SAN JUAN RIVER MONITORING PLAN

AND PROTOCOLS

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Revised

4 August 2006

SAN JUAN RIVER BASIN RECOVERY IMPLEMENTATION PROGRAM

U.S. FISH AND WILDLIFE SERVICE

REGION 2

ALBUQUERQUE, NEW MEXICO

SAN JUAN RIVER BASIN
RECOVERY IMPLEMENTATION PROGRAM
MONITORING PLAN AND PROTOCOLS

In 1991, the San Juan River Seven-Year Research Program was initiated. Subsequently, in 1992, the Research Program was place under the auspices of the San Juan River Basin Recovery Implementation Program (SJRIP). The Research Program involved a variety of activities designed to characterize the status of the resident fish community (particularly the federally-protected Colorado pikeminnow, *Ptychocheilus lucius*, and razorback sucker, *Xyrauchen texanus*); to identify and quantify those factors (biotic and abiotic) that may be limiting protected fish species, as well as other native fish species; and to identify management and conservation activities that may contribute to recovery of protected species. Much of the research begun under the Seven-Year Research Program has been completed and a variety of management and conservation activities initiated.

To guide and provide a means of evaluating progress under the SJRIP the Long Range Implementation Plan was drafted. It was designed to provide for "adaptive management" (Section 4.7 of SJRIP Long Range Plan) wherein research and particularly management/conservation activities are modified to reflect new information. To aid in the practice of adaptive management, the Long Range Plan also directed that "A long-term monitoring program be developed and implemented…" In Section 5.7.1, development and implementation of "a long-term standardized monitoring program to identify changes in the endangered and other native fish populations, status, distributions, and habitat conditions" is identified as a "Milestone."

Prior to and during the Seven-Year Research effort, several factors were identified that might limit or adversely affect the status of native fishes, particularly Colorado pikeminnow and razorback sucker, in the San Juan River. Briefly, these are;

- low population sizes of Colorado pikeminnow and razorback sucker,
- availability of suitable/needed habitats for completion of life history stages,
- absence of "natural" flow regime (high spring runoff, low summer and
- winter base flows, with storm generated flow spikes),
- water quality (temperature and contaminants),
- nonnative fishes (predators and competitors), and
- disease.

The SJRIP has, as one of its two primary goals, the conservation of populations of Colorado pikeminnow and razorback sucker in the San Juan River basin. To aid in the evaluation of achievement of these Program goals, the following Monitoring Plan goals were developed.

1. Track the status and trends of endangered and other fish populations in the San Juan River.
2. Track changes in abiotic parameters, including water quality, channel morphology, and habitat, important to the fish community.
3. Utilize data collected under Goals 1 and 2 to help assess progress towards recovery of endangered fish species

Meeting these goals will be accomplished by achieving the following objectives. These objectives form the foundation for the monitoring actions identified. Objectives are listed as they relate to each of the three SJRIP Monitoring Plan goals.

1. Track the status and trends of endangered and other fish populations in the San Juan River;
   a. determine relative annual reproductive success of Colorado pikeminnow and razorback sucker and
   b. determine population trends, including size-structure, of adult and juvenile fishes of the San Juan River.

2. Track changes in abiotic parameters, including channel morphology and habitat, important to the fish community;
   a. determine changes in channel morphology and substrate composition,
   b. determine trends in quantity of low-velocity habitat,
   c. determine trends in habitat diversity and abundance, and
   d. correlate trends in habitat changes in hydrology and channel morphology.

3. Utilize data collected under Goals 1 and 2 to help determine progress towards recovery of the endangered fish species.
   a. produce annual summaries of monitoring results and
   b. provide detailed analyses of data collected to help determine progress towards endangered species recovery in 3 years and thence every 5 years.

The San Juan River Monitoring Program is comprised of two major components and each of these is divided into several discrete monitoring activities, each with its specific protocol. Monitoring activities will focus on the reach of the San Juan River between its confluence with the Animas River (River Mile [RM] 180.0) and Clay Hills Crossing (RM 3.0). The monitoring protocols detailed herein were developed from methodologies used during the Seven-Year

Research effort. These methods were based upon published literature, the professional experience of each researcher, peer discussions and review, and project evaluations. During the Seven-Year Research effort, methods were sometimes modified to meet the exigencies of the San Juan River, to incorporate new information and technologies, or to improve efficiency of data collection and quality of data collected. Modifications of methods were implemented after peer discussion and review. The justification(s) for and explanation of modifications were detailed in annual or project completion reports.

