

# CONCHO WATER SNAKE RECOVERY PLAN



U.S. Fish and Wildlife Service  
Region 2  
Albuquerque, New Mexico  
1993

CONCHO WATER SNAKE  
RECOVERY PLAN

Prepared by:

Concho Water Snake Recovery Team

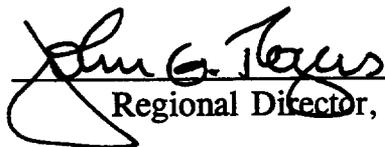
and

U.S. Fish and Wildlife Service  
Ecological Services Field Office  
Austin, Texas

for

U.S. Fish and Wildlife Service  
Region 2  
Albuquerque, New Mexico

Approved:



Regional Director, U.S. Fish and Wildlife Service

Date:

SEP 27 1993

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## LITERATURE CITATIONS

Literature citations should read as follows:

U.S. Fish and Wildlife Service. 1993. Concho Water Snake Recovery Plan. Albuquerque, New Mexico. vii + 66 pp.

## AVAILABILITY

Additional copies may be purchased from: Fish and Wildlife Reference Service  
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The fee for Recovery Plans varies depending on the number of pages.

## ACKNOWLEDGMENTS

Much information and current research presented in this plan is in progress, being developed for reports and/or publication, or otherwise unpublished. Individuals contributing this information include: Dr. James Dixon, Dr. Jack Sites, Dr. Lew Densmore, Mr. James Mueller, Mr. Martin Whiting, and Ms. Carol Malcolm.

## EXECUTIVE SUMMARY OF CONCHO WATER SNAKE RECOVERY PLAN

Current Species Status: The Concho water snake is listed as threatened. Presently, it occupies about 400 river-km in the Colorado-Concho River system in central Texas. It is vulnerable to habitat loss in the form of decreased stream flows, sedimentation, and vegetation encroachment.

Habitat Requirements and Limiting Factors: The Concho water snake requires an adequate and accessible fish prey base, shallow riffles and rapids with rocky cover, dirt banks, rocky shorelines, woody vegetation near the river and adequate stream flows (both continuous and periodic flushing flows).

Recovery Objective: Delisting.

Recovery Criteria: The Concho water snake will be considered for delisting when: (1) adequate instream flows are assured and (2) stable, viable populations occur in all three main reaches of the snake's range. These reaches are the Colorado River above Freese Dam, Colorado River below Freese Dam, and the Concho River. Additionally, movement of an adequate number of Concho water snakes must also be assured, as long as O.H. Ivie Reservoir exists, to counteract the adverse effects of population fragmentation.

### Actions Needed:

1. Protect stream flows in Colorado and Concho Rivers.
2. Monitor and evaluate populations and habitats rangewide.
3. Eliminate or reduce threats to populations, including habitat degradation, through a combination of consultation, permitting, and cooperative programs.
4. Reintroduce the Concho water snake into suitable habitat in historic range.
5. Maintain gene flow among the three nearest neighbor populations isolated by O.H. Ivie Reservoir.

Total Estimated Cost of Recovery: Costs (Dollars times 1000):

<u>Year</u>	<u>Priority 1 Tasks</u>	<u>Priority 2 Tasks</u>	<u>Priority 3 Tasks</u>	<u>Total</u>
1994	53.0	187.0	35.0	275.0
1995	53.0	170.0	35.0	258.0
1996	53.0	163.0	11.0	227.0
1997	53.0	161.0	11.0	225.0
1998	53.0	161.0	11.0	225.0
1999	53.0	161.0	11.0	225.0
2000	53.0	168.0	11.0	232.0
2001	53.0	161.0	11.0	225.0
2002	53.0	161.0	11.0	225.0
2003	53.0	161.0	11.0	225.0
2004	50.0	129.0	11.0	190.0
2005	50.0	136.0	11.0	197.0
<hr/>				
<u>Total</u>	630.0	1,919.0	180.0	2,729.0

Date of Recovery: Current requirements for delisting should be met by 2005, assuming full implementation of this plan.

## Table of Contents

Concho Water Snake Recovery Team	i
Disclaimer	ii
Literature Citations	ii
Availability	ii
Acknowledgments	ii
Executive Summary	iii
Table of Contents	v
List of Figures	vi
Abbreviations and Acronyms Used in Recovery Plan	vii
I. Introduction	1
A. Legal Status, Critical Habitat, and Recovery Priority	1
B. Description	4
C. Historic Distribution	6
D. Present Distribution	9
Colorado River Drainage	9
Concho River Drainage	12
E. Habitat Description	14
Riverine Habitat	14
Lake Habitat	15
Hibernation Sites	17
Vegetation	17
F. Ecology and Life History	18
Activity	18
Feeding	19
Reproduction	20
Growth and Maturity	20
Population Structure	21
Population Viability	21
Predators	21
G. Genetic Population Structure	23
H. Threats	25
I. Conservation Measures	28
Monitoring	28
Habitat Restoration	29
Instream flows	29
Studies	29
J. Recovery Strategy	31

II.	Recovery	33
	A. Objectives	33
	B. Recovery Criteria	33
	C. Recovery Outline	35
	D. Recovery Narrative	37
	E. Literature Cited	43
III.	Implementation Schedule	48
	Recovery Task Priorities	48
	Key to Acronyms used in Implementation Schedule	49
	Implementation Schedule	50
IV.	Appendices	52
	A. List of Commenters	52
	B. Summary of Comments and Fish and Wildlife Service Response	53
	C. Monitoring Plan for the Concho Water Snake	64

List of Figures

1.	Critical habitat of the Concho water snake	2
2.	Concho water snake distribution before 1987	7
3.	General map of area with CRMWD monitoring sites	8
4.	Current riverine distribution of the Concho water snake	10
5.	Current distribution of Concho water snakes in lakes	11
6.	Hibernacula of Concho water snakes from Dixon et al. 1989	16
7.	Concho water snake habitat monitoring program data sheet	66

## Abbreviations and Acronyms Used in Recovery Plan

cfs = cubic feet per second

cm = centimeter

CRMWD = Colorado River Municipal Water District

CRP = Conservation Reserve Program

CWA = "Clean Water Act" = Federal Water Pollution Control Act, as amended

DNA = deoxyribonucleic acid, a molecule that stores genetic information

ES = Ecological Services

ESA = Endangered Species Act of 1973, as amended

FIFRA = Federal Insecticide, Fungicide, and Rodenticide Act, as amended

FM = Farm to Market Road

FR = Federal Register

IFIM = Instream Flow Incremental Methodology

in = inch

km = kilometer

LCRA = Lower Colorado River Authority

LE = Law Enforcement

m = meter

mi = mile

MOA = Memorandum of Agreement, here between USACE, USFWS, and CRMWD

msl = mean sea level

mtDNA = mitochondrial DNA

NEPA = National Environmental Policy Act

PHABSIM = Physical Habitat Simulation Program

PIT = passive integrated transponder

PVA = population viability analysis

RPA = random primer amplification

SCS = Soil Conservation Service

SVL = snout-vent length

TAC = Texas Administrative Code

TPWD = Texas Parks and Wildlife Department

TWC = Texas Water Commission

UCRA = Upper Colorado River Authority

USACE = U.S. Army Corps of Engineers

USEPA = U.S. Environmental Protection Agency

USFWS = U.S. Fish and Wildlife Service, also shortened to Service

USGS = U.S. Geological Survey

WUA = weighted usable area

## I. INTRODUCTION

### A. Legal Status, Critical Habitat, and Recovery Priority

The State of Texas listed the Concho water snake (*Nerodia harteri paucimaculata*) as endangered on July 18, 1977 (31 TAC section 65.181-65.184). On September 3, 1986, the U.S. Fish and Wildlife Service (USFWS) listed the Concho water snake as threatened (51 FR 31412).

Critical habitat was designated by the USFWS on June 29, 1989 (54 FR 27377) (Figure 1). Critical habitat consists of the following three areas:

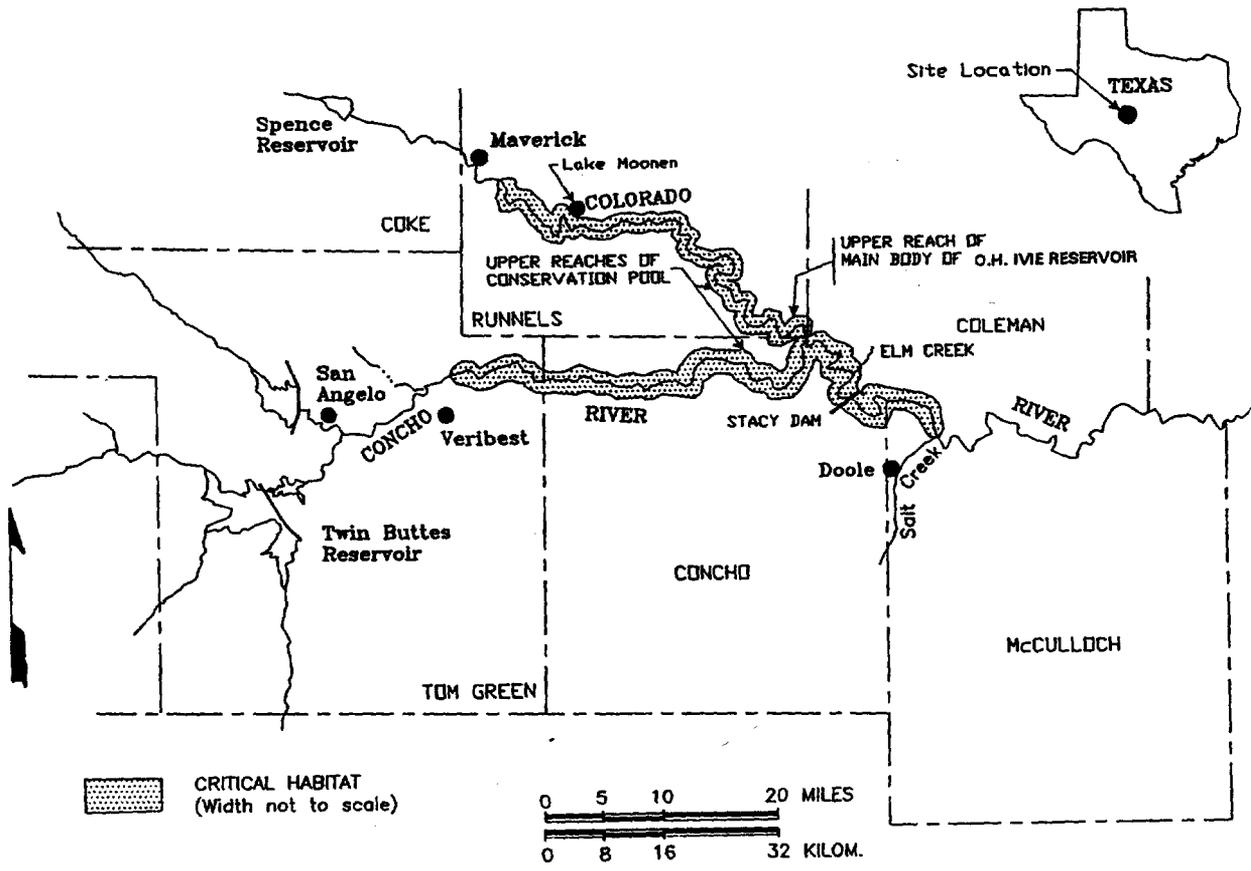
1. Concho River in Tom Green and Concho Counties, Texas. A stretch extending from Mullin's Crossing located 5 miles northeast of the town of Veribest, downstream to the confluence of the Concho and Colorado Rivers.

2. Colorado River in Runnels, Concho, Coleman, and McCulloch Counties, Texas. A stretch extending from the Farm to Market Road (FM) 3115 bridge near the town of Maverick downstream to the confluence of the Colorado and Salt Creek, northeast of the town of Doole.

Both stretches include both the river channel and the river bank up to 15 vertical feet above the water level at median discharge. However, the critical habitat is limited to no more than ½ mile upstream on any tributaries of either the Concho or Colorado Rivers.

3. The entire O.H. Ivie (formerly Stacy) Reservoir basin up to the maximum water level of 1551.5 foot elevation msl, including reservoir banks up to 15 vertical feet above the 1551.5 foot elevation.

The characteristics of these areas that are needed by the Concho water snake are known as the constituent elements. The constituent elements important to the survival of viable Concho water snake populations include: "shallow riffles and rapids with rocky cover, minimum stream flows, dirt banks, rocky shorelines, and woody riparian vegetation. Minimum flows include the following:



**FIGURE 1**

**CRITICAL HABITAT OF THE  
CONCHO WATER SNAKE  
(see text for explanation)**

(a) a continuous, daily flow of 10.0 cubic feet/second (cfs) in the Colorado River from E.V. Spence Reservoir to Ballinger, Texas;

(b) a flushing flow of 600 cfs from E.V. Spence Reservoir for a duration of 3 consecutive days (at any time during the months of November through February), at least every other year for channel maintenance;

(c) a continuous, daily minimum flow of 11.0 cfs in the Colorado River between Stacy [Freese] Dam and Pecan Bayou between April and September each year, and a minimum of 2.5 cfs between October and March of each year; and

(d) flushing flows of 2500 cfs from Stacy [O.H. Ivie] Reservoir for 2 consecutive days at least once every 2 years for channel maintenance."

The USFWS has developed guidelines for assigning priorities to the development and implementation of recovery plans for listed species (48 FR 43098). The recovery priority of the Concho water snake is 9C, indicating that it is: (1) taxonomically, a subspecies; (2) facing moderate degree of threat; (3) rated high in terms of recovery potential; and (4) in conflict with construction or other development project(s) or other forms of economic activity. Because the Concho water snake was the subject of a consultation pursuant to section 7 of the ESA that resulted in a jeopardy biological opinion (with "reasonable and prudent alternatives"), it is assigned to the conflict category. The USFWS regularly reviews the taxonomy, threats, recovery potential, and degree of associated conflict(s) and may change the recovery priority based on that review.

## B. Description

The Concho water snake (*Nerodia harteri paucimaculata*), a nonvenomous (nonpoisonous) snake, is a member of the family Colubridae. With the Brazos water snake (*Nerodia harteri harteri*), it constitutes the species *Nerodia harteri*, collectively known as Harter's water snake.

Harter's water snake was described in 1941 from the Brazos River drainage of north-central Texas (Trapido 1941). Shortly thereafter, John Marr discovered a disjunct population in the South Fork of the Concho River, a tributary of the Colorado River in west-central Texas (Marr 1944). Subsequently, Donald Tinkle and Roger Conant (1961) described the Colorado and Concho River populations as a distinct subspecies, *N. h. paucimaculata* (Concho water snake). The Brazos River population was described as the subspecies *N. h. harteri* (Brazos water snake).

