RECLAMATION

Managing Water in the West

Physical Features and Fish Distribution of a Steep Riffle Rio Grande-Bernalillo Bridge Reach

U.S. Department of the Interior
Bureau of Reclamation

REPORT-2004

Physical Features and Fish Distribution of a Steep Riffle Rio Grande-Bernalillo Bridge Reach

October 2004

U.S. BUREAU OF RECLAMATION
ALBUQUERQUE AREA OFFICE
ENVIRONMENT DIVISION

PRINCIPLE INVESTIGATORS

Tamara M. Massong
Michael D. Porter

DATA COLLECTION TEAM:

Gary Dean
Andrea Glover
Robert Doster
Shafagh Banihashemi
Dustin Thompson
Merissa Hanisko
Genevieve Phillips

Introduction

During summer routine fish sampling (September 2003) on the Rio Grande, the fish distribution changed at the second riffle downstream of the HWY 550 bridge in the city of Bernalillo (Figure 1). In fact, the marked decrease in the number of fish through this riffle suggested that fish may be avoiding the riffle altogether. On October 21-22, 2003, the riffle was again sampled for fish, plus was physically surveyed. The goal of this study is to determine if a physical feature can easily be identified in this naturally-formed riffle that explanes the decline in the local fish distribution.

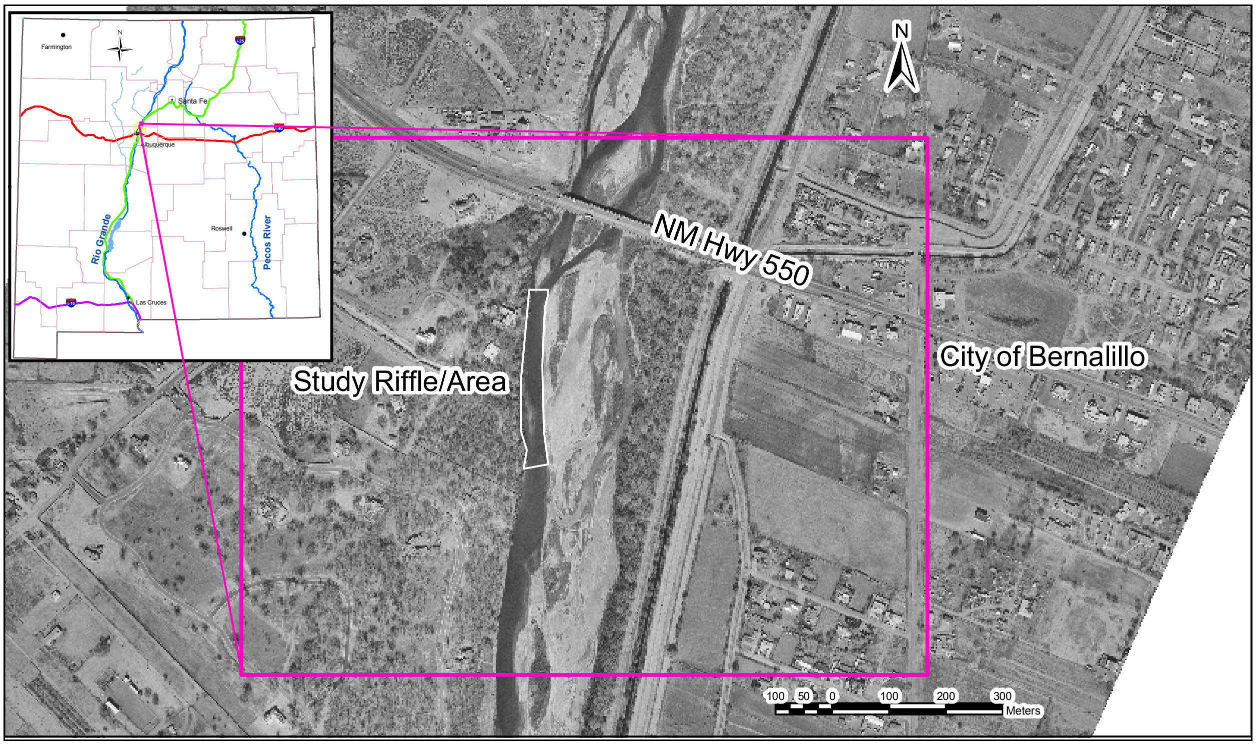

Figure 1: Riffle study area, Rio Grande near the City of Bernalillo. Bureau of Reclamation aerial photography, January 2001.

In this section of the Rio Grande, one restoration technique is the construction of low-head gradient control/restoration facilities (GRF). The GRF constructed upstream of this riffle on the Pueblo of Santa Ana consists of vertical sheet-pile covered with a rock apron with approximately a 2 foot head. This constructed feature is designed to create a lower-sloped section upstream. Ideally, the structure mimics a riffle with an upstream run/pool. The current concern with the construction of a GRF is that although the GRF itself is not designed to be fish habitat, the area upstream of the GRF is designed to improve habitat. Since the initial fish data collected in September suggested that the channel immediately upstream of the naturally forming riffle was avoided by the fish, the channel upstream of the GRF could also be river avoided by fish.