Data (biotic and abiotic) collected during the Seven-Year Research effort were analyzed, using multivariate statistical procedures, to define and delimit sampling increments for several monitoring protocols. Abiotic data were used to define eight geomorphic reaches of the San Juan River between Navajo Dam and Lake Powell (Bliesner and Lamarra, 2000). Six of these reaches (Reach 6 through 1) encompass the river reach subject to routine monitoring (Animas and San Juan rivers confluence to Clay Hills Crossing). Abiotic and biotic data were analyzed to determine the linear frequency at which much of the biological monitoring would be conducted. These analyses indicated that y-o-y/small-bodied and subadult-adult/large-bodied fishes monitoring activities should be conducted every third mile. Departures from this sampling frequency are detailed and justified in the appropriate sections. Abiotic monitoring efforts are generally linked to geomorphic reaches, except that habitat monitoring would occur in 3mile increments to overlay y-o-y/small-bodied and subadult-adult/large-bodied sampling with 2 of every 3 miles sampled.

ICTHYOFAUNAL MONITORING

Larval fish—Monitoring protocol for larval Colorado pikeminnow survey

Objectives 1a, 3a, and 3b

Prior to 2002, passive sampling devices (drift-nets and Moore Egg Collectors) were used in an effort to collect larval Colorado pikeminnow at two separate sampling stations along the San Juan River. Over ten years of passive sampling produced less than 25,000 specimens and few larval Colorado pikeminnow. Meanwhile, the larval seining method used to monitor larval Razorback sucker had proven successful and had resulted in collection of larval razorback suckers for four consecutive years (1998-2001). Therefore it was suggested that the sampling protocol for larval Colorado pikeminnow be changed to replicate that of the larval razorback sucker survey. This change from a passive to an active sampling method was acquired at the 19-21 February 2002 San Juan River Biology Committee meeting in Farmington, New Mexico. This sampling protocol will be evaluated each year to determine the most efficient and informative methodology for this phase of the monitoring program. The sampling area for this study will be the San Juan River between Cudei, New Mexico (RM 141.5) and Clay Hills, Utah (RM 2.9). Access to the river and sampling localities will be gained through the use of a non-motorized inflatable raft that will transport both personnel and collecting gear. There will not be

a predetermined number of samples per river mile nor geomorphic reach for this study. Instead, an effort will be made to collect in as many suitable larval fish habitats as possible within the river reach being sampled. Previous San Juan River investigations have clearly demonstrated that larval fish most frequently occur and are most abundant in low velocity habitats such as pools and backwaters.

Sampling efforts will begin in mid July and conclude in early September. A single, continuous effort throughout the entire study area will be made at a minimum of once per month. Sampling efforts for larval fish will concentrate on low velocity habitats using small mesh seines (1 m x 1 m x 0.8 mm). River Mile will be determined to tenth of a mile using the 2003 standardized aerial maps produced for the San Juan River Basin Recovery Implementation Program and used to designate the location of sampling sites. In addition, geographic coordinates will be determined at each site using a Garmin Navigation Geographic Positioning System (GPS) unit and recorded in Universal Transverse Mercator (UTM) Zone 12 (NAD27). In instances where coordinates can not be obtained due to poor GPS satellite signal, coordinates will be determined in the lab using a Geographic Information System based on the recorded river mile.

Meso-habitat type, length, maximum depth, substrate, turbidity (using a secchi disk) will be recorded at each site. Water quality (dissolved oxygen, conductivity, salinity, and temperature) will be recorded using a handheld multi-parameter YSI-85 water quality meter. A minimum of one digital photograph will be taken at each collection site. For all collections, the length of each seine haul will be determined in addition to the number of seine hauls per site. Ambient temperature will also be recorded. In addition to measured parameters, notes on general conditions (e.g., weather and river conditions) will be recorded on a standardized field form (Appendix I). Original field notes will be accessioned and retained at the Museum of Southwestern Biology (MSB) Division of Fishes, University of New Mexico. Scanned copies of all field notes will be electronically archived in a permanent MSB database program.

All retained specimens will be placed in plastic bags (Whirl-Paks) containing a solution of 10% formalin and a tag inscribed with unique alpha-numeric code that also is recorded on a field data sheet. Samples will be returned to the MSB laboratory where they will be sorted, specimens identified to species, enumerated, measured (minimum and maximum size [mm standard length] for each species at each site), transferred to 70% ethyl alcohol catalogued and stored within MSB.

