FY-2001 PROPOSED SCOPE OF WORK for: **Project #:** 85A
Colorado River Channel Monitoring

Lead Agency: U.S. Fish and Wildlife Service
Colorado River Fishery Project

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Category:	Expected Funding Source:
X Ongoing	X O&M funds

I. Title of Proposal:

Channel Monitoring to Evaluate Geomorphic Changes on the Mainstem Colorado River

II. Relationship to Recovery Program/Ranking Factors:

The coordinated operation of reservoirs in the upper Colorado River basin provides a current opportunity to augment streamflows to benefit the recovery of endangered fishes. There are 20-plus reservoirs in the upper basin with storage capacities exceeding 5,000 acre-feet (Liebermann et al., 1989). By coordinating releases from these reservoirs it should be possible to augment flows to improve spawning, rearing, and nursery habitats, and to prevent further loss of existing habitats. Releases will be planned and timed to accomplish several objectives, including flushing fine sediment from the bed, transporting gravel bed material, and improving access to backwaters. The proposed study will provide more detailed information on the geomorphic effects of coordinated reservoir releases.

Hydrologic studies recently completed at the University of Colorado indicate that annual peak discharges of the Colorado and Gunnison Rivers have decreased significantly since 1950 (M. Van Steeter, unpublished Ph.D. dissertation, University of Colorado, Boulder, 1996). Other modifications to the annual hydrograph include a decrease in high flow duration, and an increase in base flows. Annual suspended sediment loads of both rivers have likewise decreased, largely because the high flows that carry the majority of the sediment load have been less frequent.

Our data show that there was a particularly important period from the late 1950s through the late 1970s when annual sediment loads were 40 to 60% less than the long-term average. The net effect of the reduction in transport capacity was for sediment to accumulate in the river channel, causing it to become narrower. Van Steeter's analyses of

aerial photographs of the 15- and 18-mile reaches indicates that the area of the main channel has decreased by 15% and the area of side channels and backwaters has decreased by 25% since 1937. If no further habitat is to be lost, then the sediment supplied to the 15- and 18-mile reaches from areas upstream must be carried through the reach on a regular basis.

Results from related studies indicate that a large proportion of the annual sediment load of the Colorado River is carried on the rising limb of the snowmelt hydrograph in April and May. This relatively predictable pattern occurs because sediment is being delivered from erodible tributary basins downstream of Glenwood Springs at a time when mainstem flows have not yet reached their peak. Tributaries such as Parachute Creek and Roan Creek drain extensive areas of shale bedrock and supply abundant amounts of sediment to the upper Colorado River. The Gunnison River likewise drains extensive areas of shale bedrock. It is possible to simulate conditions wherein the sediment loads of these rivers can be optimized for a given volume of water available by shifting water available to the rising limb of the hydrograph. Whether these conditions can be achieved through coordinated reservoir releases has not been studied in any detail.

Most of the sediment carried by the Colorado and Gunnison Rivers consists of silt and fine sand. At moderate to high flows, this material moves in suspension, but at lower flows or in areas of low velocity it will settle out of suspension. The behavior of this fine sediment is an important biological issue. Fine sediment fills the interstices between gravel particles, thereby reducing the space available for macro invertebrates which are an important food source for lower order fishes. Fine sediment can also cover gravel particles and degrade the quality of spawning bar habitat (Tyus and Karp, 1989; Harvey et al., 1994). Finally, there is a tendency for fine sediment to accumulate in backwaters, which in the short term limits access to these habitats, and in the long term may fill them altogether. More detailed work is needed to evaluate the spatial patterns and problems associated with fine sediment transport and deposition in the 15- and 18-mile reaches.

Although the Colorado and Gunnison Rivers carry mostly (> 95%) suspended sediment, they both have gravel/cobble beds. Thus, the overall structure and stability of these rivers is determined by the mobility of the gravel bed material. Our previous research indicates that discharges from ½ to 2/3 of the bankfull level will move coarse substrates in the 15- and 18-mile reaches. Under the present flow regime these discharges occur about 25 days per year. Flows such as this are required to loosen embedded particles and remove fine sediment from the bed, which as noted above, are important for biological productivity and spawning success. Studies by McAda and Kaeding (1991) show that spawning sites are widely distributed throughout the Grand Valley. Related work by Osmundson et al. (1995) indicates that adult Colorado squawfish utilize a variety of habitats including riffles, runs, pools and backwaters. These and other studies suggest that, as far as the upper Colorado River is concerned, a broad-based approach is still the most appropriate way to examine the relation between habitat use, geomorphology, and substrate characteristics.

