APPENDIX B

Zia Pueblo Report

The following pages in Appendix B consist of a report written on multiple problems at Zia Pueblo which can be attributed in part to a structurally deficient irrigation diversion dam on the Rio Jemez. The situation at Zia Pueblo shows how problems with a Pueblo's irrigation system can negatively impact the general river morphology, habitat, and other structures associated with or close to the river.

ZIA AND JEMEZ PUEBLOS

RIO JEMEZ EROSION AND DEPOSITION PROBLEMS

General. Zia Pueblo is experiencing problems due to both deposition and downcutting (degradation) of the Rio Jemez. As a river downcuts, it tends towards increased meandering, channel widening as slope failures occur, and propagation of headcuts up tributaries such as arroyos and irrigation wasteways. Figures 1a and 1b show the location of some of the threatened lands and infrastructure on the Rio Jemez through Jemez and Zia Pueblos.

General erosion seems to have been taking place through Zia Reservation for decades. Zia Pueblo's old sheet-pile diversion dam on the Rio Jemez, originally constructed in the 1930's, had to be reinforced and repaired many times over the years because of erosion. Since this structure required a lot of maintenance and did not divert an adequate amount of water into the irrigation system, it was replaced about 1990 with a concrete structure further upstream. Due to insufficient funding, some shortcuts were taken with this new dam. There has not been any significant maintenance since it was built. As a result, there are some critical safety and stability issues on this new dam which must be addressed.

New Diversion Dam. The new dam was not built with proper sluicing capabilities. Therefore, it has impounded 10.5 ft of sediment immediately behind it (Figure 2). As water is slowed when it approaches a structure like a diversion dam, the decreased velocity results in a decrease in sediment carrying capacity. Sediments have been deposited behind Zia's diversion dam in this way. Once the water passes over the dam, it has a higher sediment carrying capacity and tends to pick up sediments from the river bottom and sides to come to equilibrium again. This tendency to pick up sediments from the river bottom and sides causes down cutting and erosion of the channel bottom and increased meandering as sediments are picked up from the river sides.

The new dam, then, has created depositional problems upstream of the dam and exacerbated the general scour that was already taking place downstream of the dam. The channel capacity of the Rio Jemez has been significantly decreased immediately upstream of the new diversion dam. A wasteway on Jemez Pueblo land several hundred yards upstream of the dam has backwater problems and can no longer adequately discharge its flows into the Rio Jemez because the Rio Jemez is now significantly higher than it used to be in this area. There are also some wetlands which are forming and growing in the river's historic floodplain upstream of the diversion dam on both Jemez and Zia reservations. In order to convey water during low flow, the Rio Jemez was channelized upstream from the dam. Two berms were built to contain the river and conduct it to the diversion works. However, the deposition has now decreased the channel carrying capacity between these two berms. Although engineering calculations have not yet been performed, it is doubtful that the river channel immediately upstream from the dam could contain a 10-year or 20-year flood (Figures 3 and 4).

The berms and abutments are showing signs of slope failures, erosion, and piping (Figures 4

and 5). As a short-term precaution, the berms should be compacted, raised, and protected with riprap. However, failure of the berms could wipe out part of Zia's irrigation infrastructure and a power line which is close to the dam, in addition to causing failure of the dam itself. The dam failure would be caused by the river avulsing to the side of the dam, downcutting, and undermining the dam's foundation at the abutment.

Both dispersive (highly erodible) and collapsing (loose, uncompacted) soils are predominant in the area. Testing of soils in the berms, river bank, and abutments are scheduled for the April 1998. Depending on soil test results, it may be necessary to import non-dispersive, non-collapsing soils and rebuild the berms.