Annual reports will be prepared and submitted by 31 March of the year following completion of work. The report will provide summary statistics by sampling trip and geomorphic reach, and will include all relevant catch-rate data and water quality information. Appropriate statistical procedures will be used to assess differences in fish densities by locality, sampling trip, and geomorphic reaches. Annual reports will also contain comparative study year catch-rate data.

A three- and subsequently five-year summary reports, which integrate and synthesize data from annual reports, will be prepared. An electronic copy of all reports will be formatted and submitted for inclusion in the San Juan River integrated database being developed at UNM.

Larval fish—Monitoring protocol for larval Razorback sucker survey

Objectives 1a, 3a, and 3b

The sampling methods to be employed for monitoring of larval razorback sucker are those that yielded the first documentation (1998) of reproduction by this species in the San Juan River. This sampling protocol will be evaluated each year to determine the most efficient and informative methodology for this phase of the monitoring program. The sampling area for this study will be the San Juan River between Cudei, New Mexico (RM 141.5) and Clay Hills, Utah (RM 2.9). Access to the river and sampling localities will be gained through the use of a non-motorized inflatable raft that will transport both personnel and collecting gear. There will not be a predetermined number of samples per river mile nor geomorphic reach for this study. Instead, an effort will be made to collect in as many suitable larval fish habitats as possible within the river reach being sampled. Previous San Juan River investigations have clearly demonstrated that larval fish most frequently occur and are most abundant in low velocity habitats such as pools and backwaters.

Sampling efforts will begin in mid April and conclude in late June. A single, continuous effort throughout the entire study area will be made at a minimum of once per month. Sampling efforts for larval fish will concentrate on low velocity habitats using small mesh seines (1 m x 1 m x 0.8 mm). River Mile will be determined to tenth of a mile using the 2003 standardized aerial maps produced for the San Juan River Basin Recovery Implementation Program and used to designate the location of sampling sites. In addition, geographic coordinates will be determined at each site using a Garmin Navigation Geographic Positioning System (GPS) unit and recorded in Universal Transverse Mercator (UTM) Zone 12 (NAD27). In instances where coordinates can not be obtained due to poor GPS satellite signal, coordinates will be determined in the lab using a Geographic Information System based on the recorded river mile.

Meso-habitat type, length, maximum depth, substrate, turbidity (using a secchi disk) will be recorded at each site. Water quality (dissolved oxygen, conductivity, salinity, and temperature) will be recorded using a handheld multi-parameter YSI-85 water quality meter. A minimum of one digital photograph will be taken at each collection site. For all collections, the length of each seine haul will be determined in addition to the number of seine hauls per site. Ambient temperature will also be determined. In addition to measured parameters, notes on general conditions (e.g., weather and river conditions) will be recorded on a standardized field form (Appendix I). Original field notes will be accessioned and retained at the Museum of Southwestern Biology (MSB) Division of Fishes, University of New Mexico. Scanned copies of all field notes will be electronically archived in a permanent MSB database program.

All retained specimens will be placed in plastic bags (Whirl-Paks) containing a solution of 10% formalin and a tag inscribed with unique alpha-numeric code that also is recorded on a field data sheet. Samples will be returned to the MSB laboratory where they will be sorted, specimens identified to species, enumerated, measured (minimum and maximum size [mm standard length] for each species at each site), transferred to 70% ethyl alcohol catalogued and stored within MSB.

Annual reports will be prepared and submitted by 31 March of the year following completion of work. The report will provide summary statistics by sampling trip and geomorphic reach, and will include all relevant catch-rate data and water quality information. Appropriate statistical procedures will be used to assess differences in fish densities by locality, sampling trip, and geomorphic reaches. Annual reports will also contain comparative study year catch-rate data. A three- and subsequently five-year summary reports, which integrate and synthesize data from annual reports, will be prepared. An electronic copy of all reports will be formatted and submitted for inclusion in the San Juan River integrated database being developed at UNM.

Young-of-year and small-bodied fishes monitoring

Objectives 1a, 1b, 3a, and 3b

Annual autumn young-of-year and small-bodied fishes monitoring will encompass the San Juan River from its confluence with the Animas River (River Mile [RM] 180) in Farmington, NM downstream to Clay Hills Crossing (RM 3), UT. Sampling will occur in the primary channel, secondary channels, and backwaters. Primary channel sampling will occur every third mile. Each third-mile sampled will be the mile not electrofished by large-bodied fishes monitoring crew. All secondary channels with surface water will be sampled, regardless of inflow or lack. All backwaters ($>50m^2$) will be sampled. Secondary channels are defined as channels having $\leq$25% of total discharge (visually estimated) at time of sampling and being at least 300 m in length. Young-of-year and small-bodied fishes sampling will occur annually between mid September and mid October in conjunction with large-bodied fish monitoring.