The present study will refine and verify results from earlier geomorphic studies and provide more specific information on the effects of coordinated reservoir releases. It is

assumed that reservoir releases will occur at some unknown time in the future, but in the meantime, continued monitoring of changes in channel morphology and substrate characteristics is desirable. In this study, the geomorphic effects of scheduled releases and annual snowmelt flows will be evaluated by surveys of previously established main channel and backwater cross sections, and by monitoring changes in substrate characteristics using simple devices. Larger-scale changes in channel morphology will be assessed by comparing two sets of very high quality (1:6000 scale) color aerial photographs taken in 1993 and during the period of study. Further details of the timing of sediment delivery to the 15-mile reach will be examined using older sediment records from Rifle Creek, Parachute Creek, and Plateau Creek. The present study will be coordinated with USFWS biologists in Grand Junction, and representatives of groups involved in reservoir operations. Results of this study will aid in the development of more specific instream flow recommendations.

III. Study Goals, Objectives, End Product:

Study Goals:

To develop a better understanding of sediment transport and channel dynamics in the upper Colorado River so that existing flow recommendations can be refined by biologists, and so that reservoir releases can be coordinated, timed and monitored to provide the greatest benefit to the endangered fishes.

Objectives:

1. Provide Channel monitoring to evaluate rates of channel change and geomorphic effects of coordinated reservoir releases and normal snowmelt flows.

2. Refine previous estimates of gravel and cobble mobility by verifying thresholds for coarse sediment transport.

3. Define the window of time of peak sediment delivery from unregulated tributaries.

4. Assess problems associated with fine sediment deposition and decreases in interstitial void space.

5. Compare and contrast effects of augmenting flows on the ascending and descending limbs of the annual hydrograph.

6. To develop a matrix which can be used by the coordinated reservoirs operations group to tailor reservoir operation to target multiple objectives of habitat maintenance and creation. The matrix will relate flows to the physical characteristic of the river need for endangered fish recovery an example of a similar matrix developed for the San Juan River.

7. Provide data on thresholds and durations of discharges that perform important geomorphic functions so that biologists can integrate this information with biological information and refine their flow recommendations as appropriate.

8. Simi-annual letter reports will be prepared for the Coordinated Reservoirs Work Group and the principal investigator will be invited to participate in the Work Group.

End Product:

The end product of this work will a report which summarizing how normally occurring snowmelt flows and coordinated reservoir releases affect various habitats. This report will include updated information on channel change determined from aerial photographs and field surveys, and further analyses of sediment transport relations, especially estimates of gravel mobility and an assessment of the importance of fine sediment deposition. A copy of the aerial photography will be given to George Smith of the U.S. Fish and Wildlife Service for filing until the Recovery Program develops a repository for all aerial monitoring data collected in the Program. The report will also serve as the source data for development of a flow matrix which will relate flows to the physical characteristic of the river need for endangered fish recovery an example of a similar matrix developed for the San Juan river is attached. The matrix will be completed in the final year of the study and will be a peer of the final report document. The results from the study and the matrix will be used together with biological data and information from reservoir operators to refine flow recommendations for the 15- and 18-mile reaches and to guide the annual coordinated reservoir effort.

IV. Study Area:

This research will be conducted in the 15- and 18-mile reaches of the upper Colorado River. Most of the field work will be done at sites where cross section and sediment measurements have been made previously. Many of these sites contain prominent gravel bars which become exposed at lower flows, and will allow placement of monitoring devices across broad areas. These sites can be accessed either by boat or through private property, and this will limit the potential for disturbance.

V. Study Methods:

1. Channel Monitoring

a) A series of 50-plus main channel and backwater cross sections were established in the Grand Valley in 1993, and these have been resurveyed several times since. Continued monitoring of a subset of the main channel cross sections (every fifth one) will be used to assess the general geomorphic effects of normal snowmelt flows and coordinated reservoir releases. Continued surveys of cross sections at our backwater study sites will be used to monitor localized scour and fill. The endpoints of the main channel and backwater cross sections should be permanently geo-referenced in the event that they are lost by erosion, deposition, or disturbance. The locations of these points will be

established with an electronic total station and a Global Positioning System (GPS) capable of submeter resolution with differential post-processing. The total station is available through the Geography Department, University of Colorado; the GPS will be purchased with funds from the University of Colorado and with funds from this project.

b) In the 3rd year of the study (FY-2000), or in the event of a major flood, we will arrange to have a set of color aerial photographs of the study reaches flown. These photographs will be flown to match the scale and river discharge of another set of aerial photographs taken in 1993. The 3rd year of the study is chosen so as to allow enough time to elapse from the previous flight (7 yr), and to allow enough time to analyze the photographs. The goal here is evaluate the importance of channel change over decanal time scales, which is something we have not been able to do in the past, owing to limited availability of flight lines. We would also like to resolve channel changes at a more detailed scale, which will be possible in this case because of the higher resolution of the recent photographs. Differences between the two sets of photographs will be determined using standard digitizing techniques and Geographic Information System (GIS) software (see Van Steeter, 1996). The hardware and software needed to complete this task are available in the Spatial Data Analysis Laboratory of the Geography Department, University of Colorado.