The riffle studied is approximately 350 meters downstream of the NM Hwy 550 bridge (Figure 1). The approximate flow at the time of survey was 125-150 cubic feet per second (cfs). The Rio Grande in this section has a gravel to cobble bed with sand deposits on top of the banks. Channel incision since 1992 has created a single-threaded low flow channel, with a network of high flow channels (Massong, 2003). A low-flow, gravel riffle-plane bed morphology

(Montgomery and Buffington, 1998) is the current planform present. The thalweg migrates slightly within the active low-flow channel.

Specific study objectives are: 1) determine if the fish distribution data collected earlier in September was temporally anomalous through a re-sampling of the area, and 2) if the low abundance of fish continued to exist in October, evaluate the physical habitat present immediately upstream and through the riffle.

Methods

Fish were collected using Smith-Root electrofishing gear transported on an Argo ATV. The Argo facilitated rapid collection in the shallow water. Two handheld anodes were deployed by two technicians wading alongside the ATV with two more technicians with nets walking behind the anodes. Fish were collected and transferred to a holding tank on the Argo at frequent intervals. All electrofishing was conducted by moving in an upstream direction across selected areas at the site. All fish were identified to species, counted, and released. The data were recorded onto a handheld computer. One survey was conducted in September as part of routine fish surveys by Reclamation. The area sampled was within 3 m of the shore along the bankline. Additional sampling was conducted in October to investigate the channel feature identified during the September survey. Sampling areas were classified as riffle, run, channel (main), and side channel for the October survey.

A Leica Geographic Positioning System (GPS) receiver collected topographic data along 14 cross sections outlining the island and at several points along the bank (Figure 2). Velocity and depth data were collected along the 14 cross section lines and linked spatially to the GPS data. The thalweg was identified as the deepest location on a cross section; in the absence of a deepest location, the location with the highest velocity was determined to be the thalweg. Cross section topographic data were used to calculate water-surface and thalweg slopes for the whole study area and within the actual riffle. ESRI-ArcMap 8.3 was used to analyze the physical data. Topographic and depth data were interpolated to a raster file using the weighted inverse difference method. Velocity data were rasterized through a Krig method then contours were created. Changes in channel bed grain size were noted while collecting the velocity and depth data. However, the high water depths and velocities prohibited sampling the material.

