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Consultation on fish passage at San Acacia Diversion Dam on the Middle Rio Grande River

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Introduction

In June of 2002, I was contracted by the Bureau of Reclamation (BOR) to determine the feasibility of constructing a nature-like fish passage facility at the San Acacia Dam on the Rio Grande River. The fish passage would aid in the restoration of the population of federally endangered silvery minnow in the river. I visited Albuquerque, NM, on June 18-20, in order to become familiar with area and the existing situation. During the trip I attended an orientation briefing at the BOR and visited three sites on the Rio Grande: the San Acacia Diversion Dam, a down-cutting site about a mile downstream, and the restoration section at Los Lunas. I also attended a seminar session at the Sivilleta Wildlife Refuge Conference Center and gave a presentation on nature-like fish passage facilities and river restoration concepts. The presentation was followed by a discussion with the audience, which was comprised of resources agency staff members and environmental NGOs. I also read the documentation provided by the BOR, which is listed in the references section. This report summarizes the information that I gathered on this visit and provides my recommendations based on what I have learned.

Problem settings

The Rio Grande is one of the larger rivers in the Southwestern US, and is therefore under heavy anthropogenic pressure. For many centuries, it has served as a water source for the human inhabitants of the entire valley. Water from the river is distributed over a large network of irrigation canals, most of which were built during pre-colonial times. The portion of the river within the Middle Rio Grande Conservancy District (between the Cochiti Dam and the Elephant Butte Reservoir) contains three irrigation dams, which provide water to the accompanying canals (Angostura (River Mile (RM) 209), Isleta (RM 169), and San Acacia (RM 116)). At Isleta, water is being withdrawn from the river at a rate of 700 cfs. Some of this water is returned gradually along the river prior to the San Acacia dam, where an additional 100-350 cfs is diverted. All dams are fish migration barriers and alter the flow in the river. For example, on June 23, 2002, the flow pattern along the river was as follows: Cochiti (RM 232):1050 cfs, Albuquerque (RM 180): 680cfs, Bernardo (RM 160): 65 cfs, San Acacia: 126 cfs (quite unusual for a river).

Due to the unpredictability of the river's flow, its water is not only an unreliable resource, but also a flood threat for adjacent communities, which use the floodplain for agriculture and settlements. The rapid development of the late 19th century mobilized high amounts of sediment in the basin and was probably the main cause of strong aggradation of the river bed that increased water losses and flood danger (Collier et al.1996). Further problem are interstate contracts, which require New Mexico to deliver a certain amount of water to Texas.

To respond to all of these problems, the Middle Rio Grande Comprehensive Plan (MRGCP) has been developed jointly by BOR and the Army Corps of Engineers (ACOE) and was authorized in the Flood Control Act of 1948. The Project included rehabilitation of the Middle Rio Grande Conservancy District's irrigation and drainage system as well as construction of Jemez Canyon and Abiquiu Dams. Upstream of San

Acacia, the river channel has been narrowed in many locations by a series of Kellner jettiesto aid in flood prevention, reduce evaporation and increase the amount of water transported downstream. Downstream of San Acacia, a Low Flow Conveyance canal was built along the main river channel by the BOR in late 1950's. In addition, long stretches of the river were confined by the levies that disconnected it from its floodplain. In 1973 the ACOE constructed a flood control dam at Cochiti. Since then, the dam has reduced flow peaks to approximately 7,000 cfs and has extended the falling limb of the river's hydrograph[1]. Mussetter et al. (2002) presented data indicating that, in addition to producing disconnected flow patterns, the dam has caused dramatic changes in sediment loads and transport, as well as in bed geometry.