Figure 6 shows some of the piping problems at the dam's east abutment, which may be due to dispersive soils. Holes up to 6 ft deep can be observed at the top of the abutment. Just downstream of the east abutment, a wasteway head wall and section of pipe have broken off from the remaining pipe and a large slope failure has taken place (Figures 7 and 8). It is interesting to note that this failure took place in January 1998. No flows had been diverted through the irrigation system or wasteway since October 1997. A hole in the river bank close to the head wall, similar to the one shown in Figure 6, is probably to blame. The piping most likely began near the hole and propagated to the structure, causing the blowout and damage to the wasteway head wall. It illustrates that the holes which appear on the surface can be quite small, but the piped out area below the ground surface can be quite large.

Old Diversion Dam. Roughly one-half mile downstream of the new concrete diversion dam is the old sheet pile diversion dam. It was originally a double row of sheet piling with wire-enclosed and grouted riprap in between the two sheet pile rows. With the severe scour below the old dam, both sheet pile rows are failing (Figure 9). A comparison of Figure 9, taken in September of 1997, and Figure 10, taken in March of 1998, show that the failure is progressing, as the sheet pile rows are leaning further forward in the more recent picture. Figure 11 shows a close-up of the lower sheet pile row, and Figure 12 shows a close-up of the upper sheet pile row. Figure 13 shows some large vertical banks immediately downstream of the old diversion dam formed as a result of channel degradation.

The head drop across the old dam (difference in elevation upstream and downstream from the dam) is about 12 ft. Should this dam fail, the 12 ft drop would propagate upstream to the new diversion dam and cause failure of the new dam as well. The new dam has cutoff curtains in its foundation which are only 8 ft deep (2 ft slab plus 6 ft curtain), so it could not withstand the 12 ft of erosion which would likely occur shortly after failure of the old diversion dam.

Irrigation Flume. About two miles downstream of the old diversion dam is a flume which conveys irrigation water from one side of the river to the other side (Figure 14). This was built at the same time as the new diversion dam. Originally the structure was a siphon which carried the irrigation water underneath the river bed. However, general scour led to exposure and failure of the old siphon. The structure was then replaced with a flume to carry the water above

the river. However, degradation of the river bed has continued after the flume was built, and the foundation of two flume piers is at risk of failure because of scour. The riverbed elevation when the flume was constructed was at the top of the concrete pier visible in Figure 14. Since then, the river bed has degraded about eight to ten ft. The conical concrete apron was poured around the bridge pier to try and protect the piling foundation from failure. Riprap was also added across the river immediately downstream of the flume to try and stabilize the river bed, but this has partially failed. Failure to stabilize the river bed near the flume can eventually result in foundation failure of the flume piers.

Loss of Farmland. Figures 15 and 16 are typical of the vertical banks and increased meandering all along the Rio Jemez downstream of the new diversion dam. Farm lands, pasture lands, and fencing are being lost to the river as a result of the increased meandering. The vertical banks also present a safety hazard, as a slope failure could cause livestock or people to be buried alive if they are on the banks when failure occurs.

Domestic Water Line. Figure 17 shows a domestic water line used to convey water to a subdivision on the south side of the Rio Jemez. The line, which crosses the river, was originally buried about 8 to 10 ft below the river bottom, but has now been exposed. Failure of this line would cause contamination of the water distribution system and leave the subdivision without drinking water.

Highway Bridge. Figure 18 shows the footing of a highway bridge which has been exposed due to scour. Engineering analysis has not been performed on the bridge's stability. However, continuing scour could eventually cause failure of the bridge foundation. Figure 19 shows exposed pilings from the old bridge which was taken down after construction of the new bridge. Originally, the old pilings were cut down to the level of the river bed in the late 1970's or early 1980's. Now, about five feet of piling is exposed above the water surface elevation.

Sewage Lagoons. Just downstream of the highway bridge are the pueblo's sewage lagoons. Increased river meandering is causing riverbank erosion towards the lagoons. If left unchecked, the river will eventually breach into the sewage lagoons.

Wasteways and Road Crossings. Figure 20 shows degradation and erosion of an irrigation wasteway immediately below a pipe road crossing. The degradation from the river is making its way up tributaries and wasteways. This erosion can eventually threaten the road crossing, which is Zia Pueblo's access road to farmlands, grazing lands, a lake, and the new diversion dam.

