physical removal of nonnatives (e.g. trapping, seining, etc.) should be used whenever possible to minimize the adverse effects on the ecosystem. To avoid impacting native invertebrates and other

nontarget species, chemical eradication measures (e.g. rotenone) should be used sparingly and only when absolutely necessary.

There are various habitat alterations which may adversely impact listed fishes in Pahrnagat Valley. Several techniques could be implemented to significantly reduce or eliminate the impacts, these techniques will be addressed in subsequent tasks.

Habitat requirements and life history information exist for the listed species, but very little information is available for other native species occupying the same habitats. This information is important for enhancing the understanding of ecological relationships that exist between cohabiting species in a closed ecosystem. Lastly, water quality in the Pahrnagat Valley needs to be quantified and information collected on how it may affect native species. Any data collected will be available for review by local government and any other interested parties.

132. Develop and implement habitat enhancement plans for the Pahrnagat Valley

Habitat restoration and management plans should be developed in cooperation with landowners throughout the Pahrnagat Valley. Fish and Wildlife Service cooperation with landowners will be emphasized in the development of these plans. Minimizing perturbations to the ecosystem will facilitate nonnative fish removal by reducing availability and suitability of habitat for nonnatives. One option would be to clean algae only out of predetermined swimming areas for all the springs and to remove the algae during the summer months, which is outside of prime springfish spawning. A decrease in summer water temperatures may be accomplished by revegetating the riparian overstory with native flora, by deepening the creek/ditch channel, and by creating deeper pools along the system by slowing the water down in those areas where a pool could feasibly be developed. Repositioning of barriers in Ash and Crystal Springs may provide

needed habitat connections between native species populations and still allow for water level manipulation without drastic fluctuations.

To provide additional water to the ecosystem during periods of reduced flow, several options should be explored. One possibility is to replace the existing concrete ditch with a pipeline. This alternative would provide all downstream users their entire water right instead of the decreased flow they receive now due to evaporation and leakage from the concrete ditch. All affected landowners and interests will have an opportunity to participate in considering this alternative.

Habitat restoration and management plans developed for the Pahrnagat Valley should be implemented as these plans are completed. Restoration activities to supply additional water to the Pahrnagat Creek/Ditch and to recreate contiguous habitat for native species should be given the highest priority.

2. Develop and implement monitoring plans

The stability and health of the Pahrnagat Valley aquatic and riparian ecosystem can only be assessed by regular monitoring. All the species that are important components of this system need to be included. Monitoring will provide data to evaluate the effectiveness of habitat restoration, habitat management, nonnative species eradication, and species specific responses to the aforementioned tasks. Potential problems such as reinvasion of nonnative species or the disappearance of an endemic species can be identified in a timely manner during monitoring. Monitoring data are necessary specifically to determine whether or not recovery criteria have been met.

Plans for monitoring the native fishes, mammals, and invertebrates of Pahrnagat Valley should be developed. Most earlier monitoring efforts have been sporadic and have not covered the entire range of the native species; also monitoring techniques have varied. The monitoring plan should specify data to be collected, time frames for data collection, and standardized techniques. Techniques should be the most reliable for the species being monitored and compatible with previous

monitoring activities when possible. This consistency enables statistical data comparisons to be made and a long-term data set to be generated. Once the monitoring plan for each group of native species is developed, they should be implemented. Results of monitoring should be analyzed as soon as possible and habitat enhancement and management activities modified accordingly to meet recovery objectives. This monitoring could be integrated into other conservation efforts being pursued by the Bureau of Land Management, the Nevada Division of Wildlife, and in Habitat Conservation Plans.

21. Develop and implement monitoring plan for the native fishes
22. Develop and implement monitoring plan for the native mammals associated with the riparian and wetland areas.
23. Develop and implement monitoring plan for the native aquatic invertebrates.
24. Develop and implement monitoring plan for other listed species or species of concern

3. Provide public information and education

Public information and education would facilitate efforts to meet recovery criteria for the endangered fish species in Pahranaagat Valley. Significant future recovery actions such as habitat restoration, conservation agreements, and enhancement plans would provide specific opportunities for public involvement. Public support will be especially vital in recovery efforts because most existing and historical habitats of the listed species occur on private lands.

An outreach program will seek the cooperation and support of private landowners to protect Pahranaagat Valley and its rare and unique species. Outreach activities should cover proposed and ongoing recovery actions both on and off the Pahranaagat National Wildlife Refuge. Fact sheets and brochures should be made available at local Fish and Wildlife Service offices for distribution to the public. Self-guided, interpretive trails and corresponding exhibits may be developed for

the various springs and portions of the Pahrnagat Ditch. These types of outreach would be contingent upon private landowner permission. Once a program has been developed, and as opportunities for public information become available, they should be implemented.