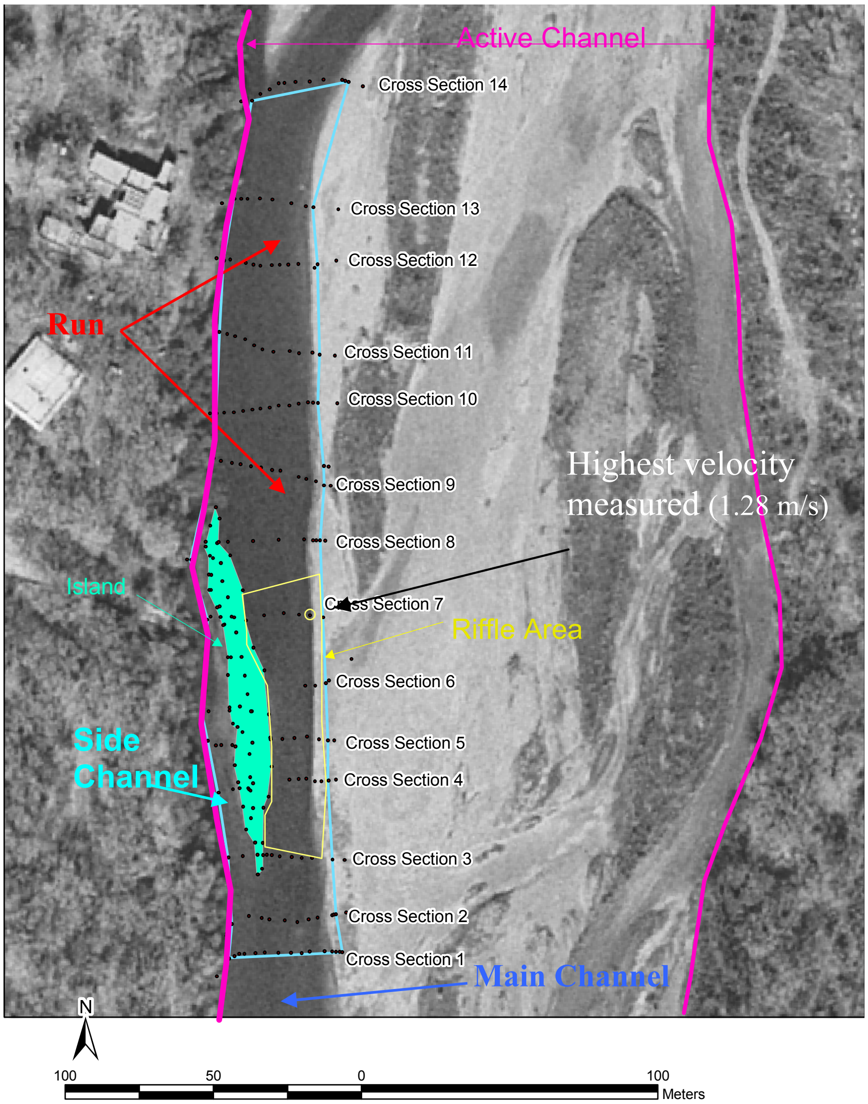

Figure 2: Location of cross sections, island, riffle and highest velocity in the study riffle, Rio Grande-Bernalillo Bridge Reach. Reclamation base aerial photo, 2001.

Fish Distribution Results

The September and October electrofishing results (Table 1) show a higher catch per unit effort (CPUE) downstream of the riffle than in the immediate vicinity of the riffle. In September 2003, the fish were collected in the channel downstream of the riffle. The October 2003 survey doubled the electrofishing effort, yet produced about 15% the number of fish of the September survey. The channel features/areas where fish were collected during October 2003 are labeled in Figure 2. More fish were collected downstream of the riffle feature (channel) than in the run upstream of the riffle.

Table 1. Electrofishing results downstream of the channel feature (September) and at the channel feature (October). Effort is measured in seconds spent electrofishing.

	September 2003				October 2003				
	Survey 1	Survey 2	Survey 3	Total	Channel	Riffle	Run	Side channel	Total
Total Effort	485	597	615	1697	552	1279	1263	381	3475
Species									
Ameiurus melas	0	0	1	1	0	0	0	0	0
Carpoides carpio	0	4	0	4	2	0	0	0	2
Catostomus commersoni	2	0	1	3	0	0	0	0	0
Cyprinella lutrensis	21	16	12	49	2	2	3	2	9
Cyprinus carpio	0	0	0	0	1	0	0	0	1
Gambusia affinis	0	0	9	9	2	0	0	1	3
Gila pandora	0	0	0	0	0	0	0	0	0
Hybognathus amarus	16	34	17	67	1	0	1	0	2
Ictalurus punctatus	1	4	1	6	2	0	0	0	2
Micropterus salmoides	1	0	0	1	0	0	0	0	0
Pimephales promelas	8	4	5	17	0	0	0	0	0
Platygobio gracilis	8	7	3	18	0	0	0	0	0
Rhinichthys cataractae	3	4	0	7	1	2	3	0	6
	60	73	49	182	11	4	7	3	25

Physical Survey Results

From the upstream study area boundary to approximately cross section #9, the channel has a plane-bed morphology (run). The channel bed is fairly uniform in the plane-bed section, such that the thalweg is most discernible by a higher flow velocity rather than depth. From cross section 9 to cross section 7, the channel bed is a steep riffle, characterized by relatively larger grain sizes on the bed, a slight shallowing, and an increased water velocity. Surface turbulence is also greater in this sub-section. Downstream of the actual riffle is the ‘pool’ area (cross section 7 to cross section 2). The highest water velocity was recorded in this sub-section at the downstream apex of the riffle “V” (Figures 3, 4, and 5). Although the topographic survey data indicates the bed has scoured relatively deeper in this sub-section (Figure 3) and has an increased water depth, this section is not a true pool. The overall water velocity is actually fastest in this sub-section (Appendix A), even at these exceptionally low flows. The bank-channel bed interface is steep throughout the study area on both sides of the channel.

The channel slope analysis found that the study area as a whole is generally less steep than the average slope of the larger Bernalillo Bridge reach (Massong 2003), however, the slope through the riffle is noticeably steeper. Massong (2003) reports an average reach slope of approximately 0.0009 m/m. Although the average thalweg slope was slightly higher than the reach slope, the average water surface slope was only 0.0006 m/m for this riffle (Table 2). The thalweg slope within the actual riffle (crest to the “V”, between cross sections 7 & 8) was over 4-times steeper than that of the study area average (Table 1, Figure 3).

Table 2: Thalweg and left water surface slopes (m/m) were calculated for the riffle, the riffle and pool, and the whole riffle area.

