Memorandum

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Date:	25 November 2002	Project: 50286
To:	Mike Wilkin	
Company/Agency:	Eco:Logic	
From:	Brad Hall	
Subject:	Glendale Diversion Weir & Intake Modification Design Truckee Municipal Water Authority	

Scope of Work and Authorization

Northwest Hydraulic Consultants (**nhc**) assisted Eco:Logic with the evaluation of two proposed diversion locations for the Glendale Water Treatment Plant. Technical areas assessed by **nhc** include hydraulic design criteria of two proposed diversion alternatives, hydraulic requirements for providing recreational canoe and kayak passage at the diversions, potential flood control issues and impacts of the structures, and hydraulic modeling requirements. **nhc** participated in a site visit, and developed this memorandum summarizing hydraulic design issues and site constraints, including a recommended work plan for completing hydraulic design and hydraulic modeling tasks in subsequent design efforts. Project authorization was provided on 1 July 2002, and the site visit was completed on 25 July 2002.

Hydrologic and Hydraulic Background

The Glendale Diversion Weir on the Truckee River was constructed to provide municipal water supply for the City of Reno, Nevada. The diversion weir consists of loosely piled concrete rubble and boulders in an angled alignment across the Truckee River just upstream of the Glendale Avenue Bridge. A large intake opening with trashrack is provided at the downstream vertex of the weir, adjacent to the Glendale Avenue Bridge on the left descending bank line. Two large CMP pipes withdraw flow destined for the Glendale treatment plant from this large intake and pass it under the bridge abutment to an open concrete channel feeding a trash screen, bypass channel, control gates, and settling pond at the treatment plant. The right bank of the river at the upstream end of the weir has a secondary diversion supplying water to the Eastman ditch. The Eastman ditch has historically supplied irrigation water to ranching operations. However, in recent years the water demand for ranch use has decreased, largely as a result of the gradual conversion of former ranch lands to urban development.

The Pioneer Diversion Weir is located approximately 2500 feet downstream of the Glendale Diversion Weir. The Pioneer Diversion is used to supply irrigation flow to farmlands to the east and south of the city of Reno. Similar to the Glendale Diversion Weir, the Pioneer diversion consists of boulders piled at an angle across the river, although slightly less oblique then the angle of the Glendale weir, with an intake located at the vertex of the angle along the right descending bank line. Overall, the Pioneer diversion weir is in better condition, and the boulder construction appears to be more stable and less vulnerable to high flood flows. A depression in the center of the weir focuses flow during lower flows.

Truckee River flows tend to follow discharge patterns typical of east-side Sierra Nevada streams, with the highest seasonal flows associated with spring snowmelt runoff, and the lowest flows in the winter. The City withdraws its peak flows from the River typically from May to September, and shuts down the plant for a 4 month maintenance period during the off-peak season. Maximum anticipated firm capacity to be delivered from the diversion to the Glendale plant is 28 MGD (43 cfs). The USGS measures Truckee River streamflow at the Truckee River at Reno gage (USGS gage no. 10348000). Continuous records extend back approximately 56 years to 1946, and the gage was operated at intermittent periods prior to that date. The total record length is approximately 78 years. The USGS gage is located about 4500 feet upstream of the Glendale Avenue diversion, about 0.4 miles upstream of Kietzke Lane Bridge. The watershed has a catchment area of 1067 mi^2, and includes the Lake Tahoe watershed. Flows are regulated by Lake Tahoe, Martis Creek Lake, Prosser Creek, Stampede, and Boca reservoirs, Donner and Independence Lakes, and several power stations. Maximum flows measured at the Truckee River at Reno, NV gage are 20,800 cfs, and minimum flow of 0 cfs during September of 1926. Average monthly mean flows for the May to September delivery period range from 252 cfs to 1533 cfs for the period of record, with the minimum occurring in September and the maximum occurring in May.

High flows during the spring snowmelt period carry the greatest amount of sediment and debris from the basin upstream to the diversion weir structure. These high sediment and debris loads occur at the same time as the peak demand requirements from the Glendale Water Treatment plant, resulting in significant maintenance effort to keep the intake clear. The average slope of the stream through the diversion reach is fairly high, with a mean channel slope of approximately three to four 4 foot drop per thousand foot run, enabling the river to carry fairly coarse bedload sediment. Debris typically consists of brush and small trees, with most larger debris generally being excluded by upstream regulating projects.

