U.S. Fish & Wildlife Service

Devils River Minnow
(Dionda diaboli)

Recovery Plan

September 2005

DEVILS RIVER MINNOW

(*Dionda diaboli*)

RECOVERY PLAN

Southwest Region

U.S. Fish and Wildlife Service

Albuquerque, New Mexico

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EXECUTIVE SUMMARY

Devils River Minnow Recovery Plan

Current Species Status: The Devils River minnow (*Dionda diaboli*) was listed as a threatened species on October 20, 1999. It has a Recovery Priority of 2. It occurs in three streams in Val Verde and Kinney counties, Texas, all tributaries to the Rio Grande: Devils River, San Felipe Creek and Pinto Creek. The current status of the species in Sycamore Creek, Texas, and in the Río Salado drainage in Mexico is not known. The species is believed to be extirpated from the lower portions of the Devils River (now Amistad Reservoir in Val Verde County), Las Moras Creek (Kinney County), and from the Río San Carlos (Mexico).

Habitat Requirements and Limiting Factors: The Devils River minnow is found in small spring-fed streams of fast-flowing waters over gravel substrates often associated with emergent aquatic vegetation. Primary threats are habitat loss and non-native species introductions.

Recovery Strategy: The recovery strategy is to reduce threats to the species by securing adequate habitat conditions (clean, free-flowing springs and streams), allowing viable, self-sustaining populations to persist in the wild throughout its remaining range (includes controlling non-native species), and where feasible, to restore populations within the historic range. The primary focus is to protect naturally functioning spring and stream ecosystems within its current and potentially restorable historic range. See section 2.2 for the full recovery strategy for Devils River minnow.

Recovery Goal: Delisting.

Recovery Criteria: Delisting the Devils River minnow should be considered when threats have been removed or reduced as indicated by the following:

(1) Population monitoring verifies stable or increasing population trends for Devils River minnow for at least 10 years throughout its range including Devils River (middle portion), San Felipe Creek, Sycamore Creek, and Pinto Creek in Texas. If reestablishment is scientifically feasible, populations should be restored in Las Moras Creek. The status of populations in the Rio Salado drainage in Mexico should also be confirmed;

(2) Adequate flows in streams supporting Devils River minnow have been assured, including Las Moras Creek (if reestablishment is feasible), through State or local groundwater management plans, water conservation plans, drought contingency plans, regulations, or equivalent binding documents;

(3) Protection of surface water quality, including the protection of the quality of groundwater sources of surface water flows, is ensured throughout the range of Devils River minnow by demonstrated compliance with water quality standards and implementation of water quality controls, particularly in urban areas such as the cities of Del Rio and Brackettville; and

(4) Management and control of non-native species by local, regional, State, and Federal authorities are demonstrated to be successful.

Actions Needed:

(1) Maintain and enhance Devils River minnow populations and habitats range-wide.

(2) Establish additional Devils River minnow populations within the historic range.

(3) Maintain genetic reserves of the Devils River minnow through captive propagation until no longer needed.

(4) Disseminate information about Devils River minnow conservation.

Total Estimated Cost of Recovery by Recovery Action Priority: (Dollars x 1000)*:

Year	*Priority 1a	Priority 1b	Priority 2	Priority 3	Total
2005-6	$175	$470	$105	$10	**$760**
2007-8	$250	$450	$140	$70	**$910**
2009-10	$200	$230	$100	$0	**$530**
2011-12	$200	$170	$0	$50	**$420**
2013-14	$150	$120	$0	$30	**$300**
Total**	**$975**	**$1,440**	**$345**	**$160**	**$2,920**

* **Priority 1a** = An action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future. **Priority 1b** = An action that by itself will not prevent extinction, but which is needed to carry out a Priority 1 action. **Priority 2** = An action that must be taken to prevent a substantial decline in species population/habitat quality or some other substantial negative effect short of extinction. **Priority 3** = All other actions necessary to meet the recovery objectives.

** Some costs for Recovery Actions were not determinable, such as costs for habitat restoration activities; therefore, total costs for recovery are likely higher than this estimate.

Date of Recovery: If recovery efforts are fully funded and carried out as outlined in this plan, recovery criteria could be met by 2014.

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1.0 BACKGROUND

1.1 Introduction

The Endangered Species Act of 1973, as amended (16 U.S.C. 1531 et seq.) (ESA), established policies and procedures for identifying, listing, and protecting species of wildlife and plants endangered or threatened with extinction. The ESA defines an "endangered species" as "any species which is in danger of extinction throughout all or a significant portion of its range." A "threatened species" is defined as "any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range."

The U.S. Fish and Wildlife Service (Service), of the Department of Interior, is responsible for administering the ESA's provisions as they apply to the Devils River minnow (*Dionda diaboli*). Section 4(f) of the ESA directs the Service to develop and implement recovery plans for listed species or populations. The purpose of a recovery plan is to identify and guide species recovery efforts. It is intended to serve as a road map for recovery—laying out where we need to go and how best to get there. Recovery plans also ensure that we use sound science and logical decision-making throughout the recovery process. Recovery plans are strictly advisory documents developed to provide recovery recommendations based on resolving the threats to the species and ensuring self-sustaining populations in the wild. Such plans are to include:

(1) A description of site-specific management actions necessary to conserve the species or population;
(2) Objective, measurable criteria which, when met, will allow the species or populations to be removed from the list; and
(3) Estimates of the time and funding required to achieve the plan's goals and intermediate steps.

Section 4 of the ESA also describes the procedures for delisting species (removing them from the list). A species can be delisted if the Secretary determines that it no longer meets endangered or threatened status based upon any of the five listing factors in section 4(a)(1) of the ESA:

(A) The present or threatened destruction, modification, or curtailment of its habitat or range;
(B) Overutilization for commercial, recreational, scientific, or educational purposes;
(C) Disease or predation;
(D) The inadequacy of existing regulatory mechanisms; or
(E) Other natural or manmade factors affecting its continued existence.

The intent of this recovery plan is to guide the recovery of the Devils River minnow so the species can be delisted. The Background section of the plan outlines the basic biology, ecology, status of the fish and its habitats, threats to the species, and conservation actions that have already occurred. The Recovery section provides the actions needed to recover this species and specific criteria for measuring when recovery has occurred. The success of this plan depends upon the collaboration of many people and organizations to secure the future existence of this species.

1.2 Status of the Species

The Devils River minnow was initially proposed for listing as endangered in 1978. However, amendments to the ESA in 1978 delayed completion of the final rule to list the species for more than two years and the proposal was withdrawn in 1980. The species remained a concern to conservationists due to its rarity and limited distribution. The Service again proposed to list the Devils River minnow as endangered on March 27, 1998 (63 Federal Register 14885-14892). However, after publication of the proposed rule, the Service, the Texas Parks and Wildlife Department (TPWD), and the City of Del Rio signed a Conservation Agreement containing specific milestones for conservation actions to improve the status of the species. This agreement, in part, reduced threats so that the Devils River minnow was designated as threatened in the final rule.

On October 20, 1999, the Service listed the Devils River minnow as a threatened species (Final Rule: 64 Federal Register 56596-56609). Critical habitat has not been designated. The reasons for listing the species were threats from range reduction, habitat loss and fragmentation, spring dewatering and other stream modifications, and possible effects of introduced species.

The Devils River minnow is also considered a threatened species by the American Fisheries Society (Williams et al. 1989) and the former Texas Organization for Endangered Species (Hubbs et al. 1991). The fish is listed by TPWD as a threatened species (Texas Parks and Wildlife Code, Chapters 67 and 68; Texas Administrative Code, Title 31, Sections 65.171 - 65.184), and by Mexico as an endangered species (Secretaria del Medio Ambiente 2002). It was also described by Garrett et al. (2002) as a threatened fish.

The Service established a recovery priority of 2 for this species based on its taxonomy, degree of threats, and recovery potential (see 48 Federal Register 43098). A priority of 2 indicates that the species faces a high degree of threat with a high potential for recovery. The Service regularly reviews listed species with regard to threats and recoverability and may update the species' recovery priority as appropriate.

1.3 Description and Taxonomy

The Devils River minnow (*Dionda diaboli* Hubbs and Brown) is a small fish in the minnow family (Cyprinidae). It was first collected from Las Moras Creek, near Brackettville, Kinney County, Texas, on April 14, 1951. It was formally described by Hubbs and Brown (1956) from specimens taken in 1951 in the Devils River at Baker's Crossing (southernmost bridge crossing of State Highway 163). The Devils River minnow is recognized as a distinct species by the American Fisheries Society (Hubbs and Brown 1956, Robins et al. 1991). Taxonomic validity is based on morphology (Hubbs and Brown 1956), genetic markers (Mayden et al. 1992), and chromosome differences (Gold et al. 1992).

Figure 1. Devils River minnow photo (used with permission, Garold W. Sneegas).

Adult Devils River minnows reach sizes of 25-53 mm (1.0-2.1 in.) standard length. The fish has a wedge-shaped caudal spot (near the tail) and a pronounced lateral stripe extending through the eye to the snout but without reaching the lower lip (Figure 1). The lateral-line pores are marked above and below by small black spots of melanin, forming two parallel rows of "dashes." The species has a narrow head and prominent dark markings on the scale pockets of the body above the lateral line, producing a crosshatched appearance when viewed from above (Hubbs and Brown 1956). The species occurs with other minnows, such as the closely related manantial roundnose minnow (*Dionda argentosa*). It can be distinguished from manantial roundnose minnow by the parallel rows of dashes along the lateral line, the wedge-shaped caudal spot, and the prominent markings on the dorsal scale pockets (Hubbs et al. 1991).

1.4 Population Trends and Distribution

The Devils River minnow has been a species of conservation concern since it was discovered in the 1950s in Las Moras Creek in Brackettville, Texas (Hubbs and Brown 1956). Within two decades from the time of original description, the species had been eliminated from two known locations—Las Moras Creek and the lower Devils River.

The Devils River minnow is native to tributary streams of the Rio Grande in Val Verde and Kinney counties, Texas, and Coahuila, Mexico (Figure 2). The reported historic range of the species was based on collections from 1951 to 1989 and included the Devils River from Beaver Lake, near Juno, downstream to near its confluence with the Rio Grande; San Felipe Creek from headwater springs to springs in Del Rio and downstream; Sycamore Creek; Las Moras Creek near Brackettville; Río San Carlos, Mexico; and the Río Salado drainage, Mexico (Brown 1954a and 1954b; Dietz 1955a and 1955b; Hubbs and Brown 1956; TGFC 1956; Dietz 1959a and 1959b; Treviño-Robinson 1959; Stapleton 1974; Harrell 1978; Hubbs 1979; Smith and Miller 1986; Hubbs 1990b; Garrett et al. 1992). A comprehensive assessment of the distribution of Devils River minnow in Texas in 1989 documented a reduced range and showed the species to be rare compared to past collections (Garrett et al. 1992). In that survey, a total of seven specimens of Devils River minnow were collected from 5 of 24 sampling locations within the historic range of the species. Garrett et al. (1992) also observed a general shift in community structure toward fishes that tend to occupy quiet water or pool habitat, conditions that are often limited in flowing spring runs. The authors hypothesized that this shift was the result of reduced stream flows from drought, exacerbated by human modification of stream habitats. In 2001, a population of Devils River minnow was discovered in the headwaters of Pinto Creek, Kinney County (Garrett et al. 2004).

Appendix A lists the known collections of Devils River minnow throughout its range. Monitoring the species' distribution and abundance has been fairly limited in both time and the number of samples taken, but its range is well known. Despite many collection efforts (Hubbs et al. 1991), the species is unknown from nearby waters such as the mainstem Rio Grande, the Río Conchos drainage, or streams tributary to the Rio Grande, other than those listed above.

1.4.1 Devils River and Tributaries, Val Verde County, Texas

Collections during the 1950s found Devils River minnow in the Devils River from Baker's Crossing (the southernmost Highway 163 bridge), downstream to the former Devils Lake (now inundated by Amistad Reservoir) (Brown 1954a and 1954b; Dietz 1955a and 1955b; Hubbs and Brown 1956; TGFC 1956; Dietz 1959a and 1959b). Harrell (1978) collected Devils River minnow from the Beaver Lake area, upstream of Juno (Figure 2), in 1973 and 1974 (specimens in Strecker Museum, Baylor University). This indicates there was sufficient surface flow in the area during those years to support populations of the fish. In 1988-89, the species was taken from three sites in the Devils River: Baker's Crossing, Finegan Springs (about 1.5 km upstream of the Dolan Creek confluence), and Dolan Creek (Hubbs and Garrett 1990; Garrett et al. 1992). Recent surveys from 1997 to 2002 have shown Devils River minnow distributed from Pecan Springs, about 10 miles upstream of Baker's Crossing, downstream to below the confluence with

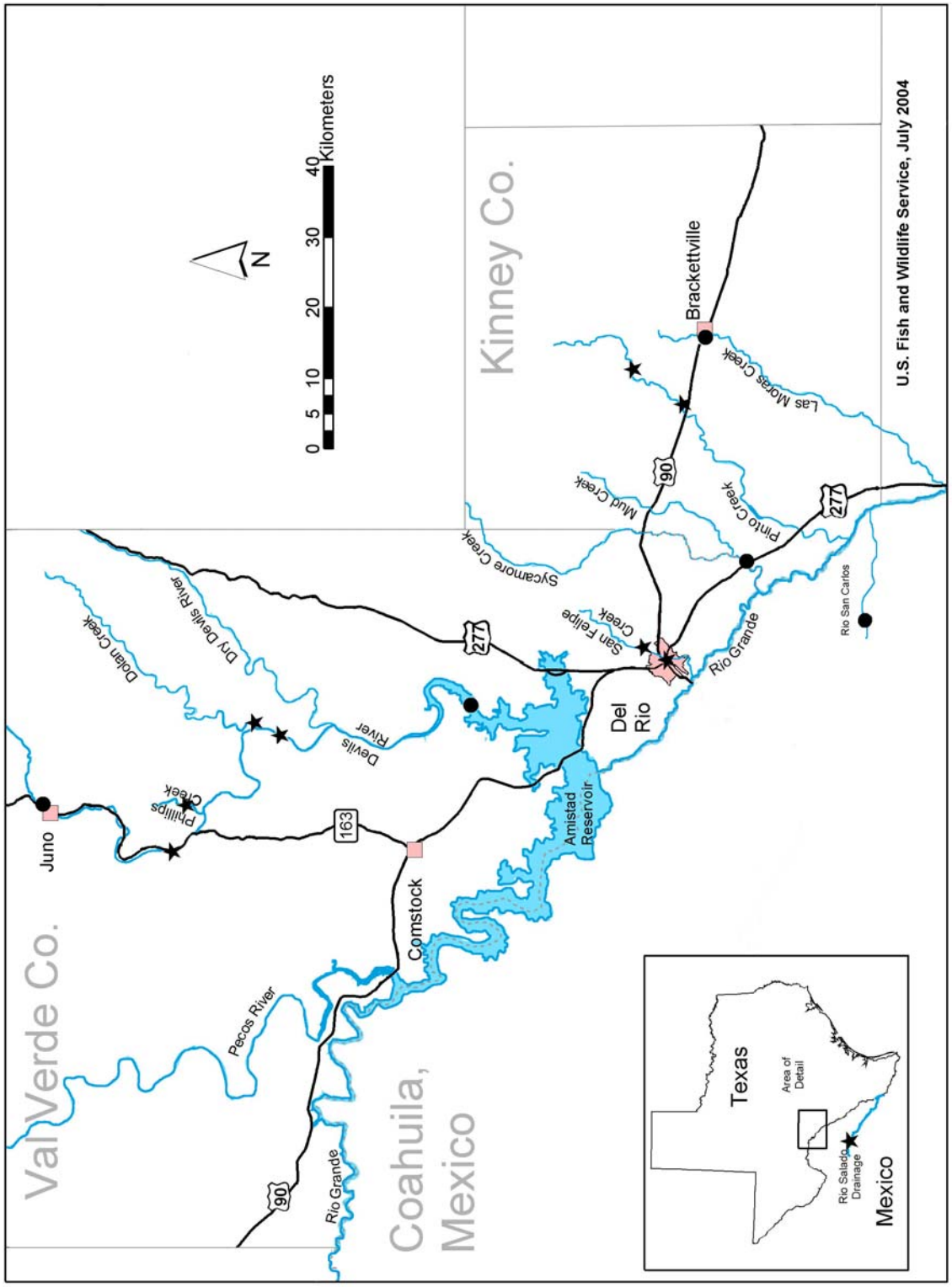

Figure 2. Devils River minnow range map. Stars indicate sites where the species has been collected since 1995 (distribution is presumed continuous between sites in the same creek). Filled circles indicate sites where the fish is either presumed or known to be extirpated.

Dolan Creek (G. Garrett, TPWD, pers. comm. 2003; Appendix C). The fish has also been collected recently in Phillips Creek and Dolan Creek, both tributaries to the Devils River (Figure 2). The species was eliminated from the lower portions of the Devils River when this area was inundated by construction of Amistad Reservoir (Garrett et al. 1992).

At Baker's Crossing, the Devils River minnow was the fifth most abundant fish collected (5 percent of 1,277 fish) in Brown's 1953 collection (Hubbs and Brown 1956). In Harrell's (1978) collections, the species was the sixth most abundant fish collected in the Devils River. Garrett et al. (1992) found the Devils River minnow to be one of the least abundant fish in the Devils River, collecting only two individuals out of 1,655 fish collected in 1989. Recent collections by G. Garrett (TPWD, pers. comm. 2004; Appendix C) document variations in Devils River minnow abundance over time. At some sites, collection efforts have resulted in no Devils River minnow being collected one year but many being collected another year. For example, based on several collections from 1997 to 2001, the species was common in Phillips Creek, but none were found in 2002. At another site, samples from upstream of Baker's Crossing to Pecan Springs in 1997 and 2000 had no Devils River minnow, but the fish was common from several sites in the same area in the summers of 2002 and 2003. We do not yet know why the abundance varies so much across years and between sites.

Annual summer surveys of the Devils River by TPWD from 2000 to 2003 entailed comprehensive collections of representatives of the entire fish fauna of the Devils River and its tributaries (G. Garrett, TPWD, pers. comm. 2003; Appendix C). Some sites between previously sampled locations were accessed for the first time by canoe and many of these yielded Devils River minnow. The 2000 survey revealed no Devils River minnow downstream of Dolan Falls (which is a large waterfall on the Devils River about 100 m downstream of the Dolan Creek confluence), and only the area upstream of Dolan Falls was sampled in 2001. In both years, no Devils River minnow were collected upstream of Baker's Crossing. However, in the 2002 surveys, Devils River minnow were collected upstream of Baker's Crossing to Pecan Springs, the current headwaters of the Devils River. Devils River minnow were also collected several miles downstream of Dolan Falls, an important extension of the known range of the fish from this local population. In 2003, no Devils River minnow were collected downstream of Dolan Falls. Devils River minnow were again taken upstream of Baker's Crossing to Pecan Springs, but in reduced numbers.

1.4.2 San Felipe Creek, Val Verde County, Texas

In 1979, Devils River minnow made up about 2 percent of all collections (total of 3,458 fish) and was the sixth most abundant of 16 species in the upper portion of the permanent flowing part of San Felipe Creek, upstream of Del Rio (Figure 2). No Devils River minnow were found in 1989 surveys in San Felipe Creek upstream of Del Rio (Garrett et al. 1992). No known collections have been made there since 1989. This area is privately owned and no information is available for insight into the species status in this area.

In 1989, only three Devils River minnow specimens were obtained in a collection of 1,651 fishes in San Felipe Creek in the City of Del Rio (Garrett et al. 1992). Data from 1997-2003 suggest that the Devils River minnow was common in the San Felipe Creek downstream of the East and

West San Felipe Springs in the urban section of the creek (G. Garrett, TPWD, unpublished data 2002, Winemiller 2003, Lopez-Fernandez and Winemiller 2005). Recent collections on San Felipe Creek in Del Rio (1999 - 2003) have yielded Devils River minnow (G. Garrett, TPWD, unpublished data 2002, Winemiller 2003) and suggest the population increased in abundance compared to what was reported from 1989 surveys (Garrett et al. 1992). No surveys have been conducted upsteam of the City of Del Rio due to limited private access. Quarterly surveys of aquatic habitat and aquatic organisms in San Felipe Creek in Del Rio have been conducted (2001 to 2003) by the Texas Agriculture Experiment Station at Texas A&M University (Winemiller 2003, Lopez-Fernandez and Winemiller 2005). The species never was collected or observed within the two spring outflow channels located on the municipal golf course. The species appears to be broadly distributed in low to moderate numbers within the mainstem San Felipe Creek, at least from the northern limit of the city golf course downstream along the length of the city greenway. The species was present in at least two of three mainstem channel sampling locations during each survey. Seasonal fluctuations in abundance were largely associated with recruitment dynamics of juveniles, which peaked in late summer and fall. Surveys in the summer and fall of 2004 found the Devils River minnow abundance very low (G. Garrett, TPWD, pers. comm. 2004).

1.4.3 Sycamore and Mud Creeks, Kinney County, Texas

Sycamore Creek constitutes a small portion of the range of Devils River minnow (Figure 2). The only known accounts of the species from this stream are an anecdotal mention of its occurrence in the 1970s (Harrell 1980) and collection of two individuals at the Highway 277 bridge crossing near the Rio Grande in 1988 and 1989 (Garrett et al. 1992). Collections in 1999 and 2002 from that site and the State Highway 90 bridge crossing of Sycamore Creek did not yield Devils River minnow (G. Garrett, TPWD, unpublished data 2002). Garrett et al. (1992) surveyed portions of Mud Creek (a tributary to Sycamore Creek) in 1989 but found no Devils River minnow. Due to limited access on private lands, few other locations in the Sycamore Creek watershed have been sampled. Additional surveys are needed to determine the current status of the fish in this watershed.

1.4.4 Pinto Creek, Kinney County, Texas

Pinto Creek (Figure 2) contains a newly discovered and important addition to the known range of Devils River minnow (Garrett et al. 2004). Garrett et al. (1992) surveyed portions of Pinto Creek downstream of the Highway 90 bridge and did not collect Devils River minnow. Upstream areas were on private land and access was unavailable until recently. Prior to collections in 2001 and 2002, most of Pinto Creek (located in Kinney County) had not been surveyed for fishes. The only previous collections were primarily at bridge crossings (Highways 277 and 90), due to limited access to private lands; but no Devils River minnow had been collected. During 2002 surveys throughout Pinto Creek, a Devils River minnow population was discovered at sites upstream of State Highway 90. The Devils River minnow was one of the more abundant fishes at these locations (Garrett et al. 2004). None were found at or below Highway 90. At sites from Highway 90 downstream, the most abundant fish was red shiner (*Cyprinella lutrensis*). At one site, just upstream of Highway 90, both species were obtained in the same location. Preliminary

evaluations suggest natural changes in water chemistry of Pinto Creek occur at about the Highway 90 Bridge, and may result in changes in the fish community (Garrett et al. 2004).

The species is found only in the relatively pristine headwaters of Pinto Creek upstream of Highway 90, despite searches downstream to Highway 277 (Garrett et al. 2004). Due to its isolation in the headwaters of Pinto Creek, this population could represent a genetically unique Devils River minnow population (Garrett et al. 2004). This population of Devils River minnow may provide important biological data on the species' habitat needs because of the sharp changes in both water quality and Devils River minnow distribution at the Highway 90 bridge (Garrett et al. 2004).

1.4.5 Las Moras Creek, Kinney County, Texas

Las Moras Creek represents the eastern extent of the historic range of the species (Figure 2). Historically, the population may have been restricted to the headspring area of Las Moras Creek in Brackettville, where 39 individuals were collected in 1951 (Hubbs and Brown 1956). The species has not been collected from this site since the 1950s and apparently has been extirpated from the Las Moras Creek drainage. This conclusion is based on the absence of the species in sampling efforts from the late 1970s to 2002 (Smith and Miller 1986; Hubbs et al. 1991; Garrett et al. 1992; G. Garrett, unpublished data 2002). The species may have been eliminated from Las Moras Creek as a result of periodic chlorination of the spring outflow for swimming pool maintenance (Garrett et al. 1992) or from drying of the spring in the 1960s (Eckhardt 2004).

1.4.6 Río San Carlos, Coahuila, Mexico

The Río San Carlos (Figure 2) is a small tributary of the Rio Grande that flows through Ciudad Acuña (Mexican city across the Rio Grande from Del Rio). Only a few individuals have been collected from this location, once in 1968 and again in 1974 (Appendix A). We are not aware of any collections of Devils River minnow from this site since 1974, and the species is presumed extirpated from this location (S. Contreras-Balderas, University of Nuevo Leon, in litt. 1997; S. Contreras-Balderas, pers. comm. 2003).

1.4.7 Río Salado Drainage, Coahuila, Mexico

The population of Devils River minnow in the Río Salado drainage of northern Mexico represents a critical portion of the southernmost extent of the range. The Río Salado is distant from the Rio Grande tributaries supporting the species in Texas. Collections of the species from the Río Salado drainage are limited to the Río Sabinas (=Río San Juan) and Río Alamo (Appendix A) from about 8 km (5 mi) northwest of Muzquiz to about 12 km (7 mi) west of Nueva Rosita (S. Contreras-Balderas, University of Nuevo Leon, in litt. 1997). Contreras-Balderas et al. (2001) reviewed the fishes of this area and reported the Devils River minnow was historically found in these two locations. In 1994, 18 Devils River minnow were collected from a site in the Río San Juan, near Muzquiz; in 2001 none were found there (Contreras-Balderas et al. 2001). In 1985, 16 Devils River minnow were collected from the Río Alamo, near Nueva Rosita; in 2001, only one individual was found there (Contreras-Balderas et al. 2001). Contreras-Balderas et al. (2001) concluded, "The Río Sabinas is highly impacted upon, due to a

combination of mining and urban/municipal pollution, garbage, deforestation, channelization, gravel pits, siltation, and damming. River quality has been lost at an average of 50 percent from original. Water runoff has been lost approximately 80 percent from original."

1.5 Life History, Ecology, and Habitat

Little information is available on life history characteristics, feeding patterns, or reproductive behaviors of this species. However, based on their long coiled intestinal tract, species of the genus *Dionda* are considered to feed primarily on algae, although larval stages may prey on invertebrates (Balon 1985; Gerking 1994). Other closely related species of *Dionda* occurring in the Edwards Plateau of central Texas and the Pecos River drainage of New Mexico and Texas spawn from January through August, laying demersal (deposited near the stream bottom), non-adhesive eggs, sometimes beneath several millimeters of gravel (Hubbs 1951; Wayne and Whiteside 1985; Johnston and Page 1992). In captivity, Devils River minnow eggs were slightly adhesive and adults preferred gravel as a spawning substrate over rocks, sand, or a manufactured spawning substrate (Gibson et al. 2004). The life expectancy of the fish has not been studied, but based on similar minnows it can be estimated at one to two years (C. Hubbs, University of Texas at Austin, pers. comm. 2003). Some fish in captivity have survived for more than 4.8 years (J. N. Fries, Service, pers. comm. 2005).

General habitat associations for Devils River minnow have been described as channels of fast-flowing, spring-fed waters over gravel substrates (Harrell 1978; Cantu and Winemiller 1997). Although the species is closely associated with spring systems, the fish most often occurs where spring flow enters a stream, rather than in the spring outflow itself (Hubbs and Garrett 1990). The species probably evolved in environmental conditions of large hydrologic variations inherent in desert river systems (Harrell 1978) that are characterized by extended droughts and extreme flash floods (USGS 1989).

The Devils River minnow is part of a unique fish fauna, which includes Mexican peripherals, local endemics, and widespread North American fishes (Hubbs 1957; Miller 1978; Garrett 1997; Edwards et al. 2004). This diversity is remarkable and just recently a new fish species was described as an endemic to San Felipe Creek (Garrett and Edwards 2003). The Devils River minnow occurs in an area where the Chihuahuan Desert, Edwards Plateau, and South Texas Brush ecoregions join. Fishes in arid regions, such as those of the Chihuahuan Desert, have been particularly affected by human development and use of water resources. Hubbs (1990a) stated that half the native fishes of the Chihuahuan Desert of Mexico and Texas are considered threatened and at least four species have been documented to be extinct (Miller et al. 1989), primarily due to habitat destruction and introduced species.

1.6 Hydrology and Geohydrology

The region of Texas within the historic range of the Devils River minnow is semi-arid, receiving a range of annual rainfall from 30 to 51 cm (12 to 20 in.). Spring-fed streams of this portion of the southwestern Edwards Plateau flow southerly into the Rio Grande. The rocky, limestone soils and shrubby vegetation are characteristic of the more arid western reaches of the Edwards Plateau. This area is underlain by the Edwards-Trinity aquifer system. This aquifer system produces the largest number of springs in Texas, including some of the largest spring systems (for example, San Felipe Springs in Del Rio and Goodenough Spring now submerged below Amistad Reservoir) (Brune 1975, 1981). Brune (1981) identified at least 48 springs occurring in Val Verde County. The principal water-bearing rock formations of the Lower Cretaceous Comanchean series dip toward the southeast and are relatively permeable, with high transmissivity values (Barker et al. 1994). The thickness of the Comanchean strata ranges from less than 1,000 feet in the area of outcropping to more than 10,000 feet (Barker et al. 1994).

