APPENDIX B
MONITORING PLAN

B. Monitoring Plan

B.1 Monitoring Purpose

The Pecos River (Pecos) at Bitter Lake National Wildlife Refuge (Refuge) is an ideal location for riverine habitat restoration. The Pecos is home to a diverse fish fauna assemblage, including the federally threatened bluntnose shiner. Investigations of the native fishery within the Middle Pecos River (Hatch 1982; Hoagstrom 1999) have revealed a preference of the native fishes for a wide, sand substrate and active channel bed. Such habitats are common north of the Refuge and become rare as one goes south from the Refuge towards Brantley Reservoir. The Refuge sits at a juncture between good quality fish and riparian habitat towards the north and poor quality habitat towards the south. The Refuge spans roughly 25 river miles of the Middle Pecos from the northern boundary of the Salt Creek Wilderness Unit to the confluence of the Hondo River within the southern Farm Unit. The good-quality habitat of the Middle Pecos in New Mexico contains some of the most diverse native fish communities within the Southwestern United States, and investigations strongly suggest that a restoration of quality habitats from poor ones is critical to the long-term survivability of these fishes (Hoagstrom 1999; Hoagstrom et al. 2008).

Planning for the restoration of the Pecos at the Refuge to date includes investigations of the hydrology and geomorphology of the Pecos at the Refuge, a preliminary restoration plan (FLO Engineering. 1999; US Bureau of Reclamation 1999), several interagency meetings for the project, and the completion of an environmental assessment for the project.

In order to establish meaningful baseline data prior to restoration, the following monitoring protocol has been developed.

B.2 Reach Delineations and Site Locations

The section of the Pecos that is being restored starts at the northern boundary of the Middle Unit of the Refuge. It continues downstream to the southern boundary of the Middle Tract, approximately 1 mile north of the Highway 380 bridge. This river section is approximately eight miles long, with a 300-foot bluff running along the east side of the river valley. For much of the length, the river is bordered by Refuge impounded wetlands on the west side. In order to plan the restoration, the river has been divided into five reaches (Figure 1; Bureau of Reclamation 1999a). Each reach has specific restoration options, which are tailored to the characteristics of that reach. The reaches are defined as follows:

1. Upstream refuge boundary to cross section BL-10 (BL = Bitter Lake), river mile 15.9 to 10.7.2.

2. Oxbow bend 1, from cross section BL-10 to BL-14, river mile 10.7 to 7.8.

3. Active channel reach, oxbow bends 2 and 3, from cross section BL-14 to BL-24, river mile 7.8 to 5.0.

4. Oxbow bends 4 and 5, from cross section BL-24 to BL-27, river mile 5.0 to 3.3.

5. Downstream reach, from cross section BL-27 to BL-32 downstream of Highway 380, river mile 3.3 to river mile 0 (confluence with Rio Hondo).

The Proposed Action calls for channel restoration within Reaches 2, 3, and 4 in the near term. In Reaches 2 and 3, restoration will include saltcedar removal, bank lowering, and native revegetation. In Reach 4, restoration will include returning the Pecos to Oxbow 4. In order to monitor these activities, four monitoring sites have been selected:

1. Scout Camp: This site will start at Scout Camp (river mile 7.8) and extend northward 1,600 feet;

2. Pecos River at Oxbow 3: Start at bottom end of Oxbow 3 (river mile 5.0) and extend northward 1,600 feet;

3. Oxbow 4: 1,600 feet within the center of Oxbow 4; and

4. Channelized Pecos Control: Start at confluence of Oxbow 5 and Pecos (river mile 3.3) and extend northward 1,600 feet.

B.3 Monitoring Objectives

Primary Objective: Monitor the effectiveness of river restoration efforts on the Pecos River at Bitter Lake NWR.

B.3.1 Components of Primary Objective

1. Establish baseline conditions for channel morphology, fish community monitoring, habitat availability, fish habitat use, riparian vegetation, and bird use for the different reaches of the Pecos River at Bitter Lake NWR and for an oxbow lake at the Refuge (Oxbow 4).

2. Monitor changes within river reaches at the Refuge that have undergone restoration activities, and compare these to similarly monitored control (non-restored) reaches.

3. Monitor the changes in open water evaporation associated with the reconnection of Oxbow 4 and activities in all reaches of the project area.