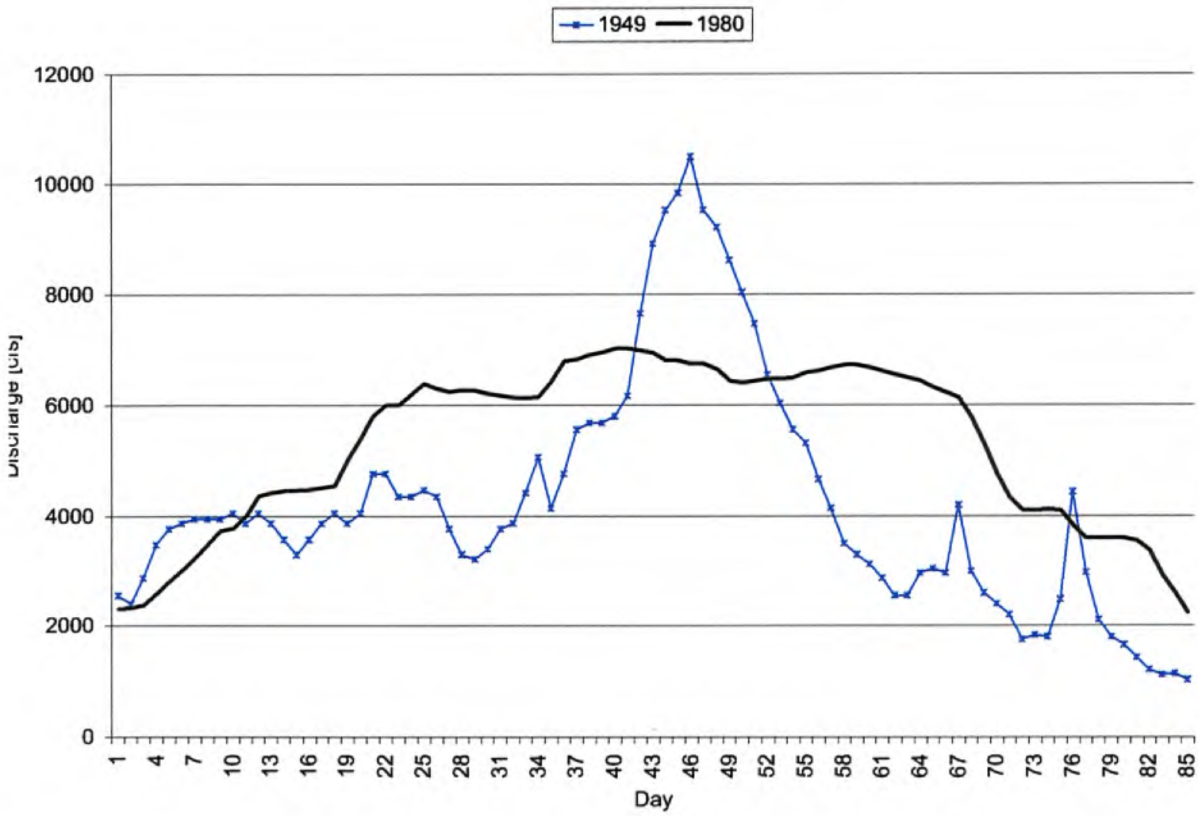

Figure 1: Typical shape of pre-construction high flow hydrograph in 1955 (up) compared with one that occurred in 1979 (down) that is typical for post-construction period (source www.usgs.gov)

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[1] One of the consequences of an extended falling limb is an increase in the period of high sheer stress that could lead to degradation of riverbed elevation.

Figure 2: View of San Acacia dam 1952 and 2002 that shows how strongly the channel has been narrowed in last 50 years.