There are no provisions for fish passage at either the Pioneer or the Glendale Diversions. Incidental fish passage may occur through the low portions of the weir crests, but the hydraulic characteristics do not meet current passage criteria. Screens are provided at the Glendale diversion intake to exclude fish and debris. However, these screens are separated from the main stem of the river by a fair distance, and the system requires fish entrained by the intake to transit a slow moving, warm water path through the intake trashrack, through twin culverts under Glendale Avenue, and then into a holding channel from which WTP flows are screened. At various intervals, fish and debris are flushed from this holding channel back to the river via a long conduit and channel. This configuration exposes downstream migrating fish to stagnant pools, higher water temperatures, and non-continuous flow velocity, all of which violate current criteria.

References

The references provided below will provide a basis for design of the two alternative weir configurations. Not all may be necessary once the final alternative concept is identified, however, the full list below should provide the necessary guidance.

a. Design References

- US Army Corps of Engineers, Engineer Manual 1110-2-1601, Hydraulic Design of Flood Control Channels
- US Army Corps of Engineers, Engineer Manual 1110-2-1602, Hydraulic Design of Reservoir Outlet Works
- US Army Corps of Engineers, Engineer Manual 1102-2-1603, Hydraulic Design of Spillways
- US Army Corps of Engineers, Hydraulic Design Criteria, Waterways Experiment Station

b. Textbooks

- Design of Small Dams, US Bureau of Reclamation
- Internal Flow Systems, Miller
- Handbook of Hydraulics, King and Brater
- Open Channel Hydraulics, Chow

c. Reports and Literature

The following reports document studies undertaken specifically for the reconstruction of the Glendale diversion weir, studies associated with other diversion dams on the Truckee River, design guidance for fish passage and recreational boat passage, and sedimentation studies of the Truckee River in Reno, Nevada.

- Eco:Logic Consulting Engineers, 2001. “Glendale Diversion Evaluation” prepared for the Truckee Meadows Water Authority. Reno, Nevada. 2001.

- Environmental Assessment Derby Dam Fish Passage Facility. U.S. Department of the Interior. U.S. Bureau of Reclamation. May, 2001.
- Cui-Ui (*Chasmistes cujus*) Second Revision Recovery Plan. U.S. Fish and Wildlife Service. Portland, Oregon. May, 1992.
- Derby Dam Fish Passage Retrofit. U.S. Department of the Interior. U.S. Bureau of Reclamation. 2001.
- Washington Department of Fish and Wildlife. *Fishway Guidelines for Washington State.* Draft Guidelines, April 25, 2000.
- Juvenile Fish Criteria, National Marine Fisheries Service, Environmental & Technical Services Division, Portland, Oregon, Revised February 16, 1995.
- Bell, Milo. *Fisheries Handbook of Engineering Requirements and Biological Criteria*. U.S. Army Corps of Engineers. 1991.
- Taggart, W.C., Pflaum, J.M., Sorenson, J.H., "Modifications of Dams for Recreational Boating," *Design Notes – Supplement to Flood Hazard News,* Dec. 1984, Supplement pp.1-4.
- Simmons, W.P., Logan, T.H., Simonds, R.A., and Brown, R.J., "Model Studies of Denver Whitewater Channel," *Journal of the Hydraulics Division,* ASCE, Vol.103, No. HY7, July 1977, pp. 763-775.
- Caisley, Marjorie, "Hydraulic Model Study of a Canoe Chute for Illinois Streams." MS Thesis, University of Illinois, Urbana, Illinois, December, 1999.
- Hall, Brad R., and William A. Thomas, " Truckee River Sedimentation Study." U.S. Army Corps of Engineers, Waterways Experiment Station, Technical Report HL 93-13, September, 1993.
- Water Engineering and Technology, Inc., "Geomorphic Analysis of the Truckee River." US Army Corps of Engineers, Contract DACW05-88-D-0044, Delivery Order 10, October 1990.

Description of Two Alternatives

Several potential modifications to the Glendale Diversion weir were identified. These modifications are briefly described in the following section, and illustrated on the attached Plates 1 through 8.

Alternative 1: Improve Existing Diversion Weir

This alternative consists of "permanent, viable improvements to the Glendale weir using the existing material." Concrete slabs and boulders would be re-stacked in place such that the weir can be made more uniform and capable of reliably diverting water to the existing Glendale water treatment plant intake (Plates 1, 2, 3, 4, and 5). Fish bypass would be provided to transport downstream-migrating fish through or over the weir, and also to enable upstream-migrating fish to pass through the weir. In addition, safe boating access will likely also have to be provided through or over the weir structure.