Barker and Ardis (1996) divided the Edwards-Trinity aquifer system into the following four subgroups (Figure 3): Balcones fault zone, Hill Country, Edwards Plateau, and Trans-Pecos. The Devils River minnow range in Texas is within the southern portion of the Edwards Plateau subgroup. The Edwards-Trinity aquifer system that underlies the Edwards Plateau extends over about 24,000 square miles of central Texas (Barker and Ardis 1996).

The contributing and recharge area for springs on the Devils River and San Felipe Creek is suspected to include a large region, extending as far north as Sheffield in Pecos County and Eldorado in Schleicher County and eastward into Edwards County (Brune 1981). Recharge to the aquifer is mostly from infiltration of precipitation through the land surface and seepage loss through stream beds (Barker and Ardis 1996). "Discharge from the aquifer mainly occurs through (1) springs in the stream-dissected northeastern and southeastern fringes of the Edwards Plateau; (2) base flow to gaining reaches of the Concho, Llano, and Pecos Rivers; and (3) wells pumped for domestic, irrigation, and stock water" (Barker and Ardis 1996). Recharge and discharge of the aquifer, in general, are estimated to average less than 2.54 cm (1 in.) per year over the Edwards Plateau (Barker and Ardis 1996). However, the flow from springs, and the resulting surface flow in streams, fluctuates considerably, depending on the amount of rainfall, recharge, and water in storage in the aquifer. Conservation of the quality and quantity of this groundwater supply is essential for the continued existence of the Devils River minnow.

The middle and upper parts of the Devils River Formation, considered the principal water-producing zone for southern Edwards County and central Val Verde County, probably support surface flow in the Devils River (Barker and Ardis 1996). The Del Rio area, where major springs support surface flows in San Felipe Creek, is within an isolated depositional area called the Maverick basin (LBG-Guyton Associates 2001). The primary water bearing stratum within this basin is the Salmon Peak Formation, the uppermost unit in the Edwards Group. In this area the Edwards-Trinity (Plateau) is in very deep strata, underlying the Edwards Group. As a result, the local aquifer around Del Rio that supports surface spring flows is actually an isolated part of the Edwards aquifer (Balcones Fault Zone) (LBG-Guyton Associates 2001).

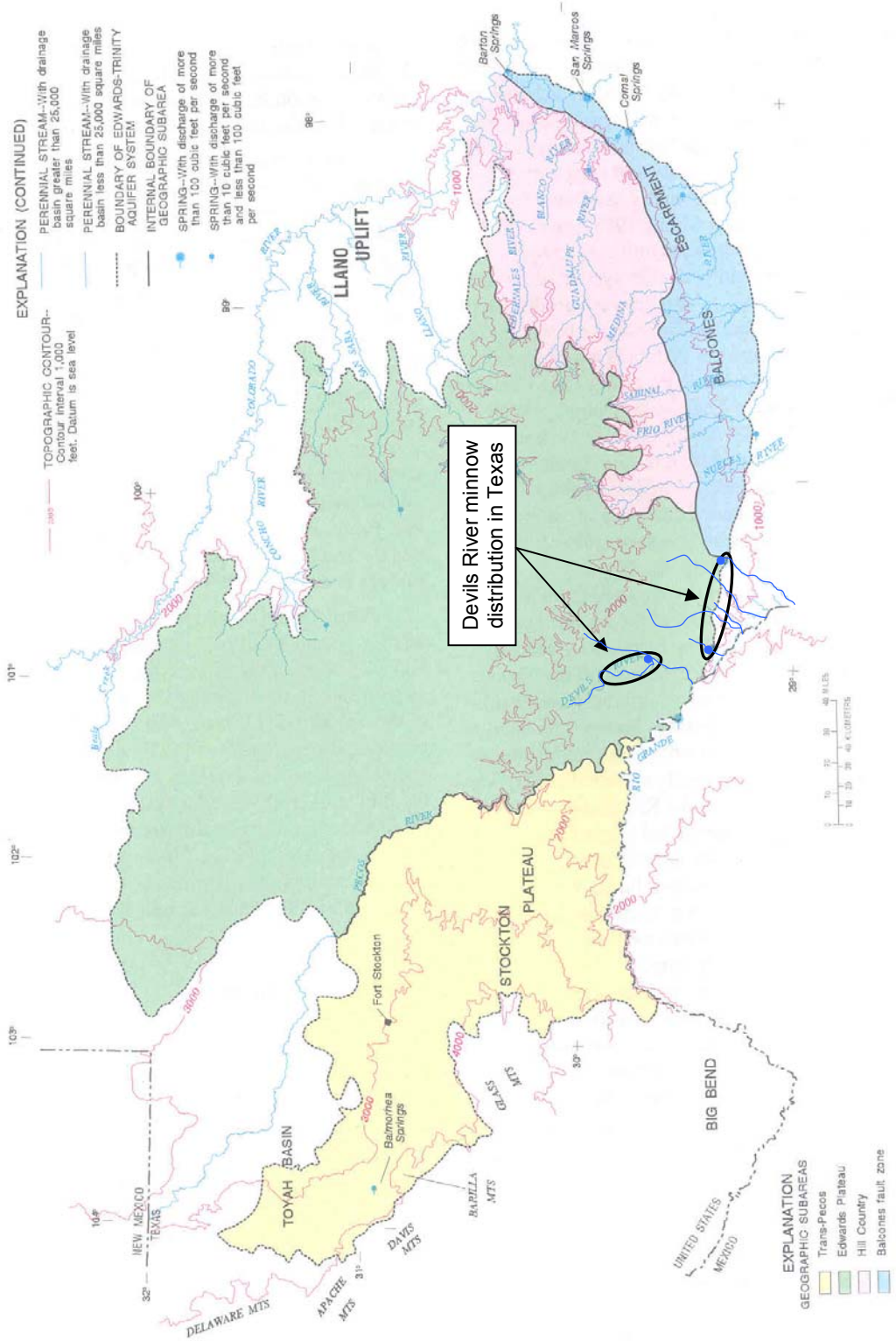

Figure 3. Location of geographic subareas of the Edwards-Trinity aquifer system, the major springs and perennial streams (*adapted from* Barker and Ardis 1996), and general distribution of the Devils River minnow in Texas.

The groundwater in Kinney County that contributes to spring flows in Las Moras, Pinto, and Sycamore creeks is from the northern part of the county in the Edwards and associated limestones (Bennett and Sayer 1962). In general, the groundwater in Kinney County from Brackettville east moves to the southeast and east into Uvalde County. Groundwater west of Brackettville moves southwestward toward the Rio Grande and Val Verde County (Bennett and Sayer 1962).

1.7 Reasons for Listing and Threats Assessment

The following discussion summarizes the reasons that the Devils River minnow was listed as a threatened species, based on consideration of the five listing factors. In addition, an updated assessment is included under each factor of the current understanding of threats to the species and its habitat.

1.7.1 Listing Factor A. The Present or Threatened Destruction, Modification, or Curtailment of Devils River Minnow Habitat or Range

1.7.1.1 Range Reduction and Habitat Loss

One of the primary reasons for listing the Devils River minnow was the considerable habitat loss that previously occurred and resulted in a reduction in both the distribution and abundance of the species. Habitat loss and modification throughout a large portion of the range of the Devils River minnow has resulted in the fragmentation and contraction of the species' range. The distribution of the minnow in the Devils River was reduced by the impoundment of Amistad Reservoir in 1968. The inundation of the lower portion of the river by Amistad Reservoir eliminated important habitat for Devils River minnow, changing a lotic environment (fast flowing water) to a lentic environment (non-flowing or slow flowing water). These alterations resulted in the elimination of Devils River minnow in the lower portions of the Devils River.

In addition, the species has not been found upstream of Pecan Springs since the early 1970s and likely no longer occurs in the upper portions of the Devils River due to lack of stream flow. There are no historical flow data in the upper part of the Devils River to verify changes in stream flows over time. Brune (1975) believed the river originated farther upstream in historic times, referring to accounts of the river in the area of Juno (Figure 2), which was described in 1916 as a beautiful stream with large live oaks. However, local landowners suggest that the river has been intermittent in this reach, at least since 1916.

The species also has been extirpated from Las Moras Creek; the exact reason is not known. However, the natural habitat of the spring was extensively altered when the outflow was dammed and stream bank vegetation was removed to create a recreational swimming pool. Water for the swimming pool comes directly from the spring and has been treated regularly with chlorine (a toxin to fish and other organisms) before being discharged into Las Moras Creek. Garrett et al. (1992) also indicated that spring flow also has been drastically reduced by drought and diversion of surface water and withdrawal of groundwater for human use. The springs are reported to have ceased flowing in the 1960s (Brune 1981; Eckhardt 2004) and then again in the 1980s (Garrett et al. 1992). Las Moras Creek downstream from the spring is degraded from pollution and channelization (Garrett et al. 1992). This combination of habitat alteration (periodic loss of spring flow and channel modification) and water quality degradation (from chlorination) is the most likely cause for the extirpation of the species from Las Moras Creek.

We believe the Devils River minnow has been extirpated from the Río San Carlos drainage in Mexico and has declined in distribution and abundance from the Río Salado drainage, primarily

due to changes in habitat from loss of stream flow, pollution, and channel manipulation (Contreras-Balderas and Lozano-Vilano 1994).

1.7.1.2 Spring Flow Declines (Water Quantity)

Groundwater discharge declines from springs and seeps are major threats to the Devils River minnow throughout its range (Garrett et al. 1992, Contreras-Balderas and Lozano-Vilano 1994). Groundwater levels in the Edwards-Trinity (Plateau) fluctuate based on the cyclical amount of precipitation for recharge and variations in discharge from well withdrawals (Barker et al. 1994). Declines have been documented where natural recharge rates have not offset the increase in withdrawal from pumping (Barker et al. 1994). As an example, the following is quoted from Barker et al. (1994), p. 40:

> During the last 50 years, water levels have declined more than 50 ft in northwestern parts of the Edwards Plateau, including parts of Ector, Glasscock, Midland, Reagan, Sterling, and Schleicher Counties (Walker, 1979, p. 96-100)…The nearly continuous, long-term nature of water-level decline in many wells reflects the direct relation to a rapid increase in the number of irrigation wells that began about 1946 and continued through the 1960s. Since the late 1970s, water levels in most parts of the Edwards Plateau have stabilized or begun to recover, reflecting the results of recent efforts to reduce the need for irrigation and to conserve water.

Historical data on stream flows in the upper portion of the Devils River are not available to confidently assess changes in habitat in this reach. However, noted declines in the northwest part of the aquifer may account for the current lack of long-term flow in the uppermost parts of the Devils River, from Beaver Lake, near Juno, to Pecan Springs (Brune 1975). Increases in groundwater withdrawal from the Edwards-Trinity (Plateau) aquifer could result in further declines in stream flow on the Devils River and affect the quantity and quality of available stream fish habitat. The downstream portion of the Devils River from the Pecan Springs area and below Baker's Crossing continues to flow naturally and has been referred to as one of the most pristine rivers in Texas. Because of groundwater reservoirs that support the remaining spring systems, the river has maintained a perennial flow since 1960 in the range of 3 to 10 cubic-meters-per-second (cms) [106 to 353 cubic-feet-per-second (cfs)] at the inflow to Amistad Reservoir (IBWC 2003).

The population of the City of Del Rio (City) and Laughlin Air Force Base was estimated to be 38,964 in 2000. Over the next 50 years, the human population and the municipal water supply demand of the City are expected to grow 46 percent and 30 percent, respectively (LBG-Guyton Associates 2001). Del Rio draws water directly from San Felipe Springs, the sole source of municipal water supply for the City and for nearby Laughlin Air Force Base. These springs typically discharge at 3.4 to 4.0 cms (120 to 140 cfs); however, during drought years in the late 1990s spring discharge fell below 1.4 cms (50 cfs) (LBG-Guyton Associates 2001). During 1995 and 1996, the average water use by the City varied seasonally from about 8 to 19 million gallons per day (about 12 to 29 cfs, 0.3 to 0.8 cms). The City recently upgraded the water treatment facility to provide a maximum of 16 million gallons per day (about 25 cfs, 0.7 cms) for municipal use (LBG-Guyton Associates 2001). This new treatment plant and associated storage and transmission facility allows for important water conservation, as the previous water system

had substantial losses due to outdated inefficiencies. With additional water conservation measures in place to reduce per capita water use, the City could decrease its water consumption from San Felipe Creek.

The City of Del Rio recently evaluated several alternatives to activate groundwater wells around the city to account for possible future water shortfalls and to decrease dependence on the San Felipe Springs (LBG-Guyton Associates 2001). These additional groundwater withdrawals from the Salmon Peak formation of the Edwards Aquifer could affect the quantity of spring flow from the San Felipe springs complex. The report recommended investigating the effects of pumping from the aquifer on the spring flow.

Increases of water withdrawals from aquifers that support spring flows in the range of the Devils River minnow (including the Devils River, San Felipe Creek, Sycamore Creek, Pinto Creek, and Las Moras Creek) could result in reduction of critical spring flows or the drying of streams that support the species. As spring flows decline due to drought or groundwater lowering from pumping, habitat for the Devils River minnow is reduced and could eventually cease to exist. The relationship of declining spring flows and habitat loss is unknown. However, when streams cease flowing, the habitat is lost and the fish populations will no longer exist. In some reaches, such as Pinto Creek, natural repopulation of streams is not possible due to the fragmented range of the species.

A number of metropolitan areas surrounding the range of the Devils River minnow (for example, San Antonio, San Angelo, Eagle Pass, and Laredo) are seeking additional water sources to support growing water consumption needs (Upper Guadalupe River Authority 2002, Khorzad 2002). Because Texas groundwater use is under the "Rule of Capture," which means that with few exceptions, landowners have the right to take all the water that can be captured under their land, there are currently few, if any, limits to the amount of groundwater that can be withdrawn from aquifers and exported to other locations. Several private water development projects are planned for pumping large amounts of groundwater from within Kinney County and piping it eastward toward San Antonio. It is unknown what effect, if any, these projects could have on the spring flows that support the stream habitat of the Devils River minnow. However, the location of these projects is close to Pinto and Las Moras creeks and they may pose a high magnitude and imminent threat to maintaining habitat for that population (Garrett et al. 2004).

Other factors also affect the level of groundwater available to support spring flows. For example, the amount of recharge to aquifers is directly related to precipitation patterns. Therefore, localized drought can result in reduced stream flows for Devils River minnow. Land management practices and watershed health also influence recharge rates. The relationship of landscape vegetation to spring flow rates is dependent on a number of factors, such as vegetation characteristics, precipitation, soils, and geology (Wilcox 2002). Loss of grasses on the landscape can alter runoff patterns to increase the rate of surface water storm flows and reduce the rates of aquifer recharge (Brune 1981).

1.7.1.3 Water Quality Degradation

Water quality degradation and contamination are inherent threats to the population in San Felipe Creek because of its urban location. Studies by the Texas Commission on Environmental Quality (TCEQ), formerly the Texas Natural Resource Conservation Commission, (TNRCC 1994, 1996) and the International Boundary and Water Commission (IBWC 1994) found elevated levels of nitrates, phosphates, and orthophosphate in San Felipe Creek, indicating potential water quality problems. Land uses in the immediate area of the springs, such as runoff from the municipal golf course, may have contributed to these conditions. Catastrophic events, such as a large contaminant spill from a transportation vehicle at a bridge crossing, also threaten the species in San Felipe Creek. Continued swimming pool maintenance practices may be negatively affecting the water quality in Las Moras Creek and degrading the stream habitat.

1.7.1.4 Stream Channel Modifications

The stream channels in San Felipe Creek in Del Rio and Las Moras Creek in Brackettville have been modified for bank stabilization, flood control, public access, road bridges, and diversion of irrigation water. Non-native vegetation dominates much of the riparian corridors. In some areas, these changes may alter the habitat for the Devils River minnow, but the extent of this threat is not known.

1.7.1.5 Habitat Degradation in Mexico

Aquatic ecosystems in the northern regions of Chihuahua and Coahuila, Mexico, are undergoing changes from increasing use of groundwater and surface water (Contreras and Lozano 1994). Watersheds throughout the Río Salado Basin have been degraded from agricultural land uses and industrial development resulting in channelization and pollution of the creeks that provide habitat for the Devils River minnow (Contreras-Balderas et al. 2001). The Río Sabinas, in particular, has been noted for decreasing stream flows (Contreras and Lozano 1994).

1.7.2 Listing Factor B. Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

Overutilization is not considered a threat to the Devils River minnow at this time.

1.7.3 Listing Factor C. Disease or Predation

The Devils River minnow is threatened by the presence of introduced fishes. Fish collections by G. Garrett in 1997 from San Felipe Creek revealed for the first time the presence of armored catfish (*Hypostomus* sp.). Collections in 2001 to 2003 have confirmed that armored catfish are reproducing and are abundant in San Felipe Creek (Lopez-Fernandez and Winemiller 2005). This fish is an exotic species with an established breeding population in the San Antonio River, Texas, and was cited as potentially competing with *Dionda episcopa* in the San Antonio River due to its food habits (Hubbs et al. 1978, Edwards 2001, Hoover et al. 2004). Although *Dionda* species are common in spring runs in Central Texas, they are now absent from these habitats in the San Antonio River, further suggesting possible displacement by the armored catfish (Hubbs et al. 1978). Lopez-Fernandez and Winemiller (2005) suggested that declining trends of Devils

River minnow at some monitoring sites might be a consequence of expanding populations of the armored catfish.

In 1999, a Raphael catfish (*Platydorus costatus*) was collected from San Felipe Creek but the species does not appear to have persisted (Howells 2001, Lopez-Fernandez and Winemiller 2005). Lopez-Fernandez and Winemiller (2005) also reported a reproducing population of blue tilapia (*Oreochromis aureus*) in San Felipe Creek. This species is known to occur in the Devils River (Garrett et al. 1992). Any of these non-native fishes could pose a major threat to the Devils River minnow population in San Felipe Creek by degrading physical habitat (eating algal cover and uprooting aquatic plants), competing for food (Lopez-Fernandez and Winemiller 2005), and preying on eggs by incidental ingestion (Hoover et al. 2004).

The smallmouth bass (*Micropterus dolomieu*), a game fish introduced to Amistad Reservoir in about 1975, is native to eastern North America but has been widely introduced as a sport fish to reservoirs and streams outside its natural range. It is believed smallmouth bass gained access to the middle and upper portions of the Devils River (upstream of Dolan Falls) from Amistad Reservoir by the early to mid-1980s but is unknown how they were moved upstream of Dolan Falls (G. Garrett, TPWD, pers. comm. 1997). The Devils River is currently managed by TPWD as a trophy smallmouth bass fishery with an 18-inch (46-cm) length minimum and a catch limit of three fish per day to maintain a healthy population of large-sized bass for anglers (Baxter 1993; Gough 1993; TPWD 2004-2005 Exceptions to Statewide Fish Harvest Regulations). TPWD has not stocked smallmouth bass in Amistad Reservoir, or any other nearby waters, since the early 1980s. Smallmouth bass do not co-occur with any other population of the Devils River minnow, other than in the Devils River.

The Devils River minnow evolved in the presence of native fishes that consume other fishes, such as largemouth bass (*Micropterus salmoides*). However, the smallmouth bass is an aggressive, non-native predator, and it is known to affect other native fish communities (Taylor et al. 1984, Moyle 1994). The Devils River minnow is within the size class of small fishes that are susceptible to predation by smallmouth bass. Robertson and Winemiller (2001) studied smallmouth bass in the Devils River near Dolan Falls. They found that the bass consumed mostly insects, but also preyed heavily on fish, with 8 of the 12 small fish species occurring in the Devils River being found in smallmouth bass stomachs. Devils River minnow were too rare in the study (and not identified in bass stomach analysis) to draw any conclusions regarding effects of the bass; however, manantial roundnose minnow (a closely-related species) was preyed upon in a proportion greater than its relative abundance in the river (Robertson and Winemiller 2001).

Ongoing studies by TPWD are investigating the potential effects of smallmouth bass on fishes of the Devils River through controlled experiments in an outdoor simulated stream environment at the Heart of the Hills Fisheries Science Center (HHFSC) in Ingram, Texas. Results have not shown that sub-adult smallmouth bass preferentially prey on Devils River minnow. Devils River minnow seem to be less susceptible to smallmouth bass predation than other minnows from the Devils River in this simulated setting (G. Garrett, TPWD, pers. comm. 2003).

The future intentional or unintentional release of non-native fishes into areas inhabited by Devils River minnow is a constant potential threat. Live bait fish are commonly discarded into nearby

waters by anglers, resulting in introductions of non-native species (Taylor et al. 1984). This situation has occurred in many streams in the southwestern U.S. to the detriment of native fish communities (Moyle 1994). In addition, exotic fishes from aquaria could be introduced into local waters. Currently, only a small number of introduced fishes occur within the range of the Devils River minnow, but the potential for unintentional introductions is high because of the number of anglers on Amistad Reservoir and the urban setting of San Felipe Creek. Threats to Devils River minnow from possible introduction and establishment of non-native fishes include diseases, parasites, competition for food and space, predation, and hybridization.

Another aquatic animal introduced into San Felipe Creek is the Asian snail, *Melanoides tuberculata*. This snail serves as an intermediate host of a gill fluke that has been documented to harm other fishes in San Felipe Creek (McDermott 2000). The effects this parasite may have on Devils River minnow are unknown.

1.7.4 Listing Factor D. The Inadequacy of Existing Regulatory Mechanisms

The State of Texas lists the Devils River minnow as a threatened species; however, the State provides no protection for the habitats of listed species. Changes to the State's baitfish regulations (see Section 1.8, below) have made it illegal to use most exotic fish for bait in this area. However, few, if any, other regulations exist that prevent the introduction of non-native species to habitats of the Devils River minnow.

Limited State regulations administered by the TCEQ can protect instream flows from some changes caused by surface water right permits and can protect water quality for wildlife and human uses. However, the instream flow requirements do not apply to most existing surface water permits and no such requirements provide protection for instream flows for the streams where the Devils River minnow occurs. TCEQ's water quality regulations, as currently implemented, apply primarily to point source discharges of pollutants and, generally, have not been applied to protect individual fish species, except in very limited circumstances.

Groundwater pumping that could affect stream flows within the Devils River minnow's range is subject to limited regulation. State agencies do not control groundwater. Texas courts have held that, with few exceptions, landowners have the right to take all the water that can be captured under their land (Rule of Capture), regardless of effects on neighbors or natural resources. Individual groundwater conservation districts, specifically authorized by the Texas legislature, have varying amounts of authority and capacity to limit groundwater pumping. Under this legal framework, the authorities for protection of groundwater aquifers for the benefit of the Devils River minnow are uncertain.

The Kinney County Groundwater Conservation District is a local authority with some regulatory control over the pumping and use of groundwater resources in Kinney County. However, the relatively new district is facing many challenges in its efforts to manage groundwater pumping. It is unknown what benefits the groundwater district may provide for the conservation of spring flows and instream flows in the creeks in Kinney County. Val Verde County is not within the jurisdiction of a groundwater conservation district.

1.7.5 Listing Factor E. Other Natural or Manmade Factors Affecting Its Continued Existence

1.7.5.1 Small, Fragmented Populations

Populations of Devils River minnow are restricted to small reaches of streams that are disconnected from one another. Amistad Reservoir has fragmented the population of the fish in the Devils River from other populations to the east. Hydrologically there are connections between San Felipe, Sycamore, Pinto, and Las Moras creeks via the Rio Grande. However, because the fish are (or were) restricted to upstream portions of these streams, and the Rio Grande is being reduced in water quality and quantity, it is highly unlikely that any genetic exchange is occurring between these populations. There is also likely no genetic exchange between U.S. and any extant Mexican populations of Devils River minnow, since they are separated by a large distance. These populations are highly vulnerable to events that could cause substantial loss of natural genetic diversity or local extirpations (such as stream desiccation or contamination). The current distribution would not allow natural recolonization from other populations. The overall risk of extinction is elevated due to such factors as the small number of fragmented populations in relative close proximity, the small fluctuating population sizes, and the short species life span (for a sample of discussions on extinction risk see Davies et al. 2004, Fagan et al. 2002, Ogrady et al. 2004, and Pimm et al. 1988).

1.7.5.2 Cumulative Threats

The cumulative nature of these threats could exacerbate their effects on Devils River minnow populations (Davies et al. 2004). For example, subtle reductions in stream flows could produce small shifts in habitat use that make the species more vulnerable to competition and predation by native and non-native fishes. Reduced stream flows often further degrade poor water quality conditions. In addition, long-term drought could affect habitat of the species, especially with increased human water use (municipal and agricultural). This species has adapted to historical natural climatic variations (such as large floods and prolonged droughts). However, in conjunction with other threats to the species (primarily habitat loss and exotic competitors/predators), drought would add to the threat of extinction.

1.8 Conservation Efforts to Date

1.8.1 Conservation Agreement

In September 1998, a Conservation Agreement (Agreement) for the Devils River minnow was signed by the Service, TPWD (in cooperation with local landowners), and the City of Del Rio to expedite conservation measures needed to ensure the continued existence of the species and facilitate recovery of the species (Appendix B). The Agreement and implementation were important steps in the conservation of Devils River minnow and its environment (Garrett 2003). The objectives of the Agreement are to reduce potential threats to the species and to stabilize and improve the species populations and the ecosystems upon which they depend. The Agreement includes a Conservation Strategy (Strategy) describing specific actions needed for conservation of the Devils River minnow. In most cases, this Recovery Plan includes, and is consistent with, these provisions.

Actions identified in the 1998 Strategy, and their status, are provided below (see Appendix B for full explanation of the Conservation Actions):

(1) Determine the current status [range wide] of the Devils River minnow and monitor changes

Annual surveys of the Devils River, San Felipe Creek, and Pinto Creek were conducted by TPWD from 2000 through 2004. Refer to sections 1.4.1 to 1.4.4 of this document for a discussion of these surveys. No new information has been collected thus far on the status of Devils River minnow in Mexico.

(2) Maintain genetically representative, captive populations of Devils River minnow at the TPWD Heart of the Hills Fisheries Science Center (HHFSC) and at one or more alternate facilities deemed appropriate by the Service for reintroduction propagation and as insurance against extinction

As part of ongoing experimental studies by TPWD, Devils River minnow have been maintained at the HHFSC since 1999 and at the San Marcos National Fish Hatchery and Technology Center (SMNFH&TC) since 2000. These captive stocks are being maintained for research purposes and not specifically as refugia populations. That is, these stocks are not yet being maintained under strict controls and in sufficient sizes to be suitable as a source for reintroduction in the wild. However, both efforts are increasing our knowledge of the life history and reproductive characteristics of the species, which will assist in future captive population maintenance.

Since August 2000, the SMNFH&TC has maintained a small captive stock of Devils River minnow to investigate potential techniques needed for captive propagation (Gibson et al. 2004). Two recirculating systems with several spawning substrates and riverine habitats (riffle, pool, “canopied” pool) were used and both systems were stocked with 19 Devils River minnows on September 5, 2001. By late November 2001, 1,152 eggs and 1,118 larvae had been recorded and about 450 fry had been produced (20 percent

survival). Work is continuing to improve survival from eggs to fry and to develop information on early life history, fecundity, growth, life span, and food requirements. Additionally, research is continuing to determine mechanisms controlling reproduction, refine culture techniques to improve efficiency, and determine fish gender. As of April 2005, the SMNFH&TC housed 121 wild stock of Devils River minnow (J. N. Fries, Service, pers. comm. 2005). Offspring from the wild stock of various ages are being used to describe the developmental process of the species. Morphometrics, meristics, and melanophore characteristics of Devils River minnow early life stages were described for individuals ranging in age from time of hatch to Day 128 (Hulbert 2005).

(3) Reintroduce Devils River minnow reared from captive populations to reestablish populations in the wild

At the time the Conservation Agreement was developed, there was concern that Devils River minnow populations in the Devils River were extirpated, or nearly so. Therefore, the conservation action to reestablish populations was focused on reintroducing fish only in the Devils River. Reintroductions of Devils River minnow into the Devils River are not anticipated as part of this Recovery Plan because the species' status in the river is better than previously documented. Future reintroductions may prove feasible in currently unoccupied areas, such as Las Moras Creek. Efforts have been made to work with the local community through the Fort Clark Springs Association (Association) to develop a restoration plan for reestablishing Devils River minnow in Las Moras Creek. The Association manages the upper few miles of Las Moras Creek, including the spring head and the connected swimming pool. The Association has shown some interest in the past in pursuing a restoration project; however, thus far the Association has declined to participate in restoration efforts for Devils River minnow in Las Moras Creek.