Primary channel young-of-year and small-bodied fish samples will be obtained primarily from shoreline habitats, but off-shore habitats will also be sampled, where feasible. The specific location of a sample site (about 200 m in length) will be at discretion of sampling crew, but each site should be in areas of moderate to high habitat diversity. Within each primary channel sample site, all mesohabitats (e.g., pool, riffle, riffle eddy, run, off-shore run, off-shore riffle, and shoal) present will be sampled. Drag seines (3.2 x 1.6 m or 3.8 x 1.6 m, 44 mm mesh; double-weighted) will be the primary capture tool. Battery-powered backpack electrofishers, in combination with block seine, may be used to sample riffle and riffle-run habitats. In mesohabitats having visible surface flow, seine hauls will be in a downstream direction or diagonal to shore. In mesohabitats where flow is imperceptible or where cover (e.g., debris pile,

root wad, or boulder)is present, the seine haul will be made in a manner that entraps fish. All seine hauls will be 10 m or less in length. Where backpack electrofisher and seine are used in tandem, the seine will be anchored perpendicular to flow. Each electrofishing effort will be 10 m or less in length. Area of each sampled mesohabitat seined or electrofished will be demarked with surveyor flags.

Secondary channel sample sites will typically be 100 to 200 m in length, and at least 100 m downstream of mouth. All mesohabitats within the site will be sampled. Specimen collection will be the same as for primary channel.

A minimum of two seine hauls will be made in each backwater sampled. One seine haul will be across backwater mouth and one parallel to a shore.

Mesohabitats will be sampled separately and data for each recorded separately. Specimens will be examined to separate native from nonnative fishes collected from a mesohabitat. Total (TL) and standard (SL) lengths ($\pm$ 1 mm) and mass (g) of each rare fish (i.e., roundtail chub, Colorado pikeminnow, or razorback sucker) collected will be determined. Each will be scanned to determine if it has been implanted with a PIT tag. If a PIT tag is not detected, one will be implanted (assuming specimen is $\geq$ 150 mm TL) and its unique alphanumeric code recorded. Total and standard lengths and mass of all other native fishes (>100 mm TL) captured will be determined and recorded. Only total length of specimens <100 mm TL will be determined. Typically, all native fishes will be released, but some may be retained. Length (TL and SL) and mass of all large-bodied ($\geq$ 150 mm TL) fishes captured will be determined and specimens disposed. All other nonnative fishes will be retained. All retained fishes from each mesohabitat will be preserved (in 10% formalin) separately and uniquely identified. After sorting, enumeration, length and mass determination, all retained specimens will be accessioned to the Museum of Southwestern Biology. Area of each seine haul or electrofishing run will be determined and recorded. The location (river mile and UTM coordinates) of each site, mesohabitats sampled, and water quality (water temperature, dissolved oxygen, specific conductance, and salinity) will be determined and recorded on standard field forms.

Data from young-of-year and small-bodied fishes monitoring will be submitted annually (written and electronic formats) by 31 March of the year following the effort. Each annual report will be mainly a tabular and graphic presentation of data, with important findings discussed. Tables and figures will present information (spatial and temporal) on fishes collected in each geomorphic reach and river-wide. All relevant information (capture location, habitat, and somatic) on rare fishes will be presented.

Original field notes will be archived by the Museum of Southwestern Biology. Summary reports will be prepared every fifth year, the first encompassing 2003 through 2007. Descriptive statistics (e.g., mean, range, standard deviation, and standard error) of data will be provided. Statistical methods to characterize changes, or lack, in fish assemblages across years and

longitudinally will include non-parametric (e.g., Kruskal-Wallis and Kolomogorov-Smirov) and parametric (e.g., t-test, regression analysis, and analysis of variance tests. Similarity and diversity indices will be used to characterize trends in fish assemblages across time and space. Each summary report will provide detailed analyses of data, discussion of detected trends and their relation to abiotic and biotic factors, and evaluation of methods to monitor young-of-year and small-bodied fishes. Also, biostatisticians will be consulted to determine most appropriate statistical analyses.

Sub-adult and adult large-bodied fish community monitoring

Objectives 1b, 3a, and 3b

Annual monitoring of large-bodied fishes in the San Juan River between the confluence of the Animas and San Juan rivers (river mile {RM} 180) and Clay Hills Crossing (RM 3) will occur between mid-September and mid-October of each year. Monitoring will occur mainly in the primary channel, however, secondary channels with sufficient flow to make them navigable via electrofishing raft will also be sampled.