The Concho water snake is characterized by a small size relative to most other water snakes. Adults rarely exceed 1 meter (m) (39 in) total length. It has four rows of alternating dark-brown spots/blotches on its back, two rows on each side (Conant and Collins 1991). The coloration on its back has been compared to a checkerboard of dark-brown spots on a gray, brown, or reddish-brown background. The Concho water snake has a light-colored (often pinkish or orange) ventral surface (belly) that is unmarked or has laterally placed spots, which are usually somewhat indistinct (Wright and Wright 1957; Conant and Collins 1991; Tennant 1984, 1985; Rose and Selcer 1989). For more information describing the subspecies and species as a whole, see Tinkle and Conant (1961), Mecham (1983), Scott et al. (1989), Rose and Selcer (1989), Rose (1989), Conant and Collins (1991), and Densmore et al. (1992).

The Concho water snake is easily distinguished from the other two species of water snakes in its range. The blotched water snake (*N. erythrogaster transversa*) has three rows of dark blotches on the dorsal surface (back). Adult diamondback water snakes (*N. rhombifer*) and blotched water snakes are larger and have darker dorsal patterns and yellow or cream-colored bellies. The diamondback water snake has a black chain-like dorsal pattern. The blotched water snake has three series of large squarish blotches on the back and sides when young. These change to a series of dorsal crossbars in young adults. Large blotched water snakes are dark and may appear to lack markings.

Compared to the Brazos water snake, the Concho water snake usually: (1) is more reddish; (2) has less prominent dorsal spots; (3) has less conspicuous dark dots on the belly; and (4) has a single row of scales between the posterior chin shields (Conant and Collins 1991). The Brazos water snake usually has two rows of small scales between the posterior chin shields (Conant and Collins 1991).

Tinkle and Conant (1961) regarded the differences in color patterns and scale characters between the Brazos water snake and the Concho water snake to be consistent with a subspecific level of divergence and described them as separate subspecies. More recently, Rose and Selcer (1989) have maintained that they are distinct at the species level. Their conclusion was based on what the authors regarded as "substantial meristic differences . . . and the fact that similar differences between other closely-related *Nerodia* populations have been deemed sufficient for specific status . . ." (Rose and Selcer 1989). The Colorado-Concho and Brazos River basins may have been separated since the Miocene (between 25 and 7 million years before present) (Rose and Selcer 1989). Densmore et al. (1992) have argued that the Concho water snake is a distinct species based, in part, on its geographic isolation and fixed differences in genetic markers. Rose and Selcer (1989) and Densmore et al. (1992) advocate the use of the scientific name *Nerodia paucimaculata* for the Concho water snake.

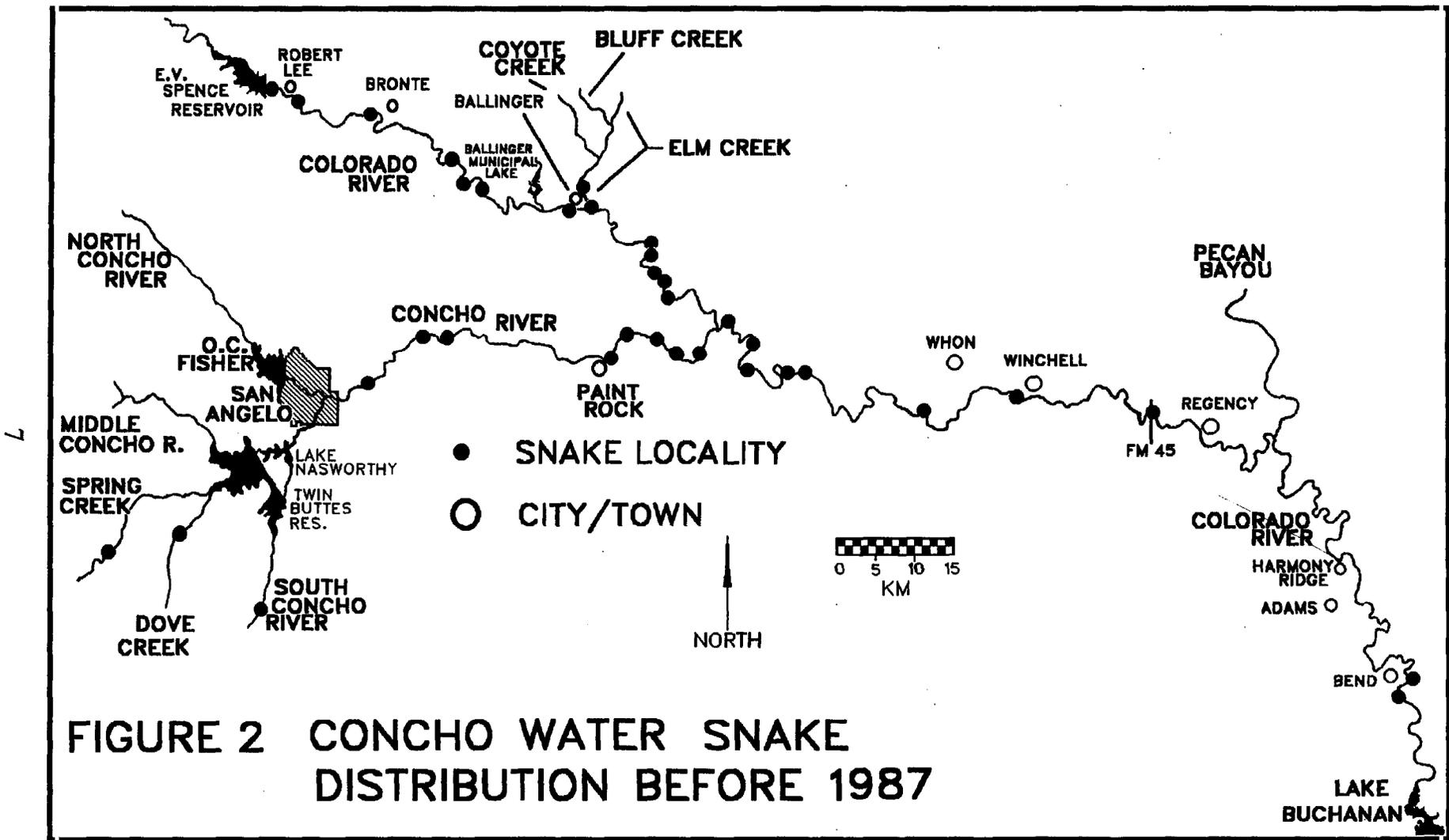
### C. Historic Distribution

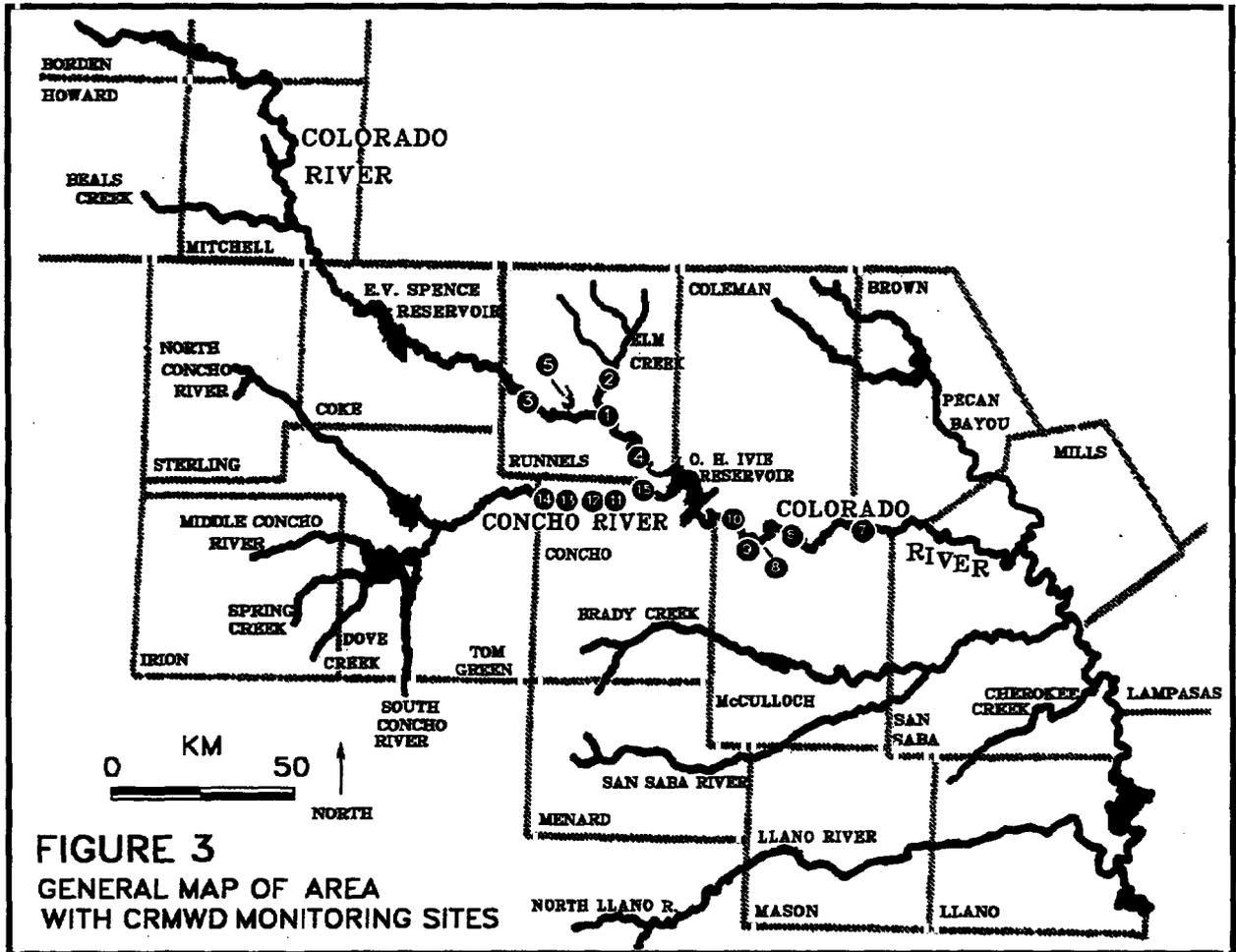
The Concho water snake was first collected from the South Concho River and Dove Creek, which are tributaries to the Concho River west of San Angelo, Texas (Marr 1944, Tinkle and Conant 1961) (Figures 2 and 3). When the subspecies was described in 1961, these records and the type locality on the Colorado River south of Robert Lee, Coke County, were the only known localities. The historic distribution based on collection sites (before 1987) of the Concho water snake is presented in Figure 2.

Mecham (1983) summarized the distribution of the Concho water snake based on unpublished records and a few museum records available at that time. The uppermost records in the Concho River drainage were the Dove Creek and South Concho localities. The uppermost record for the Colorado River was the type locality near Robert Lee. Downstream, Concho water snakes were known to occur as far as Gorman Falls near Bend, San Saba County (Mecham 1983). The distribution between these end points was poorly known. Dixon (1987) added several county records supported by specimens. Rose (1989) found the Concho water snake (about 1985) above San Angelo on Spring Creek, a tributary to Twin Buttes Reservoir, near Mertzon, Irion County.

The Concho water snake may have been more widely distributed, but E.V. Spence (Spence) Reservoir upstream and Lake Buchanan downstream have inundated many kilometers of riverine habitat at both ends of the current range. Spence's location may have coincided with the margin of the snake's distribution at the time of construction (1968). While snakes were not known from Spence for a number of years after its construction, a population was discovered there in 1987 (Thornton and Dixon 1988).

The Concho water snake's probable historic range, at a minimum, included the Colorado River from Spence Reservoir downstream to the vicinity of Lake Buchanan, Elm Creek (a tributary of the Colorado River) and its tributaries, Bluff and Coyote Creeks, all in Runnels County, and the entire Concho River (Tom Green and Concho Counties) and its headwater tributaries, Dove Creek, Spring Creek, and the South Concho River in Irion and Tom Green Counties.