(4) Continue and enhance protection of the San Felipe Creek watershed

In 2003, the City of Del Rio and San Felipe Country Club (local golf course) signed management plans for the protection, preservation, restoration, and management of San Felipe Creek (Appendix C). These plans will provide important conservation benefits to the population of Devils River minnow in San Felipe Creek. The City also has adopted a Water Conservation Plan to direct future water use activities during drought times and has taken several additional steps to enhance water conservation within the City (City of Del Rio 2002).

(5) Provide technical assistance to landowners on riparian protection and management

To date, TPWD has provided technical assistance to the City of Del Rio and the San Felipe Country Club for golf course management. In response, the golf course has changed mowing and fertilizing procedures and has instituted a minimum 10 to 15 feet no-mow buffer along the creek to improve the health of San Felipe Creek (City of Del Rio 2002).

(6) Review live bait harvest and selling practices in the Devils River area to develop methods and take appropriate actions (for example, regulation, education) to prevent further establishment of exotic, aquatic species within the historic range of Devils River minnow.

In 1998, TPWD modified its bait fish regulations to allow only native bait fish, exotics that are already well established (carp), or exotics that have historically been used but never established viable populations (golden shiner & goldfish). The remaining approved species are common native fishes. The modified bait fish regulations state:

"In Brewster, Crane, Crockett, Culberson, Ector, El Paso, Jeff Davis, Hudspeth, Loving, Pecos, Presidio, Reeves, Terrell, Upton, Val Verde, Ward and Winkler counties, the only fishes that may be used or possessed for bait while fishing are common carp, fathead minnows, gizzard and threadfin shad, golden shiners, goldfish, Mexican tetra, Rio Grande cichlid, silversides and sunfish."

(7) Document abundance and range of exotic fish species in the Devils River, San Felipe, Las Moras and Sycamore creeks using methods described in [Conservation Action] #1

See results of Conservation Action #1 above. A complete report of the results of these collections (2000-2004) will be available in the future from TPWD.

(8) Obtain and analyze changes in flow data for the Devils River, San Felipe, Las Moras, and Sycamore creeks

We are not aware of any specific action that has been taken on this task.

(9) With progeny of the captive population, use a simulated environment to determine ecological and life history requirements of Devils River minnow

Since September 1999, predation and competition experiments have been conducted in artificial streams by TPWD. Predation experiments used various sizes of sub-adult smallmouth bass as the predator and observed effects on different fish communities found in the Devils River. Results suggest that the Devils River minnow may be less susceptible to bass predation than other minnows from the Devils River (G. Garrett, TPWD, pers. comm. 2002). Since 2001, experiments on competitive interactions of native fishes have been conducted. In 2002, two additional artificial streams were constructed, bringing the total to four artificial streams. Additional replication will enhance statistical inferences drawn from the data.

(10) Determine *in situ* predator/prey interactions [in the natural environment] between smallmouth bass and Devils River minnow

A study by Robertson (1998) suggested that smallmouth bass may be affecting the native fish assemblages in the Devils River (Robertson and Winemiller 2001). However, few Devils River minnow were found in the study, and no conclusions could be reached for the effects of smallmouth bass on this species.

1.8.2 Land Conservation

Much of the land along the Devils River has been placed in conservation management during recent years, including the purchase of the 7,689-ha (19,988-acre) Devils River State Natural Area in the 1980s (Karges 2003). Since then, The Nature Conservancy (TNC) has been active in working with local landowners to conserve the lands along the Devils River by direct purchase and establishing conservation easements (Karges 2003). In all, TNC currently has about 51,592 ha (127, 458 acres) under conservation management within the Devils River watershed, with approximately 25 miles of riverfront and riparian habitat. Although land ownership and management can not address all the threats to the Devils River minnow, they do benefit the aquatic habitat for the species.

2.0 RECOVERY

2.1 Goals, Objectives, and Criteria

2.1.1 Recovery Goal

The recovery goal for the Devils River minnow is to reduce or remove threats to the species and its habitat such that its long-term survival is secured, so that the species is no longer threatened and can be delisted. The recovery plan outlines necessary actions to conserve the species and the ecosystem upon which it depends. Conservation of this species in the wild is dependent upon conservation of stream and spring flows of appropriate quantity and quality to support the species and its habitat. The goal includes protection and maintenance of the native biological aquatic communities in which the Devils River minnow occurs.

2.1.2 Recovery Objectives

Recovery objectives collectively describe the specific conditions by which the Devils River minnow recovery goals will be met. Recovery objectives for Devils River minnow include:

(1) Ensure self-sustaining populations of Devils River minnow in Devils River, San Felipe Creek, Sycamore Creek, Pinto Creek, and Las Moras Creek in Texas and in the Río Salado drainage in Coahuila, Mexico;

(2) Secure protection of adequate stream and spring flows for long-term maintenance of aquatic ecosystems upon which Devils River minnow rely;

(3) Reduce pollutants from point and non-point sources affecting areas with existing water quality problems and avoid degradation of water quality of surface water and groundwater throughout the range of the Devils River minnow;

(4) Reduce the opportunities for introduction and establishment of non-native species, and manage all current aquatic non-native species for the benefit of native biological aquatic communities throughout the range of the Devils River minnow.

2.1.3 Recovery Criteria

The ESA requires recovery plans to include "objective, measurable criteria which, when met, would result in the determination…that the species be removed from the list." Recovery criteria describe discrete targets with standards for measurement to determine that species have achieved recovery objectives and may be delisted. Developing precise measurable criteria for recovery of Devils River minnow is challenging because of information gaps about the species and its habitat. As a result, many of the recovery actions are intended to fill these gaps and will allow future development of more specific criteria. Based on the best available scientific information, Devils River minnow should be considered for delisting when:

(1) Population monitoring verifies stable or increasing population trends for Devils River minnow for at least 10 years throughout its range including Devils River (middle portion), San Felipe Creek, Sycamore Creek, and Pinto Creek in Texas. If reestablishment is scientifically feasible, populations should be restored in Las Moras Creek. The status of populations in the Rio Salado drainage in Mexico should also be confirmed.

(2) Adequate flows in streams supporting Devils River minnow have been ensured, including Las Moras Creek (if reestablishment is feasible), through State or local groundwater management plans, water conservation plans, drought contingency plans, regulations, or equivalent binding documents;

(3) Protection of surface water quality, including the protection of the quality of groundwater sources of surface water flows, is ensured throughout the range of Devils River minnow by demonstrated compliance with water quality standards and implementation of water quality controls, particularly in urban areas such as the cities of Del Rio and Brackettville; and

(4) Management and control of non-native species by local, regional, State, and Federal authorities are demonstrated to be successful.

2.2 Recovery Strategy

The general recovery strategy for the Devils River minnow is to reduce threats to the species, secure adequate habitat conditions (clean, free-flowing springs and streams), and allow viable, self-sustaining populations to persist in the wild throughout its remaining range, and where feasible to restore populations within the historic range. Many of the necessary actions for habitat protection are predicated on an increased understanding of the relationship of the Devils River minnow to its physical, chemical, and ecological environment. Several recovery actions are designed to collect information on the species and its habitat to provide for better future science-based management decisions and conservation actions. For example, an increased understanding of the species' genetics, life history, population dynamics, and responses to identified threats are needed. Implementation of the recovery plan will require adaptive management strategies to use the most up-to-date information as it becomes available.

2.2.1 Conserve Habitat

The primary focus of the recovery strategy for the Devils River minnow is the protection of naturally functioning spring and stream ecosystems within its current and potentially restorable historic range. The first priority is to ensure sufficient stream and spring flows (that is, water quantity) to maintain viable populations of native fauna and flora. Protection of underground water reservoirs (aquifers) from non-sustainable use is essential because all streams in the Devils River minnow's range are supported by these aquifers (Brune 1981; see *Section F. Hydrology and Geohydrology*). Current State of Texas regulations require that this be accomplished through local groundwater management. At this time, insufficient information is available to recommend specific flows for streams where Devils River minnow occur. Future analysis of preferred habitat use of the fish and historic stream hydrology are needed to develop specific stream flow targets; when completed these targets will be incorporated into the plan.

Water quality protection also is important to ensure that adequate habitat is available throughout the Devils River minnow's range. Based on current information, focus is placed on protection of water quality in the urban settings of Del Rio and Brackettville. However, additional research may warrant considerations for water quality protection in rural settings as well. Current information is not available to determine specific water quality needs of the Devils River minnow. Initially, water quality analysis of currently occupied habitats can be used to describe the water quality conditions needed for the species.

In some situations, restoring the natural physical stream conditions from previous stream channel modifications (small dams, stream bank changes, channelization, etc.) may be needed to allow the microhabitat conditions necessary for feeding, breeding, and sheltering of Devils River minnows. These physical components of streams work together to support the natural aquatic ecosystem upon which the species and all associated native species depend.

2.2.2 Control Non-native Species

Non-native competitors, predators, and carriers of parasites and/or diseases need to be restricted. Introduced species within the range of the Devils River minnow are a constant threat and

alleviating this threat will require ongoing enforcement of State regulations and public education. The influences of introduced species may be difficult to measure, due to the complex nature of the interactions. Potential problems could include not only non-native fishes, but also other animals or plants that could introduce a parasite or disease or alter the natural habitat.

2.2.3 Preserve Genetic Diversity

All of the remaining populations of Devils River minnow are included in the recovery criteria because of the small number of total populations remaining. To achieve recovery, threats must be reduced and populations stabilized throughout the species' range. The different populations of the Devils River minnow are considered management units. The recovery criteria use six management units, based on the streams where the fish occur, or could be restored. These six units are:

1. Devils River, Texas;
2. San Felipe Creek, Texas;
3. Sycamore Creek, Texas;
4. Pinto Creek, Texas;
5. Las Moras Creek, Texas; and
6. Río Salado drainage, Mexico.

Verifying or establishing viable populations in all six of these management units is considered necessary (if scientifically feasible) for recovery to be achieved, since they are all now isolated, vulnerable to threats, and not likely to be naturally recolonized if extirpated. Until new information is available on the genetics of these populations, they should be treated and managed as separate units. Surveys are especially needed in Sycamore Creek and in the Río Salado drainage in Mexico to assess the current status of the species and its habitat there. In the absence of more information on the feasibility of conserving Devils River minnow in these areas, both were included in the recovery criteria to decrease the risk of species extinction over the long-term. Although the Devils River minnow does not presently occur there, Las Moras Creek is believed to be "recoverable" habitat and is included as a necessary population in the recovery criteria.

2.2.4 Maintain Captive Populations

Because of the small and isolated nature of these populations, captive propagation (culture of fish in a hatchery or zoo setting) likely will be needed for the foreseeable future. Implementation of a captive propagation plan is aimed at maintaining natural genetic diversity among and within the different management units. This will help ensure conservation of genetic diversity in the event that wild populations are extirpated. Captive populations should be maintained until species' threats are sufficiently reduced that extinction in the wild is no longer likely.

2.2.5 Monitor Population Status

Once the identified threats have been sufficiently reduced, viable populations should be confirmed throughout the historic range of Devils River minnow, with the exception of upper and lower sections of the Devils River in Texas and the Río San Carlos in Mexico, where it may

not be feasible to restore habitat. Due to the species' limited distribution, it is prudent to maintain or reestablish populations in all available and restorable habitats. The lowest sections of the Devils River are excluded from the recovery criteria because the habitat is believed to be permanently lost due to the impoundment of Amistad Reservoir. Similarly, the upper section of the Devils River appears to no longer support continual stream flows, and restoration of Devils River minnow habitat there is not considered feasible. The status of the habitat in the Río San Carlos in Mexico is unknown but is presumed degraded to the extent that the species is extirpated.

Assuming a life expectancy of about 2 years, the recommended 10 years of monitoring represents at least five generations. Additional research may be necessary to evaluate the magnitude of hydrologic variations likely to occur that were not experienced during the 10 years (such as unusually large, infrequent floods or droughts) and the effects of these variations on Devils River minnow.

2.2.6 Conserve Mexican Populations

Determining an appropriate strategy for conservation of Devils River minnow in Mexico is particularly challenging because of the scarcity of information on the species there. Developing a strategy for the species in Mexico can only be adequately addressed with documented surveys and a complete assessment of threats. In addition, a thorough evaluation of the phylogenetic relationship of Devils River minnow populations in Mexico to populations in Texas also is needed. Mechanisms for interagency coordination with the appropriate personnel in Mexico are vitally needed to develop an appropriate strategy there. The recovery plan and criteria may be revised to include additional recovery actions for populations in Mexico, as the understanding of the species and its needs in Mexico increases.

2.2.7 Apply Adaptive Management

The strategy of this recovery plan is based on the best available science; however, we recognize there are considerable knowledge gaps regarding the species and the ecosystem upon which it depends. As a result of this uncertainty, the process of Devils River minnow recovery will necessitate adaptive management—that is, "we will learn by doing." Throughout the implementation of recovery actions outlined below, new information and technologies will become available. New information should be evaluated and used to modify the strategy for recovery of Devils River minnow, as appropriate. With increasing knowledge, some recovery actions will likely become obsolete and other actions will be proposed that cannot be envisioned now. Likewise, the objectives and criteria of this recovery plan may be adjusted in the future as our understanding improves. Through a continual process of planning, doing, monitoring, research and evaluation, and adjusting management, we will learn how to effectively conserve this species. The knowledge we gain from implementation of this recovery plan will be incorporated in the future recovery process.

The Service periodically reviews approved recovery plans to determine the need for modifications. This recovery plan should be considered a living document that is flexible and consistent with the available, contemporary, scientific information. This may require periodic

updates to the plan without full revisions being completed. This flexibility will maximize the usefulness of the recovery plan. The adaptive management concept ensures that all parties who choose to participate will have opportunities to contribute to the Devils River minnow recovery process. The work to accomplish the species' recovery is too large and too complex for any entity to accomplish alone. Only by working together with diverse groups of people with different knowledge and expertise can recovery objectives and criteria be achieved.

2.3 Recovery Action Outline

1. Maintain and enhance existing Devils River minnow populations and habitats.
   - 1.1 Monitor status of Devils River minnow.
     - 1.1.1 Monitor distribution and abundance in Texas.
     - 1.1.2 Assess distribution and abundance in Mexico.
     - 1.1.3 Assess and monitor threats to Texas and Mexico populations.
     - 1.1.4 Evaluate geographic variation in the species' genetic structure.
   - 1.2 Determine biological and life history requirements.
     - 1.2.1 Study competition with coexisting species.
     - 1.2.2 Study reproductive variables.
     - 1.2.3 Investigate predation by other species.
     - 1.2.4 Determine early life history characteristics and survivorship.
     - 1.2.5 Investigate disease and parasites.
     - 1.2.6 Study effects of aquatic non-native species.
   - 1.3 Identify specific habitat requirements.
     - 1.3.1 Determine physical habitat preferences.
     - 1.3.2 Determine chemical habitat preferences and tolerances (water quality).
     - 1.3.3 Determine relationships of stream flow and habitat availability.
     - 1.3.4 Determine stream flows needed for habitat maintenance.
     - 1.3.5 Study effects of riparian management strategies.
     - 1.3.6 Investigate regional hydrogeology.
   - 1.4 Manage Devils River minnow habitat.
     - 1.4.1 Seek and maintain the cooperation of landowners and government agencies.
     - 1.4.2 Ensure protection for certain stream segments and their watersheds.
     - 1.4.3 Develop and implement groundwater management plans for stream flow protection.
     - 1.4.4 Monitor stream flows.
     - 1.4.5 Monitor existing physical and chemical habitats.
     - 1.4.6 Restore and enhance habitat conditions.
     - 1.4.7 Reduce pollutants.
   - 1.5 Establish and implement procedures to prevent introduction of exotic species and control problem exotic species.
   - 1.6 Develop a recovery strategy for Mexican populations.
   - 1.7 Assess effectiveness of recovery management actions.

2. Establish additional viable Devils River minnow populations within the historic range.
   2.1 Develop landowner agreements to reintroduce in former site(s) of occurrence.
   2.2 Restore habitat conditions at former site(s) of occurrence.
      2.2.1 Assess future spring flows at reintroduction site(s).
      2.2.2 Ensure adequate water quality protection at reintroduction site(s).
      2.2.3 Develop and implement stream channel restoration projects at reintroduction site(s), if necessary.
   2.3 Develop and implement a reintroduction plan.

3. Maintain genetic reserves of Devils River minnow in captivity until no longer needed.
   3.1 Develop and implement a genetics management plan.
   3.2 Maintain captive populations in at least two appropriate facilities.

4. Disseminate information about Devils River minnow conservation.
   4.1 Develop an outreach strategy.
   4.2 Prepare and distribute an information pamphlet.
   4.3 Produce and maintain an outreach website.
   4.4 Construct an informational kiosk in Del Rio on San Felipe Creek.

5. Post-delisting monitoring.
   5.1 Develop a post-delisting monitoring plan for the Devils River minnow.

2.4 Recovery Action Narrative

Each recovery action is described below. An explanation of priority numbers is given in *Section 3.2 Recovery Action Priorities and Abbreviations.* For each individual recovery action, the estimates of cost, list of responsible parties, and a cross-reference to recovery criteria and the listing factor is given in *Section 3.3 Implementation Schedule*.

1. Maintain and enhance existing Devils River minnow populations and habitats. Recovery actions 1.1 to 1.3 are designed to collect the necessary updated information to manage Devils River minnow populations and their habitat for natural ecosystem functions. The knowledge gained in monitoring and research studies should be used in an adaptive management approach to provide new strategies for Devils River minnow recovery.

   1.1 Monitor status of Devils River minnow. Range-wide up-to-date information on the distribution, abundance, and threats to the species is needed to inform species conservation and management decisions. The last published comprehensive analysis of the fish's status in the U.S. was from data collected in 1989 (Garrett et al. 1992). TPWD has conducted numerous survey efforts over the last five years. Once published, this will provide the latest summary of the status of the species.

      1.1.1 Monitor distribution and abundance in Texas **(Priority 1b)**. Multiple years of fish surveys need to be conducted in all stream habitats ranging from Las Moras Creek watershed to the Devils River watershed to determine and monitor the current distribution and abundance of Devils River minnow in Texas. The success of this action is directly dependent on the voluntary permission of private landowners allowing biologists access to creeks on private property for surveys.

      1.1.2 Assess distribution and abundance in Mexico **(Priority 1b)**. Fish surveys are needed in the Río Salado and Río San Carlos drainages and intervening watersheds to determine the current distribution and abundance of Devils River minnow in Mexico. Cooperation of private landowners and Federal and local Mexican governments is needed to conduct research in Mexico.

      1.1.3 Assess and monitor threats to Texas and Mexico populations **(Priority 1b)**. An updated evaluation of threats to the Devils River minnow in Texas and Mexico needs to be completed. Threat evaluation should include a study of the past physical habitat changes (water quantity, water quality, substrates, stream channel geometry, stream bank) and changes in ecological factors (non-native species introductions, food sources, predators, competitors). The results will allow for high-priority recovery actions to be directed at reducing the most immediate threats. Approval and support of Mexican and U.S. governmental agencies and private landowners are needed.

      1.1.4 Evaluate geographic variation in the species' genetic structure **(Priority 2)**. The results should help in the management of populations in different watersheds,

possibly as separate units. One consideration is the possible effects of Amistad Reservoir eliminating the movement of fish and, therefore, gene flow, between the Devils River and other streams. This information will be essential for establishment of captive populations or reintroduction plans.

1.2 Determine biological and life history requirements. Management for long-term survival of the species depends on knowledge of its ecological needs. Studies aimed at developing such knowledge should be conducted, with sensitivity toward problems of over-collecting, transportation of exotics, and any other actions that may adversely affect the fish.

1.2.1 Study competition with coexisting species **(Priority 2)**. Investigations of competition will require additional knowledge of reproduction, life history, habitat use, and food preference. The Devils River minnow is thought to eat algae; however, virtually nothing is known of food preferences. Overlap in food preferences with coexisting species (for example, exotic armored catfish) could adversely affect Devils River minnow at times when resources are limited. Competition for space (for example, breeding areas) could also be a problem. One potential area of investigation is how niche separation occurs with the manantial roundnose minnow, a closely related species often found in the same habitat but at greater abundances.

1.2.2 Study reproductive variables **(Priority 1b)**. Comprehensive studies in laboratory and field settings are needed to determine reproductive traits such as timing, duration, frequency, behavior, fecundity, and habitats (including water velocities, depths, and substrate). This information can be used to assist in developing captive breeding techniques for maintaining captive populations and assessing potential competition with other fishes. The information could also be critical to management of the ecosystem to benefit reproduction of the species. For example, if a particular flow rate were needed in San Felipe Creek to provide the habitat needed to ensure egg or fry survival during a particular season, it would be important for the City of Del Rio to proactively manage water withdrawals to ensure the appropriate conditions are not compromised. Other important factors could be discovered that are currently limiting the reproduction and early survival of Devils River minnow.

1.2.3 Investigate predation by other species **(Priority 2)**. Predation levels by native and non-native fishes, including smallmouth bass, should be determined for different Devils River minnow populations through field and laboratory study. Additional investigations in the wild may need to be conducted to determine what effect, if any, predation by smallmouth bass may have on Devils River minnow. Results could direct future management actions for the smallmouth bass fishery in the Devils River, particularly in critical river segments.

1.2.4 Determine early life history characteristics and survivorship **(Priority 2)**. Nothing is known of Devils River minnow survivorship or longevity. Seasonal

mortality rates for each life history stage should be determined and could be incorporated into future management actions for Devils River minnow conservation.

1.2.5 Investigate disease and parasites **(Priority 3)**. Except for McDermott's (2000) survey for gill flukes in San Felipe Creek, no data are available on the diseases and parasites of the Devils River minnow. Advancing knowledge of the diseases and parasites of the fish could help contain any potential future epidemic.

1.2.6 Study effects of aquatic non-native species **(Priority 1b)**. Exotic species currently occurring within the range of the Devils River minnow (as well as potential future releases and establishment of other non-native organisms) are a potential threat to its survival. Effects of non-native species often are manifested through competition, predation, disease, parasitism, or hybridization—all of which are difficult to quantify. The best approach to this problem is to reduce the possibility of any releases of non-native species into the wild (see Action 1.5). A study is needed on the effects of the exotic *Melanoides* snails in San Felipe Creek (McDermott 2000) and the potential for the associated gill parasite to infect Devils River minnow. Research also is needed in San Felipe Creek to determine how the recently introduced exotic armored catfish affect the Devils River minnow. In both cases, measures should be developed to control the exotic species because of the probable negative effects.

1.3 Identify specific habitat requirements. Valuable data for protection and enhancement of the Devils River minnow would be gained from a survey of physical, chemical, and biotic features in relation to presence and abundance of the species.

1.3.1 Determine physical habitat preferences **(Priority 2)**. The specific physical characteristics (for example, water depth, velocity, substrate, vegetation) associated with stream habitats should be quantified for Devils River minnow preference. The information should be analyzed by season, age class, and stream reaches. To date, only qualitative assessments of habitat preferences have been made, suggesting the fish (adults) occupy areas with moderate depths and velocities, and gravel substrates near aquatic vegetation. This research should identify high quality habitat for Devils River minnow maintenance, restoration, or reintroduction.

1.3.2 Determine chemical habitat preferences and tolerances (water quality) **(Priority 2)**. Through both field and laboratory investigations, preferences and tolerances of Devils River minnow should be determined for a range of chemical properties (for example, water temperature, dissolved oxygen, pH, salinity, suspended sediments, total dissolved solids, nitrates, phosphates, petroleum hydrocarbons) of waters that may be found within the species range.

1.3.3 Determine relationship of stream flow and habitat availability **(Priority 1b)**. Hydrological analysis should be completed for streams known to be occupied by Devils River minnow and correlated to physical habitat availability for the fish. A range of flows should be evaluated for the various effects on overall available habitat for Devils River minnow.

1.3.4 Determine stream flows needed for habitat maintenance **(Priority 1b)**. Where stream flows may be directly influenced by human actions, optimum stream flows should be established to maintain adequate Devils River minnow populations. A specific need where a target flow regime may be useful is on San Felipe Creek, where the City of Del Rio removes water directly from the springs that supply water to the creek. This flow analysis should be based on extensive field data collection and state-of-the-art modeling techniques. This information could be used as a guide for water users, like the City of Del Rio, to develop and implement water management strategies and drought contingency plans, while still sustaining biotic integrity and conservation values of surface streams.

1.3.5 Study effects of riparian management strategies **(Priority 3)**. Conduct research to determine the effects on Devils River minnow of various land management methods (related to grazing practices in rural areas and related to bank modifications in urban settings) in riparian areas where Devils River minnow occurs.

1.3.6 Investigate regional hydrogeology **(Priority 1b)**. Determining the source and recharge zones of the aquifers that support stream flows in Devils River minnow habitat in Texas is paramount in protecting these flows. Only through comprehensive investigation, mapping, and modeling can effective groundwater management and conservation be ensured.

1.4 Manage Devils River minnow habitat. Ensuring maintenance and conservation of habitat currently supporting Devils River minnow populations is critical to recovery. Effective management should include groundwater conservation in the contributing aquifer(s); stream flow protection; physical habitat improvement in some stream reaches; pollution prevention; and cultivation of cooperative relationships with and among landowners, public agencies, and other interested parties in the area. Information gained from actions 1.1, 1.2, and 1.3 (described above) will be helpful in meeting actions 1.4 and 2.0.

1.4.1 Seek and maintain the cooperation of landowners and government agencies **(Priority 1a)**. Private landowners should be recognized for past land management actions that have allowed the species to persist in the streams on or adjacent to their property. Private landowners should be involved in recovery action planning and implementation for the Devils River minnow. Local government agencies, such as the cities of Del Rio and Brackettville, Val Verde

and Kinney counties, and local water districts, should also be involved in planning and conducting recovery implementation for the species.

1.4.2 Ensure protection for certain stream segments and their watersheds **(Priority 1a)**. Stream flow, water quality, and channel morphology should be maintained in natural conditions to provide for ecosystem functions to support Devils River minnow. Areas in Texas where the Devils River minnow currently occurs should be the focus of conservation efforts. (Areas include Devils River and tributaries from Pecan Springs to Dolan Falls; San Felipe Creek in Del Rio; upper segments of San Felipe Creek; Sycamore Creek; and upper segments of Pinto Creek). Protection should be initiated and documented in commitments by individual landowners, local governmental agencies (cities and counties) and non-governmental organizations (such as water conservation districts, landowner associations, and regional water planning groups). Land management plans that serve to improve watershed health should be developed and implemented throughout the watersheds supporting Devils River minnow.

1.4.3 Develop and implement groundwater management plans for stream flow protection **(Priority 1a)**. State and local governmental entities (for example, groundwater districts, regional water planning groups, cities, and counties) should work with landowners and other water users to develop and implement specific plans for sustainable groundwater use to ensure that surface water flow from springs and creeks are maintained for the benefit of natural ecosystems upon which the Devils River minnow depends.

1.4.4 Monitor stream flows **(Priority 1b)**. A comprehensive network of stream discharge gages should be installed and maintained for streams within the range of the Devils River minnow. The data should be readily available through online sources on the Internet. This information would provide historic flow data and current stream flow conditions to assist in management of Devils River minnow habitat. This would be especially necessary during critical low flow periods when physical habitat may be limited by lack of adequate stream flow and conservation actions may need to be triggered based on flow rates.

1.4.5 Monitor existing physical and chemical habitats **(Priority 1b)**. The status of habitat conditions at locations of all extant Devils River minnow populations needs to be monitored, at least annually, to detect changes in habitat availability. A monitoring plan should be developed to ensure uniform methods of field work over time and location to evaluate habitat trends.

1.4.6 Restore and enhance habitat conditions **(Priority 2)**. A habitat enhancement plan for San Felipe Creek in Del Rio (and any other appropriate site) aimed at improving and maintaining physical habitat for Devils River minnow should be formulated and implemented. This may include the physical reconstruction of stream banks with native vegetation and natural stream morphology.

1.4.7 Reduce pollutants **(Priority 1a)**. Pollution sources to aquatic habitats throughout the range of the Devils River minnow need to be detected and the pollutants eliminated to the maximum extent practicable. Of special concern are inputs from urban environments in San Felipe Creek from Del Rio.

1.5 Establish and implement procedures to prevent introductions of exotic species and control problem exotic species **(Priority 1a)**. Because of the dangers of predation, competition, diseases, parasites, and hybridization, further introductions of all exotic organisms that could affect the aquatic environment, should be prevented within the range of the Devils River minnow. Methods for control should be developed and implemented for existing exotic species found to be degrading Devils River minnow populations or their habitats.

1.6 Develop a recovery strategy for Mexican populations **(Priority 1b)**. As new information is gained on the status and threats to Devils River minnow populations in Mexico, collaboration between U.S. and Mexico to address transboundary conservation needs may be warranted. The strategy may or may not include similar actions necessary to achieve recovery in the U.S. and needs to be compatible with local culture and government policies.

1.7 Assess effectiveness of recovery management actions **(Priority 1b)**. Ongoing evaluations of the results of management actions should be conducted to allow for adaptive management so that changes can be made as new information becomes available.