Raft-mounted electrofishing gear will be used to collect fishes. Rafts will not be motorized. Output of electrofishing units will not exceed 400 volts and 6 amps, pulsed DC. Two electrofishing rafts will be deployed along opposite shorelines to collect fishes. Each raft will proceed downstream perpendicular to shore at a fairly constant rate of speed, with continuous electrical output. In instances where upstream wind or lack of river current precludes fishing perpendicular to shore, electrofishing rafts may be rowed downstream parallel to shore, within one oar-length of the water's edge. Each electrofishing crew will consist of one raft operator (rower) and one netter; both will be experienced in raft-mounted electrofishing techniques. Effort will be made to net all fishes stunned by the electrofisher, regardless of body size or species. To minimize injury to netted fish, they will be promptly dumped into a live live-well located directly behind the netting deck; netted fish will not be repeatedly swept through the electrical field. Sampling will be conducted in one-RM increments, with two of every three RM's being sampled. Sampling effort will be recorded as elapsed time electrofished by each raft per river RM. All fish captured will be identified and enumerated by life stage (i.e., young-of-the-year, juvenile, adult) and species. Fish will be identified by six-letter codes (first three letters of genus and first three letters of species). Every fourth sampled RM (referred to as a "designated mile" or "DM"), all fish captured will be weighed ($\pm$ 5 g) and measured ($\pm$ 1 mm total length {TL} and standard length {SL}). All nonnative fishes will be removed from the river and all native fishes will be returned alive to the river.

Each rare fish (Colorado pikeminnow, razorback sucker, roundtail chub) captured will be weighed ($\pm$ 1 g if $\leq$ 200 mm TL and $\pm$ 5 g if > 200 mm TL) and measured ($\pm$ 1 mm TL and SL), have sex determined (if possible), and be scanned for a PIT (passive integrated transponder) tag. If a specimen does not have a PIT tag, such will be implanted (if specimen is > 150 mm TL).

Water temperature will be recorded at each DM. Each RM sampled by each raft will be treated as a separate sampling collection, with a unique sample number. All data will be recorded on standard field forms (Appendix III). Rare fish information will be recorded on the standard field form for the RM in which the fish was captured.

Interim progress reports summarizing data obtained during large-bodied fish community monitoring will be submitted (electronic format) by 31 March of the year following the sampling effort. The interim progress report will minimally contain a summary of species captured, species density (number per elapsed hour of electrofishing time) by geomorphic reach, size-structure of common species populations (flannelmouth sucker, bluehead sucker, channel catfish, and common carp) by geomorphic reach, and summary information on rare fishes captured (including somatic data). Summary reports (to be produced every five years) will include an overview of long-term trends in species populations, including: size-structure; condition; distribution patterns; and relative abundance. Descriptive statistics (e.g., mean, range, and standard error) of sampling results will be provided. Statistical methods to evaluate changes in fish assemblages may include non-parametric (Kruskal-Wallis and Kolomogorov-Smirov), parametric (paired *t*-test, one-way analysis of variance {ANOVA}, and analysis of covariance tests), and linear regression analyses. Various population-estimate models (manually generated such as Schnabel or Petersen index estimates or computer programs such as CAPTURE or MARK {Cormack-Jolly-Seber}) may also be used to analyze data.

Original field notes will be retained by the entity responsible for conducting large-bodied fish community monitoring. Photocopies of all field notes will be archived with the U.S. Fish and Wildlife Service's New Mexico Fishery Resources Office in Albuquerque. Electronic data files will be submitted to the entity responsible for maintaining the San Juan River Recovery Implementation Program's integrated database by 31 March of the year following the sampling effort.

GEOMORPHOLOGY AND HABITAT MONITORING

Channel morphology

Objectives 2a and 3a

River Transects

Deposition and scour will be monitored in five of the six geomorphic reaches included in the long term monitoring study area. Reach 2 is a canyon bound reach that is not subject to channel change and will not be monitored. Two to three cross-sections in each geomorphic reach have been identified for monitoring. Each cross-section will be surveyed across the active channel post-runoff every 5 years starting in 2009 (From 1998 through 2004, these cross-sections were monitored twice each year). At least one cross-section in each reach will span the flood

plain and the full width will be surveyed to monitor the impact of high flows on the flood plain. Table 1 lists the cross-sections that fall in each category by geomorphic reach. The cross-sections are selected from those established in 1962 (lettered cross-sections), those established in 1992 and new cross-sections where the existing ones are not representative of a geomorphic reach. All cross-sections will receive a new number representing the geomorphic reach they represent as shown in table 1.