Environmental Damage. Most photographs show infestations of salt cedar and Russian olive that have occurred with the river's transformation from a wide braided channel to a narrow incised channel. The change in river morphology is altering the riparian area, leading to overall environmental degradation caused by the changing from a native ecosystem to one dominated by high-water-use, invasive phreatophytes. Effects on the native fishery are unknown at this time.

Summary. Problems of general river erosion which has been occurring for decades is being compounded by Zia Pueblo's new diversion dam. The new diversion dam itself is in danger of failure from piping, abutment and berm erosion, and scour as the old diversion dam continually gives way. The dam is also causing depositional problems on its upstream side. Other infrastructure and lands threatened by degradation include the old diversion dam, a power line, an irrigation flume, farmlands, a domestic water line, a highway bridge, road crossings, irrigation wasteways, and sewage lagoons.

Short-term solutions to the problem include raising and placing riprap to protect berms and abutments of the new diversion dam. Long-term solutions might possibly involve modifying the new dam to allow sluicing of sediments from behind the dam and prevention of piping, construction of grade control structures all along the river, bank stabilization, and salt cedar removal. These efforts would cost several million dollars. However, it is important to proceed with short-term, "bank-aid" type fixes at the present. Failure to do so could imperil the health and safety of pueblo members, millions of dollars of infrastructure, and result in the loss of agricultural revenues and the traditional, irrigated agricultural way of life to Zia tribal members.

Figure 1a. Location map.