2. Establish additional viable Devils River minnow populations within the historic range. Adequate spring flows, spring outlet restoration, alteration of swimming pool maintenance activities, and elimination of any non-native fishes may allow repatriation of the Devils River minnow in the Las Moras Creek watershed in Brackettville and downstream. Other sites within the historic range may be considered for reintroductions (Sycamore Creek, for example, if future surveys do not confirm its presence there) if determined appropriate and habitat restoration actions can be undertaken. Support of private landowners will be necessary to plan and implement the reestablishment of the Devils River minnow. There is uncertainty regarding the feasibility of reestablishing the Devils River minnow in its former range. Therefore, adaptive management principles will be essential in planning and implementing reintroduction efforts.

2.1 Develop landowner agreements in former site(s) of occurrence **(Priority 1b)**. Agreements would need to be documented to show landowner cooperation in restoration efforts and commitments to future conservation measures to ensure successful repatriation of Devils River minnow in any formerly occupied areas.

2.2 Restore habitat conditions at former site(s) of occurrence. Prior to any reintroduction of Devils River minnow in Las Moras Creek (or any other site), the following minimum conditions, should be considered to ensure habitat availability.

2.2.1 Assess future spring flows at reintroduction site(s) **(Priority 1b)**. The probability of maintaining future adequate spring flows should be considered. Ideally, documented and enforceable groundwater management (based on detailed hydrogeology studies) would be in place to provide for permanent flow at adequate levels in Las Moras Creek. This may require establishing target stream flows based on species' requirements and making those flow levels part of groundwater management goals.

2.2.2 Ensure adequate water quality protection at reintroduction site(s) **(Priority 1b)**. A comprehensive study of water quality and contaminants is needed to determine survival potential for Devils River minnow in any reintroduction site. Concerns for water quality should be addressed prior to development of reintroduction plans. For example, in Las Moras Creek, chlorination of the swimming pool fed by Las Moras Creek is suspected to limit all biota in the creek downstream (Garrett et al. 1992). These maintenance practices may need to be replaced with a less detrimental form of pool cleaning to support Devils River minnow populations. Other pollution sources need to be evaluated in Brackettville, as well. Written agreements with local landowners (including Fort Clark Springs Association) and the City of Brackettville should be developed that provide for adequate water quality in the spring outflow and downstream.

2.2.3 Develop and implement stream channel restoration projects at reintroduction site(s), if necessary **(Priority 1b)**. An analysis of the physical habitat of the spring outflow area of Las Moras Creek needs to be completed, including documentation of past changes (for example, any dredging or channelization that occurred). If substantial degradation has occurred, a stream channel restoration plan may need to be developed and implemented.

2.3 Develop and implement a reintroduction plan **(Priority 1a)**. Prior to any reintroduction efforts, a comprehensive reintroduction plan should be developed in accordance with the Service's Captive Propagation Policy (Policy Regarding Controlled Propagation of Species Listed Under the Endangered Species Act, 65 FR 56916, September 20, 2000). This plan would include, but not be limited to, a consideration of population genetics, an assessment of reintroduction effects on other native species, and a specific monitoring component to measure reintroduction results. In developing this plan the results of Recovery Actions associated with 2.1 and 2.2 should be taken into account.

3. Maintain genetic reserves of Devils River minnow in captivity until no longer needed. Captive populations should be representative of the total genetic variation and maintained in a way that is most useful for reintroduction purposes (per actions under 2, above). Maintaining captive stock also is important should a loss of natural populations ever occur. Captive-held fish also can be used to provide live or preserved specimens for scientific study and deposition in fish museums for future reference and study.

3.1 Develop and implement a genetics management plan **(Priority 1b)**. A genetics management plan should be completed in accordance with the Service's Captive Propagation Policy. The purpose of the plan is to ensure that: (1) the genetic makeup of propagated individuals is, to the extent practicable, representative of the wild populations; (2) propagated individuals are behaviorally and physiologically suitable for introduction; and, (3) this genetic make-up is maintained in captivity over generations. Until a genetics study can be completed (Action 1.1.4), each population of Devils River minnow should be separately maintained. Individuals from the Devils River drainage, San Felipe Creek drainage, Pinto Creek, Sycamore Creek, and Mexico should not be allowed to interbreed in captivity. The genetics management plan should include adaptive management provisions to incorporate biological information gained during the research and early implementation of captive propagation.

3.2 Maintain captive populations in at least two appropriate facilities **(Priority 1a)**. Develop culture techniques, incorporating reproductive ecology (as outlined in 1.2.2) and genetics considerations (as outlined in 3.1), to maintain genetically representative, captive populations of Devils River minnow. Establish and maintain these populations at HHFSC and SMNFH&TC (in accordance with the Service's Captive Propagation Policy). If one or both of these facilities is unable to maintain a captive population, alternative facilities should be used such that captive populations are maintained in at least two separate locations.

4. Disseminate information about Devils River minnow conservation. A good public information program solicits and encourages support for protection of imperiled species. Information on Devils River minnow should be disseminated to a wide audience, while focusing on the local communities within the species range.

4.1 Develop an outreach strategy **(Priority 3)**. A plan to describe the basic message and the audience should be prepared to guide public outreach efforts.

4.2 Prepare and distribute an information pamphlet **(Priority 3)**. A pamphlet on Devils River minnow ecology, life history, status, and general aspects of recovery efforts should be prepared and distributed. Content of the pamphlet should include information on how local landowners can participate in conservation efforts for the Devils River minnow. The pamphlet also could discourage introduction of bait fishes and be distributed at bait and tackle shops.

4.3 Produce and maintain an outreach website **(Priority 3)**. A website describing the Devils River minnow and threats to it and conservation efforts for it should be produced and made available to the public.

4.4 Construct an informational kiosk in the City of Del Rio on San Felipe Creek **(Priority 3)**. The largest community within the range of the Devils River minnow is the City of Del Rio. The City has several public parks along San Felipe Creek where the public can recreate (swim, fish, picnic, etc.). One or more kiosks should be constructed in

areas frequented by the public to provide information on Devils River minnow and San Felipe Creek and encourage environmental conservation of the creek.

5. Post-delisting monitoring.

5.1 Develop a post-delisting monitoring plan for the Devils River minnow **(Priority 3)**. Section 4 (g) (1) of the ESA requires that the Service monitor the status of all recovered species for at least five years following delisting. In keeping with this mandate, a post-delisting monitoring plan should be developed by the Service in cooperation with TPWD, the Rio Grande Fishes Recovery Team, Federal agencies, academic institutions, and other appropriate entities. This plan should outline the indicators that will be used to assess the population status of the Devils River minnow, develop monitoring protocols for those indicators, and evaluate factors that may trigger consideration for relisting.

2.5 Control of Threats

The following summarizes the recovery actions for the Devils River minnow that are intended to control the threats to the species. References to specific recovery actions (abbreviated RA in this section) can be reviewed in *Sections 2.3, 2.4* and *3.3* of this plan. For a review of the threats, see *Section 1.7 Reasons for Listing and Threats Assessment*. Recovery criteria refer to those listed in *Section 2.1 Goals, Objectives, and Criteria*. A summary relating threats associated with the five listing factors to the recovery criteria and recovery actions is provided in Table 1.

2.5.1 Listing Factor A. The Present or Threatened Destruction, Modification, or Curtailment of Devils River minnow Habitat or Range

2.5.1.1 Range Reduction and Habitat Loss

Some of the habitat lost in the Devils River is considered permanent and not recoverable due to stream flow loss and reservoir inundation in the upstream and downstream portions of the river, respectively. It is uncertain whether habitat losses in Mexico are recoverable. However, it appears likely that the Las Moras Creek population of Devils River minnow could be restored if the local community decided to take the necessary actions to do so. Recovery Actions (RAs) 1.4.1, 2.1, 2.2.1, 2.2.2, 2.2.3, and 2.3 guide the necessary process for restoring this population. Initiating any action to restore the population is predicated on having the support of the local community and landowners, preferably documented by written agreements. Some assurance must be demonstrated that the appropriate water quantity, water quality, and stream channel habitat conditions are present and will be maintained at any potential reintroduction site, such as Las Moras Creek. Specific measures and actions to carry out restoring and monitoring the population should be guided by a reintroduction plan. Monitoring efforts are needed throughout the Devils River minnow range to gauge population status and the threats it faces, as well as to determine when the recovery criteria might be met (RAs 1.1.1-1.1.4, 1.3.1 1.4.5, 1.7, and others).

An effective monitoring program is a key component to implement and document success of this recovery plan and providing opportunities for adaptive management (RAs 1.1.1, 1.1.2, 1.1.3, 1.1.4, and 3.1). Ongoing evaluation of the abundance and distribution of the Devils River minnow across its range will allow for the verification of the completion of Recovery Criterion 1. To properly manage the different Devils River minnow populations, information on the intraspecific genetic relationships is needed (RAs 1.1.4 and 3.1). Monitoring threats to Devils River minnow and the status of its habitat is necessary to document the fulfillment of Recovery Criteria 2, 3, and 4.

2.5.1.2 Spring Flow Declines (Water Quantity)

This recovery plan envisions protections for maintaining appropriate water quantity (Recovery Criterion 2) in streams inhabited by the Devils River minnow to be protected by local authorities. The conservation of instream flows should be demonstrated by written management plans of local and State entities with the authority and responsibility for managing groundwater and surface water resources, such as groundwater districts, cities and counties (RAs 1.4.1, 1.4.2, and 1.4.3). Additional science on the biology and ecology of the Devils River minnow (RAs 1.2.2,

1.2.4, 1.3.1, 1.3.2, 1.3.3, 1.3.4, and 1.4.5) and on hydrology and geohydrology (RAs 1.3.6 and 1.4.4) in the geographic areas supporting the species would be useful when formulating conservation measures to provide appropriate stream flows. Watershed management plans that strive for balanced, natural vegetation communities may benefit aquatic habitats depending on the site conditions and the landscape scale under management. The relationship of spring flows and vegetation management is a developing science in Texas (for example, see Ball and Taylor 2003, Hart 2004, White 2000, and Wilcox 2002).

2.5.1.3 Water Quality Degradation

Conservation of surface water quality (Recovery Criterion 3) in Texas streams primarily is regulated by the TCEQ. However, many implementing measures that will reduce pollution (RA 1.4.7) in waters that provide habitat for Devils River minnow are accomplished at the local level of private landowners and municipalities (RA 1.4.1). Only through the commitment to conservation of water quality through land management and wastewater treatment by the local communities will the needed level of protection be accomplished (RAs 1.3.5 and 1.4.2). In addition, research is needed on the specific tolerances and effects of various contaminants or water quality conditions on both individuals of Devils River minnow and on populations of the species (RA 1.3.2 and 1.4.5).

2.5.1.4 Stream Channel Modifications

Streams occupied by Devils River minnow have undergone various levels of change over time, including the establishment of non-native riparian vegetation, the modification of stream banks for erosion and flood control, and the construction of small dams and water crossing structures. Investigations on the specific microhabitats used by Devils River minnow (RAs 1.3.1, 1.3.2, and 1.4.5) and specific life history traits (RAs 1.2.2 and 1.2.4) will determine the need for future management and restoration (RAs 1.3.5 and 1.4.6) of the physical stream environments of Devils River minnow. This issue is related to Recovery Criterion 1 because providing the necessary habitat conditions is vital to ensuring stable populations. Additional information will allow for the determination as to the importance of controlling this threat for Devils River minnow recovery. Implementation of any habitat restoration or enhancement measures will need the consent of and close coordination with private landowners and/or local authorities (RA 1.4.1).

2.5.2 Listing Factor B. Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

Overutilization is not considered a threat to the Devils River minnow at this time.

2.5.3 Listing Factor C. Disease or Predation

To reduce the threat to the Devils River minnow posed by non-native species (RA 1.5), an effective outreach campaign would educate the public about the risks of releasing plants and animals into the wild (RAs 4.1, 4.2, 4.3, and 4.4). Even though specific regulations can be imposed to make importation or release of exotic species illegal, enforcement of such measures can be difficult. Preventing the establishment of non-native species requires ongoing and intense

field monitoring of the stream and riparian biota and a quick response to the information gained (RAs 1.1.3 and 1.7). Research on the specific effects of exotic species on the Devils River minnow, particularly potential problems from competition, predation, diseases, and parasites (RAs 1.2.1, 1.2.3, and 1.2.5, respectively), also is needed to identify control needs and design priority actions (RA 1.2.6).

2.5.4 Listing Factor D. The Inadequacy of Existing Regulatory Mechanisms

Reducing the threats to the Devils River minnow and its habitat will be accomplished primarily at the local level. The "regulatory mechanisms" to ensure safeguards are in place will depend on local communities and individual landowners (RAs 1.4.1-1.4.4, 1.4.7, and 1.5). Because most Devils River minnow habitat is on private land or within the cities of Del Rio and Brackettville, individual landowners and local municipalities have the best opportunity to implement conservation measures for the species. The State, through TCEQ, has some authority to protect surface water quantity and quality. However, the surface water quantity protections provide limited benefit for the Devils River minnow. Similarly, to date, the surface water quality protections have been aimed primarily at point source discharges, which are not the principal concern for the Devils River minnow. In addition, TCEQ's implementation of surface water quality protection generally has focused on protection of overall aquatic communities without knowledge of the needs of individual rare species. State and Federal agencies can play a large role in providing the expertise and financial resources to collect and disseminate the information needed at the local level to implement the various conservation measures outlined in this recovery plan.

2.5.5 Listing Factor E. Other Natural or Manmade Factors Affecting Its Continued Existence

2.5.5.1 Small, Fragmented Populations

To provide a safeguard against the extinction of Devils River minnow and to provide important opportunities for biological research (for example, RAs 1.2.1, 1.2.2, 1.2.3, 1.2.4, 1.2.5, and 1.3.2), captive populations of the species should be established and maintained (RA 3.2). To establish appropriate captive stocks (2.1, 2.2.1-3, 2.3), based on sound science of conservation genetics, additional research on genetics is required (RA 1.1.4) and a genetics management plan needs to be developed (RA 3.1). If appropriate, captive propagation efforts could provide large numbers of individuals to assist in future reintroduction efforts (RA 2.3).

2.5.5.2 Cumulative Threats

As previously emphasized in this plan, the recovery of the Devils River minnow will likely entail a flexible process of continuing to collect additional information, while modifying the recovery actions to take advantage of new information and circumstances. Therefore, it is important that this plan, including the Recovery Objectives, Criteria, and Actions, be evaluated and revised as necessary (RAs 1.1.3 and 1.7). Where particular knowledge gaps now exist, future data collection may allow for further specific plans and strategies. For example, genetic studies (RA 1.1.4) will provide the information needed to develop a genetics management plan for Devils River minnow (RA 3.1). Also, additional research on the status of the fish and its environment

in Mexico (RAs 1.1.2 and 1.1.3) could lead to a conservation strategy for Mexican populations (RA 1.6).

Implementation of most of the recovery actions needed to reduce the threats to the species will need the support of the local community (RA 1.4.1). Therefore, informing the local public about the issues and conservation needs is important to the success of this plan (RAs 4.1, 4.2, 4.3, and 4.4).

Table 1. Summary of Devils River minnow listing factors and threats, and the recovery actions intended to control those threats.

Listing Factor	Threats	Recovery Criteria	Recovery Actions
ALL (except Factor B)	ALL	ALL	1.1.3 Monitoring threats 1.4.1 Maintain landowner cooperation 1.6 Recovery strategy for Mexico 1.7 Assess recovery progress 4.1 – 4.4 Outreach 5.1 Post-delisting monitoring plan
Factor A	Population and Habitat Loss	(1)	1.1.1, 1.1.2 Monitoring populations 1.3.1 Study physical habitat 1.4.3 Groundwater management plans 2.1, 2.2.1-3, 2.3 Reestablish populations
	Spring Flow Declines (Water Quantity)	(2)	1.2.2 Study reproduction 1.2.4 Study early life history 1.3.1 Study physical habitat 1.3.3 Study stream flow and habitat 1.3.4 Determine stream flow needs 1.3.6 Investigate regional hydrogeology 1.4.2 Protect streams 1.4.3 Groundwater management plans 1.4.5 Monitor habitats
	Water Quality Degradation	(3)	1.3.2 Determine chemical preferences 1.4.2 Protect streams 1.4.5 Monitor habitats 1.4.7 Reduce pollutants
	Stream Channel Modifications	(1)	1.2.2 Study reproduction 1.2.4 Study early life history 1.3.1, 1.3.2 Study habitat 1.3.5 Study riparian management 1.4.5 Monitor habitats 1.4.6 Restore habitats
Factor B	None	None	None
Factor C	Non-native species	(4)	1.2.1 Study competitors 1.2.3 Study predators 1.2.5 Study disease and parasites 1.2.6 Study effects of exotics 1.5 Prevent introduction of exotics
Factor D	No Habitat Protection by State	(2), (3)	1.4.3 Groundwater management plans 1.4.4 Monitor stream flows
	Rule of Capture	(2)	
	Inadequate Water Quality Protection	(3)	1.4.2 Protect streams 1.4.5 Monitor habitats 1.4.7 Reduce pollutants
Factor E	Small, Fragmented Populations	(1)	1.1.4 Study genetics 3.1 Genetics management plan 2.1, 2.2.1-3, 2.3 Reestablish populations 3.2 Captive populations
	Cumulative Threats	ALL	ALL

3.0 IMPLEMENTATION SCHEDULE

The following implementation schedule outlines priorities, potential or responsible parties, and estimated costs for the specific actions for recovering the Devils River minnow. It is a guide to meeting the goals, objectives, and criteria from *Section 2 RECOVERY* of this recovery plan. The schedule: (a) lists the specific recovery actions, corresponding outline numbers, the action priorities, and the expected duration of actions ("Continuous" denotes an action that once begun should continue on a regular basis); (b) recommends agencies, groups, or individuals for carrying out these actions; and (c) estimates the financial costs for implementing the actions. These actions, when complete, should accomplish the goal of this plan -- recovery of the Devils River minnow.

3.1 Responsible Parties and Cost Estimates

The value of this plan depends on the extent to which it is implemented; the Service has neither the authority nor the resources to implement many of the proposed recovery actions. The recovery of the Devils River minnow is dependent upon the voluntary cooperation of many other organizations and individuals who are willing to implement the recovery actions. The implementation schedule identifies agencies and other potential "responsible parties" (private and public) to help implement the recovery of this species. This plan does not commit any "responsible party" to carry out a particular recovery action or to expend the estimated funds. It is only recognition that particular groups may possess the expertise, resources, and opportunity to assist in the implementation of recovery actions. Although collaboration with private landowners and others is called for in the recovery plan, no one is obligated by this plan to any recovery action or expenditure of funds. Likewise, this schedule is not intended to preclude or limit others from participating in this recovery program.

The cost estimates provided are not intended to be a specific budget but are provided solely to assist in planning. Costs designated "ND" (not determined) were not estimated at this time due to the uncertainty associated with the actions proposed. Costs with "- -" indicates no costs are expected. The total estimated cost of recovery, by priority, is provided in the Executive Summary. The schedule provides cost estimates for each action on a biannual basis. Estimated funds for agencies include only project-specific contract, staff, or operations costs in excess of base budgets. They do not include ordinary operating costs (such as staff) for existing responsibilities.

3.2 Recovery Action Priorities and Abbreviations

Priorities in column 1 of the following implementation schedule are assigned using the following guidelines:

Priority 1a = An action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.

Priority 1b = An action that by itself will not prevent extinction, but which is needed to carry out a Priority 1 action.

Priority 2 = An action that must be taken to prevent a substantial decline in species population/habitat quality or some other substantial negative effect short of extinction.

Priority 3 = All other actions necessary to meet the recovery objectives.

The assignment of these priorities does not imply that some recovery actions are of low importance, but instead implies that lower priority items may be deferred while higher priority items are being implemented.

The following abbreviations are used in the Implementation Schedule:

AGEX	Texas A&M Agricultural Extension Service
ALL	All interested parties share responsibility
BRD	Biological Resources Division, U.S. Geological Survey
EPA	U.S. Environmental Protection Agency
FWS	U.S. Fish and Wildlife Service
IBWC	International Boundary and Water Commission, U.S. Section
LOCAL	local entities, including private landowners and local government
MEX	Mexican governmental agencies
NGO	Nongovernmental organizations
NRCS	Natural Resource Conservation Service, U.S. Dept. of Agriculture
TDA	Texas Department of Agriculture
TNC	The Nature Conservancy of Texas
TCEQ	Texas Commission on Environmental Quality
TPWD	Texas Parks and Wildlife Department
TWDB	Texas Water Development Board
UNIV	Academic institutions (colleges and universities)
USGS	U.S. Geological Survey, Water Resources Division

3.3 Implementation Schedule.

Table is sorted by priority, then recovery action number. *Section 2.4 Recovery Action Narrative* has recovery action descriptions.

PRIORITY	RECOVERY ACTION #	RECOVERY ACTION DESCRIPTION	ACTION DURATION (YEARS)[a]	RESPONSIBLE PARTIES	Cost Estimates ($000)					CRITERIA[b]-CONTROL OF THREATS[c]
					YEARS 1-2	YEARS 3-4	YEARS 5-6	YEARS 7-8	YEARS 9-10	
1a	1.4.1	Seek and maintain the cooperation of landowners and government agencies.	Cont.	ALL	--[d]	--	--	--	--	ALL
1a	1.4.2	Ensure protection for certain stream segments and their watersheds.	Cont.	LOCAL, TCEQ, TNC, TPWD	50	50	50	50	50	(2), (3) – A, D
1a	1.4.3	Develop and implement groundwater management plans for stream flow protection.	5-10	LOCAL, TWDB	50	50	50	50	50	(2) - A, D
1a	1.4.7	Reduce pollutants.	Cont.	EPA, LOCAL, TDA, TCEQ	ND[4]	ND	ND	ND	ND	(3) - A
1a	1.5	Establish and implement procedures to prevent introduction of exotic species and control problem exotic species.	Cont.	LOCAL, TPWD	ND	ND	ND	ND	ND	(4) - C
1a	2.3	Develop and implement a reintroduction plan.	6	LOCAL, FWS, TPWD, UNIV, NGO	--	100	50	50		(1) - A
1a	3.2	Maintain captive populations in at least two appropriate facilities.	Cont.	FWS, TPWD, NGO	75	50	50	50	50	(1) – A, E
1b	1.1.1	Monitor distribution and abundance in Texas.	Cont.	BRD, FWS, TPWD, UNIV	30	30	30	30	30	(1) - E
1b	1.1.2	Assess distribution and abundance in Mexico.	2	BRD, IBWC, FWS, MEX, TPWD, UNIV	40	--	--	--	--	(1) - A

[a] "Cont." denotes recovery actions that require continuous activities.
[b] CRITERIA cross-references recovery actions to recovery criteria, as numbered and described on Page 2.1-2.
[c] CONTROL OF THREATS cross-references recovery actions to the five listing factors (A-E), as discussed on Page 2.5-1.
[d] -- indicates no costs are anticipated, ND indicates costs are not determinable.

PRIORITY	RECOVERY ACTION #	RECOVERY ACTION DESCRIPTION	ACTION DURATION (YEARS)[a]	RESPONSIBLE PARTIES	Cost Estimates ($000)					CRITERIA[b]-CONTROL OF THREATS[c]
					YEARS 1-2	YEARS 3-4	YEARS 5-6	YEARS 7-8	YEARS 9-10	
1b	1.1.3	Assess and monitor threats to Texas and Mexico populations.	Cont.	BRD, FWS, MEX, TPWD, UNIV	40	40	20	20	20	ALL
1b	1.2.2	Study reproductive variables.	2	BRD, FWS, TPWD, UNIV	--	30	--	--	--	(1) - A
1b	1.2.6	Study effects of aquatic non-native species.	2	BRD, FWS, TPWD, UNIV	--	40				(4) - C
1b	1.3.3	Determine relationships of stream flow and habitat availability.	4	BRD, EPA, FWS, TPWD, UNIV	50	50	--	--	--	(2) - A
1b	1.3.4	Determine stream flows needed for habitat maintenance.	4	BRD, FWS, TPWD, UNIV	50	50	--	--	--	(2) - A
1b	1.3.6	Investigate regional hydrogeology.	6	TWDB, UNIV, USGS, TNC	100	50	50			(2) - A
1b	1.4.4	Monitor stream flows.	Cont.	IBWC, TWDB, TCEQ, USGS	50	50	20	20	20	(2) - A
1b	1.4.5	Monitor existing physical and chemical habitats.	Cont.	BRD, FWS, MEX, TPWD, UNIV	25	25	25	25	25	(2), (3) - A
1b	1.6	Develop a recovery strategy for Mexican populations.	4	IBWC, MEX, FWS	--	--	50	50	--	ALL
1b	1.7	Assess effectiveness of recovery management actions.	Cont.	FWS, MEX, TPWD, UNIV	25	25	25	25	25	ALL
1b	2.1	Develop landowner agreements to reintroduce in former site(s) of occurrence.	4	LOCAL, FWS, TPWD	--	10	10	--	--	ALL
1b	2.2.1	Assess future spring flows at reintroduction site(s).	1	TWDB, UNIV, USGS	10	ND	ND	ND	ND	(1), (2) - A
1b	2.2.2	Ensure adequate water quality protection at reintroduction site(s).	Cont.	EPA, LOCAL, TCEQ	ND	ND	ND	ND	ND	(3) - A
1b	2.2.3	Develop and implement stream channel restoration projects at reintroduction site(s), if necessary.	5-8	LOCAL, FWS, TPWD	ND	ND	ND	ND	ND	(1) - A

PRIORITY	RECOVERY ACTION #	RECOVERY ACTION DESCRIPTION	ACTION DURATION (YEARS)[a]	RESPONSIBLE PARTIES	Cost Estimates ($000)					CRITERIA[b]-CONTROL OF THREATS[c]
					YEARS 1-2	YEARS 3-4	YEARS 5-6	YEARS 7-8	YEARS 9-10	
1b	3.1	Develop and implement a genetics management plan.	4	FWS, TPWD, UNIV	50	50				(1) - E
2	1.1.4	Evaluate geographic variation in the species' genetic structure.	2	BRD, FWS, TPWD, UNIV	75					(1) - A
2	1.2.1	Study competition with coexisting species.	2	BRD, FWS, TPWD, UNIV	--	--	40	--	--	(4) - C
2	1.2.3	Investigate predation by other species.	2	BRD, FWS, TPWD, UNIV	--	50	--	--	--	(4) - C
2	1.2.4	Determine early life history characteristics and survivorship.	2	BRD, FWS, TPWD, UNIV	--	30	--	--	--	(1) - A
2	1.3.1	Determine physical habitat preferences.	4	BRD, FWS, TPWD, UNIV	--	60	60	--	--	(1), (2) - A
2	1.3.2	Determine chemical habitat preferences and tolerances (water quality).	2	BRD, EPA, FWS, TCEQ, TPWD, UNIV	30	--	--	--	--	(1), (3) - A
2	1.4.6	Restore and enhance habitat conditions.	6	FWS, LOCAL, MEX, NRCS, TDA, TNC, TPWD	ND	ND	ND	ND	ND	(1), (2), (3) - A
3	1.2.5	Investigate disease and parasites.	2	BRD, FWS, TPWD, UNIV	--	--	--	50	--	(4) - C
3	1.3.5	Study effects of riparian management strategies.	2	AGEX, FWS, LOCAL, NRCS, TDA, TPWD	--	25	--	--	--	(1) - A
3	4.1	Develop an outreach strategy.	1	FWS, TPWD	10	--	--	--	--	ALL - A, C, E
3	4.2	Prepare and distribute information pamphlet.	2	FWS, TPWD	--	20	--	--	--	ALL - A, C, E
3	4.3	Produce and maintain an outreach website.	1	NGO, TPWD,	--	10	--	--	--	ALL - A, C, E
3	4.4	Construct an informational kiosk for the City of Del Rio on San Felipe Creek.	1	LOCAL, FWS, TPWD	--	15	--	--	--	ALL - A, C, E
3	5.1	Develop a post-delisting monitoring plan for the Devils River minnow	1	FWS, TPWD, LOCAL	--	--	--	--	30	ALL

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Appendix A

Collections of Devils River minnow

Appendix A. Table of collections of Devils River minnow.