The outreach program should also pursue cooperative agreements with willing partners (e.g. Lincoln County School District, public service groups, sporting associations) to assist in providing them funding for educational purposes such as workshops, lectures, civic group presentations, and exhibits.

4. Establish and maintain refugia populations

41. Establish another refugium population in the valley for the Pahrnagat roundtail chub

Only one restricted population of Pahrnagat roundtail chub is known to currently exist. In the past, the chub was confined to the Valley but probably existed throughout a larger area within the Valley. This species is vulnerable to catastrophic natural or human-induced habitat disturbances, which may eliminate or severely reduce the entire population. One or more self-sustaining refugia populations should be established to minimize the threat of extinction due to unforeseen catastrophic events.

According to information already collected on life history and habitat requirements, two sites exist in the Pahrnagat Valley, which may be locations to create artificial habitat for refugia populations (Key Pittman Wildlife Management Area and Pahrnagat National Wildlife Refuge). These sites are the preferred locations for the refugia as they are located entirely on State or Federal land. Additionally, should all private property issues or concerns be insurmountable, each or either location may be needed for survival. Selection of suitable habitats should consider existing habitat conditions, aquatic species composition, land and water uses, land ownership, and maintenance requirements. Suitable habitats must be of sufficient size to support a self-sustaining population of Pahrnagat

roundtail chub, and conflicts must be resolved. Continuous and consistent protection of the habitat must be ensured through the cooperation of any affected landowners and Federal land management agencies within the introduction area.

An introduction plan should be developed with the local working group to ensure that the introduction of Pahrnagat roundtail chub into refugia is adequately planned and properly implemented. The American Fisheries Society's "Guidelines for Introductions of Threatened And Endangered Fishes" (Williams et al. 1988) provides a summary of issues to address. The plan should identify the source of Pahrnagat roundtail chub for introduction, number of fish needed to establish a new population, methods of transport, methods of release and the number of Pahrnagat roundtail chub that can be removed at any one time without adversely affecting the source population. The Pahrnagat roundtail chub released into refugia should be free of parasites and disease. Several releases may be necessary to establish each population, and establishment may not be realized for several years. Once the introduction plan has been completed and the refugia habitat is suitable, introduction of Pahrnagat roundtail chub should proceed.

42. Manage new and existing refugia populations.

421. Develop and implement a genetic maintenance plan for existing refugia

A plan for identifying the genetic heterozygosity for the species held at Dexter National Fish Hatchery and Blue Link Spring should be developed. Transplanting these fishes yearly from the Pahrnagat Valley into their respective refugia populations may be necessary to increase gene flow within the refugia populations. Once the genetic maintenance plan has been developed, it should be implemented. Additionally, once the genetics of the Dexter fish were understood, they would be used to create and augment the refugium population on State or Federal lands.

422. Develop and implement refugia habitat management plans

Habitat management plans should be developed for each Pahranaagat roundtail chub refugium and springfish refugium. The plans should identify existing habitat conditions, the extent and character of habitat necessary to support a self-sustaining population of the listed fish, any improvements necessary to enhance the habitat, and management strategies necessary to maintain optimum habitat conditions in the long term. The plan should be flexible enough to be modified if changes are needed and should consider the effects of management activities on all endemic species. Once the habitat rehabilitation plans are developed, they should be implemented.

423. Develop and implement refugia population monitoring plans

The success of efforts to establish refugia populations of any of the listed fishes could only be evaluated by regular monitoring to determine population size, age-class structure, and distribution. Habitat quality and quantity should also be evaluated regularly. Information collected during monitoring could identify potential problems in a timely manner and guide refugia management activities. The plan should also identify the information to be collected, monitoring techniques, time-frames, etc. Once the refugia population monitoring plans have been developed, they should be implemented.

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Part IV. Implementation Schedule

This implementation schedule outlines actions and estimated costs for the recovery of the aquatic and riparian species of Pahrnagat Valley. It is a guide for meeting the objective discussed in Part II of this Recovery Plan. This schedule indicates task priorities, numbers, and descriptions; duration of each task; responsible agencies; and estimated costs. These actions, when accomplished, should bring about the recovery of Pahrnagat Valley's listed fishes and protect their habitat. It should be noted that the estimated monetary needs for all parties involved in recovery are identified and, therefore, this schedule reflects the total estimated financial requirements for the recovery of this species.