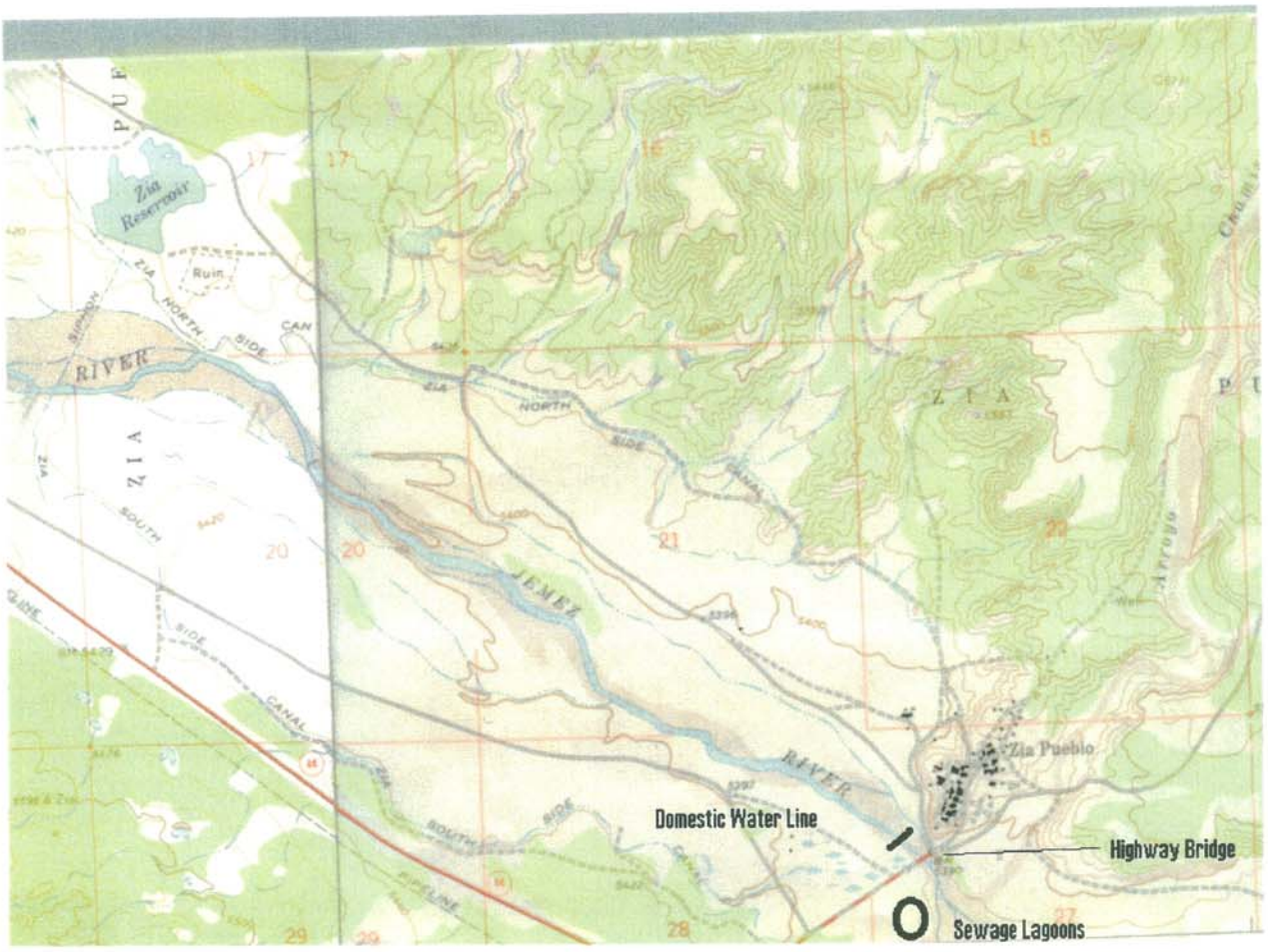

Figure 1b. Location Map.

Figure 2. New diversion dam. Dam height is 10.5 ft. Sediment goes all the way to the top of the dam on the upstream side.