Devils River Minnow Collections

Stream Segment[1]	Country, St., Co.	Date	*D. diaboli* N (collected)[2]	Location of collection	Collection No.[3]	Holding[4]
Devils River (upper)	US, TX, Val Verde	9-Sep-1953	36	2 miles south of Pecan Springs	UMMZ 168973	University of Michigan Museum
Devils River (upper)	US, TX, Val Verde	7-Oct-1953	10	Pecan Springs (30°03'N 101°11'W)	USNM 00164251	National Museum of Natural History, Smithsonian Institution
Devils River (upper)	US, TX, Val Verde	17-Nov-1953	0	1.5 miles south of Pecan Springs		
Devils River (upper)	US, TX, Val Verde	7-Mar-1970	215	31 miles north of Comstock; Hwy 163; at #3 bridge north of Juno	BU 123	Strecker Museum, Baylor University
Devils River (upper)	US, TX, Val Verde	15-Sep-1973	14	2 miles north of Juno, right side of road	BU 1448	Strecker Museum, Baylor University
Devils River (upper)	US, TX, Val Verde	15-Sep-1973	6	20 miles north of Comstock, Hwy 163; left side of road about 2 miles on Hudspeth Ranch	BU 1442	Strecker Museum, Baylor University
Devils River (upper)	US, TX, Val Verde	10-Nov-1973	17	20 miles north of Comstock, Hwy 163; 0.5 miles north of Baker's Crossing	BU 1756	Strecker Museum, Baylor University
Devils River (upper)	US, TX, Val Verde	16-Mar-1974	13	2 miles north of Juno, Beaver Lake	BU 1786	Strecker Museum, Baylor University
Devils River (upper)	US, TX, Val Verde	17-Mar-1974	3	28 miles north of Comstock; Hudspeth Spring, Hudspeth River Ranch	BU 1817	Strecker Museum, Baylor University
Devils River (upper)	US, TX, Val Verde	17-Mar-1974	11	25 miles north of Comstock, Hwy 163; 0.25 north of Baker's Crossing	BU 1804	Strecker Museum, Baylor University
Devils River (upper)	US, TX, Val Verde	13-Jul-1981	47	5.8 miles south of Juno, turn right just before highway water crossing	TCWC 7416.02	Texas A&M Univerisity
Devils River (upper)	US, TX, Val Verde	4-Nov-1997	0	Hudspeth River Ranch; 4 sites, Pecan Springs to Hudspeth Spring		
Devils River (upper)	US, TX, Val Verde	25-Nov-1997	0	400 meters upstream from Baker's Crossing		
Devils River (upper)	US, TX, Val Verde	31-Jul-2001	0	Hudspeth River Ranch; 2 sites		
Devils River (upper)	US, TX, Val Verde	30-Jul-2002	93	Hudspeth River Ranch to Baker's Crossing	TBD[5]	Texas Natural History Collections, University of Texas at Austin
Devils River (Baker's Crossing)	US, TX, Val Verde	29-Jul-1953	58	Baker's Crossing (State Highway 163 bridge)	TNHC 4214	Texas Natural History Collections, University of Texas at Austin
Devils River (Baker's Crossing)	US, TX, Val Verde	18-May-1954	4	Baker's Crossing (29°57'N 101°09'W)	UMMZ 168971 & UMMZ168972	University of Michigan Museum of Zoology
Devils River (Baker's Crossing)	US, TX, Val Verde	27-Mar-1968	16	20 miles north of Comstock, Hwy 163	BU 44	Strecker Museum, Baylor University
Devils River (Baker's Crossing)	US, TX, Val Verde	15-Sep-1973	6	20 miles north of Comstock, Hwy 163, upstream of Bakers Crossing	BU 1436	Strecker Museum, Baylor University
Devils River (Baker's Crossing)	US, TX, Val Verde	15-Sep-1973	7	20 miles north of Comstock, Hwy 163, downstream of Bakers Crossing	BU 1425	Strecker Museum, Baylor University
Devils River (Baker's Crossing)	US, TX, Val Verde	10-Nov-1973	2	25 miles north of Comstock, Hwy 163; at Baker's Crossing	BU 1829	Strecker Museum, Baylor University
Devils River (Baker's Crossing)	US, TX, Val Verde	15-Mar-1975	1	Fort Hudson Crossing	TCWC 298.04	Texas A&M Univerisity

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Devils River (Baker's Crossing)	US, TX, Val Verde	25-Mar-1988	8	Baker's Crossing (State Highway 163 bridge)	UAIC 8354.04	University of Alabama Museum
Devils River (Baker's Crossing)	US, TX, Val Verde	10-Jul-1989	1	Baker's Crossing (State Highway 163 bridge)		
Devils River (Baker's Crossing)	US, TX, Val Verde	25-Nov-1997	0	Baker's Crossing (State Highway 163 bridge)		
Devils River (Baker's Crossing)	US, TX, Val Verde	28-May-1998	0	Baker's Crossing (State Highway 163 bridge)		
Devils River (Baker's Crossing)	US, TX, Val Verde	1-Aug-2001	54	Baker's Crossing (State Highway 163 bridge)	TBD[5]	Texas Natural History Collections, University of Texas at Austin
Devils River (middle)	US, TX, Val Verde	29-May-1953	1	0.25 miles north of Dolan Falls	TNHC 3421	Texas Natural History Collections, University of Texas at Austin
Devils River (middle)	US, TX, Val Verde	9-Jul-1966	0	at Dolan Falls		
Devils River (middle)	US, TX, Val Verde	16-Mar-1974	3	22 miles north of Comstock, Rocker U Ranch	BU 1809	Strecker Museum, Baylor University
Devils River (middle)	US, TX, Val Verde	22-Jul-1974	4	Dolan Creek Ranch	TNHC 21793	Texas Natural History Collections, University of Texas at Austin
Devils River (middle)	US, TX, Val Verde	3-Nov-1988	17	at spring (DR#3)	TNHC 16046	Texas Natural History Collections, University of Texas at Austin
Devils River (middle)	US, TX, Val Verde	3-Nov-1988	14	just below spring (DR#2)	TNHC 16028	Texas Natural History Collections, University of Texas at Austin
Devils River (middle)	US, TX, Val Verde	8-Apr-1989	0	near Blue Hole		
Devils River (middle)	US, TX, Val Verde	4-Nov-1997	0	Rocker U Ranch crossing; approx 3 RM downstream of Baker's Crossing		
Devils River (middle)	US, TX, Val Verde	25-Nov-1997	0	Finegan Springs		
Devils River (middle)	US, TX, Val Verde	27-May-1998	1	Finegan Springs	TBD[5]	Texas Natural History Collections, University of Texas at Austin
Devils River (middle)	US, TX, Val Verde	11-Jul-2000	86	Baker's Crossing to Jarrett Ranch (7 RM downstream); 51 collection sites	TNHC 29392	Texas Natural History Collections, University of Texas at Austin
Devils River (middle)	US, TX, Val Verde	12-Jul-2000	147	Jarrett Ranch to Dolan Falls (approx. 8 RM); 54 collection sites	TNHC 29393	Texas Natural History Collections, University of Texas at Austin
Devils River (middle)	US, TX, Val Verde	9-Aug-2000	0	Rocker U Ranch crossing; approx 3 RM downstream of Baker's Crossing		
Devils River (middle)	US, TX, Val Verde	31-Jul-2001	66	Jarrett Ranch to Dolan Falls (approx. 8 RM); 20 collection sites	TNHC 29355	Texas Natural History Collections, University of Texas at Austin
Devils River (middle)	US, TX, Val Verde	30-Jul-2002	562	Baker's Crossing to Jarrett Ranch (7 RM downstream); 21 collection sites	TBD[5]	Texas Natural History Collections, University of Texas at Austin
Devils River (middle)	US, TX, Val Verde	31-Jul-2002	165	Jarrett Ranch to Dolan Falls (approx. 8 RM); 29 collection sites	TBD[5]	
Devils River (lower)	US, TX, Val Verde	22-Jul-1953	1	Devils Lake, head of lake, spring on west side	TNHC 5657	Texas Natural History Collections, University of Texas at Austin

Appendix A. Table of collections of Devils River minnow.

Devils River Minnow Collections

Stream Segment[1]	Country, St., Co.	Date	*D. diaboli* N (collected)[2]	Location of collection	Collection No.[3]	Holding[4]
Devils River (lower)	US, TX, Val Verde	29-Jul-1953	0	Devil's River at Hwy 90 bridge		
Devils River (lower)	US, TX, Val Verde	9-Sep-1953	0	Devil's River 1 mile above mouth of river		
Devils River (lower)	US, TX, Val Verde	27-Mar-1954	2	Devils Lake, head of lake, spring on west side	CNHM 61606	Chicago Natural History Museum
Devils River (lower)	US, TX, Val Verde	6-Oct-1954	0	Devil's River, 300 yards above confluence with Rio Grande		
Devils River (lower)	US, TX, Val Verde	17-Feb-1955	1	springs in Devil's Lake (29°36'N 100°57'W)	TNHC 4234	Texas Natural History Collections, University of Texas at Austin
Devils River (lower)	US, TX, Val Verde	6-Nov-1970	45	12 miles north of mouth with Rio Grande	BU 761	Strecker Museum, Baylor University
Devils River (lower)	US, TX, Val Verde	13-Mar-1979	0	Oak Tree Campsite to Pafford's Crossing to Little Satan Creek		
Devils River (lower)	US, TX, Val Verde	8-May-1979	0	downstream from weir dam		
Devils River (lower)	US, TX, Val Verde	13-Jul-2000	0	Dolan Falls to Blue Sage (approx. 8 RM); 27 collection sites		
Devils River (lower)	US, TX, Val Verde	1-Aug-2002	6	Dolan Falls to Blue Sage (approx. 8 RM); 24 collection sites	TBD[5]	Texas Natural History Collections, University of Texas at Austin
Devils River (lower)	US, TX, Val Verde	1-Aug-2002	0	Pafford's Crossing	TBD[5]	Texas Natural History Collections, University of Texas at Austin
Devils River (location unknown)	US, TX, Val Verde	26-Mar-1954	2	at H. Meadows	FMNH 61606	Field Museum of Natural History (Chicago)
Devils River (location unknown)	US, TX, Val Verde	26-Nov-1964	1	Devils River	TCWC 1087.01	Texas A&M Univeristy
Phillips Creek	US, TX, Val Verde	22-Apr-1998	4	headspring to ranch road crossing	TBD[5]	Texas Natural History Collections, University of Texas at Austin
Phillips Creek	US, TX, Val Verde	28-May-1998	142	entire creek	TBD[5]	Texas Natural History Collections, University of Texas at Austin
Phillips Creek	US, TX, Val Verde	9-Aug-2000	41	entire creek	TBD[5]	Texas Natural History Collections, University of Texas at Austin
Phillips Creek	US, TX, Val Verde	31-Jul-2001	0	ranch road crossing		
Phillips Creek	US, TX, Val Verde	30-Jul-2002	2	headspring to ranch road crossing	TBD[5]	Texas Natural History Collections, University of Texas at Austin
Dolan Creek	US, TX, Val Verde	8-May-1979	0			
Dolan Creek	US, TX, Val Verde	14-Mar-1980	0	Dolan Springs and creek		
Dolan Creek	US, TX, Val Verde	8-Apr-1989	1	Dolan Springs and creek		

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Devils River Minnow Collections

Stream Segment[1]	Country, St., Co.	Date	*D. diaboli* N (collected)[2]	Location of collection	Collection No.[3]	Holding[4]
Dolan Creek	US, TX, Val Verde	27-May-1998	3	side springs and pool	TBD[5]	Texas Natural History Collections, University of Texas at Austin
Dolan Creek	US, TX, Val Verde	6-Apr-2000	26	at main pool	TBD[5]	Texas Natural History Collections, University of Texas at Austin
Dolan Creek	US, TX, Val Verde	24-May-2000	11	at main pool	TBD[5]	Texas Natural History Collections, University of Texas at Austin
Dolan Creek	US, TX, Val Verde	31-Jul-2001	14	at main pool	TBD[5]	Texas Natural History Collections, University of Texas at Austin
Dolan Creek	US, TX, Val Verde	31-Jul-2002	1	at main pool	TBD[5]	Texas Natural History Collections, University of Texas at Austin
San Felipe Creek (upper)	US, TX, Val Verde	14-Mar-1979	1	Lowe Ranch	TNHC 9382	Texas Natural History Collections, University of Texas at Austin
San Felipe Creek (upper)	US, TX, Val Verde	14-Mar-1979	21	tributary, east side, Lowe Ranch	TNCH 9472	Texas Natural History Collections, University of Texas at Austin
San Felipe Creek (upper)	US, TX, Val Verde	14-Mar-1979	8	tributary, Hinds Ranch (joins slightly below new headspring	TNHC 9336	Texas Natural History Collections, University of Texas at Austin
San Felipe Creek (upper)	US, TX, Val Verde	14-Mar-1979	22	new headsprings, Hinds Ranch	TNHC 9420	Texas Natural History Collections, University of Texas at Austin
San Felipe Creek (upper)	US, TX, Val Verde	14-Mar-1979	16	far upstream of Lowe Ranch	TNHC 9370	Texas Natural History Collections, University of Texas at Austin
San Felipe Creek (upper)	US, TX, Val Verde	11-Jul-1989	0	Hinds Ranch		
San Felipe Creek (Del Rio)	US, TX, Val Verde	22-Jun-1955	5	Del Rio	TU 10413	Tulane University Museum
San Felipe Creek (Del Rio)	US, TX, Val Verde	10-Jul-1965	131	eastern edge of Del Rio, Hwy 90	TU 38795	Tulane University Museum
San Felipe Creek (Del Rio)	US, TX, Val Verde	15-May-1966	6	Del Rio, at hwy 90 crossing	TU 41237	Tulane University Museum
San Felipe Creek (Del Rio)	US, TX, Val Verde	13-Aug-1968	3	eastern edge of Del Rio, Hwy 90	TU 54423	Tulane University Museum
San Felipe Creek (Del Rio)	US, TX, Val Verde	23-Aug-1974	2	Del Rio	TU 90661	Tulane University Museum
San Felipe Creek (Del Rio)	US, TX, Val Verde	24-Nov-1977	6	1-2 km north of San Felipe Springs	TNHC 8827	Texas Natural History Collections, University of Texas at Austin
San Felipe Creek (Del Rio)	US, TX, Val Verde	14-Mar-1979	0	spring run at golf course		
San Felipe Creek (Del Rio)	US, TX, Val Verde	14-Mar-1979	3	Golf Course, not spring run	TNHC 9459	Texas Natural History Collections, University of Texas at Austin
San Felipe Creek (Del Rio)	US, TX, Val Verde	11-Jul-1989	3	at Hwy 277, downstream to Canal Street		
San Felipe Creek (Del Rio)	US, TX, Val Verde	11-Jul-1989	0	4.5 km upstream of mouth, downstream of sewage treatment plant		
San Felipe Creek (Del Rio)	US, TX, Val Verde	3-Nov-1997	54	at Hwy 277, downstream	TNHC 25184	Texas Natural History Collections, University of Texas at Austin

Appendix A. Table of collections of Devils River minnow.

Devils River Minnow Collections

Stream Segment[1]	Country, St., Co.	Date	*D. diaboli* N (collected)[2]	Location of collection	Collection No.[3]	Holding[4]
San Felipe Creek (Del Rio)	US, TX, Val Verde	3-Nov-1997	1	at Canal St.	TNHC 25191	Texas Natural History Collections, University of Texas at Austin
San Felipe Creek (Del Rio)	US, TX, Val Verde	3-Nov-1997	57	Spring outflow to Hwy 90	TNHC 25203	Texas Natural History Collections, University of Texas at Austin
San Felipe Creek (Del Rio)	US, TX, Val Verde	8-Apr-1999	0	at Hwy 90, downstream		
San Felipe Creek (Del Rio)	US, TX, Val Verde	11-Jul-1999	16	at Hwy 90, downstream	TBD[5]	Texas Natural History Collections, University of Texas at Austin
San Felipe Creek (Del Rio)	US, TX, Val Verde	22-Sep-1999	16	Hwy 90 to Canal Street; 4 collection sites	TBD[5]	Texas Natural History Collections, University of Texas at Austin
San Felipe Creek (Del Rio)	US, TX, Val Verde	25-Feb-2000	23	Hwy 90 to Canal Street; 4 collection sites	TBD[5]	Texas Natural History Collections, University of Texas at Austin
San Felipe Creek (Del Rio)	US, TX, Val Verde	28-Apr-01	18	east and west channels to 200 m below confluence	TBD[5]	Texas Natural History Collections, University of Texas at Austin
San Felipe Creek (Del Rio)	US, TX, Val Verde	3-Aug-2001	30	east and west channels to 200 m below confluence	TBD[5]	Texas Natural History Collections, University of Texas at Austin
San Felipe Creek (Del Rio)	US, TX, Val Verde	30-Oct-2001	0	at Hwy 277, downstream		
San Felipe Creek (Del Rio)	US, TX, Val Verde	3-Nov-2001	45	east and west channels to 200 m below confluence	TBD[5]	Texas Natural History Collections, University of Texas at Austin
San Felipe Creek (Del Rio)	US, TX, Val Verde	23-Mar-2002	24	east and west channels to 200 m below confluence	TBD[5]	Texas Natural History Collections, University of Texas at Austin
Cienegas Creek	US, TX, Val Verde	12-Mar-1979	0	at headwaters, Cantu Spring		
Cienegas Creek	US, TX, Val Verde	11-Jul-1989	0	upstream and downstream of sewage treatment plant		
Salt Creek	US, TX, Val Verde	12-Mar-1979	0	from Sulphur Springs to railroad crossing (approx. 2 km)		
Sacatosa Creek	US, TX, Val Verde	14-Mar-1979	0	at headsprings		
Sacatosa Creek	US, TX, Val Verde	13-Jul-1989	0	at impounded headspring		
Sycamore Creek	US, TX, Val Verde	10-May-1979	0	at Hwy 277 crossing		
Sycamore Creek	US, TX, Val Verde	12-Jul-1989	0	throughout the tributary, Mud Creek		
Sycamore Creek	US, TX, Val Verde	28-Oct-1989	0	throughout the tributary, Mud Creek		
Sycamore Creek	US, TX, Val Verde	12-Jul-1989	2	at Hwy 277 crossing		
Sycamore Creek	US, TX, Val Verde	10-Jul-1999	0	at Hwy 277 crossing		

Appendix A. Table of collections of Devils River minnow.

Devils River Minnow Collections

Stream Segment[1]	Country, St., Co.	Date	*D. diaboli* N (collected)[2]	Location of collection	Collection No.[3]	Holding[4]
Sycamore Creek	US, TX, Val Verde	6-Jun-2002	0	at Hwy 277 and Hwy 90 crossings		
Pinto Creek	US, TX, Kinney	12-Jul-1989	0	from Hwy 277 crossing upstream to FM 2804		
Pinto Creek	US, TX, Kinney	17-Dec-2001	80	headwaters on Shahan Ranch	TBD[5]	Texas Natural History Collections, University of Texas at Austin
Pinto Creek	US, TX, Kinney	5-Jun-2003	457	headwaters on Shahan Ranch to Hwy. 90. 24 collection sites	TNHC 29354	Texas Natural History Collections, University of Texas at Austin
Las Moras Creek	US, TX, Kinney	14-Apr-1951	39	Brackettville (Fort Clark Springs)	TNHC 1852	Texas Natural History Collections, University of Texas at Austin
Las Moras Creek	US, TX, Kinney	1-May-1955	1	Brackettville (Fort Clark Springs)		
Las Moras Creek	US, TX, Kinney	11-Mar-1979	0	Brackettville (Fort Clark Springs)		
Las Moras Creek	US, TX, Kinney	10-May-1979	0	road crossing off FM 1908		
Las Moras Creek	US, TX, Kinney	13-Jul-1989	0	Fort Clark Springs to approx. 7 RM downstream, near FM 1572		
Las Moras Creek	US, TX, Kinney	17-Dec-2001	0	Fort Clark Springs to approx. 2 RM downstream		
Rio San Carlos	Mexico, Coahuila	7-Aug-1968	1	27 km S of Acuna	UANL 1023	Universidad Autonoma de Nuevo Leon
Rio San Carlos	Mexico, Coahuila	31-Mar-1974	4	27 km south of Ciudad Acuna, just below highway bridge (28-40 N; 100-35 W)	UMMZ 196744	Univeristy of Michigan Museum
Rio Alamo	Mexico, Coahuila	28-Aug-1964	23	4.4 km west of Nueva Rosita, San Juan de Sabinas	UANL	Universidad Autonoma de Nuevo Leon
Rio Alamo	Mexico, Coahuila	13-Oct-1966	9	4.4 km west of Nueva Rosita	TU 95979	Tulane University Museum
Rio Alamo	Mexico, Coahuila	1985	16	Nueva Rosita, 4 km Carr. Muzquiz (27-56-53N, 101-15-23W)		
Rio Alamo	Mexico, Coahuila	2001	1	Nueva Rosita, 4 km Carr. Muzquiz (27-56-53N, 101-15-23W)		
Rio Sabinas	Mexico, Coahuila	3-Apr-1961	23	abut 2 miles west of Rosita	TU 43870	Tulane University Museum
Rio Sabinas	Mexico, Coahuila	28-Aug-1964	4	11.7 km WSW Nueva Rosita (27-52 N; 101-22 W)	UANL 753	Universidad Autonoma de Nuevo Leon
Rio Sabinas (=Rio San Juan)	Mexico, Coahuila	1978	0	Muzquiz, Carr. Boquillas (27-58-09N, 101-24-51W)		
Rio Sabinas (=Rio San Juan)	Mexico, Coahuila	21-Jul-1985	3	at bridge, 14km Carr. Muzquiz - Boquillas del Carmen, Muzquiz (27-58-09N, 101-24-51W)	UANL 9174	Universidad Autonoma de Nuevo Leon
Rio Sabinas (=Rio San Juan)	Mexico, Coahuila	8-Aug-1994	13	8 km NW of Muzquiz and 200m upstream from bridge (27-58-09N, 101-24-51W)	UANL 11598	Universidad Autonoma de Nuevo Leon

Appendix A. Table of collections of Devils River minnow.

Devils River Minnow Collections

Stream Segment[1]	Country, St., Co.	Date	*D. diaboli* N (collected)[2]	Location of collection	Collection No.[3]	Holding[4]
Rio Sabinas (=Rio San Juan)	Mexico, Coahuila	8-Aug-1994	18	8 km NW of Muzquiz and 3km downstream from bridge (27-58-09N, 101-24-51W)	UANL 11588	Universidad Autonoma de Nuevo Leon
Rio Sabinas (=Rio San Juan)	Mexico, Coahuila	2001	0	8 km NW of Muzquiz and 3km downstream from bridge (27-58-09N, 101-24-51W)		
Rio San Juan	Mexico, Coahuila	1-Jan-1985	16	at bridge, 14km Carr. Muzquiz - Boquillas del Carmen, Muzquiz	UANL 9134	Universidad Autonoma de Nuevo Leon
Rio San Juan	Mexico, Coahuila	1984	0	Nacimento Kikapoo (28-02-28N, 101-47-31W)		
Rio San Juan	Mexico, Coahuila	1985	0	Nacimento Kikapoo (28-02-28N, 101-47-31W)		
Rio San Juan	Mexico, Coahuila	2001	0	Nacimento Kikapoo (28-02-28N, 101-47-31W)		
Rio San Juan (=Sabinas)	Mexico, Coahuila	1985	0	Parque Los Ojitos		
Rio San Juan (=Sabinas)	Mexico, Coahuila	2001	0	Parque Los Ojitos		
Rio Sabinas	Mexico, Coahuila	1964	0	Sabinas (27-50-38N, 101-07-20W)		
Rio Sabinas	Mexico, Coahuila	1985	0	Sabinas (27-50-38N, 101-07-20W)		
Rio Sabinas	Mexico, Coahuila	2001	0	Sabinas (27-50-38N, 101-07-20W)		

FOOTNOTES:

1 - Devils River (upper) = Devils River upstream of Baker's Crossing (Highway 163 Bridge)
Devils River (Baker's Crossing) = Devils River at or near Highway 163 Bridge
Devils River (middle) = Devils River downstream of Baker's Crossing, upstream of Dolan Falls
Devils River (lower) = Devils River downstream of Dolan Falls

2 - Total number of Devils River minnow collected as documented in a report or in museum collection

3 - Collection No. is the museum reference number for this collection

4 - Holding is the museum or facility where collection is being curated; NA indicates no museum specimens known

5 - Collection numbers are yet To Be Determined

Appendix B

Devils River Minnow Conservation Agreement, September 1998

CONSERVATION AGREEMENT
DEVILS RIVER MINNOW
Dionda diaboli

I. INTRODUCTION

This voluntary Conservation Agreement (Agreement) for the Devils River minnow (*Dionda diaboli*) has been developed in order to expedite conservation measures needed to ensure the continued existence and facilitate recovery of the species. These measures are taken in accordance with the Endangered Species Act of 1973, as amended (ESA). The objective of the Agreement is to reduce the potential threats to the species and to stabilize and improve the species populations and the ecosystems upon which they depend. The specific conservation actions to be undertaken to make progress toward this objective are outlined in detail in the Conservation Strategy for Devils River minnow (Attachment A).

The Devils River minnow has been proposed for listing as an endangered species under the ESA by the U.S. Fish and Wildlife Service (Service). The Service is responsible for reviewing the status of the species and determining whether it warrants inclusion on the list. The full implementation of this Agreement and the associated Strategy is intended to identify and reduce potential threats to the species. If the Strategy is successful, the need for listing the species as threatened or endangered may be removed. Also, threats to the species could be reduced to only require listing as threatened rather than endangered. If the expected outcome of the Strategy is not realized, or other circumstances change, the Service is required to proceed with listing the species as threatened or endangered.

II. ADDITIONAL BENEFITS

The purpose of this Agreement is the conservation of the Devils River minnow and its unique habitat, the Devils River, San Felipe, Las Moras and Sycamore creeks. The conservation actions, however, also assure that these ecosystems will continue to provide habitat for other indigenous species (e.g., proserpine shiner, Conchos pupfish, blotched gambusia and Rio Grande darter) as well as provide a valuable resource for the citizens of Texas (e.g., Attachment B).

III. INVOLVED PARTIES

Texas Parks & Wildlife Department
4200 Smith School Road
Austin, Texas 78744

City of Del Rio
P.O. Box 4239
109 W. Broadway
Del Rio, TX 78840

United States Department of the Interior
Fish and Wildlife Service
500 Gold Avenue SW
Albuquerque, NM 87102

The Texas Parks and Wildlife Department (TPWD) has worked closely with local landowners and other stakeholders to keep them informed and aware of the intention of the TPWD to enter into this agreement for the conservation of the Devils River minnow and its habitat

IV. AUTHORITY

The signatory parties enter into this Conservation Agreement and the attached Conservation Strategy under Federal and State law, as applicable, including but not limited to Fish and Wildlife Coordination Act (as amended) 16 U.S.C. 16 et seq. and Section 2(c)(2) of the Endangered Species Act (ESA) of 1973 (as amended) which states that "the policy of Congress is that Federal agencies shall cooperate with State and local agencies to resolve water resource issues in concert with conservation of endangered species."

All parties to this Agreement recognize that they each have specific statutory responsibilities that cannot be delegated, particularly with respect to the management and conservation of wildlife and aquatic resources. Nothing in this Agreement or the Strategy is intended to abrogate any of the parties' respective responsibilities.

This agreement is subject to and is intended to be consistent with all applicable Federal and State laws.

V. STATUS AND DISTRIBUTION OF THE DEVILS RIVER MINNOW

The study by Garrett et al. (1992) revealed that Devils River minnow was very rare throughout its range in 1988-1989 and substantiated the species' extirpation reported for Las Moras Creek (Smith and Miller 1986). In 25 sampling locations within the historic range, a total of only 7 individuals were collected (Devils River = 2; San Felipe Creek = 3; Sycamore Creek = 2). The data indicate the species has decreased in both absolute numbers and relative abundance. Devils River minnow was the fifth most abundant species in 1953 at Bakers Crossing on the Devils River (Garrett et al. 1992); sixth most abundant species in the river in 1974 (Harrell 1978); and one of the least abundant species in 1989 (Garrett et al. 1992). In 1979, Devils River minnow made up 10% of the *Dionda* in the headwater springs of San Felipe Creek; in 1989 none were

collected from this site (Garrett et al. 1992). In the creek below San Felipe Springs (in Del Rio), the fish was very rare in collections in 1989 (Garrett et al. 1992).

Little published information is available on the status of the species in Mexico. The most recent collections indicate the species only occurs in two localities in Mexico. The status of the populations there appear to be very depressed and face significant threats from industrial development (Contreras-B. and Lozano-V. 1994).

The most recent information on the distribution and abundance of Devils River minnow in Devils River and San Felipe Creek was obtained during status surveys conducted in November 1997 and May 1998. Personnel from the Texas Parks and Wildlife Department sampled the fish community at sites on the upper Devils River and San Felipe Creek. No Devils River minnow were collected from locations on the Devils River but they were very common (more than 100 fish collected) from San Felipe Creek, downstream of San Felipe Springs, Dolan Creek (14 specimens) and Phillips Creek (142 specimens). Valdes Cantu and Winemiller (1997) reported that the species was still present in the Devils River at the confluence with Dolan Falls in 1994, but only in low numbers. No specimens were retained to confirm identification.

The Devils River minnow is currently listed as a threatened species by the State of Texas and as an endangered species by Mexico. The species is also included as threatened species by the Endangered Species Committee of the American Fisheries Society and listed as threatened by the Texas Organization for Endangered Species.