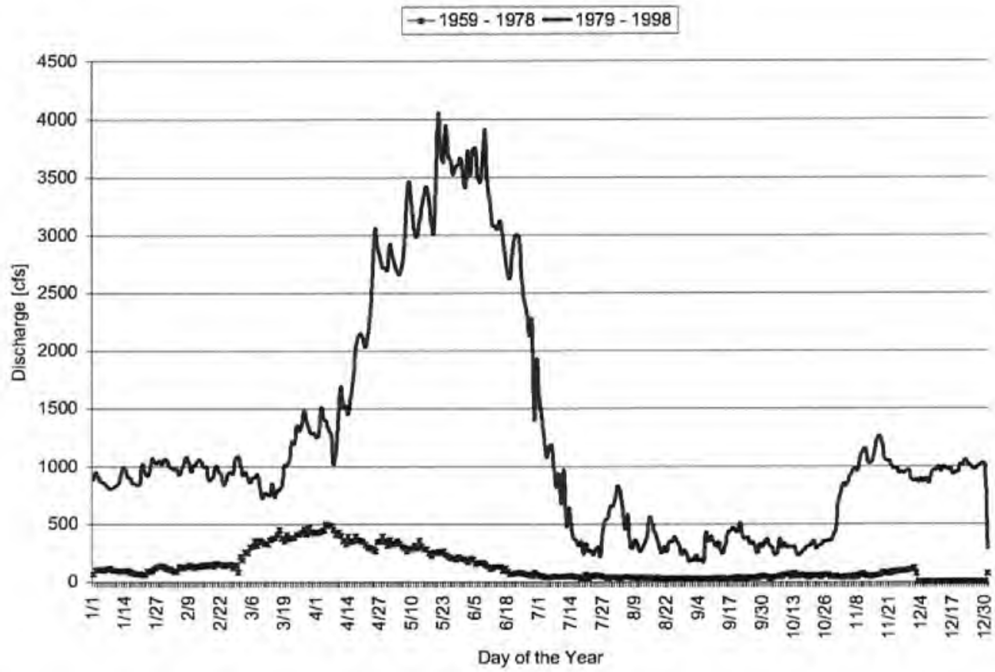

Figure 3: Median hydrographs at San Acacia dam for two 20 year periods of records (pre- and post 1979). The same pattern occurred on the San Felipe gauge.

One would expect such changes to impact the Rio Grande's flora and fauna. Obvious changes in habitat conditions (as the river character changed from braided to confined) must have modified the composition of fish fauna, especially for those species that utilize shallow but flowing side-arm habitats. Indeed, the population of silvery minnow (Hybognathus amarus) has been declining greatly. This species is usually found in shallow, slow-flowing areas behind sand bars, habitat that has been greatly reduced in the Middle Rio Grande. Interestingly, silvery minnow is much more abundant below the San Acacia Dam than it is above it. This might be due either to a lack of habitat or to a lack of connectivity between these segments, or to a combination of both factors. Under present hydro-morphological conditions (higher flows, extended duration of high flows, confined channel), the silvery minnow's drifting semi-buoyant eggs are much more likely to travel further downstream than normal. Aerial photographs show that the downstream channel is wider and should therefore be more likely to provide suitable habitat for silvery minnow. This observation is a consequence of the fact that Kellner jetties were only sporadically applied in this section. The downstream area is also much more likely to dry out (which further jeopardizes the survival of silvery minnow). To secure the survival of this species, it was proposed that a fish passage be provided or that the San Acacia Dam be removed, thereby bolstering the upstream population. It has been assumed that either solution would increase the dispersal of the downstream population, and provide refuge areas in event of a drought.

Options:

In modern running water management, fish passage facilities are state-of-the-art restoration measures intended to secure the upstream and downstream passage of all occurring fish and invertebrate species, thus ensuring that the maintenance of all such populations, as well as the preservation of quantitative community structure. Removing migration barriers is the easiest and most effective way to achieve this goal, as it would secure the unlimited passage of entire populations. The second option, the construction of a bypass channel or ramp that mimics a natural sidearm or tributary, would produce similar results. By following the form and structure of the natural channel, we would be able to secure the passage of many members of the fish community, as would be the case under natural conditions. A third option is the construction of a technical (mostly concrete) facility, such as the one at Denil, or a vertical slot pass, which would serve to maintain hydraulic conditions that fulfill the swimming performance criteria of selected species (for review see Brent Mefford report, 1999). In most cases these technical facilities were constructed for salmonid or similar species with good swimming capabilities and clearly defined upstream migration.