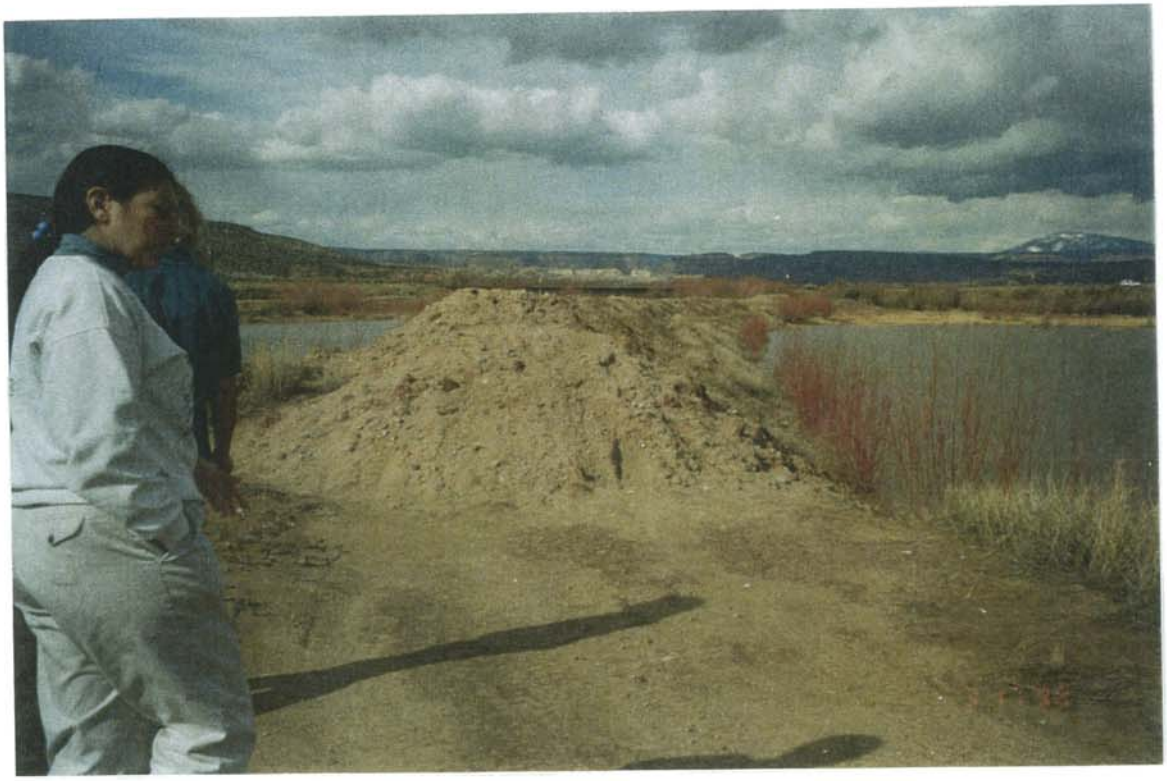

Figure 3. Picture taken from the east berm immediately upstream from Zia diversion dam. The river is on the left side of the berm, and a wetland which is forming is on the right side. Arroyo flows coming in from the east into the wetland area have been cut off from the river and no longer drain into the Rio Jemez. However, the wetland area is lower in elevation than the aggraded river bed, so most of the water throughout the year is due to seepage from the Rio Jemez through the berm and into the wetland area. A highway bridge which has a decreased carrying capacity because of the aggradation can be seen in the background. The depth of water in the Rio Jemez is a few inches, so it can be seen that the channel capacity is quite small based on the west berm height, which can be seen in the background. Dump truck loads of uncompacted fill were placed on top of the west berm to raise its height and improve the channel carrying capacity. These are visible in the foreground. However, the entire length of both berms needs to be raised to increase channel carrying capacity.

Figure 4. West berm upstream of new diversion dam, showing slope failure and decreased channel capacity.