VI. PROBLEMS FACING THE SPECIES

Very little is known of the Devils River minnow, but some problem areas are apparent. The Las Moras Creek population has been extirpated. Habitat loss has occurred through minimal flows in Sycamore Creek and inundation of the lower Devils River by lakes Walk and Devils and ultimately Amistad Reservoir. The river originally flowed approximately 50 miles, from Pecan Springs to its confluence with the Rio Grande (Taylor 1904). Many springs in the area have diminished flows, some (e.g., Beaver Springs, Juno Springs and Dead Man's Hole) have totally stopped (Brune 1981). Many of the perennial streams (Gray 1919) of the area no longer flow. USGS data from the Pafford Crossing gauging station reveals a general decrease in daily mean discharge for the period between the study by Harrell (1978) and that of Garrett et al. (1992). In the early 1950's, Dietz (1955) noted that pumping from irrigation wells was lowering the aquifer. Brune (1981) asserts (but provides no data) that the reduction in spring flows in this area is due to heavy pumping from wells and overgrazed soils with lowered capacity to absorb water and thus recharge aquifers. Local ranchers dispute Brune's (1981) assertions, stating that there has been no irrigation since 1987 and prior to that (1950's - 1960's) only 200 - 500 acres were ever in irrigation (Byron Hodge, pers. com.). Decreases in aquifer storage and discharge may be due to a variety of factors, but are almost certainly related to an overabundance of juniper (*Juniperus* spp.) and mesquite (*Prosopis glandulosa*). Improvements in aquifer recharge may be accomplished by addressing this problem through range management (Thurow and Carlson 1994; Smeins et al. 1997; Thurow and Hester 1997).

In a study on water quality of the Devils River and San Felipe Creek, the Texas Natural Resources Conservation Commission (TNRCC 1994) listed a number of parameters indicative of reduced water quality and perhaps important in understanding changes in fish community structure. Substances found in concentrations high enough to be considered as "concerns" or "possible concerns" for aquatic life or human health were nitrate-nitrogen, nitrite+nitrate, TDS, chloride, phosphate, orthophosphate, sulfates, phosphate, cadmium, lead and mercury. These substances exceeded levels established by the Texas Surface Water Quality Standards. In the case of nitrate-nitrogen and nitrite+nitrate in the Devils River, the standards were exceeded by 82% and 100% of the samples, respectively. In San Felipe Creek, the standards for nitrate-nitrogen, phosphate and orthosphosphate were exceeded by 98%, 100% and 100% of the samples, respectively.

Although some aspects of water quality and quantity may be less than ideal, the Devils River is still one of the most pristine rivers in southwestern North America. It remains relatively unpolluted, undammed and although flows have diminished, they are still substantial

The aquifer that sustains spring flows within the range of Devils River minnow is the Edwards-Trinity (Plateau) of the Georgetown and associated limestones. This major aquifer produces the largest number of springs in Texas (Brune 1975). The contributing recharge area of springs on the Devils River and San Felipe Creek is thought to include a large area to the north from near the towns of Sheffield to Eldorado (Brune 1975), although the subsurface hydrogeomorphology of the region is not well defined. The flow from springs tend to fluctuate considerably, depending on the amount of rainfall, recharge, and water in storage in the underground reservoirs. The conservation of this groundwater supply is imperative to the existence of the Devils River minnow.

Exotic species that have become established within the range of Devils River minnow are: common carp (*Cyprinus carpio*), black bullhead (*Ameiurus melas*), gulf killifish (*Fundulus grandis*), sailfin molly (*Poecilia latipinna*), inland silverside (*Menidia beryllina*), redbreast sunfish (*Lepomis auritus*), redear sunfish (*Lepomis microlophus*), smallmouth bass (*Micropterus dolomieu*) and blue tilapia (*Tilapia aurea*). Although fishes throughout the Chihuahuan Desert have been negatively impacted by introduced species (Hubbs 1990) and such factors as predation by smallmouth bass may cause negative impacts, specific effects on Devils River minnow are not known.

The Strategy is designed to assess the potential threats to the species and determine the necessary management actions the signatories to this Agreement will undertake to address those threats. This Agreement and the Strategy attempt to establish a baseline understanding of the Devils River minnow and its habitat for the purpose of providing a framework for implementation of the conservation measures.

VII. CONSERVATION ACTIONS TO BE IMPLEMENTED

In order to meet the objectives of this Agreement, ten conservation actions are being implemented. These actions, as described in the Strategy, include: 1) Determine the current status of the Devils River minnow and monitor changes; 2) Maintain genetically representative, captive populations of Devils River minnow at TPWD Heart of the Hills Research Station and at one or more alternate facilities (e.g., Dexter National Fish Hatchery) for breeding and as insurance against extinction; 3) Reintroduce Devils River minnows reared from captive populations in order to reestablish populations; 4) Continue and enhance protection of the San Felipe Creek watershed; 5) Provide technical assistance to landowners on riparian protection and management; 6) Review bait harvest/selling in the Devils River area and investigate methods (e.g., regulation, education) to prevent the further establishment of exotic, aquatic species within the historic range of Devils River minnow; 7) Document abundance and range of exotic fish species in the Devils River, San Felipe, Las Moras and Sycamore creeks; 8) Obtain and analyze changes in flow data for the Devils River, San Felipe, Las Moras and Sycamore creeks; 9) With progeny of the captive population, use a simulated environment to determine ecological and life history requirements of Devils River minnow; 10) Determine *in situ* predator/prey interactions between smallmouth bass and Devils River minnow. In addition, four general administrative actions, as outlined below, will be implemented: coordinate conservation activities; implement the conservation schedule; fund conservation actions; and assess conservation progress.

Coordinating Conservation Activities

Administration of the Conservation Agreement and information distribution will be conducted by the Devils River Minnow Conservation Team (DRMCT). The team will consist of representatives of: 1) TPWD, 2) USFWS, 3) Del Rio, 4) one or more private landowners, 5) native fish population biologist (academia), 6) hydrogeologist (state/federal agency). The DRMCT may also include technical and legal advisors and other members as deemed necessary by the signatories. Because the State of Texas presently has primary jurisdiction over Devils River minnow, the designated DRMCT leader will be the TPWD representative. Authority of the DRMCT shall be limited to developing and making recommendations for the conservation of Devils River minnow to the Agreement signatories. The DRMCT will meet annually to develop recommended yearly conservation schedules, review the Strategy and make recommendations to modify the Strategy as necessary. The DRMCT will meet as often as necessary to report on the progress of implementing the Strategy. DRMCT meeting will be open to the public. Minutes of the meetings will be kept and distributed to any interested party.

Implementing Conservation Schedule

A total of five (5) years is anticipated for full implementation of actions identified and specified in the Strategy (Table 1). Nevertheless, the parties agree that significant actions to benefit the Devils River minnow will be implemented within the first year (1998).

The DRMCT will coordinate conservation activities and monitor conservation actions taken by the signatories to this Agreement.

Funding Conservation Actions

Funding for the Conservation Agreement will be provided by a variety of sources, including, but not limited to:

1) State funding sources, including but not limited to, TPWD
2) Federal sources including but not limited to, the FWS through Section 6 Funds under the ESA
3) Private funding sources

In-kind contributions in the form of personnel, field equipment, supplies, etc., will be provided by participating agencies as necessary. In addition, each agency will have specific task responsibilities and proposed actions/commitments related to its in-kind contributions.

It is understood that all funding commitments made under this Agreement are subject to approval by the appropriate State and Federal entities. Failure to fund needed actions will result in the dissolution of the Agreement, however, this Agreement does not commit a state or federal agency to spend resources beyond its authority.

Assessing Conservation Progress

A semiannual assessment of progress towards implementing actions identified in this Agreement will be provided to the signatories of the Agreement by DRMCT. This assessment will be based on updates and evaluations by DRMCT members.

The DRMCT will produce an annual written report documenting the status of accomplishments under the Strategy. This assessment will determine the effectiveness of the Agreement and whether revisions are warranted and will be provided to the signatories of the Agreement by DRMCT.

If threats to the survival of the Devils River minnow become known that are not or cannot be resolved through this or any Conservation Agreement, the DRMCT will promptly notify all signatories. If this situation occurs, the Service may be required to take appropriate listing action under Section 4 of the ESA.

VIII. DURATION AND AMENDMENT OF AGREEMENT

The initial term of this Agreement shall be five (5) years. This Agreement shall be extended for an additional five (5) years upon agreement by the parties. Any party may withdraw from this Agreement upon sixty (60) days written notice to the other parties. Changes to the Agreement may be made upon agreement in writing of all the signatories.

IX. NATIONAL ENVIRONMENTAL POLICY ACT (NEPA) COMPLIANCE

Signing of this Agreement is covered under authorities outlined in Section IV listed above. We anticipate that any survey, collection or research activities for implementation and maintenance of the Agreement will not entail significant Federal action under the NEPA and will be given a categorical exclusion designation. All other actions will be evaluated prior to implementation and will comply with NEPA regulations.

X. SIGNATURES

TEXAS PARKS AND WILDLIFE
DEPARTMENT
4200 Smith School Road
Austin, Texas 78744

Andrew Sansom date
Executive Director

CITY OF DEL RIO
P.O. Box 4239
109 W. Broadway
Del Rio, TX 78840

Robert Chavira date
Mayor

UNITED STATES DEPARTMENT OF THE
INTERIOR
FISH AND WILDLIFE SERVICE
ECOLOGICAL SERVICES
10711 Burnet Rd, Suite 200
Hartland Bank Bldg
Austin, TX 78758

Dave Frederick date 8/17/98
State Director

UNITED STATES DEPARTMENT OF THE
INTERIOR
FISH AND WILDLIFE SERVICE
500 Gold Avenue SW
Albuquerque, New Mexico 87102

Nancy Kaufman date 9/1/98
Regional Director

ATTACHMENT A

CONSERVATION STRATEGY
Devils River minnow
Dionda diaboli

PURPOSE

The purpose of this document is to describe specific procedures and strategies required for conservation of the Devils River minnow, *Dionda diaboli*. The general conservation goal is to eliminate or significantly reduce the probability that potential threats to the minnow will actually harm this species and to recover populations of the minnow to viable levels. Though the primary focus of this Conservation Strategy is conservation of the Devils River minnow, it will also reduce or eliminate threats to the associated ecosystems and thereby provide additional benefits to the citizens of Texas.

BACKGROUND

The geographic location and historic stability of the Devils River has sustained a number of indigenous organisms. Due to limited access, the river has not been well studied. However, collections in the past decade by Garrett et al. (1992) and others indicate a diminution in abundance of several flowing-water species, particularly the Devils River minnow. In 1953, a collection at Baker's Crossing showed Devils River minnow to be the fifth-most abundant fish species there and the sixth-most abundant in the upper river (Brown 1954). In the mid-1970's Harrell (1978) found this to be the sixth-most abundant fish in the river. By 1989, collections from 24 locations throughout the range of the minnow yielded a total of only 7 individuals (Garrett et al.). Only one fish was obtained from Baker's Crossing and no more than two were obtained at any site. In 1979, Devils River minnow made up 6-18% of the *Dionda* population at the head springs area of San Felipe Creek. In 1989, none were present.

Land ownership in the areas where Devils River minnow occurs is mostly private. Exceptions include the Devils River State Natural Area, owned by Texas Parks and Wildlife Department and portions of San Felipe Creek, owned by the City of Del Rio. Primary land uses are for agriculture by cattle, sheep, and goat ranching. Generally, these areas are very remote with little human development, beyond those to support ranching operations. Primary communities within the Devils River watershed are Ozona and Sonora (each less than 5,000 in population) in the upper, intermittent portion of the stream. The Devils River is a popular location for recreational fishing and canoeing, although public access is limited.

POTENTIAL PROBLEMS FACING THE SPECIES

Because of a naturally restricted range, a reduction in that range (inundation of the lower portion of the Devils River; elimination of the Las Moras Creek population) and a decline in abundance within remaining populations (cause unknown), there is cause for concern for the status of the Devils River minnow. Remaining populations are potentially threatened by a) loss of habitat through reduction in spring flows, b) reduction in water quality and c) predation and competition with exotic species. However, since little is known of the life history requirements or the ecological interactions of the Devils River minnow, it is not possible to properly assess threats or fully implement recovery actions.

CONSERVATION ACTIONS

The following Conservation Actions are designed to: a) assess the current status of wild populations (CA #1); b) provide immediate security for the Devils River minnow (CA #2 & #3); c) implement actions needed for long-term conservation of the Devils River minnow (CA #4, #5 & #6) and d) fill in gaps in pertinent information (CA #7, #8, #9 & #10).

1) Determine the current status of the Devils River minnow and monitor changes.
    a) Coordinate access with private land owners and sample available habitat throughout the length of the Devils River, San Felipe Creek, Las Moras Creek and Sycamore Creek.
    b) Obtain scientific collecting permits from Mexico and determine if any Devils River minnows exist in the Río San Carlos, Río Alamo, Río San Juan, Río San Diego, Río San Rodrigo, Río Escondido or Río Sabinas in Coahuila, Mexico.
    c) Collect fish by seining and electrofishing all available habitats. At each collection site, all specimens collected will be identified and each species will be enumerated. Voucher specimens will be retained. Sampling effort at each site will be quantified. Sample sizes will be sufficient to show all species present and reveal relative abundance of all species present so as to allow determinations of population trends and competitive interactions. Obtain samples from selected locations in both fall and spring in order to measure seasonal fluctuations of population size. Data will be reported in terms of actual number of all fishes obtained and relative abundance.
    d) Determine microhabitat usage and species association. Area sampled, sampling duration and habitat characteristics will be recorded and used for quantitative characterization of range, relative abundance and habitat use. In addition, parameters of water quality (e.g., temperature, DO and TDS) and habitat structure (e.g., aquatic vegetation, channel morphology, substrate, flow and depth) will be measured and tested for correlation.
    e) These sampling efforts will be performed annually for the duration of the project.

2) Maintain genetically representative, captive populations of Devils River minnow at TPWD Heart of the Hills Research Station and at one or more alternate facilities deemed appropriate by USFWS (e.g., Dexter National Fish Hatchery) for reintroduction propagation and as insurance against extinction.

3) Reintroduce Devils River minnows reared from captive populations in order to reestablish populations in nature.
   a) The preferred broodstock for reintroduction is adults from the Devils River. Should those not be available, broodstock from San Felipe Creek may be used. No fewer than 50 adults (50:50 sex ratio) will be used in order minimize chance loss of rare alleles.
   b) The highest priority introduction sites will be 1) Finegan Springs, 2) Dolan Springs and 3) the vicinity of Dolan Falls. The first two are on the TPWD Devils River State Natural Area and the third is adjacent to the property of The Nature Conservancy of Texas. The first site is a known location of previous abundance and should therefore have a high probability of success. The second site has no records of smallmouth bass and the third site is the location for smallmouth bass removal in the Texas A&M experiment (#10, below).
   c) Upon analyzing results of the first stockings and determining microhabitat preferences, additional, appropriate stocking sites may be identified.
   d) Monitor reintroduced populations to assess stocking success and to record interactions with competitors and predators.

4) Continue and enhance protection of the San Felipe Creek watershed.
   a) The city of Del Rio will be working to reduce water consumption by 10-20% in San Felipe Creek by constructing a water treatment plant that improves the efficiency of the City's water storage and delivery system. The City has also hired a consulting firm to study alternate water sources to San Felipe Creek.
   b) The City is developing a Water Conservation Plan, as required by existing agreements with the Texas Water Development Board and the Border Environmental Cooperation Commission and in conjunction the Regional Water Resource Plan being developed under mandate of the Texas Natural Resource Conservation Commission.
   c) The City is also developing policies for preserving water quality and water flow as well as educating the populace on the value of San Felipe Creek as a natural resource that flows through Del Rio (Attachment B).
   d) The City has adopted a plan which limits population density over areas immediately adjacent to the San Felipe Creek.
   e) TPWD will assist the City in developing a Management Plan for the golf course that will protect San Felipe Creek from negative impacts.

5) Provide technical assistance to landowners on riparian protection and management.
   a) TPWD will provide information to private landowners regarding methods and actions for managing riparian areas such that stream flow, water quality and biological diversity are maintained.
   b) TPWD will, upon invitation by landowners, develop habitat management plans with these landowners that include the riparian management information.

c) TPWD will also provide guidance in pursuit of grants for private landowners and the City of Del Rio that will be used for activities that protect stream flow and water quality.

6) Review live bait harvest and selling practices in the Devils River area to develop methods and take appropriate actions (e.g., regulation, education) to prevent the further establishment of exotic, aquatic species within the historic range of Devils River minnow.

7) Document abundance and range of exotic fish species in the Devils River, San Felipe, Las Moras and Sycamore creeks using methods described in #1.

8) Obtain and analyze changes in flow data for the Devils River, San Felipe, Las Moras and Sycamore creeks.
   a) Existing studies such as the one performed for the Nature Conservancy will be reviewed.
   b) Any additional information needs will be resolved by requesting studies from the Texas Water Development Board and/or the Texas Natural Resources Conservation Commission designed to fill the gaps in the data.
   c) If correlations in spring flow and Devils River minnow abundance exist, a more thorough assessment of groundwater geology and recharge area will be performed.

9) With progeny of the captive population, use a simulated environment to determine ecological and life history requirements of Devils River minnow.
   a) Construct artificial habitat at Heart of the Hills Research Station designed to simulate portions of the Devils River. Information obtained in #1)d. will be used to design the artificial habitat. Two "streams" patterned after ones designed for stream ecology studies (Matthews et al. 1990; Lamberti and Steinman 1993) will be constructed to facilitate replication. Each creek will have six pools (2m dia.) and six riffles (0.5m x 2m).
   b) Determine microhabitat preference of Devils River minnow through diel and seasonal observation and analysis.
   c) Measure competition and predation interactions with associated fish species by manipulating species composition and abundance in each of the artificial streams and using procedures developed in previous studies (Finger 1982; Fraser and Cerri 1982; Schnick et al. 1986; Gilliam and Fraser 1987; Schlosser 1987; Brown 1991; Bugert and Bjornn 1991; Resetarits 1991; Vaughn et al. 1993).
   d) Determine water chemistry tolerance ranges by manipulating concentrations of components such as TDS, nitrate-nitrogen, phosphate and orthosphosphate in both static and artificial stream settings.

10) Determine *in situ* predator/prey interactions between smallmouth bass and Devils River minnow.
   a) TPWD is coordinating with Texas A&M University on a project currently underway that is designed to compare the Devils River fish community dynamics (including Devils River minnow) in the presence of smallmouth bass versus a section of stream where they have been removed.
   b) Results of the Texas A&M study will be reviewed and, if needed, TPWD will conduct further research to augment the study. The goal of the study will be to determine if smallmouth bass predation has an inordinate effect on Devils River minnows relative to

that of native predators and if so, what life stages of the two species are most important in the interaction.

c) Elimination of the smallmouth bass from the Devils River would be virtually impossible, even if warranted. However, removal from selected locations could have enough of a short-term, positive effect to allow re-establishment of Devils River minnow populations. Long-term effectiveness would be more likely achieved through regulations on bag and size limits which can be used to reduce abundance and modify population structure of smallmouth bass. Study results will be used to formulate management policies for smallmouth bass that will remove them as a threat to survival of Devils River minnows.

CRITERIA FOR SUCCESS

Because the reasons for the decline of Devils River minnow remain unknown, these actions have been designed to restore populations while simultaneously performing research that will provide guidance for maintaining the species at natural levels. Restoration of the populations may be rapid (as naturally happened with those in San Felipe Creek) or may take several years. During this time, parameters such as habitat quality, flow rates and competition/predation pressures will be better delineated and enable us to work with the community to take any needed remedial actions.

The Devils River minnow is vulnerable to extinction because of the reduced distribution and low population size. Improving this condition through captive propagation and successful reintroduction would provide immediate security for the species and allow the FWS to consider alternatives to a listing as Endangered.

Removal of the imminent risk of extinction would be attained by one or both of the following:

1) The proposed status survey may reveal the existence of a greater number of viable populations in Texas and/or Mexico than are currently known.
2) Captive propagation and stocking into the Devils River can be used to reestablish natural populations and would enhance the ability to determine causes for previous declines.

Restoration of the Devils River minnow will be considered complete when:

1) Population levels in San Felipe Creek and the Devils River are at historic levels. Two locations in San Felipe Creek (e.g., in the headsprings area and at the golf course) and three locations on the Devils River (e.g., headwaters, Baker's Crossing, Finegan Springs) will be used to represent the populations.
2) Viable populations exist in Sycamore and/or Las Moras creeks (historic levels are not known).
3) Ecological parameters that affect life history of Devils River minnow are known and appropriate safeguards are in place to insure that these parameters remain within the range needed for health of Devils River minnow populations.

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Heart of the Hills Research Station
Texas Parks & Wildlife Department
Ingram, TX 78025
gpg@ktc.com

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Table 1. Conservation actions to be implemented.

ACTION ITEM	responsible party	initiation date	task duration	estimated cost/year
Determine the current status of the Devils River minnow and monitor changes	TPWD	11/97	5 years	$1,000
Maintain genetically representative, captive populations of Devils River minnow at TPWD Heart of the Hills Research Station and at one or more alternate facilities for breeding and as insurance against extinction	TPWD FWS	11/97 8/98	5 years 5 years	$8,000 $1,000
Reintroduce Devils River minnows reared from captive populations in order to reestablish populations in nature	TPWD	4/99	4 years	$500
Enhance protection of the San Felipe Creek watershed	TPWD City of Del Rio	3/99	Ongoing	$500 $3,000,000
Provide technical assistance to landowners on riparian protection and management	TPWD	3/99	Ongoing	$1,000
Review bait harvest/selling in the Devils River area and develop methods (e.g., regulation, education) to prevent the further establishment of exotic, aquatic species within the historic range of Devils River minnow.	TPWD	8/98	1 year	$500
Document abundance and range of exotic fish species in the Devils River, San Felipe, Las Moras and Sycamore creeks	TPWD	4/98	2 years	$1,000

Obtain and analyze changes in flow data for the Devils River, San Felipe, Las Moras and Sycamore creeks	TPWD	2/98	2 years	$3,000
With progeny of the captive population, use a simulated environment to determine ecological and life history requirements of Devils River minnow	TPWD	3/98	5 years	$1,000
Determine *in situ* predator/prey interactions between smallmouth bass and Devils River minnow	TPWD	3/99	4 years	$2,000

ATTACHMENT B

(830) 774-8510

November 14, 1997

Dr. Gary Garrett
Texas Parks and Wildlife Department
Heart of the Hills Research Center
HCO7, Box 62
Ingram, TX 78025

Dear Dr. Garrett:

In the course of our discussions and your visits to the San Felipe Creek over the past few years, we have pondered several questions which are of particular importance to the City:

- How does a city show off its most beautiful natural resource without harming it?
- How does one balance preservation and development?
- What is the best way to stabilize stream banks?
- What level of maintenance is most appropriate?

Our discussions have come about because of either your scientific study or our development planning, or both. We are always appreciative of your advice and concern, and pleased that you share our conviction that an increase in human activity along the Creek does not need to lead to a decline in natural beauty.

There has been little movement of late on the City's long-standing dream of a "Creekwalk" along the San Felipe. As you know, a number of years ago the City built retaining walls and sidewalks along a portion of the Creek. We now understand that the improvements made at that time are not the best choice for the ecosystem of the San Felipe Creek. Portions of the walls and walkways are now in disrepair, and there appears to be beginnings of a renewed momentum for the Creekwalk concept. This, and the recent discussions surrounding the health of the Devils' River Minnow in the San Felipe Creek prompted the City staff to discuss again the principles and practices on which future development should occur. I thought it appropriate that we share our thoughts with you. Attached to this letter you will find an outline of our ideas. These are not adopted guidelines, but we are committed to following them as we plan for the future.

As to the issue of water conservation, which is briefly discussed on the next page, there is a recent development which may impact water use. The City is under a mandate to construct is first-ever Water Treatment Plant. As water has always been cheap and plentiful, the City has never enacted official conservation measures. With the construction of the plant (expected to cost $30 million), water bills will increase, and we anticipate that the increased cost may cause water usage may drop as much as 10-20%.

Funding is always a concern, and I would ask that you keep us in mind as you hear about grant programs which might fit our agenda. Again, thank you for your continued support. I look forward to hearing you comments and suggestions.

Sincerely,

Beth Eby
Assistant City Manager

SAN FELIPE CREEK
DEVELOPMENT GUIDELINES

Goal #1 - Public access, along the entire stretch from Highway 90 to the Rio Grande, so that citizens and visitors can enjoy the natural beauty of the San Felipe Creek.

Goal #2 - Low-impact, low-density, self-sustaining, mixed-use development, which is consistent with recreational uses, and will be an asset to the community.

Goal #3 - The inclusion of environmental education wherever possible. Interpretive signs, murals, and hands-on activities which educate the public about the various components of the ecosystem are to be encouraged. Informed citizens are the best insurance for the Creek.

Water quality is of paramount importance. All existing activities and all future planning will be scrutinized for impacts on the San Felipe Creek in terms of runoff, potential for accidental spills, and any other source of pollution.

As much as possible, stream banks are to be preserved in their natural state, or returned to their natural state, as repair of existing sidewalks and retaining walls is performed.

Stream bank retention, repair, and reinforcement, where needed, is to be enacted by the "most natural" method practicable. Return to a completely natural state with the use of native vegetation is preferred; following that, the use of fiber mats, gabions, etc., is to be considered. Concrete, brick, stone, and mortar are to be the last resort. "Channelization" is to be avoided.

New sidewalks are to be placed close enough to allow users a view of the waterway, but far enough away so as not to encourage erosion or to disrupt existing vegetation. A "buffer zone" of 10' to 20' is preferred.

Regular removal of litter and debris is important, and should occur on a regular and frequent basis. Volunteer groups are encouraged to participate. All volunteers are to receive training from the Parks and Recreation Department on how to accomplish the task with the least disruption to the Creek.

Removal of vegetative overgrowth is to proceed carefully, in consultation with Texas Parks and Wildlife Department, the Watermaster, and/or other appropriate individuals or agencies.

There should be no new diversions of water into channels, canals, pools, fountains, etc.

Water flow is to be preserved to the extent possible. The City relies on the San Felipe Springs for its drinking water, and the San Felipe Irrigation Company diverts water from the Creek into its irrigation canals. Although these uses are essential to the community, and have never been shown to adversely effect the ecosystem, conservation measures could and should be considered.

Appendix C

City of Del Rio Management Plan for San Felipe Creek and the Devils River Minnow, September 2003

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Management Plan for San Felipe Country Club in Del Rio, September 2003

CITY OF DEL RIO MANAGEMENT PLAN
FOR SAN FELIPE CREEK AND THE DEVILS RIVER MINNOW

INTRODUCTION

The intent and purpose of this document is to make recommendations to staff and set policy with respect to the protection, preservation, restoration and management of the San Felipe Creek watershed. In addition, this document records information relevant to managing the natural and cultural resources of San Felipe Creek and its springs.

MISSION

The City of Del Rio seeks to preserve and conserve the natural and cultural resources of the San Felipe Creek for the use and enjoyment of the present and future generations of Del Rio citizens and visitors. The city is a signatory on the Devils River Minnow Conservation Agreement and has representation on the Devils River Minnow Conservation Team. The Management Plan for San Felipe Creek and the Devils River Minnow will enable fulfillment of the city's obligations towards conservation and restoration of the federally threatened, Devils River minnow (*Dionda diaboli*). For the purpose of protecting the drainage basin of San Felipe Creek, the area of conservation will be designated as that bounded by the 100 year floodplain (as defined by FEMA) plus a 100' buffer (see map – Appendix 1).

GOALS

- Conservation and protection of the water quantity and quality of San Felipe Creek.
- Public access, so that citizens and visitors can enjoy recreation, cultural resources and the natural beauty of San Felipe Creek.
- Low-impact, low-density, self-sustained, mixed-use development, which is consistent with recreational uses and with conservation of cultural and biological resources, and will be an asset to the community.
- Inclusion of environmental education wherever possible.

LOCATION AND HISTORY

San Felipe Creek emanates from the third largest spring system in Texas. Although there are several springs throughout the aquifer area, the City of Del Rio uses only the two main springs for its water supply. The aquifer derives its water from the Edwards and Trinity plateau, which lies on the Balcones fault zone. The underground water is believed to cover over 6,500 square miles. The West spring is classified as ground water and the East spring is classified as ground water under the influence of surface water.

In the pre-history of San Felipe Springs many different Indian tribes inhabited the springs, including the Apache and Pueblo Indians. In 1650 the first mission was built near the springs. In 1657 Franciscan Priests held a mass on the grounds around the springs and named them San Felipe Del Rio. The name San Felipe was used in honor of the King of Spain (which at the time was Phillip) and Del Rio meaning "of the river". San Felipe Springs offered and continue to

offer many opportunities for agriculture and manufacturing in Val Verde County. The creek was the lifeline of the newborn community of San Felipe Del Rio. Water from the springs was used to water all crops and develop the first winery in the state of Texas (Val Verde Winery). Two gristmills were built to provide the first source of power in and around the area. San Felipe Agriculture, Manufacturing, and Irrigation Company played a key component in the building of two grist mills which provided power to the community and the canal system that irrigated the surrounding ranches and farm lands.