Elevation data will be obtained by stretching a marked cable across the river between anchor points for each transect and measuring the channel depth relative to a local bench mark. River depths will be measured at 5 to 10 ft increments, depending on location, length of cross-section and change in elevation. Substrate type at the point of depth measurement will be characterized as sand or gravel/cobble and recorded. The full-width flood plain surveys will be completed with a total station or sub-centimeter accuracy GPS receiver outside the active channel at points representing changes in grade (e.g. tops of hills, edges of channels, toes of banks).

The survey data will be plotted using Autocad and the average and maximum change in channel depth since the preceding survey will be computed. Substrate attributes also will be noted in the files. Percent composition of substrate by type will be computed for each measurement**.**

Data will be summarized and the results reported in the year collected. These reports will contain cross-section plots, change in average cross-section elevation from pre- to post- runoff and from the previous year and percent substrate composition noted. The flow/morphology relationships will also be analyzed for verification or adjustment and reported in these years.

Table 1. Cross-section locations by geomorphic reach

Geomorphic Reach	X-Section No.	Former Identification	River mile
6	CS6-01	Section T	175.0
	CS6-02	RT-01	168.3
	CS6-03	RT-02	154.4
5	CS5-01	RT-03	142.7
	CS5-02	RT-04	136.6
	CS5-03*	RT-05	132.7
4	CS4-01	RT-06	124.0
	CS4-02	RT-07	122.1
	CS4-03*	Section E	118.2
3	CS3-01	RT-09	90.8
	CS3-02*	RT-10	82.3**
	CS3-03	RT-11	70.0
1	CS1-01	C-01	12.7

	CS1-02	C-02	4.1

*Valley-wide cross-sections surveyed to monitor floodplain changes
**Valley-wide cross-section located at RM 82.2

Detailed Reaches

Two detailed reaches have been identified in the San Juan River that will be used to monitor fluvial processes that affect detailed channel reaches. Each reach was selected to include the following habitat types at least 75 percent of the years between 1993 and 2003: backwater, riffle, slackwater, island. The reaches are hydraulically contained to allow 2-dimensional flow modeling. They also have exhibited use by both Colorado pikeminnow and razorback sucker.

The upper most detailed section is within Reach 5 at RM 137. It has a valley trend length of approximately 3,300 ft and a river channel length (main channel) of about 3,900 ft. The second detailed section is in Reach 3 at RM 82. The site's valley trend length is about 4,200 ft with a river channel length of about 4,500 ft.

Each detailed reach will be surveyed annually post-runoff. Survey point density will be sufficient to represent the channel topography to the bank-full water line (average point density of approximately 800 sq ft per point). Surveys will be completed utilizing either a total station or sub-centimeter accuracy GPS system. Characterization of substrate (cobble/gravel or fines) will be made at the time of survey. Water's edge will also be surveyed. Islands and banks will be surveyed to the extent vegetation allows, but only when high flows have occurred that may have altered the topography.

The survey data will be plotted and a three-dimensional surface of the channel developed. Change between surveys will be calculated by intersecting the surface generated for the previous survey with that for the current survey.

Habitat will be mapped in detail on rectified base videography or aerial photo prints with a scale of 1 inch equal 75 ft. The detailed reaches will also be mapped at the standard mapping resolution (1 inch equal approx. 200 ft.) as a part of the regular habitat mapping. The detailed mapping will be completed at the same general time as the standard fall mapping. All procedures listed in the Habitat section, below, will be followed. The data will be processed using the same methods employed for the standard mapping.

There are a number of fish monitoring programs that will collect fish within these detailed sections that will be investigated in this study. As these areas are sampled, habitat

mapping crews will interface to document habitats where rare and native fish are captured. After initial trips to correlate habitat classification, these data will be collected with the fish capture data by other crews and analyzed as a part of this study. This will allow establishment of a direct link between habitat use, habitat availability, and potential temporal changes in habitats.

To better understand the hydraulic properties of these complex reaches, the two-dimensional steady state model developed in 2005-2006 will be updated with the new survey data and recalibrated. Thee survey data will be used to re-configure the model and the water surface elevations will be used for calibration. The change in water surface profiles will be predicted as a result of the change in channel form. Velocities predicted from the model can be used to determine shear stress and sediment transport through these detailed reaches to compare with the empirical data on channel change.