	Thalweg	Left Water Surface
Riffle (cross sections 9 to 7)	0.0048	0.0027
Riffle and Pool (cross sections 9 to 2)	0.0011	0.0007
Whole Riffle Area (linear regression of all data)	0.0010	0.0006

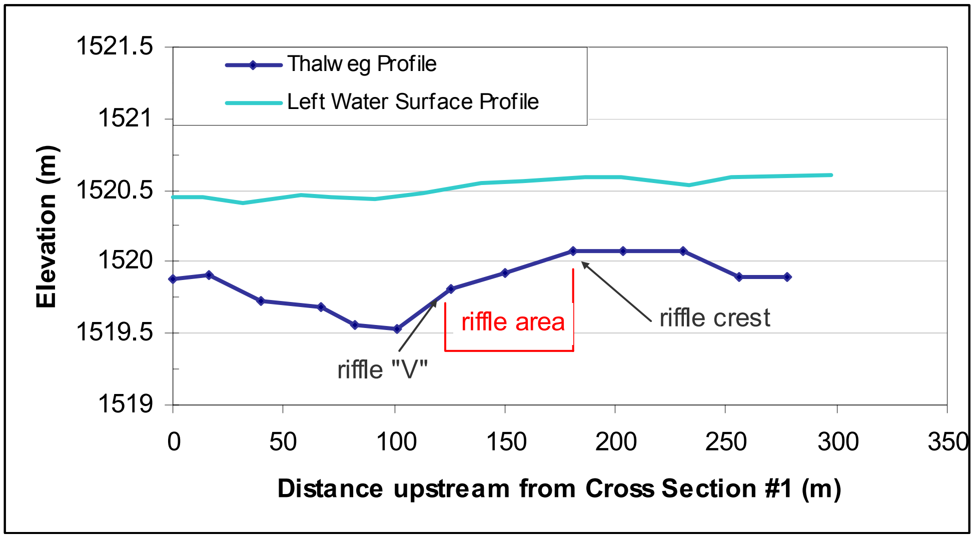

Figure 3: Elevation profile of the thalweg and the left water surface; flow direction is from right to left. The actual riffle area is noted in red with the riffle crest (cross section 9) and the approximate location of the riffle "V" (cross section 7) identified.

The location of the thalweg shifts from the west side of the river just upstream of the study riffle, to the east side of the channel (Figure 4). The slightly alternating thalweg may be indicative of the early formation of a meandering channel that may migrate laterally. In support of this hypothesis, the channel appears to have migrated approximately 3 meters to the east since 2001, as indicated by the east channel bank location surveyed in October and the 2001 geo-rectified aerial photography (Figure 4).