OVERVIEW AND SIGNIFICANCE

San Felipe Springs are the only source of water for the City of Del Rio and Laughlin Air Force Base. Flow from San Felipe Springs typically ranges from 50 to 90 MGD (million gallons per day; 77-139 cfs). Its meandering creek provides for recreational use, outdoor experiences and excellent habitat for wildlife. Its serene flow allows for several passive parks and swimming areas. The surrounding vegetation and landscape allows for excellent bird watching. The City of Del Rio, with local funds and grants (made possible by the NadBank/EPA), began construction of a water treatment plant in February 2001 and the plant was completed in August 2002. The water treatment plant is expected to pump 16 MGD from the East and West springs. Average daily water usage is currently 11-12 MGD. By the end of 2002, wells north of city may be able to supplement water supply by up to 4 MGD. The treatment plant is located on the east side of the creek. However, in order to pump water from the West Spring the contractors designed a structure that will not disrupt the ecology of the creek. The water treatment plant does not disrupt the flow of the creek. In light of a $14 million dollar grant given to the City of Del Rio by the Nadbank/EPA, we acknowledge the commitment to the conservation of the San Felipe Creek by both the City and Federal Government. With the anticipated growth of Del Rio the water treatment plant will also allow for expansion.

Nature tourism is the fastest growing segment of the tourism industry in Texas. San Felipe Creek has been designated by Texas Parks and Wildlife Department as a Nature Viewing Site for the Central Texas Nature Viewing Trail and will attract birdwatchers to the community.

HABITAT

Quality habitat for Devils River minnow is also quality habitat for most of the other organisms in the drainage, including humans. Protecting and in some instances enhancing the habitat can be beneficial to the Devils River minnow and the people of Del Rio. Components of the habitat interact and affect each other. These components include:

Stream – The stream consists of the flowing, aquatic habitat and its interactive organisms and physical elements. Organisms include plants, invertebrates, amphibians and fishes as well as terrestrial animals that depend on the stream. Physical elements include temperature, water chemistry, gradient, current and substrate.

Riparian – This zone is the area adjacent to and interactive with the stream. Natural riparian areas are structurally diverse and more productive in plant and animal biomass than adjacent upland areas. Riparian areas supply food, cover, and water for many organisms, and serve as

migration routes for a variety of wildlife. Because riparian ecosystems often are relatively small areas and occur in conjunction with waterways, they are vulnerable to alteration.

Watershed - The watershed consists of all the surrounding land area that sheds rainfall into the San Felipe Creek Basin. It is made up of both upland, undeveloped lots and urban, highly developed residential and business areas. The status of the watershed can have a direct impact on the quality of water in San Felipe Creek and its ecosystem. Non-point sources and direct sources of pollution through runoff can especially have a damaging effect on the ecosystem. The upland zone is the area adjacent to the riparian zone. Natural upland areas in the San Felipe watershed contain many tree and shrub type plants, such as, huisache, cenizo, hackberry, and prickly pear cactus. These upland areas are key in providing food and habitat for maintaining the native fauna of West Texas. Upland habitat provides additional benefit by reducing sediment loads, fertilizer runoff, and contaminants from flowing directly into the creek.

DEVELOPMENT AND CONSERVATION

Subsequent to the flood of August 1998, the City of Del Rio has acquired a substantial amount of land adjacent to San Felipe Creek. The City of Del Rio Parks and Recreation Department plans to develop these areas into passive parks. The Parks will be developed with one major goal in mind, which is to create a people-friendly area that is conducive to nature. The theme is for the area to remain in its "natural state". Areas such as Bird Watching Sanctuaries, Walking Trails will be developed in conjunction with Passive Parks. For example: Trails will be built 10 to 20 feet away from (where possible) the creek, allowing natural vegetation to grow and act as a natural buffer zone between the creek and the developed area.

Because it is an urban park, other recreational opportunities will also be made available (e.g., baseball fields, playgrounds, etc.), but the City of Del Rio will take a precautionary stance in the development of San Felipe Creek. Wise planning, in conjunction with the Devils River Minnow Conservation Team, should allow a multi-functional greenbelt that protects the natural resources as well as provides the greatest benefit to the citizens of Del Rio.

WATER QUALITY

Water quality is of paramount importance. All existing activities and all future planning will be scrutinized for impacts on San Felipe Creek in terms of urban runoff, potential for accidental spills, and any other source of pollution.

The use of pesticides and fertilizers should be minimized on city property and discouraged from use among private citizens along the creek. All possible sources of point and non-point source pollution should be investigated and eliminated.

The population of domestic ducks which reside near Highway 90 serve as a direct source of concentrated fecal pollution causing excessive growth of water plants and algae. In still waters, such as the Blue Hole area, when these plants die in the summer and decompose the process removes oxygen in the creek waters which may directly and negatively impact fish populations as well as other aquatic inhabitants. In addition, the presence of large amounts of feces and

coliform bacteria may present a health hazard to the children who swim at the Blue Hole. For these reasons, it is recommended that these domestic ducks be removed from the area.

Commercial development along the creek should be discouraged. Not only would it put these entities at risk in the event of a flood, but it would also create other sources of pollution. The City has the ability to control and restrict inappropriate development in the drainage basin through zoning ordinances.

The construction of conventional-style parking lots should be especially discouraged. Rainfall runoff from parking lots along the creek will end up polluting the creek with oils, gasoline and other pollutants. In the event that the construction of a parking lot is necessary, provisions should be made to construct a catchment (retention pond) to process the runoff or it should be directed to extensive areas of native vegetation to filter pollutants out.

The city of Del Rio Code of Ordinances has various existing ordinances that pertain to protecting water quality. Chapter 11, Flood Damage Prevention, is designed to minimize flood losses. It provides for the restriction or prohibition of uses, provides for the protection of facilities, controls the alterations of natural floodplains, stream channels or other natural barriers which accommodate floodwaters, controls the filling, dredging, grading, or other developments that may increase flood damage, and prevents or regulates the construction of flood barriers. The areas of special flood hazards are identified by the Federal Emergency Management Administration (FEMA) and permits are required for construction to ensure conformance with this ordinance. This ordinance also designates the City Manager as the Floodplain Administrator.

Another Ordinance is contained in Chapter 19.5, Parks, Recreation and Public Gathering Places. This provides for the conduct in public parks and in city property adjacent to the San Felipe Creek. It regulates behavior, recreational activities, traffic, commercial activities, sanitation, park property, and enforcement. Specifically, Article IV, San Felipe Creek Walk, Sections 19.5-150 to 19.5-173 provides for the planning, management and coordination of the activities which are conducted in that area and this is accomplished by the designation of the San Felipe Creek Walk Association as the official agency of the city to accomplish this.

Chapter 23, Sewers, regulates the discharge of wastes, provides rules for private sewage facilities and for licensing and regulation of the removal and disposition of private sewage facility wastes. Section 23.21 Same- To Public waters, states that no waste or wastewater may be discharged to public waters which contains acids, plating solutions or concentrated solutions. Fats, wax, grease, oils in excess of 100 mg/l or which may solidify or become viscous at temperatures between 32°F and 150°F may not be discharged into public waters. Objectionable or toxic substances, liquids or gases are similarly restricted and disallowed. Permits for discharges are required.

Chapter 24, Solid Waste, regulates the collection and disposal of solid wastes. This chapter provides for the residential garbage collection and for commercial disposal of wastes. The city landfill, permitted by TCEQ, is inspected periodically. Permit number for this facility is MSW 207A, as amended. Wastes are not allowed to collect in order to prevent such wastes from being

carried or moved from the property by actions of the sun, wind, rain, or snow. Such wastes, if not collected and removed, could ultimately be deposited in public waters.

Also, Chapter 29, Water, contains general provisions for the city as the water purveyor, for regulation of wells, and for water conservation and drought contingency plans. The city council or its designated agent, the City Engineer, shall inspect the wells, have made or make analysis of the well waters, go unto private lands to inspect the wells, supervise and inspect the construction and require the owners to furnish all information on the well to include logs, geologic information and depth and size of well constructed. Further, the City is to monitor the daily water demand in case of emergency. The drought contingency plan provides for controls of water usage during droughts or emergencies.

The City of Del Rio via Ordinance No. O:2000-01 approved a revised Drought Contingency Plan and Water Management Plan on January 11, 2000. The plans contain various aspects to determine what is drought condition, what triggers the drought contingency plan, enforcement and fines, in order to establish practices for the conservation of water.

The plan defines essential water use, non-essential water use and other such watering. The plans set three contingency trigger conditions and these are mild water shortage, moderate water shortage, and severe water shortage. These trigger conditions set the plan in motion. Basically, this is a measurement of stored water quantities in the Bedell Reservoirs and others.

Once the plan is put into effect, notification is given to citizens via radio, television, and newspaper notices. Enforcement can be accomplished by fines and citations for non-compliance. The plan also can require a minimal use of water for watering purposes and establishes watering days based on locations and time of the year.

Since it was approved by the City Council, the plan has been put into use only on one occasion.

All ordinances above or parts thereof were briefly discussed and are pertinent to protecting the water quality in the San Felipe Creek and the two springs which provide the source of water for the city for domestic and industrial use, recreational use, and to maintain the quality of the public waters of the city.

PRESERVING NATURAL FLOW

Natural water flow is to be preserved to the greatest extent possible. There should be no new diversions of water into channels, canals, pools, fountains etc. The City relies on the San Felipe Springs for its drinking water, and the San Felipe Irrigation Company diverts water from the Creek into its irrigation canals. Although these users are essential to the community, and have never been shown to adversely affect the ecosystem, conservation measures could and should be considered.

Fountains in the creek are not advisable. They reduce flow through evaporation and they communicate a “water waste” message to the community. Natural flow is not only important to

the San Felipe Creek ecosystem but also affects the Rio Grande ecosystem and ultimately, fresh-water inflow to estuaries of the Gulf of Mexico.

STREAM BANK AND RIPARIAN MANAGEMENT

As much as possible, stream banks are to be preserved in their natural state, or returned to their natural state as repair of existing sidewalks and retaining walls is performed.

Stream bank retention, repair, and reinforcement, where needed, is to be enacted by the "most natural" method practicable. Return to completely natural state with the use of native vegetation is preferred; following that, the use of fiber mats, gabions, etc., is to be considered. Concrete, brick, stone, and mortar are to be the last resort. "Channelization" is to be avoided.

New sidewalks may be placed close enough to allow users a view of the waterway, but must be far enough away so as not to encourage erosion or to disrupt existing vegetation. As a general rule, sidewalks should be no closer to the stream bank than 10' and should meander up to 40'-50' from the stream. Occasional water's-edge viewing areas may be constructed. These will be at natural "hard spots" on the stream bank and will be constructed to look and function as part of the natural system.

Buffer zones of native vegetation will serve as traps for any pollutants (fertilizers, pesticides, etc.) which may runoff from neighboring streets, parking lots, residential areas, or the golf course. It also will be attractive to birds, butterflies and other forms of wildlife which nature tourists and native residents will enjoy viewing.

In developed areas, such as along the creek-walk, the buffer zone should extend from the edge of the water up to within 2' of the sidewalk. A "buffer zone" of 10' to 20' is preferred. In undeveloped areas, it should extend all the way to the edge of any private property.

Private property owners (within the 100 yr + 100' zone) should be encouraged to allow their lots to revert to native vegetation as much as practical. To enhance the process, No Mow zones should be designated in open space areas adjacent to the creek. Mosaic patterns should be used to make the resulting combination of open and closed areas pleasing to the eye by avoiding hard edges. As a practical guide, no mowing should take place within and under the drip line of existing trees. No Mow zones also serve to provide habitat for birds and other wildlife.

Passive restoration of native vegetation, including shrubs and trees is the most practical, economically feasible, and preferred method for re-establishment.

EDUCATION

Interpretive signs, murals, and hands-on activities which educate the public about the various components of the ecosystem are to be encouraged. Citizens should be informed of the potential harm of introducing non-native organisms into or adjacent to the creek. In particular, aquarium fishes can be devastating to a spring-fed ecosystem such as San Felipe Creek. Informed citizens are the best insurance for San Felipe Creek.

LITTER REMOVAL

Regular removal of man-made litter and debris is important, and should occur on a regular and frequent basis. Volunteer groups should be encouraged to participate. All volunteers are to receive training from the Parks and Recreation Department on how to accomplish the task with the least disruption of the creek.

Dead tree snags should be left to provide nesting habitat for cavity nesting birds and perching locations for songbirds. They should be trimmed if they occur in high public use areas to prevent injury to citizens from falling branches and can be cut down entirely if the danger is too great. Dead trees that fall into the creek should be allowed to remain. They provide loafing areas for birds, amphibians and reptiles as well as shade and escape cover for fish.

Removal of vegetative overgrowth is to proceed carefully, in consultation with Texas Parks and Wildlife Department, the Water master, and or other appropriate individuals or agencies.

REMOVAL OF NOXIOUS, EXOTIC VEGETATION AND THE RESTORATION OF NATIVE PLANTS

Rivercane (*Arundo donax*) should be removed along the length of the creek with the cooperation and under the close supervision of personnel of the Texas Parks and Wildlife Department using EPA "wetlands" approved herbicide. This should be done only by prescription (due to the presence of a threatened fish species) and should be performed in the upper reaches of the creek first, to prevent re-establishment of the cane in lower areas through fragmentation. This should only be done after an agreement has been reached to allow re-vegetation of these areas with native vegetation through natural means. One year of experimentation with herbicides in lower reaches of the creek (where the Devil's River Minnow is known not to occur) should first be performed to fully assess the effects of treatments to aquatic species and the surrounding ecosystem.

Exotic plant removal should ultimately be done in short stretches at a time in order to maintain the stability of existing banks in the event of a flood. Other introduced plant species (Chinese tallow, elephant ears) should also be selectively removed from creek side areas.

As unwanted plants are removed, revegetation with native species is critical to success and system stability. Some segment-specific revegetation (e.g., butterfly gardens) may be desirable in some areas and passive revegetation may work best in others.

SIGNATURES

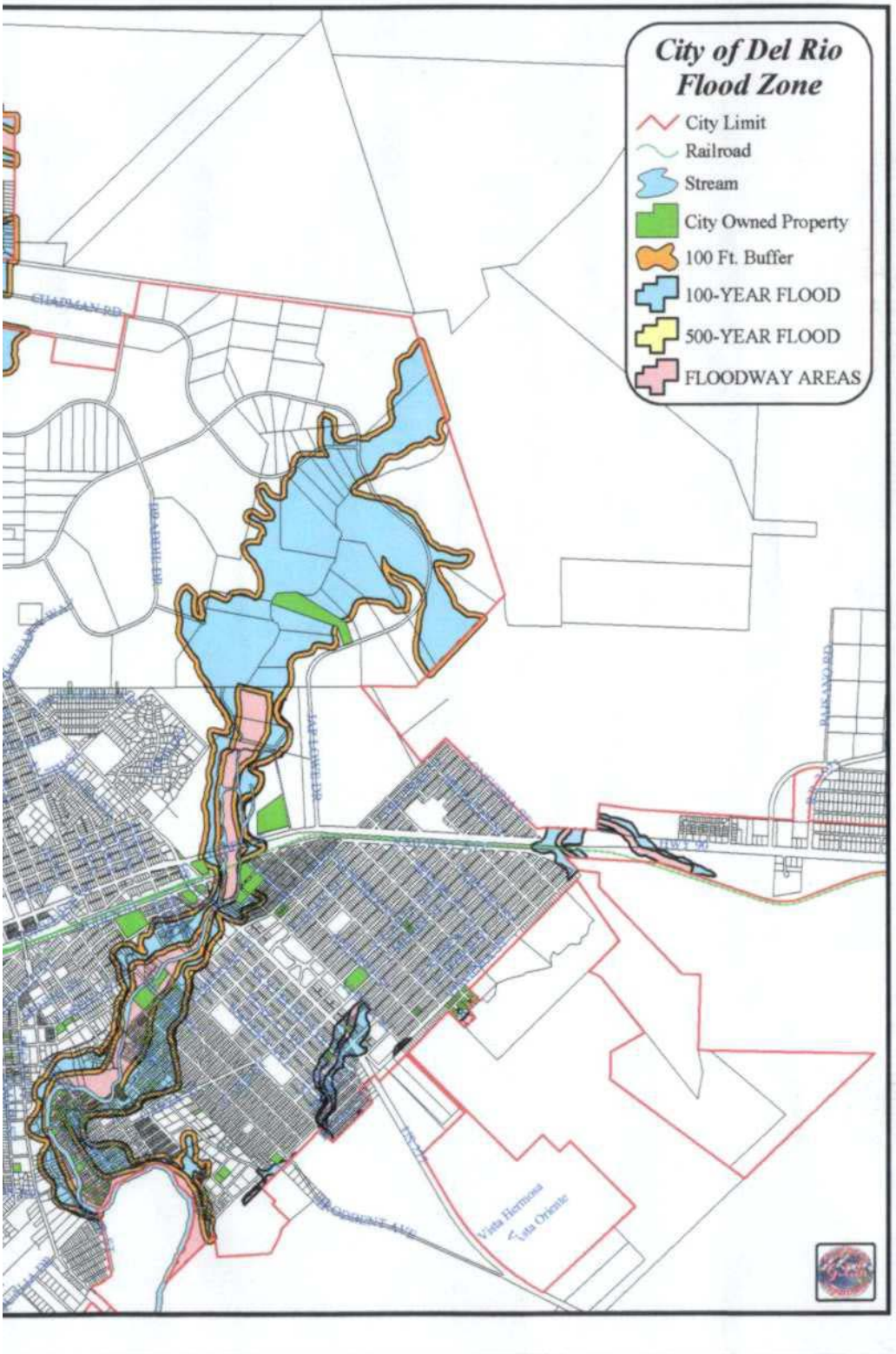
/s/ September 25, 2003

Dora Alcala
Mayor

/s/ September 25, 2003

Rafael Castillo
City Manager

APPENDIX 1 - Map of the 100 year floodplain (as defined by FEMA) plus a 100’ buffer.



APPENDIX 2 - Species of San Felipe Creek watershed

COMMON PLANTS

Trees

- Pecan (domestic maybe some native)
- Sugar Hackberry
- Black Willow *Salix nigra*
- Texas Ash and Arizona Ash (non-native)
- Bald Cypress (probably introduced) *Taxodium distichum*
- Sycamore
- Cottonwood (probably introduced)
- Mulberry
- River Walnut
- Huisache
- Chinaberry (exotic)
- Tree Tobacco (*Nocotiana glauca)*
- Retama (Parkinsonia aculeata)

Shrubs

- Buttonbush
- Granjeno
- Seepwillow Baccharis
- Cenizo (*Leucophyllum)*
- Kidneywood

Grasses

- African Rivercane (noxious exotic) *Arundo donax*
- Dallisgrass (introduced but great for birds)
- Bushy Bluestem
- Silver Bluestem
- Plains Bristlegrass
- Common bermuda

Forbs, Annuals & Perrenials

- Goldenrod
- Cardinal Flower
- American Water-willow
- Elephant Ears (exotic)
- White Boneset
- Golden-Eye (*Viguera dentata*)
- Redbud *Menodora heterophylla*
- Winecup
- Pink Evening Primrose
- Blue-eyed Grass *Sisyrinchium ensigerum*
- River Primrose *Oenothera jamesii*
- Frogfruit
- Blue Curls (Phacalea)
- Henbit
- Mexican Sage
- Dandelion
- Widow's Tears, Dayflower
- False Ragweed (*Partheneum sp.)*
- Marsh Fleabane
- Wild Petunia (*Ruellia sp.)*
- Wild Tobacco (*Nicotiana repanda)*
- Mexican Bastardia (*Bastardia viscosa)*
- Artemesia (*Artemesia ludoviciana)*
- Giant Ragweed (*Ambrosia trifida)I*
- Western Ragweed (*Ambrosia sp.)*

Vines

- Mustang Grape
- Sawleaf Greenbriar
- Poison Ivy
- Carolina Snailseed
- Pearl Milkweed (*Matelea reticulata)*
- Climbing Milkweed (*Sarcostema sp.)*
- Old Man's Beard (*Clematis drummondi*)

AVIFAUNA

- Pied-billed Grebe
- Neotropic Cormorant
- Double-crested Cormorant
- Ring-necked Duck
- Bufflehead
- Black-bellied Whistling-Duck
- Snowy Egret
- Great Blue Heron
- Green Heron
- Yellow-crowned Night-Heron
- Black Vulture
- Turkey Vulture
- Swainson's Hawk
- Red-Shouldered Hawk
- Sharp-shinned Hawk
- Zone-tailed Hawk
- Spotted Sandpiper
- American Coot
- Rock Dove
- Mourning Dove
- White-winged Dove
- Inca Dove
- Groove-billed Ani
- Chimney Swift
- Black-chinned Hummingbird
- Belted Kingfisher
- Green Kingfisher
- Ringed Kingfisher
- Golden-fronted Woodpecker
- Ladder-backed Woodpecker
- Northern Flicker
- Black Phoebe
- Vermilion Flycatcher
- Ash-throated Flycatcher
- Couch's Kingbird
- Western Kingbird
- Scissor-tailed Flycatcher
- Great Kiskadee
- Cedar Waxwing
- American Robin
- Northern Mockingbird
- European Starling
- Bewick's Wren
- Carolina Wren
- Purple Martin
- Barn Swallow
- Ruby-crowned Kinglet
- House Sparrow
- Pine Siskin
- American Goldfinch
- Lesser Goldfinch
- House Finch
- Yellow-rumped Warbler
- Common Yellowthroat
- Lincoln's Sparrow
- Chipping Sparrow
- Olive Sparrow
- Field Sparrow
- Summer Tanager
- Northern Cardinal
- Painted Bunting
- Red-winged Blackbird
- Great-tailed Grackle
- Hooded Oriole

SMALL MAMMALS

- Evening Bat
- Brazilian Free-tailed Bat
- Nine-banded Armadillo
- Eastern Cottontail
- Black-tailed Jackrabbit
- Mexican Ground Squirrel
- Spotted Ground Squirrel
- Eastern Fox Squirrel
- American Beaver
- Nutria (exotic)
- Common Gray Fox
- Striped Skunk
- Common Hog-nosed Skunk
- White-tailed Deer
- Ring-tailed Cat

NATIVE FISHES

- Mexican tetra
- Proserpine shiner
- Manantial roundnose minnow
- Devils River minnow
- Texas shiner
- Tamaulipas shiner
- Yellow bullhead
- Headwater catfish
- Mexican mosquitofish
- Gambusia sp.
- Longear sunfish
- Largemouth bass
- Rio Grande darter
- Rio Grande cichlid

Management Plan for San Felipe Country Club in Del Rio

BACKGROUND AND HISTORY:

Del Rio businessmen William Moore Abbey, B.B. Stafford, and C.C. Belcher formed a private corporation called the San Felipe Country Club in July 1921. Created to "support and maintain a Country Club for golf, tennis, and other innocent sports," its major feature was a nine-hole par-three golf course built around three of the largest of the San Felipe Springs. San Felipe was the first course civil engineer and professional golfer John Bredemus designed and built in Texas, and it solidified his reputation as a golf course architect. Bredemus went on to design many other important courses in Texas and Mexico. He co-founded the Texas Professional Golf Association in 1922 and was inducted into the Texas Golf Hall of Fame in 1991, 45 years after his death. With its original layout and early landscape remarkably intact, the San Felipe course is a prime example of early-twentieth-century golf course design.

The country club and golf course were successful right from the start, due largely to the promotional work of William Abbey. Soon after it opened, Del Rio golfers were playing in tournaments, and Abbey won the Princeton golf trophy in 1924. The first clubhouse for the San Felipe Country Club had been constructed in 1919 as an army officer's club and quarters for Camp Del Rio. The original building burned in 1927, and a second one built in 1947 still serves as the clubhouse. By 1953, a swimming pool and new tennis courts had been built on the country club grounds.

A second private organization, Del Rio Country Club, was formed in 1935. Primarily a social club, it coexisted with the golf club for many years. The two merged in 1966 and kept the name San Felipe Country Club. According to local historian and avid golfer Doug Newton, the San Felipe Country Club has been the center of social life for Del Rio's professional and business families ever since.

San Felipe Country Club Golf Course is approximately 70 acres in size. The country club is private, but the golf course which is owned by the City of Del Rio is open to the general public. Twenty to twenty-five thousand rounds of golf are played on the 9-hole course annually.

San Felipe Creek runs through the middle of the golf course in a north to south orientation for a total length of 2,100 feet. The upstream source of its flow comes from small springs and streams that originate on private property. The east and west springs which occur on the golf course proper are located on respective sides of the creek. Each of the springs serves as the source of drinking water for the city of Del Rio. Water is pumped from the springs up to the Water Treatment Plant located east of and adjacent to the golf course. The remaining water from the springs flows into the creek and serves as the major source of flow for San Felipe Creek.

The east springs form a stream that flows freely for 2,500 feet on the golf course before joining San Felipe Creek, just north of the Highway 90 Bridge on the golf course. The west

spring flows for 1,400 feet through the golf course and then joins San Felipe Creek 200 feet south of the Highway 90 Bridge, below the golf course. San Felipe Creek runs for another 5 miles until it reaches the Rio Grande (Camp Dresser & McKee, Biological Assessment Final Report, May 2000)

The federally threatened, Devils River minnow occurs in San Felipe Creek and in particular, it is found most often in and just downstream of the San Felipe Country Club. This species was listed by the U. S. Fish and Wildlife Service in 1999 due to reduced population size and range. Factors identified as threats to this species included degradation of water quality and loss of habitat. The city of Del Rio is a signatory on the Devils River Minnow Conservation Agreement and has representation on the Devils River Minnow Conservation Team. The city has developed the San Felipe Creek Management Plan which will enable fulfillment of the city's obligations towards conservation and restoration of the Devils River minnow. Because San Felipe Springs emanate from within the San Felipe Country Club and an important segment of the creek flows through the grounds, it is the wish of the Country Club to insure that actions taken on this property do not detrimentally affect quality of San Felipe Creek or the Devils River minnow. For that reason, the Management Plan for San Felipe Country Club in Del Rio is designed to act in concert with the city's management plan and help to protect important natural resources in Del Rio.

OBJECTIVES:

- To use environmentally sensitive techniques for managing and maintaining a high quality golf course for the benefit of users while also promoting natural diversity.
- To protect and enhance the quality of San Felipe Creek and San Felipe Springs for the benefit of the Devils River minnow and the entire creek and riparian ecosystem.

DESIGN:

Any future construction or development should be designed to fit within the layout of the topography of the golf course, preserve selected habitats and avoid adverse effects on San Felipe Creek. Natural resource experts from Texas Parks & Wildlife Department should be brought in during the early planning phases for any development to ensure the protection of important wildlife habitats.

PROTECTION:

Protected areas should be kept free of intrusion. Except in rare cases, all equipment and personnel should be restricted to fairways or greens. A No-Mow buffer zone should be maintained along the edges of all water courses and springs to serve as a filter for any excess fertilizers or pesticides that may runoff during hard rains or watering and to prevent bank erosion. In addition, a wide buffer zone of native vegetation around the springs and their stream courses which eventually join San Felipe Creek can help keep errant golf balls out of these water areas. No-Mow buffer zones should be as wide as possible with a minimum of 20-30 feet, except in areas where it interferes with normal golf play. Examples of exceptions would be greens # 2 and #4 where the No-Mow Zone would be minimized to allow for a functional green. No chemical treatments should take place within these zones, except for noxious plant removal by prescription only. Protected areas are the riparian corridor and any future areas the country club decides to designate as No Mow zones such as along boundary fence lines. If No-Mow zones are

established along boundary fences they would serve as habitat for birds as well as a filter for noise and chemical pollutants from the surrounding urban area. An increase in the local passerine bird population could help control insect pests on the golf course and function as a component of the integrated pest management plan.

RESTORATION:

Areas that must be disturbed anywhere on the golf course and are not fairways or greens should be re-seeded with native seed mixes or allowed to re-vegetate naturally using passive restoration.

PEST MANAGEMENT:

San Felipe Country Club is committed to using the most environmentally sensitive pest management solutions. Integrated Pest Management is the desired approach to dealing with pests. Integrated Pest Management, according to the University of California Statewide Integrated Pest Management Program, is "a strategy that focuses on long-term prevention or suppression of pest problems through a combination of techniques such as encouraging biological control, use of resistant varieties, and adoption of alternate cultural practices such as modification of irrigation or pruning to make the habitat less conducive to pest development. Pesticides are used only when careful monitoring indicates they are needed according to pre-established guidelines, treatment thresholds, or to prevent pests from significantly interfering with the purposes for which plants are being grown". The San Felipe Country Club will develop its own integrated pest management plan specifically designed to fit the purposes and needs of the Country Club while protecting the integrity of San Felipe Creek. An acceptable low level of damage by pests should be determined and incorporated into the plan. Research into the most environmentally compatible pesticides with consideration of organic\biological techniques should be initiated.