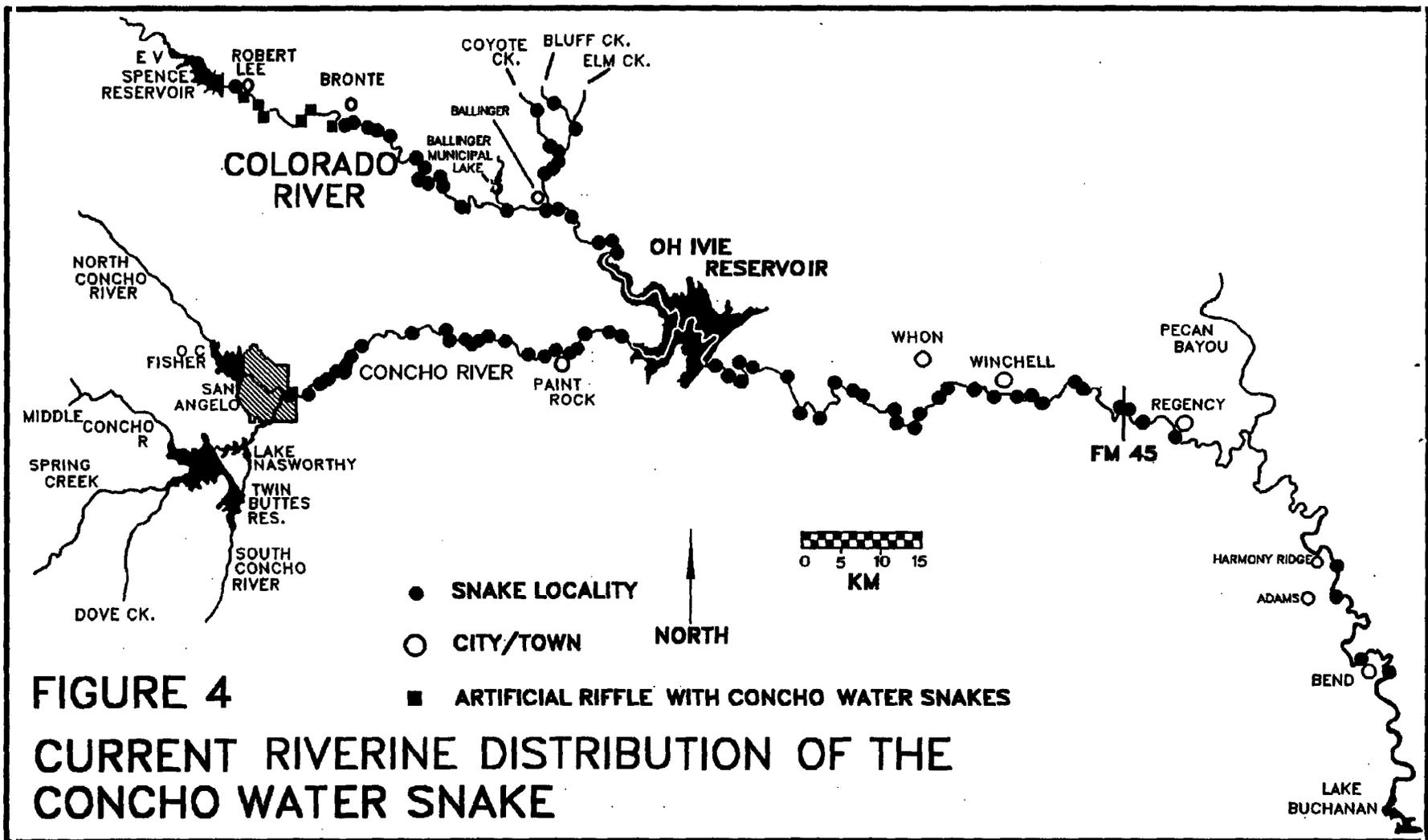
#### **D. Present Distribution**

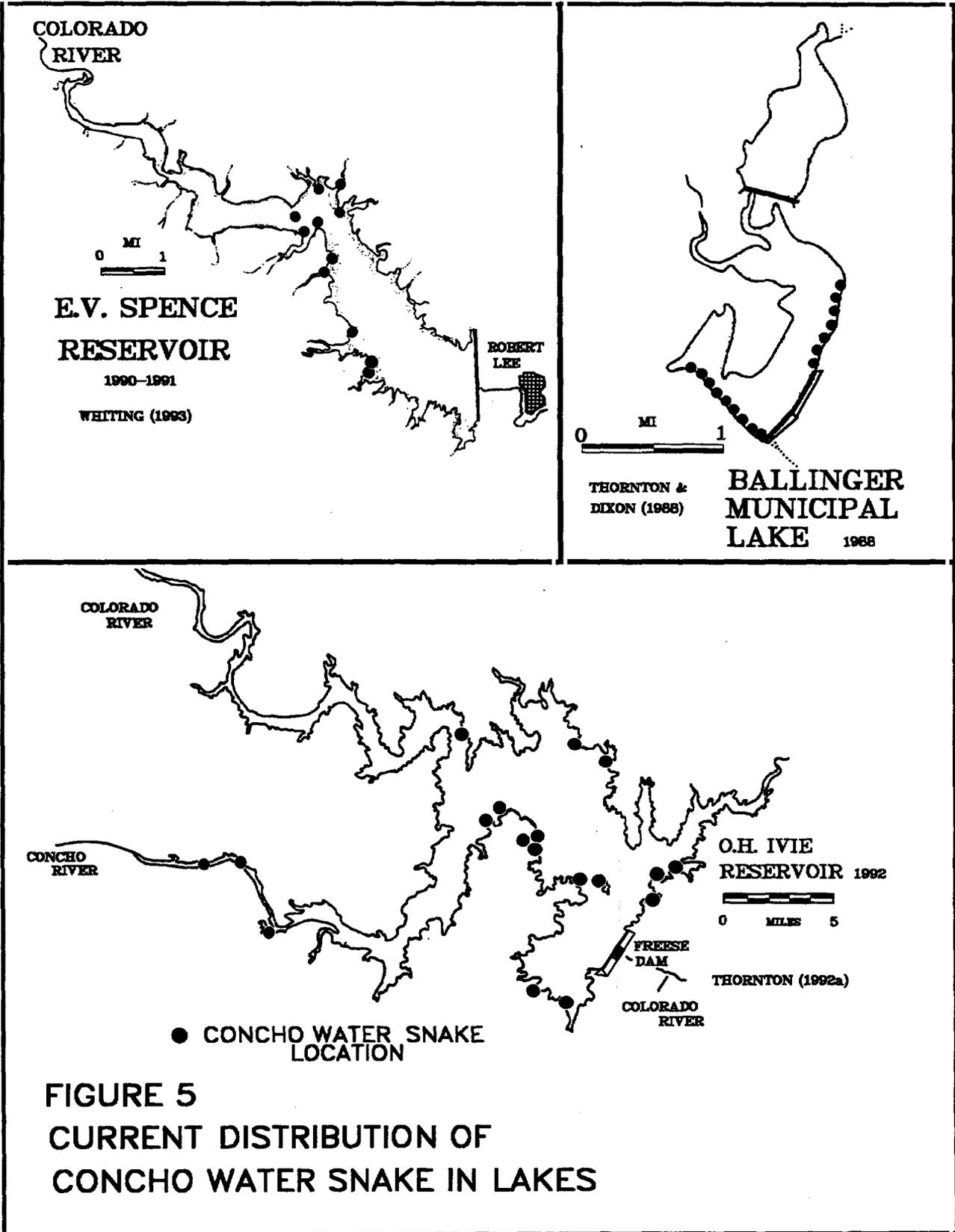
Presently, the known distribution of the Concho water snake includes the following counties: Brown, Coke, Coleman, Concho, Lampasas, McCulloch, Mills, Runnels, San Saba, and Tom Green.

Scott et al. (1989), Thornton (1992a), and Whiting (1993) have summarized what is essentially the current distribution of the Concho water snake (Figures 4 and 5). Their data show relatively continuous occupation of riverine habitat of the Colorado River below the town of Bronte, Coke County, of Elm, Coyote, and Bluff creeks below Winters, Runnels County, and of the Concho River from San Angelo, Tom Green County, downstream to its confluence with the Colorado River, and thence downstream to the vicinity of FM 45 bridge over the Colorado River in Mills and San Saba counties, a distance of about 375 river-km (233 river-miles). Lake populations that appear to be isolated were found in E.V. Spence Reservoir and Ballinger Municipal Lake (formerly Lake Moonen). Somewhat disjunct riverine populations occur along the Colorado River near the towns of Regency, Harmony Ridge, Adams, and Bend (all above Lake Buchanan). Although a recently collected specimen from Spring Creek above San Angelo exists (Rose 1989), the continued presence of a population there has not been confirmed despite several searches (James R. Dixon, Texas A&M University, personal communication, 1991).

**Colorado River Drainage** - The aquatic habitat above Spence Reservoir has been drastically altered by three large reservoirs: Lake Colorado City, Champion Creek Reservoir, and Lake J.B. Thomas. Because of recurring periods of little precipitation, there are long periods of time when no water is released downstream from the reservoirs. Tributaries that have been surveyed include Champion Creek, which is impounded, and Beals Creek (Scott et al. 1989). Immediately above Lake Thomas, Borden County, on the Colorado River proper, the riverbed is an arid wash. Here the river is dry for too long during the year to support water snake populations (Scott et al. 1989).

Early studies found Concho water snakes to be abundant just below the town of Robert Lee, Coke County (Tinkle and Conant 1961, Williams 1969). The construction of Robert Lee Dam (impounding E.V. Spence Reservoir), about 4-km upstream from the site, has altered the Colorado River near Robert Lee, such that neither Brnovak (1975)





**FIGURE 5**  
**CURRENT DISTRIBUTION OF**  
**CONCHO WATER SNAKE IN LAKES**

nor Scott et al. (1989) were able to find Concho water snakes in the Colorado River any farther upstream than the vicinity of Bronte, Coke County, which is about 27 river-km (17 river-miles) below Robert Lee. However, an isolated population was found along 24 km (15 miles) of shoreline at E.V. Spence Reservoir (Figure 5), which has about 220 km (137 miles) of shoreline at conservation pool level (Scott et al. 1989). Concho water snakes have been found at all six recently (1989) constructed artificial riffles in the 27 km (17 mile) stretch between Robert Lee Dam and Bronte (Thornton 1991) (see Figure 4 and Section I, **Conservation Measures** for a discussion of the artificial riffles ).

In the Colorado River below Bronte, Concho water snake populations appear to be fairly continuous to about the FM 45 bridge upstream from the mouth of Pecan Bayou, Mills County, a distance of about 256 river-km (159 river-miles). Concho water snakes occur in Elm, Coyote, and Bluff Creeks, in Runnels County. Concho water snakes are found in recently (1984) created Ballinger Municipal Lake (formerly Lake Moonen), formed by an impoundment on Valley Creek (Figure 5). Concho water snakes are scattered in the 129 river-km (80 river-miles) between the FM 45 bridge over the Colorado River and Bend, San Saba County. Despite several searches of this reach of the Colorado River, Concho water snakes have been found only in two localities near Regency and two localities near Harmony Ridge and Adams (Figure 4). However, this area should be surveyed again during conditions when snakes would be most likely to be detected. The Concho water snakes are also found in a reach of the Colorado River (about 18 km (9 miles) of river) near Gorman Falls and the town of Bend.

The Concho water snake has not been found in Pecan Bayou and San Saba and Llano Rivers, all tributaries to the Colorado River.

Thornton (1992a) found Concho water snakes at 19 sites, which correspond to about 13 general localities, in O.H. Ivie Reservoir (Figure 5). Neonate, juvenile, and adult Concho water snakes have been found at some of these localities indicating reproduction is taking place in O.H. Ivie Reservoir. The status of the Concho water snake in O.H. Ivie Reservoir will be the subject of a report, due in December, 1995, from the Colorado River Municipal Water District (CRMWD) to the USFWS.

**Concho River Drainage** - Although Concho water snake specimens exist from Dove Creek (Tinkle and Conant 1961) and the South Concho River (Marr 1944) above San Angelo in Tom Green County, recent surveys failed to find the species despite

intensive canoe and shoreline searches (Scott et al. 1989). The Spring Creek population probably does not exist.

Although the Concho River has been dammed and channelized within the City of San Angelo, a population of Concho water snakes persists just below the Bell Street bridge. Given recent dispersal data, these snakes are probably in genetic contact with Concho water snakes below San Angelo. In the Concho River below San Angelo, Concho water snakes have been found in an area about 6 river-km (4 river-miles) downstream from Bell Street Dam. From this point they are present in all suitable habitat to the confluence with O.H. Ivie Reservoir, a distance of about 69 river-km (43 river-miles).

## **E. Habitat Description**

**Riverine Habitat** - Typical riverine habitat suitable for the Concho water snake is centered around riffles (Dixon et al. 1988, Rose 1989). Scott et al. (1989) considered the density of riffles to be one of the major determinants of Concho water snake distribution. Riffles are a section of a river where the water is usually more shallow and the current is of greater velocity than in the connecting pools. Riffles begin when the upper pool overflows at a change in gradient and forms rapids. The stream flows over rock rubble or solid to terraced bedrock substrate through a chute channel that is usually narrower than the streambed. The riffle ends when the rapids enter the next downstream pool. The run of the riffle includes the area just below the upper pool (head of the riffle) where the water becomes noticeably faster and extends to a point (foot of the riffle) where the water becomes quiet again as it enters the lower pool. The streambed debris in a riffle often forms bars, shoals, or islands separated by flowing water. Parts of some riffles may be stabilized by vegetation or they may be constricted by low-head dams, low water crossings, or other artificial structures across the channel bed.

Thornton (1992*b*) discusses the geologic setting, stream gradients, and channel configurations for reaches of the Colorado and Concho Rivers supporting Concho water snakes.

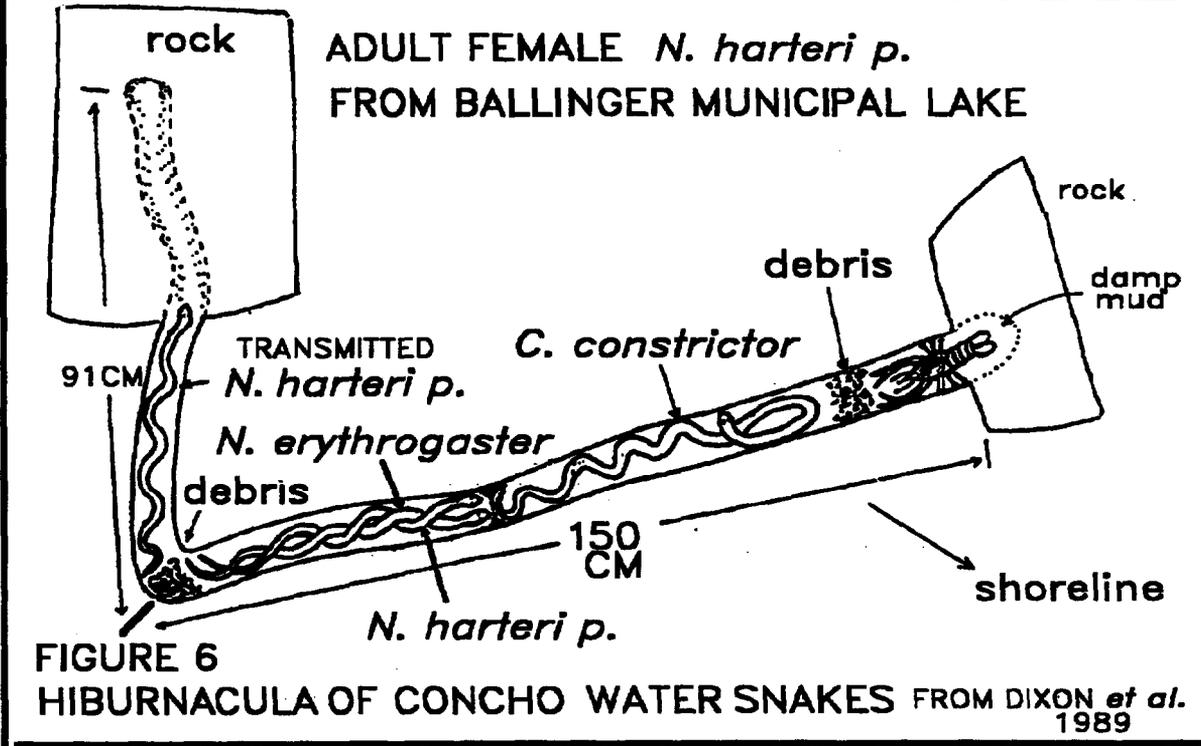
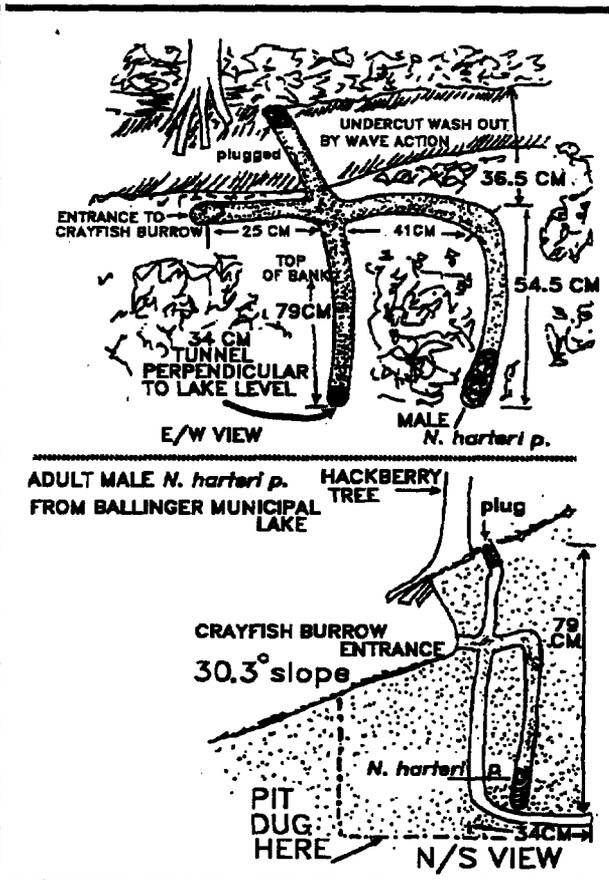
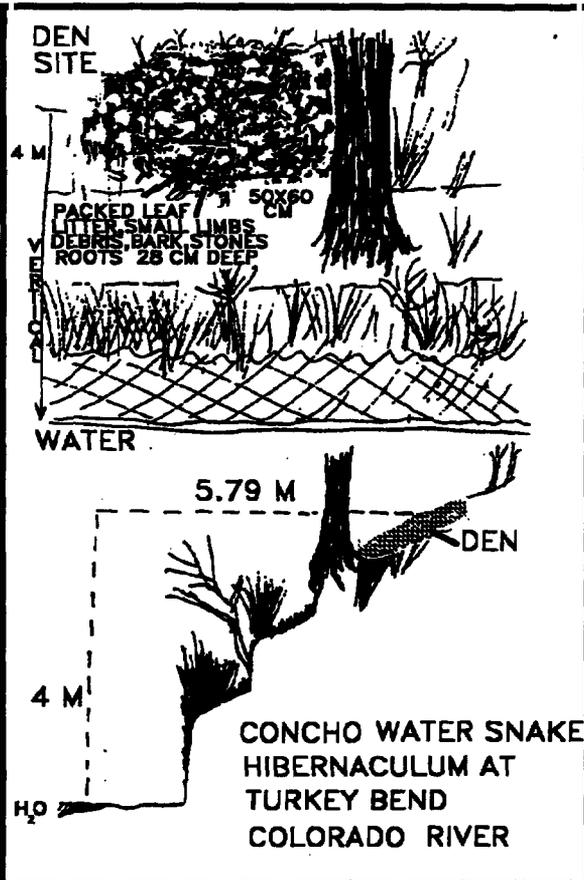
Limestone bedrock shelves in and along the stream channel seem to support the largest snake populations (Thornton and Dixon 1988; Thornton 1989, 1990, 1991, 1992*a*; Dixon et al. 1988, 1989). Shelf rock has numerous splits, crevices, and cracks; and flakes slough off to create a jumbled stream cobble that the Concho water snake uses for foraging and refuge. In the absence of shelf rock, other rock, such as limestone boulders, can provide adequate habitat.