Utilizing the results of the model and habitat mapping, response of the channel form and habitat to spring runoff can be analyzed and habitat conditions at a range of flows predicted. Multiple years of data will be needed to calibrate response calculations and fully interpret the data. Change in these relationships will be documented.

Annual reports will document channel and habitat results and present changes since the previous season. Every 5 years, channel and habitat change in response to hydrology will be analyzed and integrated with the cross-section survey results to assess effectiveness and appropriateness of flow recommendations.

Habitat mapping

Objectives 2b and 3a

Annually, digital aerial photography or videography will be obtained for the San Juan River between RM 180 and RM 0 and printed at an approximate scale of 200 ft/inch. Thirty-eight categories of aquatic habitat (Table 2) will be mapped in the field utilizing prints of the digital imagery as a base map. The flights to capture the imagery will be completed as soon after runoff as practical, targeting flows below 1,000 cfs. Field mapping will be completed at flows between 500 and 1,000 cfs when possible and be completed in the same general time frame as the fall adult monitoring trip (typically plus or minus a month if the flow conditions allow).

Table 2. Summary of habitat mapping categories utilized in the field mapping program.

Map No.	Habitat Type	Map No.	Habitat Type	Map No.	Habitat Type
1	Backwater	11	Scour Run	26	Rootwad Pile

2	Backwater Pool	12	Shore Run	27	Abandoned Channel (dry)
3	Pool	13	Undercut Run	28	Sand Bar
4	Debris Pool	14	Riffle/Run	29	Tributary
5	Rootwad Pool	15	Riffle	30	Shoal/Riffle
6	Eddy	16	Riffle Eddy	31	Island
7	Edge Pool	17	Shore Riffle	32	Rapid
8	Shoal	18	Riffle/Chute	33	Irrigation Return
8a	Sand Shoal	19	Chute	34	Inundated Vegetation
8b	Cobble Shoal	20	Slackwater	35	Pocket Water
9	Shoal/Run	21	Isolated Pool	36	Boulders
9a	Sand Shoal/Run	22	Embayment	37	Waterfall
9b	Cobble Shoal/Run	24	Overhang Vegetation		
10	Run	25	Cobble Bar		

Field mapping will be entered into a Geographic Information System (GIS) for analysis to produce coded polygons (habitats) for which surface areas are computed and sorted individually. The data will then be retrieved and analyzed by cross-tabulation of the factors being correlated (e.g., habitat area by river mile). These data will be processed and summarized annually. Every 5 years, the flow-habitat relationships will be re-examined and updated and trends in habitat change characterized. Geographic Information System coverage of the habitat mapping will be produced and included in the database on an annual basis.

Water temperature

Objectives 2c and 3a

Water temperature monitors will be maintained on the San Juan River at Navajo Dam, Archuleta, Farmington, Shiprock, Four Corners, Montezuma Creek and Mexican Hat and on the Animas River at Farmington. Hourly data will be downloaded twice yearly and summarized and plotted annually.

OPERATION OF PUBLIC SERVICE COMPANY OF NEW MEXICO FISH PASSAGE STRUCTURE

Objectives 1a, 1b, 3a, 3b

Operation of the fish ladder will begin no later that 1 April and will operate until 31 October of each year. If data suggests significant movement of rare fishes is occurring at or near 31 October it may be requested by the Biology Committee that operation continues until collections become rare or infrequent.

During operational season the passage will be visited at least once each day to check traps, sort and enumerate fish, and for general maintenance. Researchers will determine how many traps will fish, for how long, and when to harvest based on observations.

To check for the presence of fish, water levels will be lowered to a level that makes harvesting feasible. All fish will be netted and transferred to a sorting tray. Fish will be enumerated by species with native fish transferred to a holding tank for placement upstream of the weir. All non-native fishes will be removed from the system and will be disposed of at the discretion of researchers. Any fish with an external anchor tag will be measured (nearest $\pm$ 1mm), weighed (nearest $\pm$ 5 grams), and anchor tag number recorded. All rare fish collected will be measured (nearest $\pm$ 1mm), weighed (nearest $\pm$ 5 grams), checked for the presence of a Passive Implant Transponder (PIT) tag. If no tag is present, fish > 150 mm total length will be implanted with a PIT tag. Native fish will be released above the weir and non-natives will be removed from the system.