Alternative 2: New Diversion Weir at Existing Location

This alternative consists of a complete re-design of the existing diversion structure to provide safe boating access, reliable and effective downstream and upstream fish passage, and reduced maintenance requirements associated with sediment and debris management. Several types and configurations for the weir may be evaluated, but generally all fall along roughly the same cross section of the Truckee River as the existing diversion weir. These potential alternatives are described below:

- One configuration might consist of a conventional concrete weir incorporating a boatway for kayaks and other types of light watercraft and recreational equipment. The weir would be provided with a fish bypass structure(s) for both upstream and downstream migrating fish. This configuration could include strategically placed boulders and rocks designed to reduce visual impacts of the structure and enhance environmental aesthetics.

- Another configuration might consist of a concrete apron and an inflatable rubber dam or drum gate type of weir (Plate 6 and 7). A boatway for kayaks and other types of light watercraft and recreational equipment and fish bypass structure(s) for both upstream and downstream migrating fish would also be incorporated in the design. This alternative would permit the weir to be deflated or lowered for passage of flood flows, potentially reducing flood stage. The weir could also be lowered during the 4 month time period that flow diversion is not required and off-line maintenance of the Glendale Water Treatment Plant is completed. This alternative may offer the greatest flexibility for regulating stage and diversion capacity to the water treatment plant.

- Another configuration may include a more natural appearing engineered boulder/concrete structure (Plate 8) that appears more like a natural stream channel than a weir. However, flow control and diversion reliability may not be as precise as with the rubber dam, drum gate, or fixed concrete weir alternatives.

With all of these configurations, an improved screening system to exclude fish and other biota from the Glendale Water Treatment plant intake channel would likely be beneficial, but not necessary. The existing screening system appears to work reliably, however, may not meet updated screening criteria or bypass criteria. Also, an upgraded screening system may reduce maintenance requirements and repair costs.

Hydraulic Design Criteria & Site Constraints

Hydraulic design criteria for the two proposed diversion alternatives must include fish passage criteria, fish screening criteria, boat passage criteria, sediment management criteria, and debris management criteria. The following discussion is organized according to the five areas listed:

a. Fish Passage Criteria

An adult fish passage structure may consist of a ladder or a roughened channel. Ladders may be of the vertical slot type, well-suited for sites where forebay and tailwater elevations vary significantly, or of the pool and weir type, ideal for sites where the typical forebay and tailwater elevations do not vary significantly. The characteristics of this site suggest that a pool and weir type fishway would be best suited. The long length of the diversion weir provides for relatively stable pool elevation. Design criteria suggested by the Washington Department of Fish and Wildlife (WDFW, 2000) and Milo Bell (Bell, 1991) for both vertical slot type and pool and weir type fishways are provided below.

- Minimum fish ladder width: 8 ft.
- Maximum head drop between pools: 1.2 ft (may be tailored for species and type of fish ladder).
- Minimum head drop between pools: 0.5 ft.
- Minimum pool size: Based on energy dissipation of 4 foot pounds per second per cubic foot of water in pool, or a velocity of 4-5 fps in Denil type.
- Transport velocity: 1.0 to 4.0 fps (2.0 fps preferred).
- Fish Ladder Entrance Head: 1.0 to 1.5 ft.
- Trash rack minimum width between bars: 6 inches.
- Trash rack minimum space between horizontal members: 18 inches.
- Minimum size of orifice: 18 inches by 18 inches.
- Minimum depth through ladder: 3.0 ft.
- Minimum width of slots: 9 inches.

More natural fishways consisting of roughened chutes or boulder fishway channels have no specific design criteria developed to date. However, as a general rule, the following guidelines may apply.

- Maximum length of high velocity flow section = fish swimming burst speed x 5 seconds
- Minimum resting pool dimension dictated by energy dissipation of 4 ft-lbs per second per cubic foot of water in the pool.
- Chute alignment from pool to pool must be relatively straight
- Maximum head drop from resting pool to resting pool 1.0 ft

b. Fish Screening Criteria

These criteria are extracted from the California Department of Fish and Game requirements and general NMFS Juvenile Fish Passage Criteria, which most closely approximate those necessary to protect Nevada's fish species of interest (primarily Lahontan Cutthroat Trout [LCT] and Cui-ui). As discussed in the Environmental Assessment for the Derby Dam Fish Passage Facility (BUREC, 2001), Cui-ui at the larval stage are assumed lost through the screen, and consequently cannot be protected. However, juveniles of both LCT and Cui-ui are to be excluded from the intake by some type of screening system.