2. Evaluation of Flow Hydrograph-Sediment Load Relations

a) In the 1950s and 1960s the USGS and USBR made a number of sediment and water quality measurements on unregulated tributaries immediately upstream of the study area (Rifle Creek, Palisade Creek, Roan Creek and Plateau Creek). These data are published in several USGS reports (Iorns et al., 1964, 1965, plus Water Supply Papers and Annual Summaries), but we have not examined them in any detail. These data provide an opportunity to examine seasonal patterns of sediment delivery from tributaries and will be used to refine the window of time of peak sediment delivery to the main stem.

b) In conjunction with the above work, we will explore the possibility of using more frequently measured parameters, such as dissolved solids, as surrogates for suspended sediment loads. If such a relation exists, we hope to use the trends in dissolved solids to evaluate seasonal patterns of sediment delivery more accurately.

3. Field Studies of Sediment Transport

The following plans assume that coordinated reservoir releases will occur at some (unknown) time in the future. The plan will be modified accordingly as details of coordinated reservoir releases become available. In the meantime we assume that continued monitoring of changes in substrate characteristics is desirable.

The field work described in the following section will be done at a minimum of 6 sites (gravel bars) in the Grand Valley. If in the early phases of the project we learn that it is better to make fewer measurements at more sites, then we will modify the plan accordingly. The sites will be selected in consultation with USFWS Biologists in Grand Junction who are doing companion studies of particle embeddedness, primary

productivity, and aquatic invertebrates. If at some time in the future a spawning site is positively identified in the Grand Valley, then some of the emphasis here will shift to making more detailed measurements at the site of interest.

a) Fine Sediment Deposition: A series of traps will be installed at the gravel-bar study sites to monitor fine sediment deposition. Each trap will consist of either a cylindrical container (large diameter PVC pipe) into which a smaller removable can be placed, or a flexible bag that can be winched from the bed. The can (bag) will be back-filled with sediment that has been screened to remove the finer sizes (< 8 mm). The traps will be set out at low flow in groups of 2 or 3 at different locations on the bar. The exact location of each trap will be determined using the electronic theodolite (total station). In the following year half of the traps will be removed, cleaned, and replaced. Based on conversations with other geomorphologists who have tried this technique, we don't anticipate that the traps will be washed away, but we don't anticipate that they will last for much more than 2 years. Thus we will probably need to replace them after 2 years. This scheme will provide a measure of annual fine sediment deposition as well as some measure of cumulative deposition.

b) Scour and Fill: The easiest way to monitor bed scour and fill , other than frequent surveys, is to install "scour chains". These devices are simply sturdy metal chains placed vertically into the streambed. If the bed scours (or fills), the free end of the chain is deflected (or buried). After the flow has receded the chains are excavated and the depth of scour (or fill) is measured. Approximately 10 scour chains will be installed at each of the study sites. Their locations will be determined using the total station.

c) Tagged particles: There isn't a good, agreed-upon method for evaluating whether bed particles move or precisely when they move. Painted rocks are often used for this purpose, but recovery rates are typically very low, and the data are sometimes suspect because placed rocks tend to move more easily than ones that have been deposited by natural processes. As an alternative Wilcock et al. (1996) placed a known number of particles of a distinctive color (pure quartz) in a cylinder in the bed prior to a reservoir release, and then recorded how many particles were remaining in the cylinder once the release was over. Using this method they were able to calculate both the entrainment rate and depth of scour, both of which are important with respect to flushing fine sediment from the bed. We propose installing several of these devices at each of the study sites.

VI. Task Description:

Task 1: Evaluate the relative contribution of suspended sediment from tributaries between Rifle, CO and Palisade, CO. Refine estimates of the timing of peak sediment delivery.

Task 2: Survey cross sections of the main channel and backwaters. Locate cross section endpoints with GPS. Provide summaries to USFWS as needed.

Task 3: Install devices to monitor fine sediment deposition, scour, and coarse sediment transport. Service or replace them as necessary.

Task 4: Arrange aerial photography of the 15- and 18-mile reaches. Digitize channel features, transfer digital data to a GIS and calculate changes in channel area.

Task 5: Write a report summarizing study objectives, methods and major findings. This report will include a matrix which will relate flow events to:

Flow and duration needed to mobilize and build bars
Flow and duration needed to clean backwaters
Flow and duration needed to clean bars
Maximize habitat diversity
Maintenance of cobble for Colorado squawfish spawning

The report will be prepared in draft by November 30, 2001 and will be submitted to the Recovery Program Geomorphology peer review panel and the Biology Committee for review. The report will be finalized and submitted to the Recovery Program by April 30, 2002.

VII. Study Schedule:

FY-1998:	Tasks 1-3
FY-1999:	Tasks 2-3
FY-2000:	Tasks 2-4
FY-2001:	Tasks 3, 5

VIII. Proposed Budget:

FY 2000	
Labor	10,000
Travel	2,000
Equipment	1,000
Air Photos	6,000
	19,000
CU overhead	4,900
Total	23,900

FY 2001	
Labor	14,000
Travel	3,000
Lab Use	2,500
	19,500
CU overhead	4,600
Total	$24,100

TOTAL for 4 years of the study $ 86,500

IX. References:

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