Securing the passage of the silvery minnow at the San Acacia Dam is a challenging endeavor. Little is known about the species' life history. For example, it is not clear if any kind of directed migration movement (e.g. spawning) exists, or what the associated stimuli or migration distances are. Silvery minnows exhibit low swimming capabilities, a sandy bottom orientation, and relatively unorganized movement in the river. Consequently, the primary design criteria for a fish passage facility would be the maintenance of a low gradient and low velocities. Additionally, to ensure that a sufficient number of individuals will be able to find the fish passage along the 600-ft wide dam, the entrance to the passage should be of considerable size. These considerations make standard technical facilities such as Denil pass impractical, leaving us with the choice of either completely removing the dam, or creating a nature-like bypass channel. Strictly from the standpoint of optimizing fish passage, opening the entire channel through the removal of the dam would be the ideal solution, as it would ensure a one hundred percent passage rate. From the perspective of river management, however, two questions remain to be answered: how could the irrigation system continue to be supplied with the same level of water, and how does the dam function as a gradient control and sediment trap? Some options for resolving these concerns are listed in the BOR Reconnaissance Investigation Report from July 6, 2000, which includes estimates of the associated costs. These estimates do not include the benefits that would result from reducing the maintenance/repair expenses of the old dam structure.

The alternative, constructing a nature-like bypass channel mimicking the natural river, would ensure the passage of species typically occurring there. In Europe, several such constructions have been successful in providing passage for cyprinid fish species such as the bleak *(Alburnus alburnus)*, which are similar to silvery minnow. Because the passage must maintain a low gradient and a low velocity profile, the passage design needs to be of considerable length. As presented in laboratory experiments at Colorado State University, the gradient limit for silvery minnow is one percent. This value