Juvenile snakes are largely restricted to rocky riffles (Rose 1989, Scott et al. 1989). Neonates are generally found in gravel bars or shoreline settings where rock sizes range from small cobbles (64-128 mm or 2.5-5 in) to small boulders (256-512 mm or 10-20 in) using Lane's (1947) rock classification. However, some habitats with thriving populations (e.g., Paint Rock, Concho County) lack this typical gravel bar setting. Here, the juvenile snakes may use boulders and shelf rock for cover. During their second year, snakes begin to use larger rocks usually medium (51-102 cm or 20-40 in) to large boulders (102-204 cm or 40-80 in) (Scott et al. 1989).

Scott et al. (1989) and Rose (1989) reported that maturing/older individuals use a much wider range of habitats than juveniles. A recently completed radio telemetry study on the Concho water snake found that adult snakes used a variety of available cover sites for resting including exposed bedrock, thick herbaceous vegetation, debris piles, and crayfish burrows (Figure 6 taken from Dixon et al. 1989). However, only riffles were used for foraging. Gravid females occupied dense patches of vegetation and debris piles almost exclusively during the latter stages of gestation (James Dixon, personal communication). Concho water snake utilization of microhabitat types (underground/soil, rock, herbaceous vegetation/organic debris, water, and woody vegetation) was described by Greene (1993). Usage and differences among age class (neonate, juvenile, and adult) and sex by month were detailed.

In the course of consultation with the U.S. Army Corps of Engineers regarding the construction of O.H. Ivie Reservoir, the USFWS collected hydrologic and physical data to establish flow levels necessary for the snake's survival (Michael Spear, U.S. Fish and Wildlife Service, *in litt.*, 1986). The USFWS's Instream Flow Incremental Methodology (IFIM) was used to analyze existing and predicted Concho water snake habitat. Habitat at various flows was modeled using the Physical Habitat Simulation (PHABSIM) program. This analysis estimated that inundation of O.H. Ivie Reservoir and projected stream flow changes would result in a total loss of 26% of Concho water snake's juvenile foraging habitat.

**Lake Habitat** - In reservoir settings, the typical habitat element is broken rock along the shoreline (Dixon et al. 1988). Although snakes seem to prefer the shallower areas, they are occasionally found on steeper shorelines where rock is available. Differences among age classes in their uses of different-sized rocks is similar to those in river settings. Juveniles and adults bask on dead shrubs and trees that have been killed by fluctuating lake levels. At E.V. Spence Reservoir, where there are virtually no dead trees or shrubs, snakes bask on the ground, generally among the protection of rocks (Martin Whiting, Texas A&M University, College Station, *in litt.*, 1992). Whiting (1993) described the distribution, movements, growth rates, habitat use, and age structure for the Concho water snake in E.V. Spence Reservoir.



**Hibernation Sites** - Most of the information on adult hibernation sites has been gathered by the excavation of seven radio-tagged snakes from three sites (hibernacula) in the winter (Dixon et al. 1989). All three sites were within 5 m (16 ft) of water and contained moist substrates. Cloacal temperatures of the seven Concho water snakes ranged from 6.3 to 18.3° C (43.3 to 64.9° F). The adult snakes were using spaces beneath shelf rock and crayfish burrows as hibernacula. Young of the year were found using subterranean spaces within loose rock/soil aggregations during hibernation (Dixon et al. 1990).

**Vegetation** - Bank and shoreline vegetation plays an important role in providing cover and basking sites for Concho water snakes. The exact type of vegetation does not appear to be important, but its use depends on vegetation density and orientation. Gravid females will seek basking sites protected by thick, dense vegetation. Larger trees and shrubs, such as salt-cedar (*Tamarix gallica*), pecan (*Carya illinoensis*), cedar elm (*Ulmus crassifolia*), and willow (*Salix* sp.) that have limbs over the water, provide basking sites for all ages except neonates. Switchgrass (*Panicum virgatum*) and Mexican devil weed (*Aster spinosus*) are the most common herbaceous vegetation along the river banks and both provide cover and basking sites for all age classes. Thornton and Dixon (1988) report a dense variety of the non-native johnsongrass (*Sorghum halepense*) growing on gravel bars and along river banks apparently unaffected by high flows (greater than 500 cfs). Greene (1993) described riparian vegetation including: mesquite (*Prosopis juliflora* var. *glandulosa*), western soapberry (*Sapindus drummondi*), hackberry (*Celtis laevigata*), button-bush (*Cephalanthus occidentalis*), agarita (*Berberis trifoliolata*), Texas prickly pear (*Opuntia engelmanni*), slender stem cactus (*Opuntia leptocaulis*), greenbriar (*Smilax* sp.), and poison ivy (*Rhus radicans*).

## **F. Ecology and Life History**

**Activity** - Concho water snakes are active primarily from March through October with considerable variation depending on season and weather. Funnel trapping showed that peak annual adult activity occurs during the spring (Dixon et al. 1991). Males were caught in much greater number than females during April and early May. This coincided with the breeding season as determined by the detection of sperm in the cloacas of females. Based on trapping success, adult activity gradually decreases during June and remains low until mid-September. A secondary increase in activity occurs during late September and early October. Snakes probably enter hibernacula in late October, although they may bask throughout the winter on warm days (Rose 1989, James Mueller, EG&G Energy Measurements, pers. comm., and Dixon et al. 1989). Newborn Concho water snakes, born in August and September, are common under rocks in late summer and early fall (Dixon et al. 1991).

Daily activity patterns of Concho water snakes have been studied in detail by Dixon et al. (1988, 1989) and Greene (1993). They found that, in the heat of the summer, snakes were active in the mornings and evenings until about 2100 hour. Rose (1989) found them feeding generally in the morning and early afternoon.

Daily movements and home ranges of adult Concho water snakes were studied by radiotelemetry and by recapturing marked snakes (Dixon et al. 1988, 1989, 1990, 1991; Mueller 1990; Greene 1993). There has been no overall tabulation of the results, but some patterns are consistent. Based on single-seasons of observation (March through October), three radiotagged males moved on 56-72% of the days of observation, and gravid and non-gravid females moved on 34% and 52% of the days, respectively. Average daily movements for five males (calculated on move-days only) varied between 43 and 99 m/day (141 and 325 ft/day). Eight gravid females averaged between 19 and 40 m/day (62 and 131 ft/day), with the distance travelled diminishing as parturition approached. A single non-gravid female averaged 68 m/day (223 ft/day). Linear distances of river habitat occupied were 350 to 470 m (1148 to 1542 ft) for three males, and two females moved 210 m (689 ft) and 365 m (1198 ft). Mueller (1990) reported the greatest distance recorded for an individual snake between recaptures was about 5 km (3.1 mi). Several long-range movements have been recorded for snakes between river monitoring sites. Thornton (CRMWD, pers. comm.) has recorded movements of 7.2 km (4.5 mi) and 14.9 km (9.3 mi); the latter was over a 4 year period.

**Feeding** - The Concho water snake's diet is composed almost entirely of fish (Williams 1969; Dixon et al. 1988, 1989, 1990, 1991, 1992; Thornton 1990, 1992a; Rose 1989). In riverine habitats, primarily minnows (Cyprinidae) are consumed. Neonates feed almost exclusively on minnows, especially the red shiner (*Cyprinella lutrensis*) and bullhead minnow (*Pimephales vigilax*). Dietary diversity increases with snake body size. In addition to minnows, large snakes consume mosquitofish (*Gambusia affinis*), channel catfish (*Ictalurus punctatus*), flathead catfish (*Pylodictus olivaris*), gizzard shad (*Dorosoma cepedianum*), and several species of sunfish (*Lepomis cyanellus*, *L. macrochirus*, and *L. megalotis*) (Dixon et al. 1991). The diet of Concho water snakes in Ballinger Municipal Lake also included a variety of minnows and other fish (Dixon et al. 1991), but the bigscale logperch (*Percina macrolepida*) was the dominant prey in the diet of neonates and juveniles (Dixon et al. 1991).

Snakes catch prey from a stationary position near fish concentrations or by actively searching under and around rocks in riffles (Thornton 1987, Dixon et al. 1989, 1991; Rose 1989). The "sit-and-wait" strategy was most often seen in juveniles (Dixon et al. 1989).

A series of large fish kills in the Colorado River segment of the Concho water snake's range occurred in August and September, 1989. The exact cause of the fish kills (which were not total kills) is not known. Toxin-producing phytoplankton, such as *Anabaena* sp. and *Prymnesium parvum*, may have contributed to the kill (Palafox and Glass, Texas Parks and Wildlife Department, *in litt.*, 1989). Some Concho water snakes were observed feeding on dead fish during the kill (James Dixon, pers. comm.). The effect of the fish kill on the fish community structure in the Colorado River is not known; nor is it known whether algae-related toxins were actually present in the Colorado River before or during the fish-kill. Additionally, the effect of these algae-related toxins on the Concho water snake is not known. Dixon et al. (1989) reported the fish-kill occurred at two of their monitoring sites. Fish were apparently absent at these sites for three weeks following the kill. They suggested that the observed drop in Concho water snake weight in late September of 1989 was probably due to the fish-kill, but also considered that the weight loss was possibly part of a natural pattern of annual variation related to differences in microclimate, food availability, or both. According to Scott et al. (*in litt.*, 1992), the fish-kill did not appear to affect the snake's survivorship or reproduction.

**Reproduction** - The reproductive biology of the Concho water snake was described by Dixon et al. (1988, 1989, 1990, 1991). The presence of spermatozoa in the cloacal fluid of females indicates that mating occurs predominantly during April and early May and secondarily in October. Roughly 85% of sexually mature females were gravid each year. Litter sizes estimated by palpation averaged 10 (range = 4-29) embryos per female. Greene (1993) reported a mean litter size of 11 based on follicle counts from dissected snakes. In other studies, litter sizes based on follicle counts of dissected females averaged 14.5 (range = 17-24; Rose 1989) and 18.6 (range = 9-29; Williams 1969). Follicle counts probably overestimate clutch size (Seigel and Ford 1987). All three studies showed a positive relationship between female body size and litter size. Births occur from late July through September (Dixon et al. 1988, 1989, 1990, 1991; Mueller 1990). Baker et al. (1972) described the Concho water snake chromosomes.

**Growth and Maturity** - Concho water snakes show rapid growth and early maturity (Dixon et al. 1990, 1991; Scott and Malcolm 1990). Females grow more rapidly and mature at larger sizes than males, producing a size difference between sexes, with adult females averaging 30% longer than adult males. Among populations, considerable differences and variability in growth rates and sexual maturation sizes have been observed, apparently as a function of prey availability (Dixon et al. 1991). The growth rate of young juvenile Concho water snakes from Ballinger Municipal Lake (Lake Moonen) was determined to be about half of those from the Colorado River, implicating differences in availability of food resources for this age class (Dixon et al. 1989). Growth in older juveniles and young adults in Ballinger Municipal Lake appeared to compensate for the early growth suppression and may be related to pondweed (*Potamogeton* sp.) production in the latter half of June (Dixon et al. 1989). Reviewing three years of data, Dixon et al. (1991) found neonate growth to be significantly different between lake and riverine locations. Ballinger Municipal Lake snakes grew at about half the rate of Colorado River snakes. Dixon et al. (1991) found that both sexes of Concho water snakes grew faster at two riverine sites when compared to the population at E.V. Spence Reservoir. Whiting (1993) found that females from a riverine population (near Cervenka Dam) had a higher mean growth rate than females from E.V. Spence Reservoir.

Typically, males become mature at about 380 mm snout-vent length (SVL) at an age of 11-12 months, and females mature at about 460 mm SVL. They produce their first litters at either two or three years of age (Dixon et al. 1990).

The average SVL of 287 neonates born in captivity from 25 litters was 175 mm (Dixon et al. 1991). Williams (1969) reported that an average neonate, when first caught, had an average SVL of 205 mm, increasing to 275 mm by the onset of hibernation. The maximum SVLs recorded for Concho water snakes are 615 mm for males and 820 mm for females (Dixon et al. 1991).

**Population Structure** - Concho water snake survivorship appears to be strongly related to age. Survival estimates of first-year individuals are about 20% (Williams 1969, Mueller 1990). An adult survival rate of at least 50% would be necessary to produce a stable age distribution and to counteract the high mortality of the first-year cohort (Mueller 1990). The actual causes of Concho water snake mortality have not been well defined but predation is considered to be a significant source of mortality (Greene 1993). Williams (1969) reported that almost all of the snakes in his study population were less than 4 years old. Similarly, a life table derived from mark-recapture data predicted that one in 100 snakes exceeds 5 years of age and only one in 1,000 would survive 10 years (Mueller 1990). Whiting (1993) developed life tables for snakes from E.V. Spence Reservoir and the Cervenka locality on the Colorado River.

**Population Viability** - A population viability analysis (PVA) has been conducted for the Concho water snake (Soulé and Gilpin 1986; Gilpin 1989; Soulé 1986, 1989). These analyses were done when much less information was available on the Concho water snake. Soulé and Gilpin (1986) recommended further research regarding Concho water snake demographics and studies to estimate the rate of turnover on riffle populations. Although much more research has been conducted on the snake and better information is now available upon which a PVA could be based, additional research is still needed.