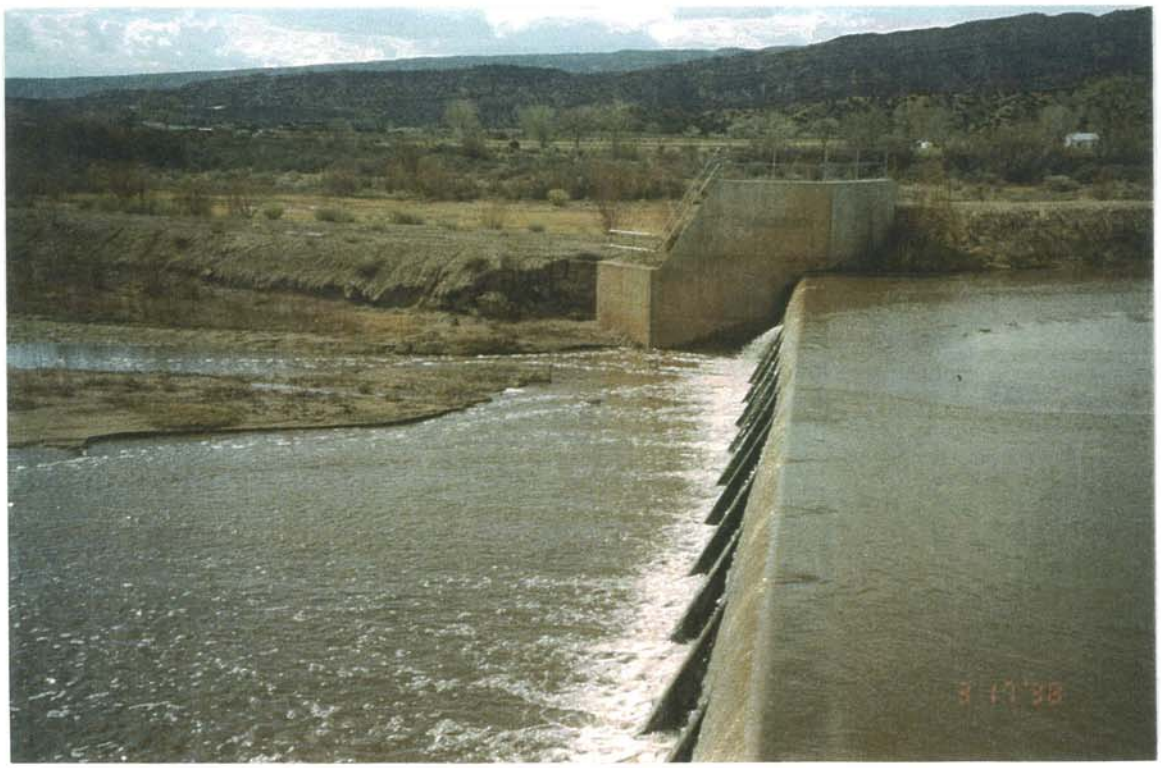

Figure 5. Erosion at downstream side of west abutment of new diversion dam.

Figure 6. Piping through new diversion dam east abutment.

Figure 7. Headwall of irrigation wasteway, showing piping failure.

Figure 8. Headwall of irrigation wasteway, showing piping and slope failure.

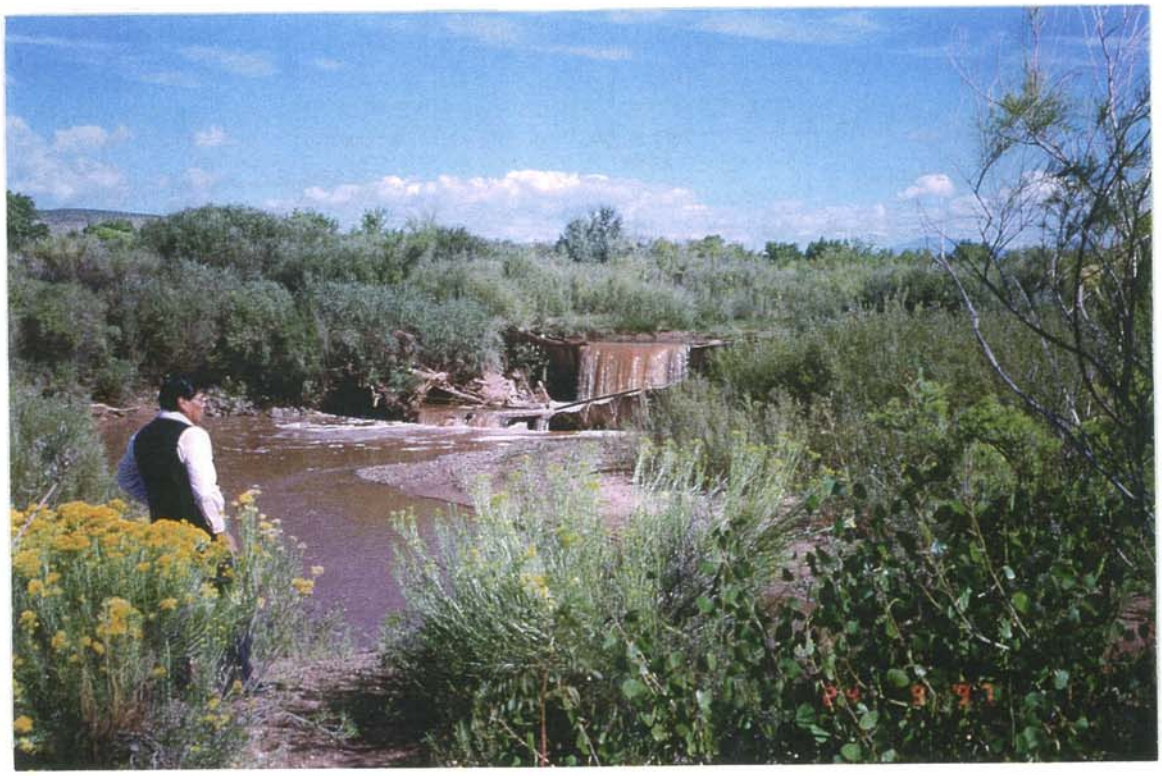

Figure 9. Old sheet-pile diversion dam showing both rows of sheet piling. Head drop across structure is about 12 ft.