B.3.2 Components of Monitoring

The monitoring project is divided into four components:

1. Fish community monitoring, habitat availability, and use;
2. Vegetation and habitat surveys (aerial photography based);
3. Bird use surveys; and
4. Oxbow 4 evaporative area monitoring.

B.3.3 Timing of Data Collection

Data will be collected four times per year in order to bind seasonal conditions. Depending upon the time of year, the following data will be collected:

A. Winter—January/ February

Transects characterizing in-channel habitat, cross section, discharge measurement, bed forms, shoreline survey, seine hauls, seine haul point measurements, and fish monitoring

B. Late Spring—May/ June

Fish community monitoring

C. Post Summer Rains—August/ September

Transects characterizing in-channel habitat, cross section, discharge measurement, bed forms, shoreline survey, seine hauls, seine haul point measurements, fish community monitoring, and vegetation survey

D. Fall—Late October/ November

Fish community monitoring

1. Fish Habitat Availability and Habitat Use

The following methods will be used to collect data that characterize the macro-habitat and meso-habitat use of each site. It is important to track both the habitat availability and use so that data collected during this investigation can be compared with data collected during the Hoagstrom study of the 1990s.

Macro-habitat (habitat availability):

A. Transects characterizing in channel habitat

B. Cross section

C. Discharge Measurement

E. Bed forms characterization

F. Sediment

G. Shoreline Survey

H. Sediment

Meso-habitat (habitat use):

I. Seine hauls within discrete habitats

J. Seine haul point measurements

K. Fish monitoring

A. Transects: Point Measurements Along Transects and Cross Sections

A point measurement network will be established at each site to characterize macro-habitat. The network consists of 10 transect lines established perpendicular to the bank line/ high-flow thalweg direction at each site, placed 100 feet apart. One of these transect lines will be the cross section for the site.

Point measurement spacing will be 4.0 feet along each transect line. For every point measurement, water column depth (0.01 feet) and mean column velocity (0.01 feet/sec) will be measured. Water column depth will be measured using a top-set wading rod, marked in tenths of feet. Mean column velocity will be measured with a Marsh McBirney Flo Mate 2000 current meter, using the 0.6 depth method for depths < 2.0 feet, and the two-point method will be utilized for depths > 2.0 feet (Rantz et al. 1982). Angle of flow direction to the transect will be measured for each point.

B. Cross Sections

In order to characterize site macro-habitat (channel morphology), 32 cross sections have been established (Bureau of Reclamation 1999a). One cross section will be chosen for monitoring within each of the five sites. Each cross section will be monitored using a Laser Alignment, Inc. LB-10 laser level, stadia rod, and tag line once a year. The endpoints of all cross sections have been surveyed using a survey scale real time kinematic global positioning system, allowing for the monitoring of hydraulic parameters (slope, sinuosity, etc.) within a site and between sites.

C. Discharge Measurement

At each site cross section, a discharge measurement will be conducted. Data will also be commingled with transect line point measurement data (see “Point Measurements Along Transects and Cross Sections”). Mean column velocity and water column depth measurement will be measured at points spaced every 4.0 feet along the cross section. If necessary, cell size will be adjusted to meet the USGS discharge measurement criteria (cell sizes will be adjusted to 1 foot or less).

D. Bed Form Characterization

Within the unvegetated active channel of each cross section, channel bed forms will be characterized. The unvegetated portion of each cross section will be divided into bed form regime segments. Start and stop points of these regimes will be described using the tag line for the cross section survey. Within each regime segment, primary and secondary bed forms will be characterized as to bed form spacing, bed form height, and bed form length. If there is not a distinct break between regimes, the transition zone will be characterized by three sampling points, and the location of each of these points on the tag line will be noted.

E. Sediment Characterization

Sediment samples will be collected within the unvegetated channel every 20 feet along each cross section line using a 2–inch-diameter PVC tube driven 6 inches into the substrate. These samples will be commingled into a single sample representing each site visit. Commingled sediment samples will be analyzed for grain size distribution. Sediment sampling will be done once yearly, during the summer sampling period (see Timing of Data Collection).