In the implementation schedule, tasks are arranged in priority order. The assigned priorities are defined as follows:

Priority 1 - An action that must be undertaken to prevent extinction or to prevent any of the listed fishes from declining irreversibly in the foreseeable future.

Priority 2 - An action that must be undertaken to prevent a significant decline in a listed fish's population distribution or size, or habitat quality, or some other significant negative impact short of extinction.

Priority 3 - All other actions necessary to meet the recovery objective.

Definitions for terms and acronyms used in: Implementation Schedule

Continual = Task will be implemented on an annual basis once it is begun and will continue until no longer required for recovery.
Total Cost = Projected cost of task from start to task completion.

Responsible Parties:

FWS = U.S. Fish and Wildlife Service
BRD = Biological Resources Division-
U.S. Geological Survey
NDOW = Nevada Division of Wildlife
BLM = Bureau of Land Management
* = Lead Agency

Recovery Plan Implementation Schedule for the Pahrnagat Valley

Priority Number	Task Number	Task Description	Task Duration (Years)	Responsible Parties	Total Cost (\$1,000's) 1998-2015	Cost Estimates (\$1,000's)				
						FY 1998	FY 1999	FY 2000	FY 2001	FY 2002
1	11	Develop and implement conservation agreements	Continual	FWS* NDOW	45	15	5	5	5	5
					23	5	2	2	2	2
1	12	Establish a working group with local landowners, private interest groups, and county representatives	Continual	FWS* NDOW BLM	20	4	4	3	3	3
					15	2	2	1	1	1
1	131	Identify and control factors limiting native species abundance and distribution	10	FWS* BRD NDOW*	45	12	12	10	10	3
					10	2	2	2	2	2
					17	5	4	4	2	2
1	132	Develop and implement habitat enhancement plans for the Pahrnagat Valley	Continual	FWS* NDOW BLM	25	5	5	5	5	5
					15	3	3	3	3	3
1	421	Develop and implement a genetic maintenance plan for existing refugia	Continual	FWS* NDOW BLM	20	10	2	1	1	1
					20	10	2	1	1	1
2	21	Develop and implement monitoring plan for native fishes	20	BRD* FWS* NDOW*	80	8	5	5	5	5
					30	2	2	2	2	2
					38	4	4	2	2	2
2	24	Develop and implement monitoring plan for other listed species and species of concern	20	NDOW* FWS	50	8	5	5	5	5
					20	2	2	2	2	2
					28	4	4	2	2	2
2	41	Establish another refugium population in the valley for the Pahrnagat roundtail chub	Continual	FWS* BRD NDOW	25	10	5	5	5	2
					20	5	5	5	5	5
					23	8	5	5	5	2

Recovery Plan Implementation Schedule for the Pahrangat Valley (continued)

Priority Number	Task Number	Task Description	Task Duration (Years)	Responsible Parties	Total Cost (\$1,000's) 1998-2015	Cost Estimates (\$1,000's)				
						FY 1998	FY 1999	FY 2000	FY 2001	FY 2002
3	22	Develop and implement monitoring plan for the native mammals associated with riparian and wetland areas	20	BRD*	50	8	5	5	5	5
				FWS*	20	2	2	2	2	
				NDOW*	20	4	4	2	2	
3	23	Develop and implement monitoring plan for the native aquatic invertebrates	20	BRD*	50	8	5	5	5	5
				FWS*	20	2	2	2	2	
				NDOW	28	4	4	2	2	
3	422	Develop and implement refugia habitat management plans	Continual	FWS*	20	0	0	5	2	2
				BRD	20	0	0	5	2	
				NDOW	20	0	0	5	2	
3	423	Develop and implement refugia population monitoring plans	Continual	BRD*	20	0	0	5	2	2
				FWS	20	0	0	5	2	
				NDOW	20	0	0	5	2	

V. APPENDICES

A. PUBLIC/PEER REVIEW

The draft recovery plan was made available to the public for comment as required by the 1988 amendments to the Endangered Species Act of 1973. The public comment period was announced in the Federal Register on September 12, 1995 and closed on November 13, 1995 and was reopened from August 7, 1997 to November 5, 1997. Copies of the draft plan were provided to qualified members of the academic and scientific community for peer review. The U.S. Fish and Wildlife Service solicited or received comments on the document from the academic and scientific community, private individuals, industry representatives, and Federal, State, and local agencies listed below. Before completion of this final recovery plan, the Fish and Wildlife Service received a total of 121 response letters, as indicated by an asterisk (*). The comments provided in these letters were considered in preparation of this final recovery plan and incorporated, as appropriate. Other significant comments are addressed by the Fish and Wildlife Service in Appendix B. All letters of comment on the plan are on file at the Fish and Wildlife Service's Reno Fish and Wildlife Office in Reno.