**Predators** - Dixon et al. (1990) and Greene (1993) documented several natural predators of the Concho water snake including kingsnakes (*Lampropeltis getula*), coachwhip snakes (*Masticophis flagellum*), racers (*Coluber constrictor*), raccoons (*Procyon lotor*), and great blue herons (*Ardea herodias*). Raptors were also implicated in several instances of predation. The red-tailed hawk (*Buteo jamaicensis*), Swainson's hawk (*Buteo swainsoni*), great horned owl (*Bubo virginianus*), and barred owl (*Strix varia*) have been observed in Concho water snake habitat, and all are known to include snakes in their diets (Ross 1989). Additional potential predators reported to prey on related species include bass (*Micropterus* spp.), channel catfish (*Ictalurus punctatus*), bullfrogs (*Rana catesbeiana*), and water moccasins (*Agkistrodon piscivorus*) (Hamilton

and Pollack 1955, McGrew 1963, Parmley and Mulford 1985, Dixon et al. 1988, and Mueller 1990).

The effects of the recreational fishery in O.H. Ivie Reservoir (and adjoining upstream river segments) on the Concho water snake and its prey base are unknown. Since its inundation, O.H. Ivie Reservoir has been stocked with largemouth bass (*Micropterus salmoides*), smallmouth bass (*Micropterus dolomieu*), white crappie (*Pomoxis annularis*), bluegill (*Lepomis macrochirus*), blue catfish (*Ictalurus furcatus*), channel catfish (*Ictalurus punctatus*), flathead catfish (*Pylodictus olivaris*), walleye (*Stizostedion vitreum*), and threadfin shad (*Dorosoma petenense*). The viability of the Concho water snake in O.H. Ivie Reservoir will depend, in part, on the availability of prey and degree of predation on Concho water snakes.

## G. Genetic Population Structure

To date, studies using protein electrophoresis have failed to show any genetic variability among populations of Concho water snake or between the Concho water snake and Brazos water snake (Lawson 1987, Rose and Selcer 1989, Sites and Evans 1990). However, Sites and Densmore (1991), using a method involving random primer amplification (RPA) of nuclear DNA, concluded variation is present in the nuclear genome of Concho water snakes, but not detectable by protein electrophoresis. Sites and Densmore (1991) found substantial mtDNA variability within and among localities sampled. Their analyses indicated a population structure consisting of a linear array of demes (local populations) connected by occasional gene flow.

Using mitochondrial DNA (mtDNA), Dr. Lew Densmore and co-workers have also found fixed differences between the Concho water snake and Brazos water snake indicating the two taxa have not been in contact for a substantial amount of time and are "independently evolving lineages" (Densmore et al. 1992).

When Freese Dam/O.H. Ivie Reservoir was constructed, a continuous population of Concho water snakes was fragmented. The dam and reservoir (filled in 1990) then became a barrier to movement and gene flow. A Memorandum of Agreement between the CRMWD, U.S. Army Corps of Engineers, and USFWS provides for the maintenance of genetic heterogeneity in the Concho water snake, including moving Concho water snakes as long as Freese Dam is in place.

Based on work described in Sites and Densmore (1991), Dr. J. Sites (Brigham Young University, *in litt.*, 1992) estimated that the reciprocal transfer every 5 years of three snakes between each population isolated by the filling of O.H. Ivie Reservoir would effectively counteract any genetic effects imposed by the reservoir. Sites recommended both sexes be transferred. Recommended snake sizes (greater than 420 mm SVL for males and greater than 475 mm for females) are intended to avoid the higher mortality associated with smaller/younger snakes. Furthermore, females should not be gravid since gravid females have been observed basking more than other classes, which presumably makes them more susceptible to predation (J.R. Dixon, pers. comm.). The best females for relocation are ones that are just approaching sexual maturity. Assuming some gene flow would likely occur between the upper Colorado River and Concho River populations, Sites recommended no transfers between those two localities. However,

available data indicate that these two populations are not connected. Thus, recovery tasks described in Parts II and III involve reciprocal transfers between the Concho River, upper Colorado River, and lower Colorado River. The general basis for the frequency of transfers (generation time) and number of individuals transferred can be found in Lande and Barrowclough (1987).

## H. Threats

The Concho water snake occupies a restricted geographic range in the Concho and Colorado River Basins in central Texas. Optimal habitat consists of free-flowing streams over rocky substrates periodically scoured by floods (which provide relatively sediment free rock rubble and open banks), abundant rock debris and crevices for shelter, and shallow riffles which are considered critical to juvenile survival.

The threats to the Concho water snake include: (1) habitat loss and degradation resulting from: (a) reservoir inundation and (b) modifications to flow regimes related to water diversion and/or impoundment; (2) pollution or degradation of water quality in the Concho and Colorado Rivers or tributaries; (3) fragmentation and isolation of populations following habitat disturbances; (4) loss of adequate instream flow due to natural and/or man-made conditions; and (5) sediment loading and deposition coupled with vegetation encroachment of rocky/bedrock riffle habitats used by Concho water snakes. The threats are interrelated. Below dams on the Colorado (e.g., E.V. Spence Reservoir) normal river flow has been severely reduced and scouring which maintains the streambed has been virtually eliminated. Sediment deposition arises from this lack of channel maintenance and affects the suitability of juvenile habitat.

In reservoirs, Concho water snakes need rocky shorelines. Lake-dwelling populations are present in E.V. Spence Reservoir, Ballinger Municipal Lake (Lake Moonen), and O.H. Ivie Reservoir. The populations at Spence and Ballinger are effectively isolated from riverine populations. The long-term status of the O.H. Ivie population is uncertain.

As O.H. Ivie Reservoir matures, sediment deposition will occur in the upper reaches/arms where water velocity drops and suspended material settles out. The filling process is determined in part by basin morphometry/geology and climatic factors (Wetzel 1983). Other reservoirs in the basin acting as sediment traps would also affect the filling process. It is anticipated that sedimentation will eventually extend to shallower areas used by Concho water snakes.

The effects of the recreational fishery in O.H. Ivie Reservoir (and adjoining river segments) on the Concho water snake and its prey base are unknown. A number of fish species stocked in Ivie may prey upon Concho water snakes or compete with Concho

water snakes for small fish. Available data need to be reviewed. If necessary, studies should be conducted to determine impacts (present and future as the fishery matures) to the Concho water snake in O.H. Ivie Reservoir proper and adjacent riverine habitat in the Concho and Colorado Rivers. Any proposal to stock fishes in habitat occupied by the Concho water snake, including rivers, should be reviewed for possible direct and indirect impacts to the snake.

Pollution may be reducing the value of habitat in certain portions of the range. The Clean River Act (SB-818) requires river authorities/entities and the Texas Water Commission (TWC) to perform a basin-wide comprehensive assessment of the environmental factors affecting water quality. The intent is to identify existing and potential pollution problems and eventually reduce or eliminate certain water quality problems. Unfortunately, the assessment will not be available until the next report cycle in 1994. However, statements made at an April, 1992, Clean Rivers Act public meeting expressed a number of concerns related to the non-point source pollution in the San Angelo vicinity; petroleum production, refining, and transportation in the watershed; and treated sewage disposal and a feedlot near the Concho River.

Point source and non-point source pollution in the Concho River in the vicinity of San Angelo have not been adequately evaluated. CRMWD has a limited surface water monitoring program (Lower Colorado River Authority 1992), consisting primarily of salinity measurements.

The City of San Angelo has a no-discharge permit for sewage involving land treatment near the Concho River. The TWC has issued a noncompliance penalty to the City for exceeding its permitted irrigation application rate (J. Naldepka, City of San Angelo, *in litt.*, 1992). The overapplication has resulted in seepage to the river. In 1992, the permittee was under an enforcement action by the TWC to address this problem. The Concho River may be able to assimilate some of this nutrient loading; however an assessment of actual impacts is not available.

The U.S. Geological Survey reports high nitrate values for the Concho River near Paint Rock. The source(s) of this high nitrate concentration may be resolved through work stemming from the Clean Rivers Act. Pollutants with concentrations above State or Federal water quality standards for the Concho and Colorado Rivers include: nitrates, sulphates, total dissolved solids, chlorides, phosphorus, and fecal coliform. Sediment has

been identified as a non-point source pollutant in the part of the basin occupied by the Concho water snake.

A number of pipelines conveying a variety of oil and gas products cross Concho water snake habitat. A concern is that leakage or spills could render segments of the Colorado River, Concho River, or certain tributaries unsuitable for the snake or the fishery upon which it depends.

The extent of unauthorized water diversions from the Concho and Colorado Rivers and impoundment/harvesting of water in tributaries of the Concho and Colorado Rivers is unknown.

## **I. Conservation Measures**

The conservation measures now in place for the Concho water snake stem almost entirely from the requirements of the December 19, 1986, biological opinion and Memorandum of Agreement (MOA) associated with the U.S. Army Corps of Engineers permit for the construction of O.H. Ivie (Stacy) Reservoir by the CRMWD. These measures include, but are not limited to, minimum flows from Spence and O.H. Ivie Reservoirs on a continuous, daily basis; stream channel maintenance (flushing flows) (described in Section A); studies of Concho water snake biology, genetics, and physical habitat; construction of artificial riffles; and monitoring of habitats, prey species, and snake populations.

The management alternatives developed in and required by the biological opinion also involve habitat rehabilitation where silt and vegetation has encroached, along with protection of existing and rehabilitated habitats. CRMWD is also required to use its legal authority to prevent water development projects that impound more than 200 acre-feet and discourage those that impound less than 200 acre-feet.

The U.S. Department of Agriculture's Conservation Reserve Program (CRP), which provides incentives to set aside highly erodible lands, benefits Concho water snake habitat in that it reduces soil erosion and contributes to maintaining water quality of surface waters in the Colorado River basin. It is anticipated that when the primary sources of sedimentation in the watershed are identified, enrollment in the CRP may significantly reduce the threat of sedimentation of riffle habitat.

**Monitoring** - Since 1987, the CRMWD has monitored Concho water snake populations at 15 sites three times each year. Snakes are counted, measured, and permanently marked. Since 1989, physical aspects of the habitat have been recorded and changes noted. The monitoring program is expected to continue through 1996. The shoreline of O.H. Ivie Reservoir has been characterized into areas of potential habitat. Presently, CRMWD researchers are searching the shoreline to document the reservoir's Concho water snake distribution (Thornton 1991).

Fish populations were surveyed at the monitoring sites in the fall of each year. In addition, several other sites and seasons were sampled in an intensive seining and snake-trapping effort in 1991 (Thornton 1991).

**Habitat Restoration** - As part of the biological opinion for O.H. Ivie Reservoir, six artificial riffles were built in 1989 in an apparently unoccupied reach of the Colorado River below Spence Reservoir. Colonization of all of the six artificial riffles is encouraging. The habitat in this stretch of the Colorado River had been heavily degraded by siltation and vegetation encroachment after the construction of Robert Lee Dam. Though historically it had supported an abundant Concho water snake population, none were found during surveys in the late 1980s. The fish prey base was surveyed in 1990 and found to be similar to that in habitat occupied by the Concho water snake. In 1991, four of the artificial riffles were found to be occupied by Concho water snakes. In 1992, all six riffles were occupied. This indicates that physical habitat may be limiting Concho water snake distribution in some stream segments.

**Instream flows** - The CRMWD is releasing water from both Spence and O.H. Ivie Reservoirs according to a schedule specified in the biological opinion and critical habitat described in Section A of this plan. These flows should be reviewed regarding their sufficiency to rehabilitate and maintain the habitat downstream of these reservoirs for use by the Concho water snake.

**Studies** - Several ongoing or recently completed studies are:

Texas A&M University, Department of Wildlife and Fisheries Sciences. Dr. James R. Dixon, Brian Greene, James Mueller, and Martin Whiting have conducted research of the Concho water snake since 1988. Studies of age distribution, growth, movement, reproduction, hibernation, food and feeding, behavior, predation, and habitat use were completed in 1993.

Colorado River Municipal Water District. Okla W. Thornton, Jr. is the biologist in charge of the District's studies. Studies, completed to date, have investigated the stability and changes in habitats and stream channel profiles, and availability and distribution of food items (Thornton 1991). Thornton (1992*b*) reported on geophysical aspects of Concho water snake habitat.

Brigham Young University, Department of Zoology and Texas Tech University, Department of Biological Sciences. Drs. Jack W. Sites, Jr., R. Paul Evans, and Lew Densmore have studied genetic structure of populations of the Concho water snake, using

protein electrophoresis, mtDNA, and RPA nuclear-DNA analyses (Sites and Densmore 1991). Their studies were completed in 1991.

U.S. Fish and Wildlife Service, National Ecology Research Center. Dr. Norman J. Scott, Jr., has completed laboratory studies of the growth of the three species of water snakes in the area and the thermal properties of the juvenile habitat.

## **J. Recovery Strategy**

Current research (Thornton 1987, 1989, 1990, 1991, 1992a; Thornton and Dixon 1988; Dixon et al. 1988, 1989, 1990, 1991) suggests that, if habitat conditions remain stable, the likelihood of extinction of the Concho water snake is low for the foreseeable future. Maintenance of adequate instream flows is essential to maintaining both the quantity and quality of Concho water snake habitat.

This plan describes the minimum effort thought necessary to provide for the long term survival of the Concho water snake in its natural habitat. Many other measures could be used to enhance this effort, such as: (1) detailed studies of the effects of the management of O.H. Ivie Reservoir (e.g., reservoir operation rules) on snakes in the reservoir and adjacent riverine habitat and further demographic research and (2) an evaluation of the O.H. Ivie Reservoir fishery, particularly regarding its potential interaction with riverine populations. If after these studies, data indicate adverse effects to riverine populations, corrective measures should be investigated and implemented.

In general, the recovery strategy is to maintain the habitat and distribution of the Concho water snake throughout all areas currently occupied to provide for viable populations. Actions must be taken to insure that a combination of natural and/or man-made factors does not result in inadequate instream flows, which would have serious effects on the Concho water snake, its habitat, and prey base. Additionally, time is needed to evaluate changes such as sedimentation and the adequacy of current flushing flows (related in part to reservoir development) on Concho water snake habitat.

If significant amounts of habitat are lost in the future, it is likely to be due to a combination of factors. The outlined recovery actions are designed to:

- (1) secure adequate stream flows;
- (2) identify and monitor the cumulative effects of all deleterious factors on the habitat and distribution of the Concho water snake, including sedimentation, vegetation encroachment, and water quality;
- (3) provide for protection under the law;
- (4) further secure the status of the snake by reestablishing the Concho water snake in river segments and creeks where they have been extirpated;

- (5) mitigate the possible adverse genetic effects of population fragmentation caused by the construction of Freese Dam (creating O.H. Ivie Reservoir); and,
- (6) further refine data by which an objective decision can be made about whether to remove the Concho water snake from the Federal list of threatened and endangered species and determine if the delisting criteria have been met.