Figure 10. Old diversion dam.

Figure 11. Bottom row of sheet piling, old diversion dam.

Figure 12. Top row of sheet piling, old diversion dam.

Figure 13. High vertical banks, 15 to 18 ft high, immediately downstream of old diversion dam. Increased meandering is also apparent.

Figure 14. Irrigation flume showing degradation, riprap structure, and concrete apron around pier foundation.

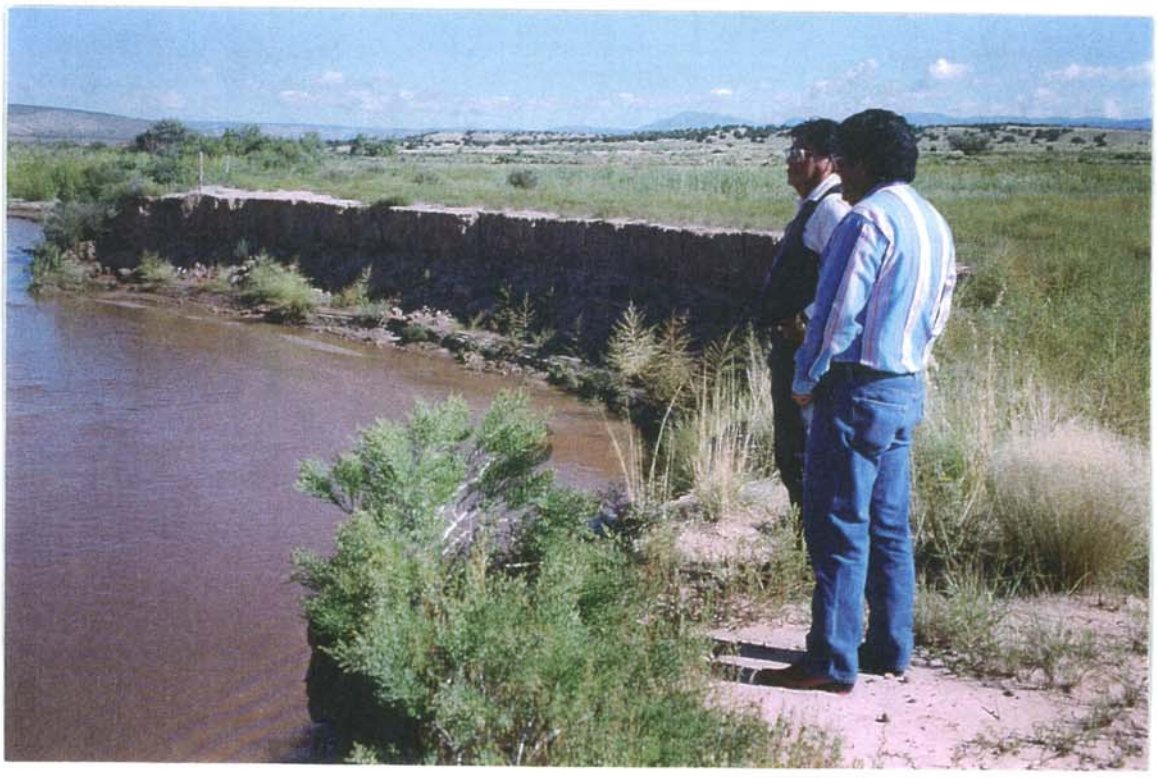

Figure 15. Meandering and vertical banks claiming farmland. Bank height is about 15 ft.

Figure 16. Meandering and vertical banks upstream of flume.

Figure 17. Domestic water line becoming visible in river.

Figure 18. BIA bridge footing exposed by erosion. This bridge is the only access to Zia Pueblo during bad weather.

Figure 19. Old bridge piles show river degradation.

Figure 20. Erosion and widening of irrigation wasteway at road crossing. The road and crossing are both threatened. This is Zia Pueblo's main access to farmlands, grazing lands, Zia Lake, and the new diversion dam.