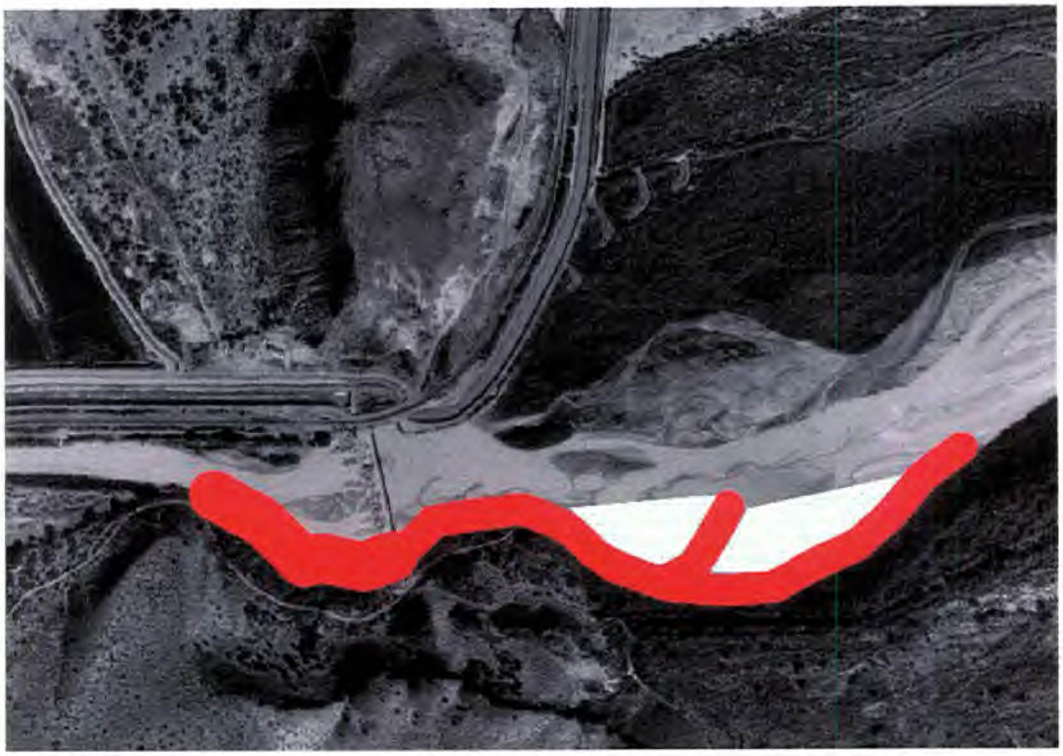

Figure 4: Proposed location of bypass channel sketched on aerial photograph. The red line shows proposed alignment and approximate size of the channel. The white hatch symbolizes the backwater/side arm area, presently covered with mature vegetation.

Conclusions

From a technical standpoint, both dam removal and the construction of a natural bypass channel are viable. In each case it can be anticipated that the fish passage could be restored to a high extent. Obviously, the effectiveness of dam removal for fish passage should be higher. However, the problems of the Rio Grande are complex, and a management decision cannot be based on only one criteria. The performance of fish passage as a measure to restore the population of silvery minnow needs to be evaluated. As mentioned before, the habitat quality upstream of San Acacia dam does not appear to support a sustainable population of silvery minnows. It is not evident that improving the passage of silvery minnow around San Acacia dam will have the expected effect on population size upstream of the dam. The lack of fish passage on a single dam cannot be the only reason for a population decline encompassing over 50 miles of the river. Especially because other obstacles to fish migration, such as one created by arroyo sediment at the mouth of Rio Salado (BOR Reconnaissance Investigation Report, Grogan pers. comm), are not very far upstream. It seems much more likely that physical habitat degradation is responsible for the population decline. Therefore, in my opinion, a fish passage facility could support population recovery only if adequate habitat conditions were also provided.

Another issue to consider is the condition of sediment starvation of the river downstream of San Acacia. This sediment starvation causes dramatic degradation of the riverbed. The existing dam controls the gradient of the river. Removing the dam could possibly cause further headcutting all the way to the mouth of Rio Salado. Regardless of whether the dam will be removed or not, measures to stop the degradation of the riverbed downstream of San Acacia and raise it to the level of the adjacent floodplain are necessary.

My conclusion is that it is premature to determine which measure is the best for the recovery of the silver minnow population. Without more data and the development of our knowledge base, it is almost impossible to predict which action will improve the ecological status of the Rio Grande. Consequently, I can neither recommend a bypass channel nor dam removal specifically if they are considered in isolation from habitat improvement measures upstream of the dam.

Recommendations

My general recommendation is that a fish passage should be incorporated in restoration plans for the entire Middle Rio Grande. The fish passage should be understood to be an accompanying measure relating to recovery of the river and silvery minnow population. In spite of many studies, the system appears to be not well known. Its dynamics, such as reasons for downcutting and the decline of the silvery minnow population, cannot be precisely defined at this time. A high economical value of water resources and consequential heavy use of the river call for a scientifically sound long-term management plan that will build on a precise knowledge of riverine processes. A long-term management plan must incorporate the ecological as well as socio-economical aspects of river management. Building upon a comprehensive, interdisciplinary ecosystem study, this management concept should define the measures that are necessary for restoration of the entire ecosystem.

Appendix 1 presents an example of a study that could lead to the development of such a restoration plan. It was performed in Austria on the river Traisen, which has very similar problems to the Rio Grande. It could be therefore used as a successful template for establishing a long-term strategy. It included a wide range of disciplines covering aquatic and riparian ecology as well as river and civil engineering. Two teams of scientists lead this collaborative effort: one team representing the ecological sciences and one team representing resource-use engineers. In the first step, both teams define their vision of a target system, or in other words, how they would like the Rio Grande to be. Subsequently, each team compares their vision with present situation and identifies the list of deficits and improvement goals. In the third step, both groups define a list of integrated objectives in close collaboration. This list builds the foundation for a modular framework of restoration measures, which is used for a long-term master plan that addresses various circumstances along the river corridor (e.g. city, country site, unpopulated).