Several apparently vigorous Concho water snake populations have been studied since 1986 (Dixon et al. 1988, 1989, 1990, 1991; Thornton 1987, 1989, 1990, 1991; Thornton and Dixon 1988). Surveys, to date, indicate that age classes (neonates, juveniles, or adults) are variable in size from year to year (Mueller 1990). Adult Concho water snakes are typically few in numbers compared to other age classes. Past and current research augmented by the 10-year monitoring plan described in the Recovery Narrative should provide information on the status of the Concho water snake rangewide.

## **II. RECOVERY**

### **A. Objective**

The objective of this recovery plan is to outline the tasks necessary to recover the Concho water snake to the point that the protective provisions of the Endangered Species Act are no longer necessary and it can be removed from the threatened and endangered species list.

### **B. Recovery Criteria**

The Concho water snake will be considered for delisting when all of the following criteria are met:

- (1) adequate instream flows are assured even when the species is delisted;
- (2) viable populations are present in each of the three major reaches (the Colorado River above Freese Dam, Colorado River below Freese Dam, and the Concho River). Here, population is defined as all Concho water snakes in a given area, in this case, each major river reach.
- (3) movement of an adequate number of Concho water snakes is assured to counteract the adverse impacts of population fragmentation. These movements should occur as long as Freese Dam is in place or until such time that the USFWS determines that Concho water snake populations in the three reaches are viable and "artificial movement" among them is not needed.

A viable population is one that: (1) is self-sustaining; (2) can persist for the long-term; and, (3) can maintain "its vigor and its potential for evolutionary adaptation" (Soulé 1987). Self-sustaining means that the population has the capacity to maintain itself without significant intervention. Long-term is defined as the foreseeable ecological future and would involve typically hundreds of years (Soulé 1987).

Concho water snakes within each major reach are found in "local populations" or demes (following Mayr 1970), which are associated with patches of habitat, usually a riffle complex. Here, deme is defined as all potentially interbreeding individuals (snakes)

at a given locality/riffle complex. Available information indicates that the distribution of the Concho water snake is a linear array (along a river or creek course) of demes. In this linear arrangement of habitat patches (the longitudinal distribution of riffle complexes in a river reach), demes experience both local extinction (extirpation) and recolonization as snakes move in from neighboring riffles. Although there may be temporary discontinuities within a population (reach), snakes probably move regularly across these discontinuities, recolonizing segments that become extirpated, and forming a single gene pool. Genetic contacts between smaller outlying groups of snakes (i.e., E.V. Spence Reservoir, Ballinger Municipal Lake) and snakes of the upper Colorado River proper are less certain, but might occur.

The future well-being of the Concho water snake should be ensured if the three major populations and several of the smaller ones are maintained near present levels. A sampling plan is designed to characterize the stability of each major population by sampling 40 sites each year over a ten-year period. At least 12 monitoring sites should be placed in each major reach. The data derived from this monitoring will be used to help determine if the Concho water snake should be considered for delisting.

The results of monitoring will provide information on (or an estimate of) the rates at which demes go extinct and are recolonized (i.e., "patch turnover" following Soulé and Gilpin 1986). It will be cause for alarm if a number of demes disappear and are not replaced. In this event, delisting should be delayed until the causes of the disappearances can be determined and corrected.

Determination of whether criterion 2 is met will be based, in part, on information developed from 10 years of monitoring at 40 localities distributed throughout the range. The Service will consider it an indication that criterion 2 is met if:

- (1) Concho water snakes are present in at least 7 of 10 years of monitoring in 38 of the 40 sites; and
- (2) Concho water snakes are present in a total of 11 of 12 monitoring sites in each reach at least once in the last three years of monitoring.

### **C. Recovery Outline**

The following is an outline of recovery tasks needed to attain the objective of this plan. Detailed information on each of the tasks is contained in the recovery narrative in Section D.

1. Assure adequate stream flows rangewide by appropriate means.
  - 1.1. Monitor hydrology and physical habitat in Concho and Colorado Rivers and review all relevant data.
  - 1.2. Ensure adequate instream flows occur to maintain viable populations of Concho water snakes.
2. Evaluate the status of the Concho water snake and the extent of other threats rangewide.
  - 2.1. Identify 50 and establish 40 monitoring sites throughout the range of the Concho water snake on the Concho and Colorado Rivers and Elm, Coyote, and Bluff Creeks.
  - 2.2. Monitor 40 sites annually for a minimum of 10 years. Survey for snakes and monitor hydrology and physical habitat.
  - 2.3. Assess potential for contaminants to affect Concho water snake and/or the Concho - Colorado River ecosystem, and act to abate threat(s) from contaminants if identified.
3. Provide legal protection.
  - 3.1. Enforce existing Federal and State laws.
  - 3.2. Conduct consultations under section 7 of the Endangered Species Act for actions that may affect the Concho water snake and/or its critical habitat.

4. Reintroduce the Concho water snake into suitable habitat in the historic range and monitor these populations.
  - 4.1. Evaluate the potential for reintroduction of the Concho water snake in the Concho River drainage upstream from San Angelo. If appropriate, proceed with reintroduction and follow-up monitoring.
  - 4.2. Monitor reintroduced populations.
  - 4.3. Evaluate the potential and merits for other reintroduction sites in suitable habitat in the historic range. If a potential site would contribute to the long-term survival of the Concho water snake, proceed with reintroduction and follow-up monitoring.
5. Maintain gene flow among populations isolated by O.H. Ivie Reservoir through snake translocations.
6. Develop and implement a post-recovery monitoring plan with appropriate Federal, State, public and/or private entities.

**D. Recovery Narrative**

1. **Assure adequate stream flows rangewide by appropriate means.** Adequate stream flows are essential to the continued survival of the Concho water snake. Instream flows in the Concho and Colorado Rivers and certain tributaries should be evaluated and adequate flows protected by appropriate and available means.
  - 1.1. **Monitor hydrology and physical habitat in Concho and Colorado Rivers and review all relevant data.** Review all hydrologic, reservoir, meteorological, and water diversion data for effects to instream flow. Monitor suitable habitat for losses from sedimentation and vegetation encroachment. Characterize status of physical habitat rangewide and determine if sedimentation is a long-term threat. A rangewide evaluation of stream channel stability, sediment source and deposition, vegetation encroachment and water chemistry should be done. A comparison of the number, size, and distribution of riffle complexes rangewide should be made. Water quality should be monitored. The effects of spreader (check) dams (existing and planned) on Concho water snake habitat should be evaluated.
  - 1.2. **Ensure adequate instream flows occur to maintain viable populations of Concho water snakes.** Protect stream flows in the Concho and Colorado Rivers and certain tributaries through implementation of the MOA and other appropriate means. Assurance that adequate flows will continue even after the species is delisted must be provided before the Concho water snake can be considered recovered.
2. **Evaluate the status of the Concho water snake and the extent of other threats rangewide.** Establish an adequate number of monitoring sites (40) and monitor the Concho water snake and factors affecting suitability of habitat. To identify, evaluate, and reduce threats to the Concho water snake and quality and quantity of its habitat, a monitoring program involving 10 years of data collection should be conducted. If, after this monitoring, there is: (1) no significant reduction in the range of the species, (2) no significant threats to its well-being, and (3) other recovery criteria are met, it can be considered for delisting.

Data allowing estimates of local population size, net reproductive rate, death rate, and movement of individuals among populations have been collected by researchers from Texas A&M University and CRMWD. It is intended that this information be used to the maximum extent possible in evaluating the status of the Concho water snake.

The monitoring plan should also permit an estimate of the rate at which riffle/riffle complexes turnover. Here, turnover means the process of local occupied patches of habitat (riffle complexes) going extinct and then being recolonized.

- 2.1. Identify 50 and establish 40 monitoring sites throughout the range of the Concho water snake on the Concho and Colorado Rivers and Elm, Coyote, and Bluff Creeks. Fifty sites should be selected from the breadth of the Concho water snake's range. Forty will be used for monitoring and ten will be used as alternate sites in the event that a monitoring site becomes unusable. See Appendix C for details.
- 2.2. Monitor 40 sites annually for a minimum of 10 years. Survey for snakes and monitor hydrology and physical habitat. The same 40 sites should be monitored each year, starting the year following their establishment. If for some reason, monitoring can not be done that year, monitoring resumes the next spring, until 10 years of data are collected. See Appendix C.
- 2.3. Assess potential for contaminants to affect Concho water snake and/or the Concho - Colorado River ecosystem, and act to abate threat(s) from contaminants if identified. All available information related to water quality in the Concho and Colorado Rivers and certain tributaries should be reviewed and evaluated for potential to affect the snake or its prey base. Contaminants of concern include: nitrates, sulphates, total dissolved solids, chlorides, phosphorus, fecal coliform, municipal wastewater, urban runoff, petroleum production and transportation, agricultural chemicals with potential to affect aquatic wildlife (insecticides, herbicides, fungicides, and fertilizers), and sediment. Neither the USGS nor CRMWD currently monitor for organic contaminants such as pesticides. Sediment will be dealt with under Task 1.1. The factors potentially involved in the fish kills of 1989 should also be reassessed.

3. Provide legal protection. The majority of the Concho water snake conservation measures in place today are the result of the interagency consultation required by the ESA.
  - 3.1. Enforce existing Federal and State laws. Regulations under the Endangered Species Act, Lacey Act, and State endangered species/wildlife protection laws should be enforced to assist in conservation of the species.
  - 3.2. Conduct consultations under section 7 of the Endangered Species Act for actions that may affect the Concho water snake and/or its critical habitat. All Federal agencies are required to consult with the USFWS if any action authorized, funded, or carried out by the Federal agency may affect the Concho water snake or its designated critical habitat. They are also required to avoid jeopardy to the snake or adverse modification of its critical habitat.
  
4. Reintroduce the Concho water snake into suitable habitat in the historic range and monitor these populations. Generally, the larger the geographic range that a species occupies, the less susceptible it is to extinction, particularly due to catastrophic events. Two areas worth considering as reintroduction sites follow:
  - (1) The Concho water snake formerly occurred in tributaries to the Concho River above San Angelo. The causes of their extirpation from this area are not known, but several streams retain most of their historic flows and the habitats appear to be relatively unmodified. Reestablishment of populations above San Angelo could provide an important source of snakes in the event that a catastrophe affects the Concho River population below San Angelo.
  
  - (2) The Concho water snake appears to have a spotty distribution along the Colorado River between FM 45 and Bend and may be absent between Regency and Harmony Ridge (see Figure 4). Scott et al. (1989) suggested that the distance between riffles may be a determinant of the snakes distribution, and the distance between riffles in this portion of the Colorado may have resulted in this apparent break in the distribution of the Concho water snake. They suggested that natural recolonization of habitat patches in this reach would not be likely due to: (1) the relative distances between riffles in this reach, (2) lower density of riffles per km,

and (3) the fact that Concho water snakes do not typically move large distances. The actual factors determining the sparse distribution of Concho water snakes in portions of this reach are not known, but potentially could involve natural conditions (such as geology, stream gradient and/or distance between riffles (Thornton 1992b), natural events (such as a long-term drought) and/or man-affected conditions. Scott et al. (1989) considered their search effort in this reach (3.5 hours per site) sufficient to detect the presence of snakes. They searched 15 of 43 identified riffles between Highway 45 and Bend. Their surveys (1979 - 1987) did not report Concho water snakes near Harmony Ridge nor Adams, though a 1988 survey (Thornton and Dixon 1988) did find one adult and two juveniles in this area. The Colorado River between Regency and Bend should be considered for possible habitat management/enhancement and potentially for reintroduction efforts.

- 4.1. Evaluate the potential for reintroduction of the Concho water snake in the Concho River drainage upstream from San Angelo. If appropriate, proceed with reintroduction and follow-up monitoring. Two secure sites should be chosen for good habitat and prey base on different tributaries and 40 snakes released at each site. The candidate sites should be thoroughly evaluated for potential to support Concho water snakes. If the sites are suitable, 80 Concho water snakes should be captured during late April and May from various sites in the upper Concho River. A good mix of juveniles and adults should be retained. The sex, snout-vent length, and weight should be recorded and a passive integrated transponder (PIT) implanted in each.
- 4.2. Monitor reintroduced populations. Starting in the fall of the year of the introduction, the introduced populations should be monitored twice a year, in the spring (May 1-15) and fall (September 1-15). At each site, efforts should include trapping at least 100 trap-nights using 25 minnow traps modified to retain all snakes, including neonates. The sex, weight, and snout-vent length should be recorded and PIT implanted, if the snake is not already carrying one. The reintroductions should be monitored for at least 10 years.

The decision whether or not to add additional snakes to the reintroduction sites after the first year should be made after data on the persistence of the initial introductions are available.

- 4.3. Evaluate the potential and merits for other reintroduction sites in suitable habitat in the historic range. If a potential site would contribute to the long-term survival of the Concho water snake, proceed with reintroduction and follow-up monitoring. The Colorado River between Regency and Bend should be resurveyed for Concho water snakes, potential habitat enhancement, and reintroduction efforts. Reintroduction and monitoring outlined in 4.1. and 4.2. should be followed, except the number of sites to be monitored may be different.
5. Maintain gene flow among populations isolated by O.H. Ivie Reservoir through snake translocations. Most of the following procedures follow recommendations made by Sites (*in litt.*, 1992), building on Sites and Densmore (1991). Gene flow should be maintained through the translocation of snakes. A thorough effort should be made to evaluate the survivability of translocated snakes and the production of offspring. To provide for gene flow among the three populations isolated by the construction of O.H. Ivie Reservoir, snakes of both sexes should be moved every 5 years according to the following pattern:
- (1) move four snakes (two of each sex) from the Colorado River just above O.H. Ivie Reservoir to the Concho River near its confluence with the reservoir and vice versa;
  - (2) move four snakes (two of each sex) from the confluence of the Concho River and O.H. Ivie Reservoir to the Colorado River below O.H. Ivie Reservoir and vice versa; and
  - (3) move four snakes (two of each sex) snakes from the Colorado River just above O.H. Ivie Reservoir to the Colorado River below O.H. Ivie Reservoir and vice versa.

Both sexes should be transferred. Males should be larger than 420 mm SVL and females should be larger than 475 mm SVL and non-gravid. This will entail the

moving of a total of 8 snakes from each of the three sites every 5 years. No snakes from O.H. Ivie Reservoir should be involved in this translocation process. Survivability and reproduction of translocated snakes should be researched. The likelihood of transferred individuals producing offspring should be evaluated. If feasible, use of genetic markers should be employed to track gene flow in the individuals associated with the translocations. To employ this method, it will be necessary to have good baseline information on selected markers for all three populations. Thus, the success and extent of gene flow provided by the translocations may be estimated by the frequency of the introduced markers. The potential for subpopulations in O.H. Ivie Reservoir to mix and export individuals to adjacent upstream populations without human intervention should be reviewed every 2 years.

6. Develop and implement a post-recovery monitoring plan with appropriate Federal, State, public and/or private entities. All data from monitoring during recovery implementation should be evaluated and a post-recovery monitoring plan developed. Monitoring should continue for at least 5 years after de-listing, as required by the 1988 amendments to the Endangered Species Act. USFWS should work with TPWD and others to monitor the Concho water snake rangewide, possibly in a manner similar to monitoring during recovery implementation.