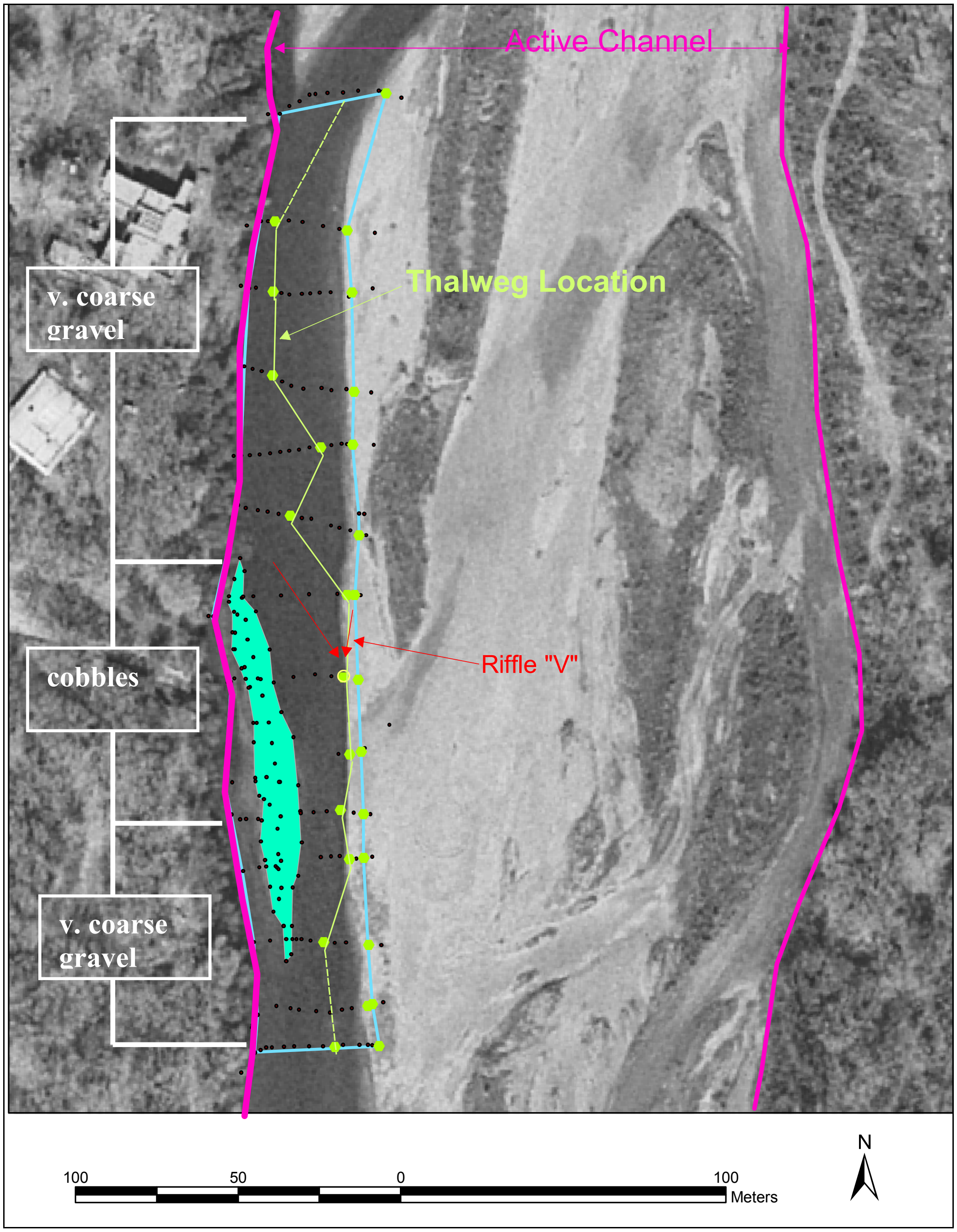

Figure 4: Thalweg location as defined by the fastest flow of water on date of survey. The dashed, yellow line indicates estimated thalweg location. Reclamation base aerial photo, 2001.

The velocity data (Figure 5) also indicates that the thalweg location has shifted to the east at the riffle location. These data also show that the highest water velocities measured in October were just downstream from the riffle crest (Figure 5). Downstream from the riffle, the channel has a relatively deeper water depth; however the water velocities were only slightly lower than those measured in the riffle.

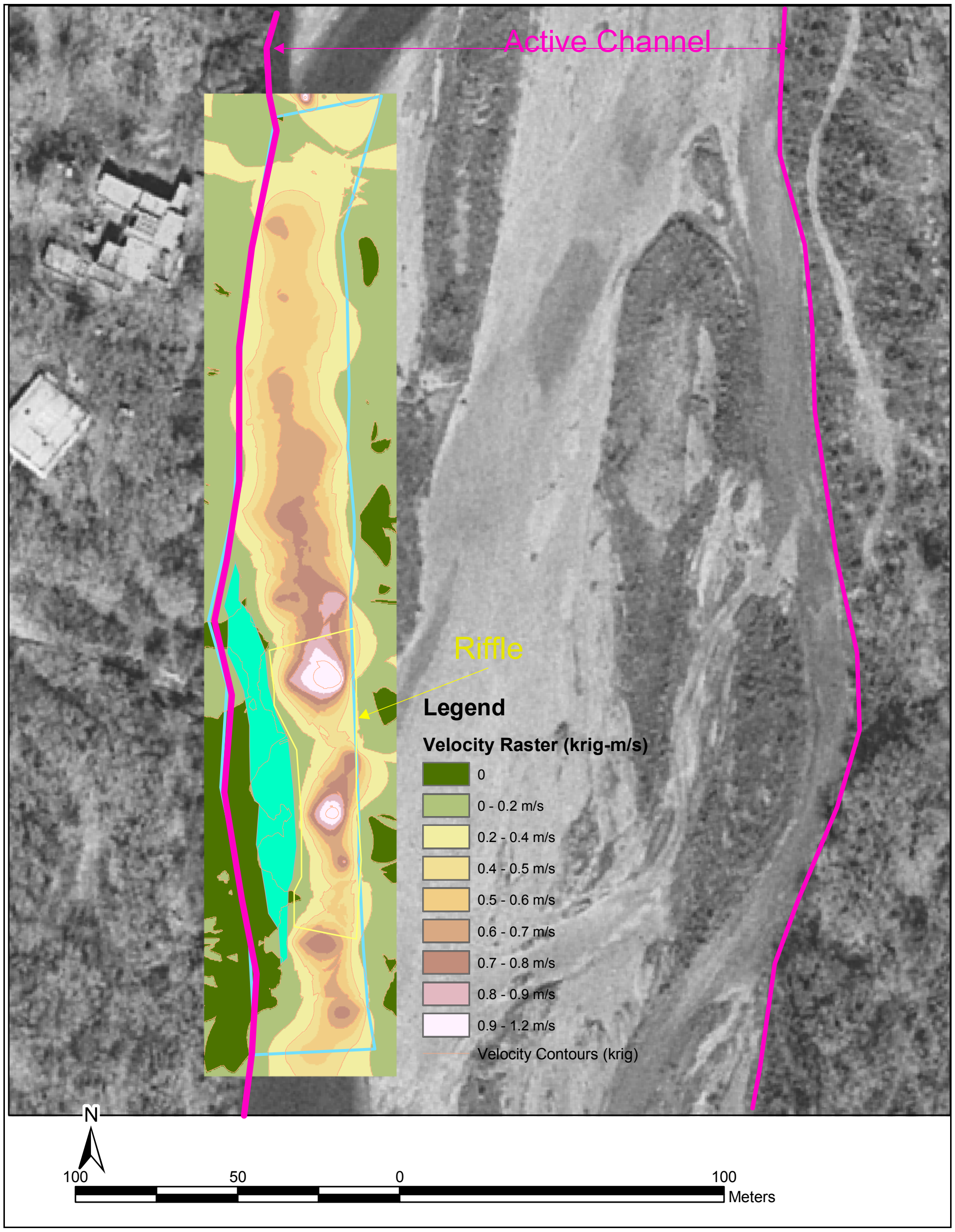

Figure 5: Rasterized velocity data throughout the study area underlying the estimate velocity contours, Rio Grande-Bernalillo Bridge Reach. The brighter areas indicate faster moving water. Reclamation base aerial photo, 2001.