Researchers or their representatives will also be responsible for periodic cleaning of riverborne sediment that accumulates within the trap during increased flow events. Daily cleaning of surface and submerged trash, debris, and riverborne algae from the trash racks and bar screens in the forebay and aluminum conduit screens in the fish trap will be conducted. Amount of effort varies seasonally. Representatives from the Navajo Nation Fish and Wildlife Department, Bureau of Reclamation, and the U.S. Fish and Wildlife Service will perform inspections of the fish ladder every three years to identify design deficiencies and maintenance requirements.

Monthly reports, summarizing data obtained during operation of the fish passage will be provided to the Program Coordinators office in electronic format by the 15th of each month during operational season. Monthly reports will summarize the number of fish by species, length/weight, and tag data including the time and date of operation. An annual report summarizing data collected throughout the operational year will be submitted (written and electronic formats) by 31 March of the year following sampling.

REPORTING AND COORDINATION

Annual reports will consist primarily of tabulated data (with figures and maps, as appropriate) obtained during each monitoring effort. Important findings will be presented as brief narratives. After submission of annual reports to SJRIP Biology Committee, potential changes to monitoring protocols will be discussed and evaluated the the Biology Committee. If changes are deemed appropriate, by two-thirds majority of Biology Committee, the SJRIP Monitoring Protocol will be changed accordingly. The first summary reports, synthesizing data from annual reports, will be prepared after three years of monitoring (2002) and thence summary reports will be completed every five years. Information in annual reports and particularly summary reports will be used to evaluate program progress and as a basis for practicing "adaptive" management in the SJRIP.

Minimally, summary reports on biological monitoring will contain information on patterns or trends in the abundance and size-structure of common species (native and nonnative), somatic condition of common fish species, assessments of recruitment, and longitudinal abundance and population size-structure patterns. The summary reports on monitoring abiotic conditions will be similar to biological reports in that detailed analyses and narratives of results will be presented for each monitoring activity. These reports will discuss changes in abiotic conditions (e.g., channel morphology, spawning bars, sediment dynamics) in relation to river flow regimes. Appropriate uni- and multi-variate statistical methods will be used to assess data for both biotic and abiotic monitoring efforts.

Biotic and abiotic summary reports will be issued as a single document. To the extent appropriate, linkages among biotic and abiotic information will be made and discussed in a document summary.

All data in each annual report will also be submitted on disk or by e-mail for incorporation into the SJRIP GIS database maintained on San Juan River research and monitoring activities. Annual monitoring results will be submitted to USFWS, Region 2 and SJRIP GIS database manager by 31 March of the year following collection. Three-and five-year summary reports will be due to the SJRIP Biology Committee by 1 October of the year following completion of the reporting segment. All reports should be in scientific journal style and format (e.g., The Southwestern Naturalist). All reports will be draft until reviewed and accepted by SJRIP Biology Committee. Upon acceptance of reports, Biology Committee will submit a joint annual or summary report to SJRIP Coordinating Committee within three months of final Biology Committee approval. Once annual and summary reports are accepted by the SJRIP Biology and Coordination committees, they will be made available to the public.

Other SJRIP sponsored research activities will be conducted in a manner and schedule to ensure that their field work does not interfere with or disrupt monitoring activities. If there are questions regarding this potential, the principal investigator for the research activity must communicate the nature and extent of the proposed activity with the entity responsible for the monitoring segment(s) that might be affected and the SJRIP Biology Committee. If potential

conflicts are not resolvable among investigators, the matter will be taken to the SJRIP Biology Committee for resolution.

Appendix I. Standardized field sheet for the Museum of Southwestern Biology, Division of Fishes.

Field No.: .....

Date: ...../..... Sample: ..... Acc. No.: .....

State/Country: ..... Locality: .....

.....

County: ..... Drainage: ..... Quad.: .....

Coordinate System: ..... N/S: ..... E/W: ..... Zone: .....

Shore Description: ..... Air Temp.: .....°C

Water Description: .....

Substrate: ..... Water Depth: .....m

Aquatic Vegetation/Cover: .....

Water Temp.: .....°C Velocity (est.): ..... m/s Width (est.): .....m

Secchi Depth: ..... cm D.O.: .....mg/l Conductivity: .....µS Salinity: .....ppt pH: .....

Method of Capture: ...../.....

No. Hauls: ..... Area: ..... m^2 Shocking Sec.: ..... Volts: ..... Amps: .....

Distance from Shore (est.): ..... m Depth of Capture: .....m

Collected by: .....

.....

Time: (start) ..... h (stop) .....h Notes taken by: .....

Orig. Preservative: ..... Photographs: .....

Released fishes: Yes / No (list separately):

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