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B. PUBLIC COMMENTS AND SERVICE RESPONSES

This section consolidates, summarizes, and provides the Fish and Wildlife Service's response to *significant* comments *not* addressed by changes in the text. Specific comments that reoccurred in the letters are addressed only once.

Comment: Most taxonomists accept a study that removed the genus *Crenichthys* from the Family Cyprinodontidae and placed it in the Family Goodeidae and this correction should be stated in the plan.

Response: The Fish and Wildlife Service uses the American Fisheries Society publication, *Common and Scientific Names of Fishes from the United States and Canada*, for the most currently accepted scientific nomenclature. It specifically states that the genus *Crenichthys* will remain in the Family Cyprinodontidae pending further confirmation and research. Based on these findings the Fish and Wildlife Service feels the correction would be premature until the concept is more widely accepted by the scientific community.

Comment: The recovery plan does not adequately address the recovery of an ecosystem nor does it provide protection for the populations of listed species.

Response: The Fish and Wildlife Service feels that protecting the listed fishes and their habitats will provide the necessary protection for the other species that also utilize these areas.

Comment: Monitoring nonnative species is important for assessing their impact on the listed fishes and as such should be a separate monitoring program.

Response: The Fish and Wildlife Service agrees that monitoring of nonnative species is important but does not feel it should be included as a separate monitoring program since the goal is to remove nonnative fish entirely, and in the interim they will be monitored along with the native fishes.

Comment: Establishing populations of Pahranaagat roundtail chub at Pahranaagat National Wildlife Refuge should not be considered a "refugium" since the refuge

lies within historical habitat.

Response: The Fish and Wildlife Service agrees that the Pahranaagat National Wildlife Refuge lies within the historical range of the chub but does not feel suitable habitat still exists. It was the Fish and Wildlife Service's intention to create a pond or deepen an existing spring to hold the chub thereby creating a refugium for the chub.

Comment: A commenter requested the National Environmental Policy Act (NEPA) document the Fish and Wildlife Service needs to implement the recovery plan.

Response: Recovery plans are in a category of activities that are excluded from analysis under the National Environmental Policy Act since they are only planning documents suggesting potential actions by the Fish and Wildlife Service, other Federal or State agencies, local governments, the private sector, or a combination of the entities previously mentioned. Recovery plans impose no obligations on any agency, entity, or persons to implement the various tasks. Implementation of recovery actions will be subjected to National Environmental Policy Act compliance, as appropriate, at the time they are "proposed" and an environmental assessment or environmental impact statement would be completed and distributed to affected parties for comments at that time.

Comment: Some commenters expected negative effects to property values, property rights, and water rights as a result of implementation of the recovery plan.

Response: Since most of the habitat for the listed fishes is found on private property, the Fish and Wildlife Service believes landowner cooperation is necessary for recovery of these fishes. The Fish and Wildlife Service will work with each willing landowner to protect their land and water rights and to recover the species. Currently, the Fish and Wildlife Service is involved in developing a Habitat Conservation Plan that would allow development of one of the springs in the valley and protect two listed fishes, one that inhabits the spring and another that occurs downstream of the spring. Additionally, the Fish and

Wildlife Service has worked with private landowners in other States to showcase the listed species found on their property which has provided an economic benefit for the landowner as well as an educational opportunity for the public.

Comment: The recovery plan calls the landowner and their way of life a threat and states they have to be neutralized or eliminated.

Response: Recovery of a species does depend upon the removal or modification of the threats to the species. The Fish and Wildlife Service feels that the Pahranaagat roundtail chub can be recovered if the threats stated in the plan (habitat alteration, nonnative species introduction, and disease) are modified so they no longer threaten the chub and without impacting the local economy or way of life. The Fish and Wildlife Service is working with the local landowners and agencies to solicit alternative methods of reaching recovery for the fishes and minimizing cultural and economic impacts.

Comment: The recovery plan violates several presidential executive orders and the Regulatory Flexibility Act.

Response: The Fish and Wildlife Service believes it has complied with all laws and executive orders. A recovery plan is a planning document not a proposed rule action, therefore the Regulatory Flexibility Act would not apply to the finalization of a recovery plan.