Discussion

The most noticeable physical difference between this riffle area and others described in the general geomorphic literature is the lack of a well formed pool area downstream of the steep riffle. A well-formed pool area exhibits slower and deeper moving water than that found in the riffle itself, especially during low flow periods. Although the channel depths were greater in the area downstream from the riffle, the velocity was not substantially slower. Inspection of several riffles immediately upstream and downstream of the study area appeared to also lack a defined pool downstream of the gravel/cobble riffle. Extensive high velocity stretches of river without low velocity flow areas could be limiting fish populations in these specific areas. Wesche and Grogan (2003) describe river features upstream of San Acacia Dam with mean water velocities 0.57-1.32 m/s, and boundary velocities of 0.23-0.65 m/s as potential movement barriers to the smaller Rio Grande fishes.

Other than the lack of a pool, the plane-bed/run area has relatively high velocities across the entire cross section. These high velocities may be in part due to the lack of pools downstream of the riffles. In other systems, functioning pools slow the flow of water throughout the reach. At low flows, the channel throughout this area is best described as a riffle-plane bed or riffle-run morphology; additional information is necessary to determine whether this area will evolve into a pool-riffle or a pool-riffle-run morphology.

There are several GRFs in various phases of construction upstream of Bernalillo on the Rio Grande. The structures are designed to control river slope, and do not contain specific slow flowing areas like pools. Although a pool could form downstream of the end of the riprap apron, formation of a pool within the structure is not possible. Visual inspection upstream of the Reclamation GRF at Santa Ana Pueblo indicates a run-like environment. The lack of low velocity features within the constructed river channel may limit the usable area for fish. Additional data collection at GRF is recommended to clarify the habitat utilization by the fish community.

Comparison of catch rates from September and October fish surveys at the Highway 550 Bridge, upstream of the riffle, does not show any differences in numbers over the two month period (Dudley et al 2003). While the sampling of lesser numbers of fish was expected in October, the extremely low numbers of fish upstream of the riffle in the run was not anticipated.

Although silvery minnow are not abundant in this riffle, several pieces of data indicate that high water velocities are not a significant barrier to upstream movement by silvery minnows. In 2002 and 2003, the Fish and Wildlife Service released over 200,000 VIE (visible implantable elasomer) tagged silvery minnows downstream of the study site (Remshardt pers. comm., 2003). A small number of VIE tagged silvery minnows have been collected upstream of the riffle and the current GRF near Angostura Diversion Dam (Dudley et al. 2003; Dudley 2004a, 2004b). These observations indicate that silvery minnows are moving upstream past areas of high water velocity and steep physical features (riffles and low head dams).

In September 2003, survey #3 sampled the east bank immediately downstream of the riffle in proximity to the thalweg. During the sampling, fish along the east bank were observed adjacent to the steep shore. Later measurements at similar flows quantified water velocities around the thalweg from 0.6 to 1.2 m/s, with velocities adjacent to the bank in the 0.2-0.5 m/s range. The association of silvery minnows with vertical features has also been observed when electrofishing near River Mile 114 below San Acacia Dam and around Calabacillas Arroyo in Albuquerque, New Mexico (Porter, pers. obs.). These observations suggest that silvery minnow behavior allows them to locate lower water velocities by swimming adjacent to banklines or other vertical features, thereby avoiding high velocity current.

These observations provide essential context for interpreting the results from the Riverine Habitat Simulation software (RHABSIM) used in Wesche and Grogan (2003). RHABSIM provides a coarse evaluation of habitat suitability using mean water velocity for the silvery minnows at their sites. The usage of mean water velocities is appropriate for describing usable habitat for fish. It has limited biological application for evaluating passage of small-bodied fishes like the silvery minnow that demonstrate behavioral preference for low water velocities at the substrate boundaries. The nose-in water velocities of 0.23-0.65 m/s (Wesche and Grogan 2003) are representative of velocities found adjacent to the bankline and substrate. There is increasing evidence that silvery minnows actively seek out these lower velocity flows and can move upstream through a variety of high velocity features.

Literature Cited

Bestgen, K., B. Mefford, J. Bundy, C. Walford, B. Compton, S. Seal, and T. Sorenson. 2003. Swimming performance of Rio Grande silvery minnow. Completion report submitted to U.S. Bureau of Reclamation and U.S. Fish and Wildlife Service, Albuquerque, New Mexico. Colorado State University Larval Fish Laboratory Contribution 132. Ft. Collins, CO. 71 pp.