F. Shoreline Survey

Shoreline surveys are conducted to assess the shoreline complexity and position at differing flows. A Garmin Global Positioning System Map 76 will be used at the highest track resolution. The survey entails walking the eastern and western shoreline of a site while recording position with the GPS unit in track mode, where feasible. Where shorelines are concealed due to vegetation, the survey will be conducted through point measurements along exposed shorelines.

G. Seine Haul Procedure

Between 15 and 20 seine hauls per site will be done with a 3.0-meter-long by 1.2-meter-deep, 3.2 millimeter seine with double leads. The number of seine hauls per site will be determined by seine crew captain and will continue until all habitats within the site have been sampled. Seining will proceed in direction of flow, and technique will vary with type of habitat sampled. Habitats will be categorized as either: 1) fluvial turbulent (dune crest plunges, lateral plunges, confluence pools, riffles); 2) fluvial non-turbulent (pools, bypass channels, runs, divergence runs); or 3) non-fluvial (lateral embayments, mid-channel embayments, backwaters, forewaters, and isolated pools). Seine hauls will proceed through areas of discrete habitat (areas of similar depth and velocity), and boundaries will be marked with flags. Substrate type (silt, sand, gravel, or cobble) and cohesion (loose or compacted) will be recorded for each haul. Habitat features will be recorded, including type of debry on substrate (woody, non-woody, and detritus), algae, submerged vegetation, and aerial overhang. Fluvial patterns (neutral, diverging, or converging) also will be recorded.

H. Seine Haul Point Measurements

The starting and end points for each seine haul will be marked with flags. Seine haul width and length will be measured, and nine point measurements will be conducted within each seine haul (Hoagstrom 2003). Three transects will be arranged from upstream

to downstream (one transect at top of seine haul, one at mid point, one at bottom of seine haul), with three point measurements on each transect (Hoagstrom 2003). Transects and point measurements will be spaced to fit area seined; point measurements will be more closely spaced in smaller areas seined (Hoagstrom 2003), providing greater resolution for more complex habitats (such as debry on substrate).

Water column depth and water column velocity will be the quantitative measurements used to describe meso-habitat (Aadland 1993). For every point measurement, water column depth and mean column velocity will be determined. Depth will be measured using a top-set rod. Mean column velocity will be determined using a Marsh-McBirney current velocity meter attached to a top-set rod. The sixth-tenths depth method will be utilized for all mean column velocity measurements in depths up to 2.0 feet (Rantz et al. 1982). For depths > 2.0 feet, the two-point (two-tenths and eight-tenths) will be used (Rantz et al. 1982).

Other Data: Standard water quality parameters (dissolved oxygen, pH, salinity, total dissolved solids, and temperature) will be collected three times during the day—when sampling is initiated, at midday, and when sampling is over. Water quality will be collected with a Hydro Lab Surveyor 4A. Collection of water quality will be collected in the main flow and will represent the study area, not individual seine hauls.

2. Vegetation and Habitat Monitoring through Aerial Imagery and Spectral Analysis

Riverine habitat and riparian vegetation will be monitored through aerial imagery. A comprehensive, pre-restoration habitat and vegetation map is to be completed during the summer of 2008. This map will be the baseline for change detection. Upon completion of all restoration activities (summer of 2012), a similar map will be created for change analysis.

3. Bird Use Surveys

The refuge currently runs a MAPS (Monitoring Avian Productivity and Survivorship) banding station, strategically placed along the Pecos River in order to document avian response to these restoration efforts. With the use of mist nets, small-medium sized avian species are captured within this proposed restored area and banded in order to obtain information on avian nesting, fitness, site fidelity, and overall productivity of bird species utilizing the site. This is a long term effort which will be conducted on an annual basis during avian breeding season (see MAPS protocol). All pertinent data is recorded, utilizing Institute for Bird Populations protocols.

When staff becomes available, an off-road point count will be set in place along the Pecos River restoration area. This effort will provide a large scale documentation of bird species utilizing these habitats before and after restoration actions. Refuge personnel and volunteers will conduct a weekly tern survey to document any tern use of the restored river channel during their active breeding season (May to August).

4. Phase I Evaporative Area Monitoring

In order to assess the net effects of reconnecting Oxbow 4 on the net evaporative consumption of water, the following methodology shall be deployed:

1. Monthly monitoring of the stage-area-volume of Oxbow 4 prior to reconnection: On 12/5/06, a staff plate was placed in Oxbow 4 to measure the water level. During the winter of 2007, a survey will be conducted so that this level can be related to stage and volume. Additionally, water levels in the Pecos River shall be monitored.