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### **III. IMPLEMENTATION SCHEDULE**

The following Implementation Schedule outlines actions and estimated costs for recovering the Concho water snake. It is a guide to meeting the objective elaborated in Part II of this plan. The schedule indicates recovery plan tasks, corresponding outline numbers, task priorities, duration of tasks ("continuous" denotes a task that once begun should continue on an annual basis), which agencies are responsible for performing these tasks, and estimated costs for various agencies involved. The estimated costs are generally based on staff time needed per task. One exception is the USGS line item under Task 1.1. That cost estimate is based on annual costs to operate nine stream monitoring stations in the Concho water snake's current range. These actions, when accomplished, should result in the recovery of the Concho water snake and protection of its habitat.

The costs estimated are intended to assist in planning. This recovery plan does not obligate any entity, private or public, to expend the estimated funds. Though work with private landowners is called for in the recovery plan, they are not obligated to expend any funds.

#### **Recovery Task Priorities**

- 1 = An action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.
- 2 = An action that must be taken to prevent a significant decline in species population/habitat quality, or some other significant negative impact short of extinction.
- 3 = All other actions necessary to provide for full recovery of the species.

## **Key to Acronyms Used in Implementation Schedule**

BR = Bureau of Reclamation

CRMWD = Colorado River Municipal Water District

CWA = Clean Water Act

FIFRA = Federal Insecticide, Fungicide, and Rodenticide Act

FWS = U.S. Fish and Wildlife Service (Region 2 is the responsible region)

    FWS-ES = Ecological Services

    FWS-LE = Law Enforcement

SCS = Soil Conservation Service

TPWD = Texas Parks and Wildlife Department

TWC = Texas Water Commission

USACE = U.S. Army Corps of Engineers

USEPA = U.S. Environmental Protection Agency

USGS = U.S. Geological Survey

**CONCHO WATER SNAKE RECOVERY PLAN IMPLEMENTATION SCHEDULE**

PRIORITY NUMBER	TASK NUMBER	TASK DESCRIPTION	TASK DURATION (YEARS)	RESPONSIBLE PARTY	COST ESTIMATES (\$000) THOUSANDS DOLLARS			COMMENTS
					FISCAL YEAR 1	FISCAL YEAR 2	FISCAL YEAR 3	
1	1.2	PROTECT AND ASSURE ADEQUATE INSTREAM FLOWS RANGEWIDE	CONTINUOUS	FWS-ES CRMWD TPWD TWC USACE	2 5 1 40 5	2 5 1 40 5	2 5 1 40 5	SAME COSTS ESTIMATED FOR ALL FOLLOWING YEARS
2	1.1	MONITOR HYDROLOGY AND PHYSICAL HABITAT RANGEWIDE	CONTINUOUS	FWS-ES CRMWD TPWD USGS	2 10 2 81	2 10 2 81	2 10 2 81	SAME COSTS ESTIMATED FOR ALL FOLLOWING YEARS
2	2.1	ESTABLISH MONITORING SITES RANGEWIDE	1	FWS-ES TPWD	18 7			
2	2.2	MONITOR 40 SITES FOR 10 YEARS	10	FWS-ES CRMWD TPWD	5 10 5	5 10 5	5 10 5	CRMWD ONLY FOR 1ST 3 YEARS & SUBSET OF SITES; CRMWD WORK INCLUDES MONITORING REQUIRED UNDER § 7: 18/YR FOR ALL FOLLOWING YEARS SPLIT BY FWS & TPWD
2	2.3	ASSESS AND ABATE THREATS TO WATER QUALITY	CONTINUOUS	FWS-ES CRMWD TPWD TWC USEPA	2 2 2 2 2	2 2 2 2 2	2 2 2 2 2	SAME COSTS ESTIMATED FOR ALL FOLLOWING YEARS
2	3.1	ENFORCE EXISTING LAWS AND REGULATIONS	CONTINUOUS	FWS-LE CRMWD TPWD TWC USACE	1 3 1 20 1	1 3 1 20 1	1 3 1 20 1	SAME COSTS ESTIMATED FOR ALL FOLLOWING YEARS

**CONCHO WATER SNAKE RECOVERY PLAN IMPLEMENTATION SCHEDULE**

PRIORITY NUMBER	TASK NUMBER	TASK DESCRIPTION	TASK DURATION (YEARS)	RESPONSIBLE PARTY	COST ESTIMATES (\$000) THOUSANDS DOLLARS			COMMENTS
					FISCAL YEAR 1	FISCAL YEAR 2	FISCAL YEAR 3	
2	3.2	PROTECT THROUGH SECTION 7 CONSULTATION	CONTINUOUS	FWS-ES USACE USEPA ANY FEDERAL AGENCY	5 3 3	5 3 3	5 3 3	SAME COSTS ESTIMATED FOR ALL FOLLOWING YEARS USACE: CWA § 404 USEPA: FIFRA & CWA
2	5	TRANSLOCATE AND MONITOR SNAKES AMONG CONCHO, LOWER COLORADO, & UPPER COLORADO RIVERS	CONTINUOUS	CRMWD		8	1	5 YR CYCLE STARTS 1995. 8/YR FOR CYCLE YEAR 1 AND 1/YR FOR CYCLE YEARS 2, 3, 4, 5
3	4.1	EVALUATE & REINTRODUCE SNAKES ABOVE SAN ANGELO	2	FWS-ES BR TPWD	2 25 2	2 25 2		
3	4.2	MONITOR REINTRODUCTION ABOVE SAN ANGELO	10	FWS-ES BR TPWD			1 5 1	FUTURE COSTS SAME AS YEAR 3 FOR NEXT 9 YEARS
3	4.3	EVALUATE SITES RANGEWIDE, REINTRODUCE, MONITOR 10 YEARS	12	FWS-ES TPWD	3 3	3 3	2 2	FUTURE COSTS SAME AS YEAR 3 FOR FOLLOWING 9 YEARS. COSTS MAY BE HIGHER IF HABITAT ENHANCEMENT NEEDED
3	6	DEVELOP AND IMPLEMENT POST-RECOVERY MONITORING PLAN	5	FWS-ES TPWD				USFWS 35 TOTAL TPWD 10 TOTAL FOR 5 YEARS POST-RECOVERY

Appendix A.

LIST OF INDIVIDUALS AND AGENCIES PROVIDING COMMENTS  
ON THE DRAFT CONCHO WATER SNAKE RECOVERY PLAN

Charles E. Bradshaw

Dr. James J. Bull, University of Texas, Austin, TX

Will and Karen Byler

Paul T. Chippindale, University of Texas, Austin, TX

Roger Conant

Dr. James R. Dixon, Texas A&M University, College Station, TX

Kerry and Connie S. Glass

Brian D. Greene

Bertha M. Ham

Dr. David M. Hillis, University of Texas, Austin, TX

Mitchell Jansa

Paul Jansa

Steve Jansa

Gerard A. Kasberg

Barbara Marshall

Dr. Terry C. Maxwell, Angelo State University, San Angelo, TX

Charly McTee, Texas Wildlife Association, San Antonio, TX

James M. Mueller, EG&E Energy Measurements, Las Vegas, NV

Harry W. Oneth, Soil Conservation Service, Temple, TX

Fred Ore, Bureau of Reclamation, Austin, TX

Craig D. Pedersen, Texas Water Development Board, Austin, TX

Dr. Andrew Price, Texas Parks and Wildlife Department, Austin, TX

Dr. Norman J. Scott, Jr., USFWS, Univ. of NM, Albuquerque, NM

Dr. Jack W. Sites, Jr., Brigham Young University, Provo, UT

Okla W. Thornton, Jr., CRMWD, Leaday, TX

Wayne Vaughn

Paula and Jerry Vinson

M.C. Vinson

Frank C. Wells, U.S. Geological Survey, Austin, TX

Martin J. Whiting, Texas A&M University, College Station, TX

John R. Wood

PRINCIPAL COMMENTS RECEIVED ON THE  
CONCHO WATER SNAKE RECOVERY PLAN

In July and August of 1992, the USFWS (Service) distributed 166 copies of the draft Concho Water Snake Recovery Plan. The USFWS also distributed 318 letters notifying potentially interested parties (including persons who had commented on Concho water snake critical habitat designation, county commissioners, local, State, and Federal agencies and conservation organizations) that the plan was available for public review and comment. The USFWS received letters of comment from 34 individuals or agencies. One individual submitted two comment letters. Some letters represented comments of more than one individual. All comments were considered when revising the draft recovery plan. The USFWS appreciates the time that each of the commenters took to review the draft and to submit their comments.

The comments discussed below represent a composite of those received prior to the close of the public comment period. Comments of similar nature are grouped together. Substantive comments that question approach or methodology are discussed here. Comments regarding simple editorial suggestions, such as better wording or spelling and punctuation changes, were incorporated as appropriate without discussion here.

All comments received are retained as a part of the administrative record of recovery plan development in the USFWS's Ecological Services Field Office in Austin, Texas. References made are to the final version of the Recovery Plan, except where noted. A summary of principal comments and the USFWS's response follows.

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**Comment 1.** The draft recovery plan does not describe the benefits provided by Soil Conservation Service floodwater retarding structures (impoundments). Ninety-one of these structures exist in the Concho and Colorado River watershed and 11 more are planned for future construction.

**Service Response:** The USFWS is interested in any information that would provide an assessment of the effects of these structures. We agree that reduced sedimentation of Concho water snake habitat is beneficial. However, channel maintenance provided by high flows and floods are also considered beneficial in terms of scouring sediment from riffle habitat. Additionally, the loss of instream flow due to evaporation (or diversion) from such impoundments would affect the hydrology of rivers and creeks occupied by Concho water snakes. Knowledge of the location and actual operation of these impoundments would also aid in determining their effects on the hydrology and sedimentation of riverine habitat occupied by Concho water snakes. Additional analysis is needed to determine the impacts (positive and adverse) of these structures on the Concho water snake.

**Comment 2.** The draft recovery plan does not describe the benefits of conservation treatments such as the Conservation Reserve Program.

**Service Response:** We agree that the Conservation Reserve Program is beneficial to Concho water snake habitat since it reduces soil loss due to wind and water erosion and contributes to maintaining water quality of surface waters and wetlands. The final Recovery Plan recognizes this benefit.

**Comment 3.** Since streamflow is an important determinant of Concho water snake habitat and this information is to be collected at monitoring sites, what means will be used to relate gage height to flow?

**Service Response:** This is an important point and relates to both the establishment of monitoring sites and physical parameters measured during monitoring. When monitoring sites are established (typically at riffles/riffle complexes), the intent is to place a staff gage at the most appropriate location (which may be near the head of the riffle and not the longitudinal center of the monitoring site) and develop a discharge estimate based on channel profile, flow measurements, and staff level. Regarding the range of discharges at a site, lower (base) flows are the primary interest. The stability of the channel will affect the ability to estimate discharge. If during monitoring the channel profile shifts, new leveling work would be needed to reestablish a more accurate discharge estimate. Hopefully, monitoring visits would be supplemented by data collected by interested landowners/parties, since streamflow is usually important to them. Weekly, perhaps daily, staff readings could be collected by volunteers.

**Comment 4.** Costs associated with reconnaissance and evaluation of the Spring Creek area for reintroduction of the Concho water snake were provided by the Bureau of Reclamation.

**Service Response:** These costs have been incorporated.

**Comment 5.** The draft recovery plan lists protection of stream flows in the Colorado and Concho Rivers among the actions needed. Several commenters were concerned about impacts to water rights.

**Service Response:** The Texas Water Commission is the authority that administers rights to use the state's surface water. The Recovery Plan is a document for planning and guidance only and does not constitute an action decision by the Service to affect water rights acquired by any person, corporation, or agency. The flows from E.V. Spence and O.H. Ivie Reservoirs discussed in Section A stem from formal consultation between the U.S. Army Corps of Engineers and the Service over the permit for the construction of O.H. Ivie Reservoir. The instream flows needed by the Concho water snake do not require withdrawal or diversion from the natural watercourse. The Texas Water Commission is responsible for determining: (1) if water is available for use; (2) if the use of water affects vested water rights; and (3) if the use is detrimental to the public welfare.

**Comment 6.** What is the relationship between the designation of critical habitat for the Concho water snake and possible designation of segments of the Concho or Colorado Rivers as a "scenic river" for hiking, camping, etc.?

**Service Response:** This Recovery Plan does not address the issue of designating areas as a "scenic river". Recreation along the Concho and Colorado Rivers, such as hiking and camping, is compatible with conservation of the Concho water snake. However, the Service is unaware of any attempt to designate these areas, in part or in whole, as a scenic river.

**Comment 7.** Recovery efforts should abandon plans to transfer snakes between the Colorado and Concho Rivers above O.H. Ivie Reservoir due to a combination of various points, including: (1) the persistence of Concho water snakes in O.H. Ivie Reservoir would provide for gene flow, (2) transferred snakes would attempt to return to their natal home and fall prey to predators, (3) transferred snakes could introduce disease and/or parasites to new areas, and (4) handling snakes may be harmful. The transfer of snakes is not needed. The genetic consequences are not severe. The reservoir may provide suitable habitat (and presumably some connectivity). How long would the translocation program continue? The creation of suitable habitat patches along strategic areas of shoreline may provide genetic contact.

**Service Response:** The general plan to transfer snakes to counteract the effects of fragmentation has been modified. Two scenarios would provide for "genetic contact" between the upper Colorado and Concho populations. First, snakes may eventually move from the Concho River to the Colorado River through Ivie Reservoir (and vice versa). However, a number of factors could affect the likelihood of that movement (e.g., predation). A second scenario is that riverine snakes interbreed with reservoir snakes and their offspring, through dispersal, would eventually provide genetic contact. For this to occur, the O.H. Ivie population would have to provide some connectivity. Presently, such connectivity is not in evidence.

Important factors that will affect the likelihood of connectivity through O.H. Ivie Reservoir include: (1) the suitability of habitat for Concho water snakes along certain shoreline segments of O.H. Ivie Reservoir; and (2) the persistence and distribution of snakes in the reservoir. Monitoring snakes at sites above the reservoir on the Concho and Colorado Rivers and the reservoir may provide information on movements in and between these areas. The Service believes that reciprocal transplantation of snakes among the three isolated areas is prudent until data show either: (1) genetic contact has taken place (or is likely to have taken place); or (2) all three populations of concern, even though isolated, are viable. The possible negative effects of such transfers are considered to be minimal.

The Service believes that movement among fragmented populations should continue until data indicate that such actions are no longer warranted. If strategic sections of O.H. Ivie shoreline are suitable (or made suitable) for Concho water snakes, the likelihood of naturally maintained genetic contact would be substantially increased.

**Comment 8.** The frequency of transfers should be every 5 years and the number of individuals transferred should be three instead of five. Both sexes should be transferred but males should be larger than 420 mm SVL and females should be larger than 475 mm SVL and non-gravid.

**Service Response:** With the exception of changing the frequency of transfers to four snakes, so that equal numbers of both sexes would be moved, these recommendations have been incorporated.