Dudley, R.K., S.J. Gottlieb, and S.P. Platania 2003, Rio Grande silvery minnow Population Monitoring 2003, http://www.usbr.gov/uc/albuq/envprog/rg/index.html .

Dudley, R.K. 2004a, Rio Grande silvery minnow marked by USFWS-FRO March 2004. 1 pp.

Dudley, R.K. 2004b, Rio Grande silvery minnow marked by USFWS-FRO April 2004. 1 pp.

Massong, T. M., 2003, Geomorphology Summary, Rio Grande-Bernalillo Bridge Reach, unpublished Technical Report (draft), Bureau of Reclamation, Albuquerque, NM, 20 p.

Montgomery, D. R., and J. M. Buffington, 1998, Channel Processes, Classification and Response, Chapter 2, *River Ecology and Management*, eds. R. Naiman and R. Bilby, Springer-Verlag New York, Inc. p. 13-42.

Wesche, T.A. and S. Grogan 2003. Evaluation of potential barriers to fish movement above and below San Acacia Diversion Dam. Report to U.S. Bureau of Reclamation. 38 pp.

Appendix A - Physical Channel Features

The interpolated topographic data clearly distinguishes the movement of the thalweg from the west bank at the top of the study area (darker colors are higher ground) to the east bank through the riffle area (Figure A-1). The lowest topographic data is just downstream from the riffle crest, or approximately half way through the riffle. In fact, the elevation of the channel bed increases slightly downstream of the riffle/island. The water depth data indicate a similar trend with the thalweg location (Figure A-2). However the deepest water was found slightly downstream from the lowest elevation area (Figures A-1 and A-2).