FERTILIZATION:

Fertilization is a necessary component to golf course management. Fertilizers will be used judiciously and only in quantities necessary. The County Club has no desire to be excessive or wasteful and recognizes that runoff from excessive use is harmful to San Felipe Creek.

NOXIOUS VEGETATION:

African rivercane, Chinese tallow, elephant ears and other invasive, exotic vegetation should be systematically removed using EPA wetland approved herbicides by prescription only. Rodeo is approved by the EPA to be used in wetland areas. The desired and most effective technique for application is by using a wick on individual stems that have been cut during the fall. An inventory of vegetation along watercourses should be performed by natural resource specialists.

OUT OF PLAY AREAS:

These areas are managed as native habitat. The open areas are managed as native short grasslands; while the wooded areas are managed as desert woodlands. Desert woodlands usually are found in low lying areas with deeper soils. Vegetation associated with these areas includes mature mesquite and sugar hackberry trees, and an assortment of shrub species such as granjeno, guayacan and Texas colubrina.

TEE BOXES:

Tee boxes at San Felipe Country Club are framed with native wildflowers and grasses.

LANDSCAPING:

The landscaping around the buildings and other facilities should be predominantly native vegetation. Grass clippings and other debris should never be disposed into San Felipe Creek. Grasses on fairways, greens and tee boxes are Bermuda-419 & Common Bermuda grass.

IRRIGATION:

The irrigation system at San Felipe Country Club should be state of the art. This system should make wise use of the irrigation water. The Country Club currently is receiving all of its irrigation water from the Water Treatment Plant in the form of backwash waste water thus increasing the efficiency of water use and eliminating the need for a discharge permit. The raw water storage lagoons have a capacity of approximately 190,000 gallons. When it is drawn down to a specific level, the Country Club is no longer able to continue pumping. There are two pumps that have a pumping capacity of 1,500 gallons per minute but only one pump can be used at a time.

RUNOFF AND WATER RECYCLING:

Runoff from the parking areas should be shunted through vegetation and then ultimately to surface retention ponds. This captures and filters the runoff so that it may be used in irrigation. Water used in the daily cleaning and maintenance of the equipment should be run through a filtering system, polished, and used again.

EROSION CONTROL:

Bare soil is mulched to cut down on wind erosion. As previously mentioned, vegetation should also be used around the ponds to cut down on bank erosion as well.

TRANSITION ZONES:

The "transition zones" of habitat (or "edges" where maintained areas meet natural ones) are managed as "soft edges" with gradually increasing heights of vegetation. This maximizes the beauty of the golf course as well as the biodiversity of these areas. These transition zones are the outer edges of the No-Mow Zones along the creek corridor and along property boundary fences (See map)

SIGNATURES

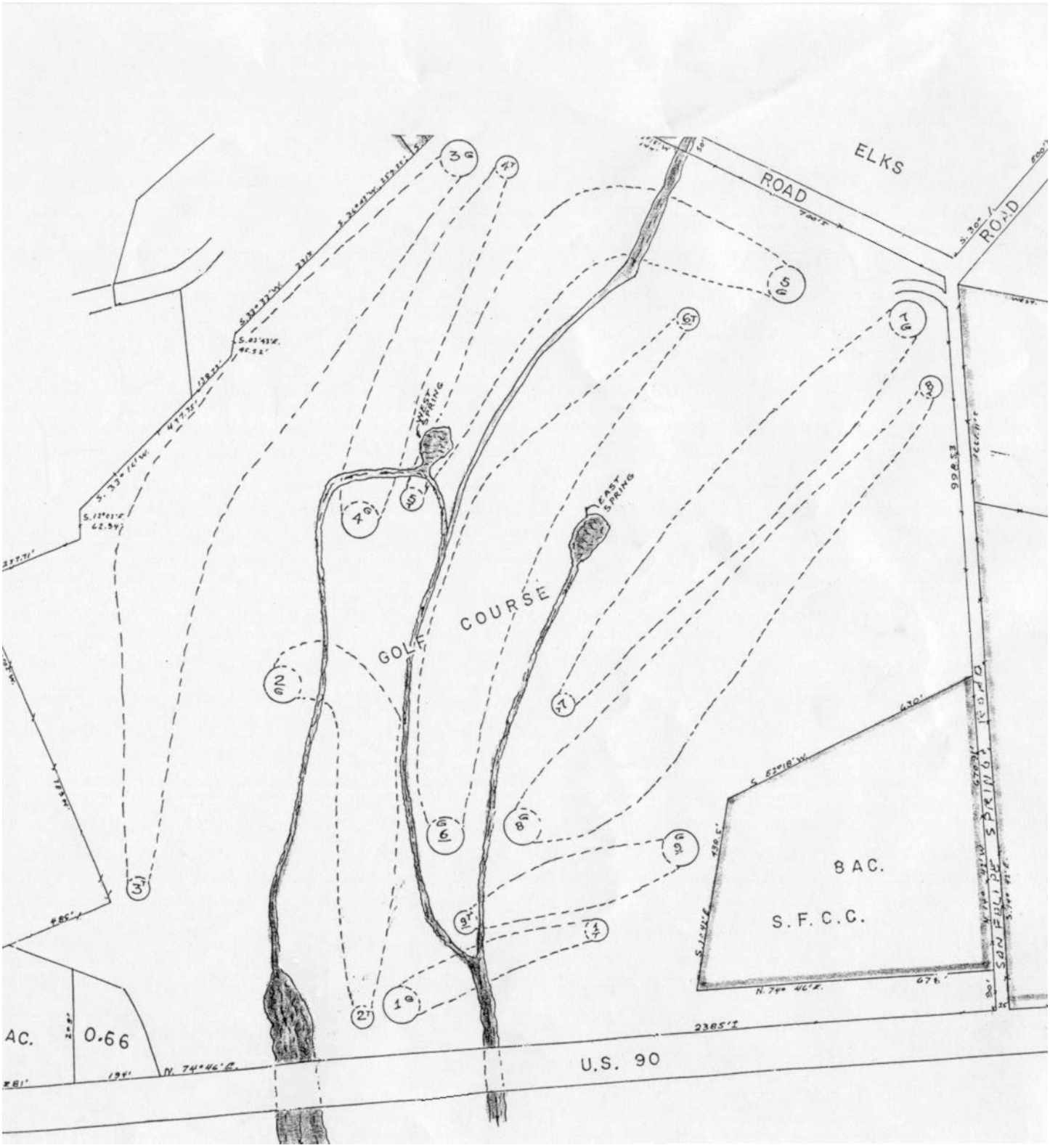
/s/ September 25, 2003

William D. Fritsch,
President, San Felipe Country Club

/s/ September 25, 2003

Andy Dayton
Golf Course Superintendent & Golf Pro

Map of San Felipe Country Club.



Appendix D

Comments on the Draft Recovery Plan and Responses

D.1 Public Review

A draft of this recovery plan was published and distributed for review by all interested parties. The Service published a notice in the Federal Register on February 23, 2005 (70 FR 8818-8819) that the document was available for public review and comment. The comment period lasted for 45 days and closed on April 11, 2005. We posted an electronic version of the draft recovery plan on the website of Region 2 of the Service. In addition, we also posted a fact sheet, questions and answers document, and a press release on the website that were available for review. We sent out by regular mail over 230 post cards to interested parties announcing the availability of the document. We distributed the press release to local news organizations. We mailed out several hard copies of the plan as requests were received.

D.2 Peer Review

Before the draft recovery plan was available, we asked seven individuals to serve as peer reviewers of the document. All agreed to participate, but five actually provided comments. The qualifications of the five peer reviewers and the requested focus of their review are provided in Table D-1.

Table D-1. Peer reviewers of the draft Devils River Minnow Recovery Plan.

Peer Reviewer	Qualifications	Focus of Review
Dr. Paul Holden	BIO-WEST, Inc., environmental consultants, Logan, Utah; long-time leader in research and conservation of western fishes; has served on many other recovery teams for aquatic species	Biology, Ecology, Recovery Strategy
Dr. Edith Marsh-Matthews	Assistant Curator of Fishes, Sam Noble Oklahoma Museum of Natural History, University of Oklahoma; Research biologist in stream ecology of freshwater fishes	Biology and Ecology
Dr. Tim Bonner	Assistant Professor, Department of Biology, Texas State University at San Marcos, research fisheries biologist	Biology and Ecology
Mr. Myron Hess, Esq.	National Wildlife Federation; attorney and policy specialist for water conservation in Texas; Project Partner, Texas Water Matters	Recovery Strategy, Water Planning
Mr. Tully Shahan, Esq.	Kinney County Attorney; member of Plateau Regional Water Planning Group; landowner on Pinto Creek; Director, West Nueces-Las Moras Soil and Water Conservation District; member, Texas Water Conservation Implementation Task Force	Implementation of Recovery Tasks

D.3 Public Comments Received

We received 10 responses during the comment period from interested parties. Of these, six provided substantive comments for which responses are included in the final recovery plan. The remaining four made no specific suggestion for changes to the draft plan. Of these four, three indicated support for recovery of the species, and one stated the Devils River minnow should be removed from the threatened species list.

D.4 Responses to Comments

Some comments were provided that were outside of the scope of the recovery planning process. For instance, some suggested changes in the listing status of the species (either to remove from the list or to list as endangered) or encouraged the Service to enforce other provisions of the ESA. Many suggested editorial changes to the text of the recovery plan, and the final recovery plan has been revised to incorporate many of these suggestions. The remaining substantive comments were taken into consideration in this final version of the Recovery Plan, and specific responses are provided below. Several of the comments were similar in nature and were combined and summarized for brevity. Comments are arranged into four categories based on the related topics of the comments: data quality, threats, recovery strategy, and recovery implementation.

D.4.1 Data Quality

D.4.1.1 *Comment:* The call in the Draft Recovery Plan for many studies points out the general lack of scientific information available on which to base this Recovery Plan.
Response: There are considerable knowledge gaps about the Devils River minnow and its conservation needs. Our mandate under the Endangered Species Act is to use the best available science to implement the programs for conservation of threatened and endangered species. While there is still much to be learned that will assist us to better manage the Devils River minnow, the basic threats to the species (water quantity, water quality, and non-native species) and general conservation needs (natural flows, clean water, and no non-native species) are obvious. Additional studies to fine-tune our understanding of the species and how it relates to its environment will allow us to better manage for its long-term survival.

D.4.1.2 *Comment:* With more sampling, Sycamore Creek may yield more fish (and at Mud Creek), and you may be pleasantly surprised by their abundance similar to recent findings at Pinto Creek.
Response: We agree that additional sampling in upstream areas of Sycamore and Mud creeks may find extant populations of Devils River minnow. The Recovery Plan calls for range-wide monitoring for the species to determine its status in locations such as this.

D.4.1.3 *Comment:* Clarify that much of the historic sampling was fairly limited in both time and samples; so as not to mislead readers on the amount of existing knowledge of the species.
Response: Changes were made to the Recovery Plan, Section 1.4, to more accurately reflect the historic efforts for sampling the species.

D.4.1.4 *Comment:* Research is needed on the specific tolerances and effects of various contaminants or water quality conditions on both individuals of Devils River minnows and on populations of the species (RA 1.3.2). It is unclear whether the Plan can assure that water pollutants can be curtailed to further minnow recovery.
Response: We agree that the research requested is needed to better understand how aquatic contaminants and water quality affect Devils River minnow. The Recovery Plan lays out a strategy for long-term conservation of the species by recommending actions that address the threats to the species. While there is no assurance that these actions will be taken, we believe that water pollutants can be controlled within the range of the species, depending on the willingness of local land and water managers (both rural and urban) to engage in watershed management practices that will maintain high quality groundwater and surface water. TCEQ has active programs aimed at protecting water from pollutants.

D.4.2 Threats

D.4.2.1 *Comment:* Brush encroachment across the watershed has also contributed to reduced spring flows. One way to enhance stream flow would be to eradicate some invasive cedar, willow, and mesquite forests in the watershed and along the Devils River itself.
Response: We support land management practices that strive for healthy, native vegetation communities across watersheds. We realize that healthy watersheds will produce natural hydrology for aquatic environments and conserve habitats for native aquatic organisms, like the Devils River minnow. We believe brush control projects must be well-planned and part of larger efforts to restore watersheds to support native natural resources. We have added language to the Plan in sections 1.7.1.2 (regarding threats to habitat) and 2.4 (Recovery Action 1.4.2, regarding watershed management).

D.4.2.2 *Comment:* TPWD introduced the smallmouth bass that decimated the Devils River minnow in many areas. The plan should disclose whether smallmouth bass are still being stocked by TPWD and whether other actions by this agency - especially those financed with Federal funds - are contributing to the harm of the Devils River minnow caused by smallmouth bass and other non-native fish.
Response: TPWD only stocked smallmouth bass into Amistad Reservoir in the early 1980s and have not stocked the species since that time. It is not known how the species traversed Dolan Falls and became established in the upper reaches of the Devils River. TPWD (or any other agency) does not stock any species considered to be harmful to the Devils River minnow. In addition, outdoor laboratory experiments and field studies have not provided evidence that smallmouth bass are particularly effective predators on Devils River minnow. It is still uncertain what effect smallmouth bass have on Devils River minnow.

D.4.2.3 *Comment:* No place can it be proved that the Devils River ran or is running from Beaver Lake to the confluence. Historic collections of Devils River minnows from this area were probably during intermittent stream flow. For all practical purposes, the Devils River begins at Pecan Springs.
Response: We agree that the Devils River begins at Pecan Springs. We appreciate the insight of comments from local landowners that shed light on the historical condition of area streams.

However, there is no empirical data to determine the historic extent of stream flows upstream of Pecan Springs. We do know that Devils River minnow were collected in the 1970s from Beaver Lake, well upstream of Pecan Springs. While this reach may have been flowing only temporarily, it would have likely had to sustain flows for considerable time for the species to be collected there. This suggests the range of the Devils River minnow was once farther upstream than it is today. Past time periods of drought and flooding have undoubtedly affected the extent of the flowing portion of the Devils River and the range of the Devils River minnow. This is part of the natural dynamic character of the river and the natural hydrologic regime for which the native fish community is adapted.

D.4.2.4 *Comment:* How do we know that areas dewatered are natural or not? Habitat and spring flow reductions are not the problem at this time, instead other threats may be of more importance. Information on the relationship between Devils River minnow and flow reduction is weak.
Response: Streams becoming dewatered in some areas are certainly a natural part of a natural hydrologic process resulting from droughts. In addition, most of the streams do not have adequate historic gauge records to conclusively determine a natural flow record and correlation to human-caused effects on flows. However, the fishes (and freshwater mussels in Las Moras Creek, see Howells [2003]) that once inhabited streams like Las Moras Creek would not have been able to survive dewatering, had it occurred as a natural phenomenon in the past. In addition, during prehistoric times if the fish were lost from a particular stream reach, there would likely have been opportunities for recolonization from other populations. This is very unlikely in present-day situation due to the fragmented habitat from dams. We know that drought does contribute to declining stream flow, however, groundwater pumping in excess of recharge also can contribute to declining spring flows and dewatering of otherwise perennial streams (Brune 1981). We do not know the specific effects of decreasing stream flows on the abundance of Devils River minnow. However, we are certain that if streams are dewatered, the species will not survive and is very unlikely to be naturally repopulated because their range is fragmented by dams. Other threats, such as water quality and non-native species, may be more important in affecting the species today. But the threat of complete dewatering of habitats is the most likely threat to result in complete loss of the species in the future.

Even natural events, such as droughts that lead to habitat loss, are considered in threatened and endangered species conservation. Often the effects of natural events on biological communities have a more serious effect on populations of rare species when coupled with other human-caused threats. For example, the effects of drought on spring flows may be much more detrimental when groundwater withdrawal for human needs is increased at the same time as the decrease in precipitation.

D.4.2.5 *Comment:* One landowner stated that he had observed obvious decrease of spring flow into Pinto Creek when irrigation wells in the Pinto Valley were pumping, indicating that any further groundwater withdrawal will have a direct, adverse impact on spring flows necessary to maintain adequate flows in Pinto Creek to support the Devils River minnow.
Response: The Service agrees that groundwater pumping can have direct effects on the quantity of spring flows and this activity is a considerable concern to the maintenance of Devils River minnow habitat.

D.4.2.6 *Comment:* The Service should consider whether minnow collection has factored in diminished populations in the wild.
Response: We do not believe that collection of Devils River minnow for scientific research and recovery purposes is a threat to the species. The number of individuals taken from the wild is a relatively small number. The Service limits researchers with valid recovery permits to a certain small number of voucher specimens they can remove from the wild during collection activities.

D.4.2.7 *Comment:* Add the Service as a responsible party for Recovery Actions #1.4.2 and #1.4.3. The Service has enforcement responsibilities under the ESA that are far broader than waiting until the dead bodies of the species are found before enforcement action is initiated. The Recovery Plan is one tool to exercise the Service's ESA authorities.
Response: We have added the Service as a responsible party for these two actions. The Recovery Plan does not, of itself, provided any enforcement responsibilities under the ESA. The Service can and will participate in proactive recovery efforts when our involvement is requested by State or local entities and our resources allow. Enforcement responsibilities of the Service would only be for projects involving a Federal action (ESA section 7 interagency consultation could occur) or where take of the species could occur (ESA section 9 prohibitions).

D.4.3 Recovery Strategy

D.4.3.1 *Comment:* The Recovery Plan is too vague and lacks descriptions of precise actions to be taken. For example, "restoring stream conditions," and "reducing pollutants," and "ensuring in-stream flows" are not sufficient to determine the actions needed to be accomplished for recovery. The Plan fails to adequately address these threats individually or cumulatively.
Response: The Recovery Plan is intended to be as specific as possible based on the best available science. Section 2.5, Control of Threats, is intended to explain how the specific recovery actions proposed in the plan relate to the recovery goals and criteria to reduce the threats to the species. In addition, Section 3.3, Implementation Schedule, includes a column that relates every proposed recovery action to a recovery criterion and one of the five listing factors that describe threats to the species. However, it is a challenge to prescribe detailed recovery actions when the exact remedies for the threats are not fully known. For example, we know that streams in urban environments are likely to become polluted and that human pollutants are destructive to natural aquatic environments. However, we do not know the intensity of water quality pollutants or their effects on the Devils River minnow because the data have not been collected. So in the absence of definite knowledge, we suggest the studies needed to better define these kinds of threats and general actions to reduce them. Any actions that serve to improve water quality would be helpful to alleviate this threat. Similarly, any actions that serve to maintain natural stream flows and protect aquatic habitats would be beneficial to the species' conservation.

The plan is intentionally broad in areas where we acknowledge uncertainty to allow flexibility for future work to determine what specific actions need to be taken to benefit the species. The Recovery Strategy (Section 2.2) outlines a perspective of adaptive management to adjust the strategy as additional information is gained (Section 2.2.7, Apply Adaptive Management). The implementation of many of the recovery actions designed to study the Devils River minnow and the threats to its existence, will continue to build on the foundation of science to construct new

and creative ways to conserve the species and its ecosystem. We believe the plan's flexibility is actually beneficial by making it a living document that can integrate future novel conservation methods among potential partners in recovery implementation.

D.4.3.2 *Comment:* The recovery strategy is too general and proposes everything you would ever want to know about a species. Instead, the plan needs to focus on the limiting factors and correcting them. These factors broadly include loss of habitat, generally stream flow, and loss of recruitment.
Response: We believe it is prudent to take a broad approach to the recovery strategy when there is considerable uncertainty regarding the species and its habitats. While the broad factors limiting the population are known, the detailed specific needs for recovery can not be predicted without first conducting the scientific studies upon which to base management recommendations. It would not be prudent to eliminate the recommendation for much additional scientific investigation without a higher degree of certainty about the limiting factors for the species. Instead, we have attempted to focus on the highest priority needs through ranking the recovery actions in a logical fashion. This is intended to emphasize those actions, including identifying and correcting limiting factors and reducing the most imminent threats.

D.4.3.3 *Comment:* Recovery Criterion 3, regarding protection of water quality, seems unduly narrow to focus only on surface water. The need for protection of groundwater quality should be included as well.
Response: We concur, and changes were made to the plan accordingly. The protection of groundwater quality in formations that support stream flows in the range of the Devils River minnow is also an important consideration in the overall conservation of habitat for the species.

D.4.3.4 *Comment:* A very intense monitoring program, monthly or at least seasonally rather than annually, is needed—both monitoring Devils River minnow and potential limiting factors, such as stream flow, water quality, etc. Suggest raising Recovery Action 1.1.1 up to priority level 1a.
Response: We agree that more work needs to be done to better monitor the species and determine population relationships to the physical environment. However, these efforts are limited by the availability of resources to conduct such monitoring and detailed studies. The information we have regarding the Devils River minnow has largely been obtained through ongoing efforts by the TPWD and small Federal and private grant funding. Ideally, future habitat use studies will produce the necessary information to allow more precise recovery criteria and actions to be proposed. Very little information is available on the early life history, recruitment, and survivorship of the species in the wild. We agree this information could prove to be critical in the strategy for recovery of the fish. Monitoring is a critically important part of the recovery, however, it does not meet the definition of a priority task of 1a, therefore, the current priority of 1b was maintained.

D.4.3.5 *Comment:* The Plan needs a strong commitment to understand recruitment and the factors that limit recruitment. Much of 1.2, Biological and Life History Requirements, should be replaced by determining population level limiting factors. Suggest raising Recovery Actions 1.2.4 up to priority level 1a.
Response: We agree that investigations into limiting factors and, specifically, recruitment strategies of the fish, are important endeavors and may lead to better management options. In

response to this comment we have raised Recovery Action 1.2.4 from priority level 3 to 2. We do not believe it meets the definition of a priority 1a or 1b action. It would be premature at this time to eliminate the other recovery tasks for basic biological research. These actions are considered a lower priority and we agree that other actions should be completed first.

D.4.3.6 *Comment:* The plan understates the potential for the Kinney County Groundwater Conservation District to contribute to protection of the Devils River minnow.
Response: We concur and changes were made to the Plan to incorporate language that reflects the groundwater management authority of the Kinney County Groundwater Conservation District. We believe it is through cooperation of the District and other local entities that habitats for the Devils River minnow can be conserved.

D.4.3.7 *Comment:* Why were there no water users on the recovery team?
Response: The Rio Grande Fishes Recovery Team oversees recovery planning for seven listed fish species in New Mexico and Texas. Therefore, the Team covers a wide range of areas and interests and it is not feasible to have stakeholders from each different area participate directly as Team members. However, the Team does seek consultants from a wide range of interests from Federal and state agencies and private interests. Input from individual stakeholders was sought early in the process for recovery planning for the Devils River minnow from those who participated in the Devils River Minnow Conservation Agreement. These stakeholders included landowner representatives from Val Verde and Kinney counties and the City of Del Rio. The Service is committed to working collaboratively to build partnerships for the implementation of this recovery plan and does not limit these partnerships to Recovery Team members.

D.4.3.8 *Comment:* Suggest we leave Mexico out of the equation. Let their scientists prepare separate reports and findings using their money.
Response: The Service does not have any regulatory responsibilities for the Devils River minnow in Mexico. However, we must use sound conservation biology principles in our approach to ensuring the species does not go extinct. We feel it is important to plan for future research of the populations of the fish in Mexico and recognize the potential need for conservation of the fish there. We envision this will include working cooperatively with colleagues in Mexico and encouraging partners in Mexico to work on conservation of the species there.

D.4.4 Recovery Implementation

D.4.4.1 *Comment:* Reintroduction into Las Moras Creek seems rather far reaching unless you find a way to keep the spring flowing. Las Moras Spring ceased flowing in the 1980s also. There is uncertainty about whether chlorination of the swimming pool led to the loss of Devils River minnow or whether it was due to lack of spring flow. Withdrawal of groundwater will continue to influence Las Moras Spring flow. Discussion is occurring about exporting thousands of acre-feet of water from the supporting aquifer.
Response: We agree that to restore the Devils River minnow into Las Moras Creek long-term, we must have some assurance that local groundwater management is in place to ensure that the spring that supports the creek will remain flowing. The Recovery Plan anticipates that the Kinney County Groundwater Conservation District will implement groundwater conservation

plans to accomplish this important recovery strategy in Kinney County for Las Moras Creek. We agree that the loss of the fish from Las Moras Creek may have been due to the loss of flows from the spring. However, chlorine is harmful to aquatic life, and large, repeated input of chlorine into Las Moras Creek is not recommended for water quality maintenance.

D.4.4.2 *Comment:* Establishing additional Devils River minnow populations depend on numerous factors and may not be feasible. The goal is worth pursuing because efforts to reestablish populations will result in improved habitat for all fishes in the target streams. Preservation of genetic diversity through protection of all known populations will be essential for reintroduction (if feasible).
Response: We agree this aspect of the Recovery Plan to establish a new population at Las Moras Creek will be particularly challenging. But based on the best available information we believe it is a necessary action to ensure the long-term viability of the species. We also agree that, in the absence of genetic data and because the few existing populations are small, isolated with localized threats, and vulnerable to loss from random events (for example, droughts, floods, or diseases), we should continue to conserve all known populations of the Devils River minnow.

D.4.4.3 *Comment:* Concerned about funding the project (for restoration of Devils River minnow to Las Moras Creek) on a local basis. Taxpayers of Kinney County would not have the funds or be in favor of this issue. The cost of reestablishing Devils River minnow habitat (channel modification) is not mentioned in the Plan. Reestablishment will stop development and drive up cost of building due to need for Environmental Impact Statements and permits.
Response: Reestablishing Devils River minnow in Las Moras Creek is an important goal of the Recovery Plan. The species has such a restricted natural range, which is now reduced and fragmented, that restoring this population is important to ensuring the species long-term viability. The more populations we can conserve, the lower the overall risk of extinction of the species. However, we are not certain that such an effort is feasible, either biologically, because the species might not persist there if reintroduced, or practically, local support would not be in favor of such a project. The Service would not carry out such a project without the full support of state and local governmental authorities. In addition, any costs associated with this project would most likely be born by Federal and state agencies. Local taxpayers would not be required to pay for such a project, although voluntary cost-sharing by providing in-kind services from a nonfederal entity is a possibility. If the fish were proposed for reintroduction, it would likely be through a program of the Fish and Wildlife Service that reduced the potential for regulatory burdens on the local community. For example, we may be able to implement a Safe Harbor Agreement or designate the population as nonessential, experimental under section 10(j) of the ESA.

D.4.4.4 *Comment:* Many measures depend on non-federal, voluntary actions and there are no assurances these steps will actually be taken. The plan should disclose whether Federal agency actions or the use of Federal funds (for example, Corps of Engineers' permitting) are contributing to the imperilment of minnows via lowered instream flows or lower water quality.
Response: We are not aware of any Federal actions or funds that are contributing to the threats to Devils River minnow at this time. It is true that the recovery of this species is largely dependent upon the voluntary actions of local entities to accomplish recovery. While there is no assurance that voluntary actions will be taken, recovery for the species is not mandated by the ESA and is dependent on voluntary participation of various stakeholders. With the appropriate coordination

and communication, we believe that recovery can be achieved through the voluntary actions of our partners. The Service has a variety of programs available to assist State agencies and local communities achieve recovery successes, including funding grants, technical support and local agreements.

D.4.4.5 *Comment:* Suggest the Service establish temporary, minimum spring flow amounts for each stream that is inhabited by the Devils River minnow, below which "take" of the species or irreparable destruction of critical habitat will likely occur.
Response: Adequate biological and hydrological information is not available upon which to base specific flow recommendations for the conservation of the species. The Service recognizes that more information is needed to make management recommendations for instream flows and Recovery Actions under heading "1.3 Identify specific habitat preferences," in the Recovery Action Outline, are intended to collect just such information. Critical habitat is not designated for the Devils River minnow.

D.4.4.6 *Comment:* The Plan backs away from recommending prohibition on the release of exotics in minnow streams because they would be "impractical." This could lead to the extinction of the minnow. Another commenter indicated uncertainty about whether bait fish released on fishing trips has affected the environment, but indicated it is a consideration.
Response: We agree that bait fish released into Devils River minnow habitat are a concern. However, we believe the regulations TPWD have put in place are a reasonable attempt to control this threat. Only selected non-native species are allowed for legal use as live bait. These species have been used in this area for decades and have not shown to be a detriment to the natural environment.

D.4.4.7 *Comment:* The 10-year timeframe for recovery is overly optimistic.
Response: In estimating the time needed for recovery, we make the most optimistic estimate assuming resources will be available and partners will be willing to cooperate in the implementation of the Recovery Plan. Obviously without adequate funding and assistance from partners, recovery will take longer. Since we do not know when these will be available, we give the most optimistic timeframe that recovery would be possible if these resources were available to implement the plan as outlined.

D.4.4.8 *Comment:* Increase in the number of Devils River minnows collected in the Devils River over the last 5 years proves that cooperation between USFWS, TPWD and landowners can be compatible and accomplish goals.
Response: We agree that collaboration and cooperation are the key factors in the future success of conserving the natural environment and recovering the Devils River minnow.

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