2. Piezometer transects: A piezometer transect has been installed in association with Oxbow 4 and the Pecos River. Groundwater shall be monitored monthly, and wells are to be outfitted with pressure transducers for high-resolution monitoring.

3. Seepage runs: Seepage runs in the Pecos River in association with Oxbow 4 shall be conducted yearly.

4. Analysis of historic photography: The USFWS has a collection of aerial images of the Refuge from 1996. These images shall be digitized to delineate open water areas in Oxbow 4.

5. Phase II Project Evaporative Area Monitoring

In order to assess the net effects of the Phase II restoration on evaporative consumption of water, the Service will develop monitoring protocols for these reaches, in cooperation with the New Mexico Interstate Stream Commission.

B.4 Additional Monitoring

B.4.1 Fish Community Monitoring on the Middle Pecos River

The following fish community monitoring effort on the Middle Pecos River will provide valuable data on baseline fish community trends.

The purpose of this study is to acquire information on species population status, particularly the Pecos bluntnose shiner, *Notropis simus pecosensis*, and predicting trends in species numbers.

Sites will be selected from the DeBaca-Chaves county line downstream to the upper end of Brantley Reservoir. A total of 12 to 15 sites will be sampled 4 to 6 times per year with a 3.05-meter x 1.5-meter x 3.2-millimeter seine. Eight to fifteen seine hauls will be conducted at each site, depending on the amount of habitat heterogeneity. All habitat types present at the time of sampling will be sampled. Each seine haul will be measured for length and width, and maximum depth will be recorded. Care will be taken to sample only discrete meso-habitat types. Meso-habitat types will be categorized and recorded. Water quality characteristics will be measured at each sample site and will include conductivity ($mS.cm^{-1}$), specific conductance ($mS.cm^{-1}$), dissolved oxygen (mg/l), O_2

percent saturation (%), and salinity (ppt). Additional water quality measurements will be recorded from isolated or nearly isolated habitats.

All fish that can be identified with 100 percent assurance will be measured to the nearest 1.0 millimeter and released. All other fish specimens will be preserved in 10 percent formalin in the field and returned to the laboratory, where they will be rinsed in water, measured and enumerated, and then stored in 70 percent ethanol. Standard length on all preserved fish specimens will be measured with an electronic caliper to the nearest 0.01 millimeter. USFWS-NMFWCO personnel will process, identify, and measure all specimens collected. Once fish have been identified, enumerated, and measured, they will be accessioned into the fish collection at the Museum of Southwest Biology, University of New Mexico for long-term storage.

Sites will be sampled on a seasonal basis: spring, summer, fall, and winter. Sites will be selected to provide broad coverage and on the basis of accessibility. The number of sites and the frequency of sampling will be selected a priori, based on power analysis calculations, which will determine the degree of confidence in predicting trends in species population numbers (i.e., whether species numbers are increasing, decreasing, or not changing appreciably). Global positioning system coordinates will be recorded for each site.

Catch per Unit Effort (CPUE) will be calculated for each species based on fish numbers and total area sampled (square meters). These density estimates will be used to monitor species populations. Relative abundance estimates and species diversity indices will be used to monitor changes in fish community structure.

Mean daily discharge (cfs) will be obtained from the US Geological Survey to assess whether hydrologic patterns influence species numbers, species richness, and species distribution patterns.

Table B-1. List of Sampling Sites for Pecos River Fish Community Monitoring. Site names follow Hoagstrom (2003).

Site	River Mile	County
Willow Creek	623.0	Chaves
Six Mile Draw	615.6	Chaves
Crockett Draw	611.0	Chaves
Cortez Pipeline	606.1	Chaves
Bosque Draw	604.9	Chaves
Gasline Crossing	594.7	Chaves
US Highway 70 Bridge	588.1	Chaves
Scout Camp, BLNWR	575.8	Chaves
US Highway 380 Crossing	570.9	Chaves
Dexter Bridge Crossing	551.9	Chaves
Lake Arthur Falls	522.2	Chaves
US Highway 82 Bridge	503.8	Eddy
Brantley Reservoir Inflow	483.7	Eddy

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