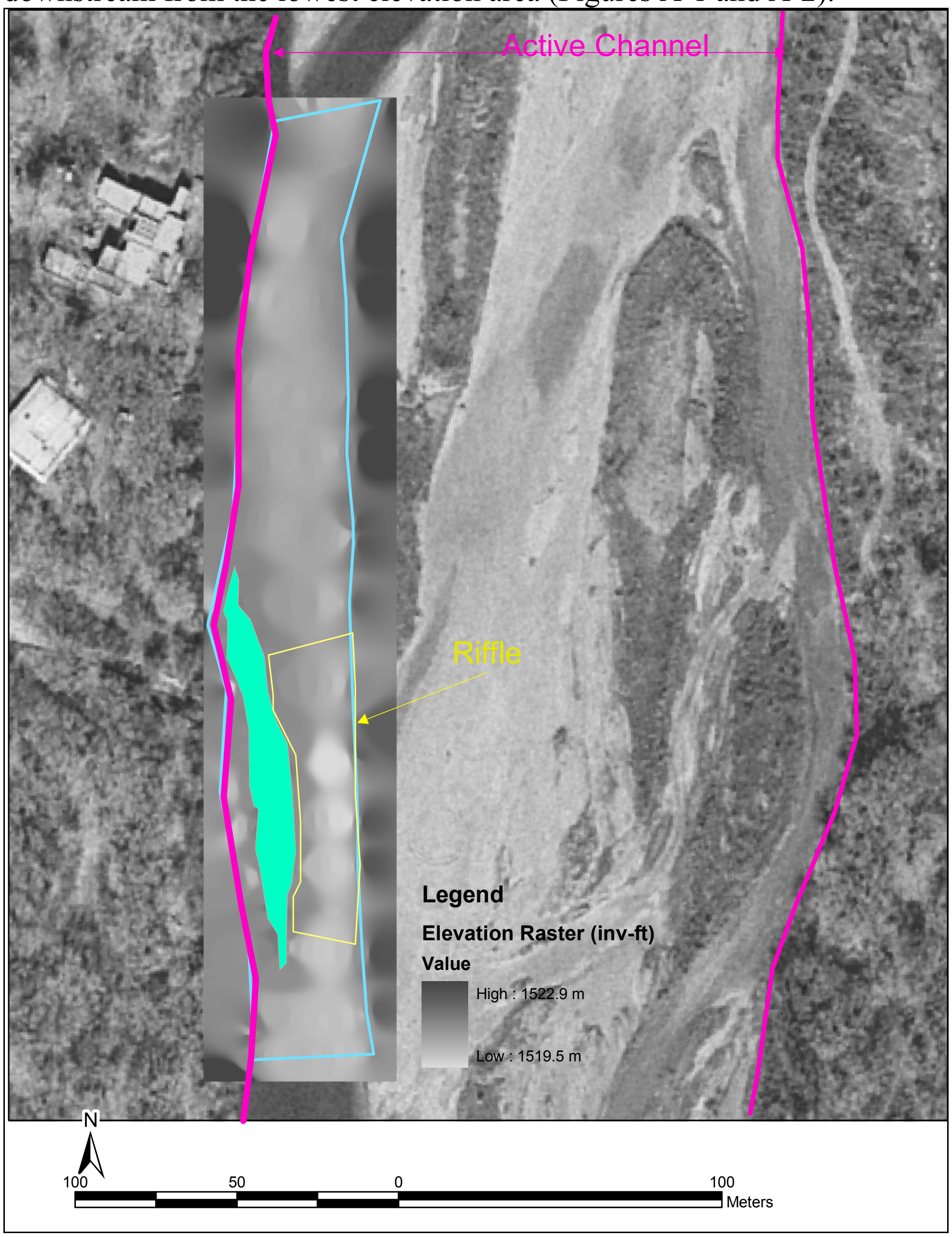

Figure A-1: Rasterized topographic data throughout the study area, Rio Grande-Bernalillo Bridge Reach. The lighter colors indicate a lower elevation. Reclamation base aerial photo, 2001.

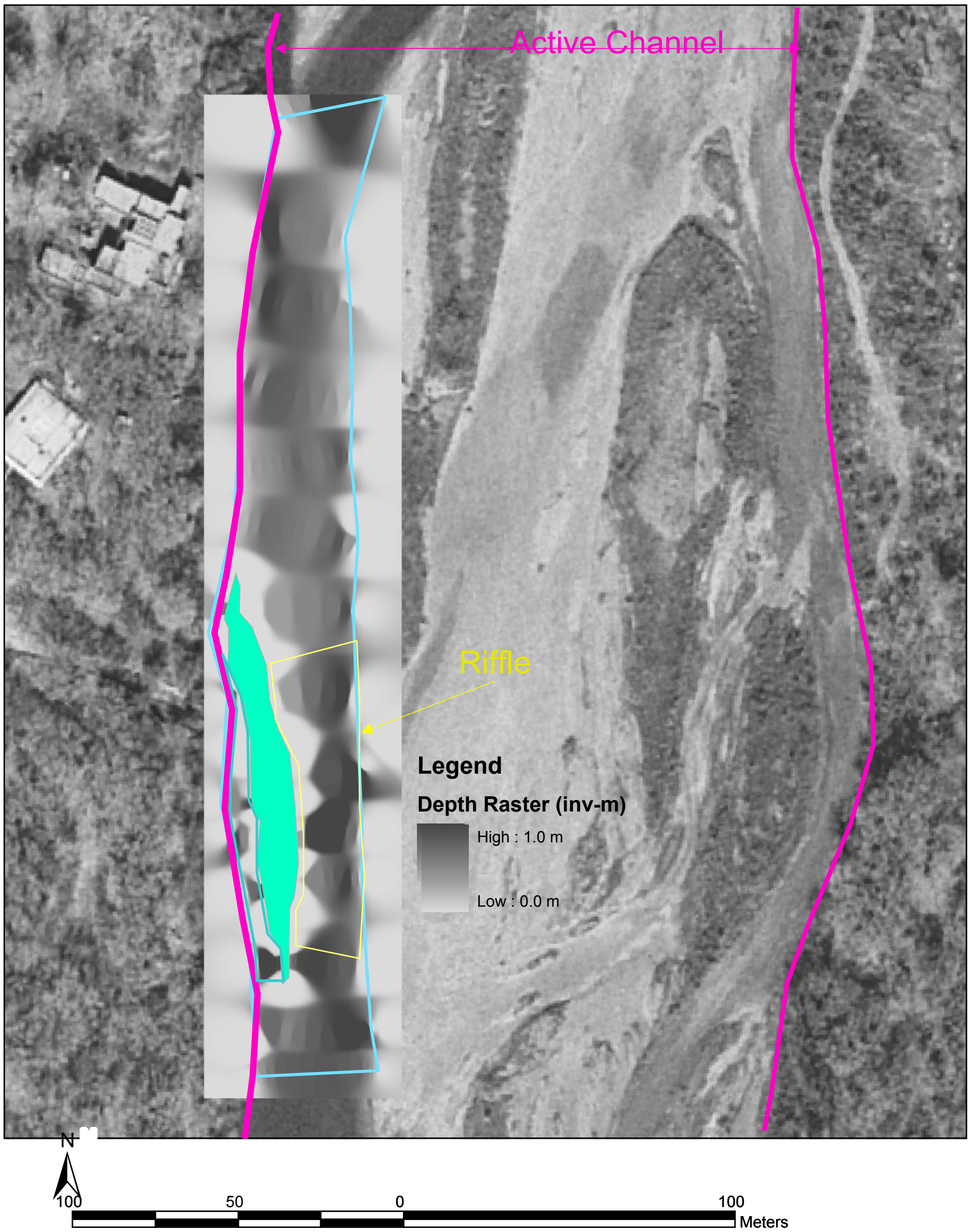

Figure A-2: Rasterized water depth data throughout the study area, Rio Grande-Bernalillo Bridge Reach. The darker colors indicate a deeper water level. Reclamation base aerial photo, 2001.