**Comment 9.** Limiting recovery effort to the Colorado River proper ignores known populations in tributaries.

**Service Response:** Recovery efforts encompass all known populations, including the Concho River and other tributaries of the Colorado such as Elm Creek.

**Comment 10.** Nowhere is the population size of Concho water snake stated nor population goals set forth. Baseline populations are neither stated nor estimated, and it is difficult to see how valid judgments may be made as to the trends of the various populations.

**Service Response:** An extensive amount of good data has been collected over the past 5 years by researchers from Texas A&M University and CRMWD. Population estimates are available for most monitored populations. Because many of the threats are to Concho water snake habitat which would affect all snakes in a given area, recovery actions are focused on habitat considerations and not necessarily numbers of individuals. Some threats are population size related (such as adverse genetic effects due to a small effective population size) and the Service intends that adequate information is gathered to understand and minimize these kinds of threats as well.

**Comment 11.** "Flows in the upper Colorado River basin are strongly affected by the semi-arid weather patterns they are derived from. During dry periods, inflows to E.V. Spence and O.H. Ivie Reservoir are less than your estimated flow needs of the Concho water snake. During such periods, . . . these reservoirs can not make releases from storage without forfeiting a significant amount of their precious water supply yield. Does the USFWS intend to request releases from storage for this purpose? It does not seem possible to meet [all of] the estimated needs all of the time."

Service Response: The U.S. Army Corps of Engineers is the Federal permitting/regulatory agency with purview over releases from E.V. Spence and O.H. Ivie Reservoirs. The USFWS provided a biological opinion to the USACE that required certain flows be met to avoid jeopardy to the Concho water snake. There are two types of flow required for both E.V. Spence and O.H. Ivie Reservoirs: (1) minimum flows and (2) channel maintenance flows.

Regarding minimum flow releases from E.V. Spence Reservoir, these flows are not dependent upon presence or absence of flow into the reservoir, is in addition to releases for downstream water rights, and shall not be depleted below the 10 cfs level by any water user.

Regarding minimum flow releases from O.H. Ivie Reservoir, these flows are not dependent upon the presence or absence of water flowing into the reservoir and must be protected from legal and illegal water diversion. Furthermore, minimum flows from O.H. Ivie Reservoir (Freese Dam) are to be sufficient to maintain 11 cfs from Freese Dam to the confluence of the Colorado River and Pecan Bayou.

Regarding channel maintenance flow releases from E.V. Spence Reservoir, these flows are not required during periods of extended drought or conditions that may call for water rationing by the municipalities serviced by the CRMWD.

Regarding channel maintenance flow releases from O.H. Ivie Reservoir, these flows are not dependent upon flows into O.H. Ivie Reservoir.

**Comment 12.** One commenter recommended multiple changes in the Recovery Narrative using terms such as "must" and "must be".

Service Response: Recovery plans are for planning and guidance only and do not in themselves constitute action decisions made by the Service. Therefore, they use terminology that recommends rather than dictates what actions are needed. We intend for this recovery plan to be consistent with USFWS policy and all applicable laws such as National Environmental Policy Act (NEPA).

**Comment 13.** A group of commenters opposed any further funding for Concho water snake conservation (especially for habitat construction). Some of these same commenters advocated releases from Freese Dam at 11 cfs (October through March) and 22 cfs (April through September) and that warmer water should be released from Freese Dam.

**Service Response:** The Service is encouraged by the results of the six artificial riffles constructed to date. Concho water snake conservation efforts may be enhanced by the construction of additional artificial riffles, particularly in segments of the Concho River, Colorado River, or tributaries, where physical habitat limitations or distances between habitat may be restricting the Concho water snake. Regarding stream temperature, O.H. Ivie Reservoir will typically stratify during the warmest months of the year. In summer, the deeper reservoir waters are expected to be about 13° C (55° F). This is substantially cooler than the ambient river temperature in summer, which is about 27° C (80° F). It is the Service's understanding that when the reservoir is stratified, all releases are to come only from the warmer surface waters. Permit release flows required by the LCRA should also come from the warmer surface waters.

Regarding the discharge of 22 cfs, the CRMWD, LCRA, TWC, and USACE are the agencies with authority over releases. The instream flow of 11 cfs mentioned in Section A is the minimum that CRMWD may release to maintain Concho water snake habitat between Freese Dam and Pecan Bayou and is based on PHABSIM modeling for the Concho water snake. Releases above 11 cfs between April and September are under the purview of agencies such as CRMWD and LCRA.

The remaining comments were submitted by the Concho Water Snake Recovery Team.

**Comment 14.** Regarding the designation of recovery priority of 9C, there are no ongoing or planned construction projects that are in conflict with the recovery of the snake.

**Service Response:** Service guidelines published at 48 FR 43104 state: "Conflict with construction or other development projects would be identified in large part by consultations conducted with Federal agencies under section 7 of the Act. Any species

identified through section 7 consultations as having generated a negative biological opinion which concluded that a given proposed project would violate section 7(a)(2) of the Endangered Species Act or resulted in the recommendation of reasonable and prudent alternatives to avoid a negative biological opinion, would be assigned to the conflict category and would be given priority over all other candidates for recovery plan preparation and implementation in the same numerical category not involving a conflict".

**Comment 15.** Regarding the third paragraph in the section on **Genetic Population Structure**, Section G: With the establishment of snakes in Ivie Reservoir, the Concho and upper Colorado River snakes are still in genetic continuity. The dam separated the upper Colorado-Concho populations from those of the lower Colorado River.

Service Response: Definitive data are not available to indicate genetic interchange between snakes in O.H. Ivie Reservoir and the three river reaches. It is likely that Freese Dam is a barrier to Concho water snake movement. If data become available in the future that indicate genetic interchange occurs in this area, the recommendations in this recovery plan may change. See response to Comment 7.

**Comment 16.** Regarding **Threats** in Section H: The Spence population has persisted for more than 20 years and the Ballinger snakes for 8 years. The O.H. Ivie Reservoir population is expected to be "similarly robust".

Service Response: We are unaware of any evidence for occupation of E.V. Spence Reservoir by Concho water snakes as early as 1972. Since 1987, we would agree. The historical distribution prepared by the team would lead one to conclude that based on historical records, Concho water snakes were no further upstream than the vicinity of Robert Lee. Because of reservoir sedimentation and other factors, it is not known if the E.V. Spence Reservoir and Ballinger Municipal Lake populations will persist in the long-term. The Service believes it is prudent to gather more information on the O.H. Ivie Reservoir population prior to making predictions about its long-term persistence.

**Comment 17.** Regarding the passage in the section on **Conservation Measures** in Section I dealing with population viability analysis: The team believes that the population viability analysis (PVA) conducted by Soulé and Gilpin is basically flawed. Subsequent research has shown that the basic assumptions used to develop the PVA were incorrect. The team believes it is extremely doubtful that its long-term predictions will materialize.

**Service Response:** The Service tries to touch on or cite all major works on a species in the background of a recovery plan. We recognize the limitations inherent in this study. However, we believe it provided preliminary information pertinent to the conservation of the Concho water snake. Therefore this study has been included in the background. We have moved the discussion of the PVA from **Conservation Measures** to a section on population viability.

**Comment 18. Regarding Recovery Criteria:** the teams's recommended recovery criterion was when Concho water snakes are present in at least 94% (38) of 40 monitoring localities . . . at the end of a 10-year monitoring period. The persistence or disappearance of the snakes at the monitoring sites will meaningfully summarize the combined effects of reproductive effort, prey base fluctuations, habitat disturbance, and all other factors in the population biology of the Concho water snake. The viability and stability of the populations is assessed by the combined information from the monitoring sites within each population.

**Service Response:** The monitoring plan and recovery criteria have been modified. The intent of the plan's criteria is to ascertain the status of the Concho water snake (i.e., are each of the three populations viable) through the information developed by monitoring 40 sites (distributed rangewide) for 10 years.

**Comment 19.** The team knows of no evidence for the statement that "Historically, the Concho water snake occurred in the segment/reach of the Colorado River between FM 45 and Bend," and the team believes that restocking efforts there will not add much to the future prospects for the survival of the Concho water snake.

**Service Response:** The current distribution includes localities within this segment (see Figure 4). We believe that it appears this segment has significant potential to improve the long-term survival of the Concho water snake. The idea is the larger the geographic range of a taxon, the less susceptible it is to catastrophic events which could lead to extinction. Additionally, instream flows may be more continuous in the lower part of the snake's range. Task 4.3 calls for evaluation of the potential for this area to contribute to the long-term survival (recovery) of the snake prior to any decision on reintroduction.

**Comment 20. Regarding Task 1.2 of the Recovery Narrative:** The MOA has a limited life span, is obsolete, and has not been effective. We believe that the needs of the

Concho water snake are better served without this complication. Stream flows must be assured in some more durable way.

**Service Response:** We agree that stream flows should be assured in the most durable manner possible. The purpose of the MOA is to direct the implementation of the reasonable and prudent alternatives specified in the biological opinion for the construction of O.H. Ivie Reservoir. The CRMWD was directed to perform a number of tasks directly related to stream flow (e.g., use its legal authority to protect restored habitat areas in the upper Colorado River from unauthorized appropriation). We believe the actions related to that agreement are an important part of achieving recovery objectives.

**Comment 21.** Regarding Task 6, 6.1, and 6.2 of the **Recovery Narrative:** The team recommended eliminating Task 6. They believe that their plan to monitor snakes at 40 sites will adequately evaluate the effects of fish introductions into O.H. Ivie Reservoir.

**Service Response:** The team's plan would monitor the presence of snakes at sites other than O.H. Ivie Reservoir and would not adequately evaluate the status of the Concho water snake in O.H. Ivie Reservoir. Direct monitoring of the population of snakes at O.H. Ivie Reservoir was not addressed in the team's draft plan. The status of the O.H. Ivie Reservoir population, the subject of Task 6 in the draft plan, will be evaluated through other recovery plan tasks (e.g., Task 2 through monitoring nearby demes and Task 3 through conservation actions/measures resultant from section 7 consultations). Task 6 has been eliminated. Nonetheless, the Service believes the potential exists for the recreational fishery to affect the viability of the O.H. Ivie Reservoir population and adjacent riverine populations. The status of the O.H. Ivie Reservoir population may indirectly affect recovery efforts since it may act as a source of (or sink for) Concho water snakes with reference to nearby riverine populations.

**Comment 22.** Monitoring physical habitat should be deleted from Task 1.1 as it is monitored in Task 2.2.

**Service Response:** Task 2.2 will assess physical habitat at monitoring localities. The aim of monitoring physical habitat in Task 1.1 is to identify habitat changes that may be present but not detectable at monitoring sites. Information developed in Task 2.2 will help but has limitations (e.g., changes occurring in a time frame longer than the 10 year monitoring plan would not be seen).

**Comment 23.** Monitoring hydrology should be deleted from Task 2.2. as it is monitored in Task 1.1.

Service Response: Site-specific hydrologic monitoring should occur as part of Task 2.2 (e.g., discharge estimated when visited via staff gage). The hydrologic monitoring intended in Task 1.1 involves monitoring reservoir release data and USGS/TWC records.

**Comment 24.** The cooperation of SCS should be sought to eliminate "check-dams" on the ephemeral tributaries to the Concho and Colorado River.

Service Response: An evaluation of the effects of smaller dams in the watershed is included under Task 1. USFWS and SCS actions are covered under Task 3.2.

## Appendix C.

### Monitoring Plan for the Concho Water Snake

Fifty monitoring sites should be selected from throughout the Concho water snake's range. The main reaches are defined as the upper Colorado (i.e, above O.H. Ivie Reservoir), lower Colorado, and Concho Rivers. Each reach should have at least 12 monitoring sites. Riverine sites selected should include occupied riffles (patches). Site selection should not be biased with reference to estimated population sizes. Of the 50, 40 should be established as monitoring sites. The remaining 10 should be used in the event that monitoring can not continue at an original site. In that event, the nearest reserve site should be monitored. The 10 sites in reserve should be evenly distributed throughout the range. Fifteen of the 40 sites should be those that are currently monitored by the CRMWD. The other sites should be chosen in the spring (May 1 to June 15) on the basis of the results of trapping and searching of juvenile habitats. A site includes 250 m upstream and downstream and should be established with a permanent marker and a stream height staff gage in the best location for estimating flow (discharge). The sites should be relatively evenly distributed throughout the range of the snake, including one each in Spence Reservoir and Ballinger Municipal Lake, and no closer than 5 km to each other.

The 40 sites should be monitored annually for a minimum of 10 years. Surveys should be done during the period May 1 - June 15 during daylight hours (0700-1800). Searches should end when a Concho water snake is found or after all juvenile habitat has been searched. If no snakes are found during the search, 35 minnow traps should be placed in appropriate habitats within the monitoring site. The traps should be checked at least every 4 hours. Traps should be set until dusk. If no snakes have been observed, the same search and trapping procedures should be followed during subsequent visits at two-week intervals. If no snakes have been observed after three visits, the Concho water snake should be considered to be absent at that site for that year. Data for all Concho water snakes observed, trapped, PIT tagged, etc. should be recorded.

The general habitat conditions should be recorded on videotape. Each year, panoramas should be videotaped while standing in the middle of the stream at the center of the monitoring site and recording views of upstream, downstream, and both banks. Separate videotapes should be reserved for each site to facilitate comparisons among years.

At each visit, habitat observations pertinent to possible threats to the snake should be recorded. Habitat observations should be recorded using a checklist (Figure 7). Especially important are observations of artificial discharges, diversions, run-off, changes in water quality, changes in vegetation, smells, fish die-offs, agricultural practices, bank erosion, and sedimentation affecting riffle substrate.

If access to an established site is denied by the landowner, or is lost for any other reason, monitoring should be moved to the nearest extra site for the duration of the monitoring program.

FIGURE 7 - Concho Water Snake Habitat Monitoring Program Data Sheet

Site Name \_\_\_\_\_ Site Number \_\_\_\_\_  
Observer \_\_\_\_\_ Date \_\_\_\_\_  
Starting Time \_\_\_\_\_ End Time \_\_\_\_\_  
Gage Height \_\_\_\_\_  
Weather \_\_\_\_\_  
Videotape # \_\_\_\_\_  
Temperature: Air \_\_\_\_\_ Water \_\_\_\_\_

Snakes found (Yes/No) Time found: \_\_\_\_\_

**Observations**

Artificial discharges, runoff, diversions \_\_\_\_\_  
\_\_\_\_\_

**Water quality**

Smells \_\_\_\_\_ Taste \_\_\_\_\_  
Salt deposits \_\_\_\_\_ Turbidity \_\_\_\_\_  
Algal blooms \_\_\_\_\_ Dead Fish \_\_\_\_\_

**Watershed**

Adjacent landuse \_\_\_\_\_  
Agricultural practices \_\_\_\_\_  
Sedimentation \_\_\_\_\_  
Bank erosion \_\_\_\_\_  
Degree of vegetative encroachment \_\_\_\_\_  
Kind of vegetative encroachment \_\_\_\_\_

**Comments**

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_