Comment: The Fish and Wildlife Service will be held in trespass if it attempts any activity stated in the plan on my private property or in any waters in which the landowner owns interest.

Response: As stated in the recovery plan, the Fish and Wildlife Service will be working cooperatively with landowners. The Fish and Wildlife Service will not enter private lands illegally.

Comment: The Pahranaagat River is incorrectly labeled as a river.

Response: The Fish and Wildlife Services agrees, and upon further investigation has labeled it the Pahrnagat Creek and for the reasons stated in the document referred to it as Pahrnagat Ditch in certain stretches of the water body.

Comment: The recovery task of developing a refugium in Pahrnagat Valley for Pahrnagat roundtail chub should be changed to a priority 1 from a priority 2 because there is only one wild population.

Response: While the Fish and Wildlife Service agrees that only one wild population exists, we do not feel this recovery task warrants a priority 1 rating. Priority 1 ratings are those actions that are undertaken to prevent the extinction or an irreversible decline of a listed species. A refugium population for the chub is already in existence so if the population were to disappear from the wild, it could be reestablished. Furthermore, the recovery task to maintain the genetic integrity of the refugium population is classified as a priority 1 to ensure the genetic consistency of this population were it ever to be needed for reestablishment.

Comment: The recovery criteria should/may change pending the acceptance of the genetic work for the springfish subspecies.

Response: The Fish and Wildlife Service feels it would be premature to discuss the recovery of the springfish subspecies pending scientific review and acceptance of the study.

Comment: What is the definition of “common” in terms of fish numbers?

Response: The Fish and Wildlife Service has tried to replace the word common with numbers in as many areas as was possible. Unfortunately, the Fish and Wildlife Service does not have any numbers for historic sightings.

Comment: An objection was stated that data used for the water quality parameter tables did not come from the State Water Engineer.

Response: The Fish and Wildlife Service contacted the State Water Engineer for

this information. The Fish and Wildlife Service was told that while the State Water Engineer's Office has current information on water rights, the monitoring is contracted to the United States Geological Service and currently there is no contract for waters in Pahrangat Valley.

Comment: The total volume of water discharged by Crystal and Ash Springs does not reach the Pahrangat National Wildlife Refuge during the winter months because the ditch is not cleaned.

Response: The Fish and Wildlife Service agrees and is currently working with landowners to clean the ditch.

Comment: The commenter noted that the two citations for historic expeditions in the recovery plan did not spend much time in the Pahrangat Valley, nor is the entire citation in the hands of the Lincoln County reviewers, or that the citations do not mention the appearance/disappearance of the "desert river" not mentioned in this document.

Response: The portions of the citation that the Fish and Wildlife Service used and has on file were sent to the reviewer. The complete publications are available at the Universities in Salt Lake City, Utah, and Las Vegas, Nevada should the commenter wish a complete copy. Additionally, it is unclear what the commenter meant by the appearance/disappearance of a desert river not mentioned in this document. Lastly, the Fish and Wildlife Service agrees that one of the historic expeditions was only in the Valley for a month but the other citation covers a period of 7 years.

Comment: The reference to previous agricultural activity resulting in a conversion of riparian habitat to pastures and generating a sparse riparian corridor should be removed from the plan.

Response: The Fish and Wildlife Service believes the referenced information is useful for describing what has happened in the valley, and more importantly, for the characterizing the changes which have occurred since the chub was listed and the different actions that may be utilized to recover the chub without heavily

impacting the surrounding landowners and their operations.

Comment: The recovery plan should state that the pipeline mentioned as a possible solution for recovery of the Pahrnagat roundtail chub will not affect any landowner with land along the ditch or disturb the landowners uses of the ditch.

Response: While the Fish and Wildlife Service does not intend to disallow any of the current land practices or uses of the ditch, there may be some minor, long term modifications of land uses of the ditch (ie log fences, revegetating the banks with additional native plants). Additionally, there may be some short term impacts in terms of construction to landowner who may have the pipeline easement on their property. Given these minor impacts that may occur, the Fish and Wildlife Service did not feel it appropriate to emphatically state that no landowner would be affected by the pipeline. In considering the pipeline as a potential alternative to meeting listed species and local custom and cultural needs, the Fish and Wildlife Service believes that implementation of the pipeline throughout the valley will provide an overall benefit to the landowners and the listed fish. Implementation of the pipeline concept cannot take place without the consent of the affected irrigation districts. While short term impacts from construction may minimally impact individual landowners, their land uses and water rights would remain intact while providing overall long-term benefits.

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