- Maximum average sweeping velocity about 4 fps (Juvenile Fish Criteria, 1995)
- Minimum average sweeping velocity at least twice that of the approach velocity (California Dept. of Fish and Game, 1986)
- Maximum screen exposure time 60 seconds (Juvenile Fish Criteria, 1995)
- Maximum normal velocity through screen material 0.33 fps for continuously cleaned screens (California Dept. of Fish and Game, 1986)[1]
- Maximum normal velocity through screen material 0.0825 fps for intermittently cleaned screens (California Dept. of Fish and Game, 1986)[1]
- Maximum screen mesh opening 1.75 mm (Juvenile Fish Criteria, 1995)
- Entrance velocity to the fish bypass greater than 2.0 fps (Juvenile Fish Criteria, 1995)

[1] Note: Velocity measured 3 inches away from screen face.

c. Boat Passage Criteria

Boat passes typically consist of several drops and pools in a channel through a low-head dam. The channel allows boaters to descend the drop of the dam more gradually and safely. A large percentage of the boaters on the Truckee through Reno are kayakers (Charles Albright, personnel communication). Kayaks are generally between 7 and 12 feet long. While upright kayaks draw about 4-6" of water, however, while overturned kayakers draw about 2-3 feet of water, with the kayaker's head being the deepest part of the overturned watercraft. These dimensions must be kept in mind in the design of boat passages.
Recommended design criteria are given below:

- Minimum width of a drop: 15 ft to prevent pinning of boats on rocks
- Minimum width of a pool: 30 ft to allow for eddy formation
- Minimum pool depth: 3 ft to provide ample head room for overturned kayakers
- Minimum pool length: 40 ft to provide enough room for one or more kayak roll attempts
- Rock and boulder construction, concrete drops have uniform edges that encourage formation of keeper holes that trap boaters and debris

- Difficulty of rapids formed by drops should be consistent with the difficulty of the rest of the river reach so as to not present short, more difficult reaches to less experience rowers
- Hydraulic jump formation at drops should be undulating and standing waves; plunging jets and submerged rollers of water off of drops should be avoided

d. Sediment Management Criteria

The modified diversion should enhance passage of sediment to the reach downstream of the diversion weir and minimize accumulations in the vicinity of the diversion and trashracks. Opportunities for high flow flushing of sediment accumulated in the vicinity of the diversion entrance during periods of low flow should be identified. Sedimentation studies completed by the Corps of Engineers (Hall and Thomas, 1993) indicates that the average annual bedload (i.e. medium and coarse sand, gravel, and cobble) on the Truckee River in the vicinity of the Glendale Diversion is approximately 51,000 tons/year. Average annual suspended sediment load (fine sand, silt, and clay) is approximately 250,000 tons/year. Measured suspended sediment concentrations are typically fairly low (~10 mg/liter) for flows less than 500 cfs, but concentrations in excess of 1,000 mg/liter have been measured during flows ranging from approximately 5,000 to 15,000 cfs. The USGS stage-discharge rating curve for the Truckee River at Reno gage has shifted to slightly higher stages (< 0.5 foot) for discharges less than 1,000 cfs, indicating deposition of the coarse bedload in the vicinity of the gage, which is located a short distance upstream from the diversion.

e. Debris Management Criteria

Woody debris and stream detritus are to be excluded from the diversion intake by whatever means is necessary. The following criteria may be used as general guidelines for the design of trashracks and cleaning systems to exclude this debris.

- Maximum size of woody debris to be a log 12 inches in diameter and 15 feet long.
- Maximum velocity of woody debris at impact 12 fps.
- Woody debris wetted unit weight 55 lbs per cubic foot.
- Trashrack minimum spacing 12 inches.
- Trashrack cleaning to be automatic and continuous.

f. Hydrologic Criteria

The following monthly mean flows are extracted from the USGS streamflow records for the Truckee River gage at Reno (gage number 10348000) for the period of record (approx. 78 years).

- Monthly Mean Flow for January - 676 cfs
- Monthly Mean Flow for February - 750 cfs
- Monthly Mean Flow for March - 913 cfs
- Monthly Mean Flow for April - 1,246 cfs

- Monthly Mean Flow for May - 1,533 cfs
- Monthly Mean Flow for June - 1,078 cfs
- Monthly Mean Flow for July - 434 cfs
- Monthly Mean Flow for August - 257 cfs
- Monthly Mean Flow for September - 252 cfs
- Monthly Mean Flow for October - 279 cfs
- Monthly Mean Flow for November - 421 cfs
- Monthly Mean Flow for December - 568 cfs

The following figure provides annual peak flows of record for the Truckee River at Reno gage.

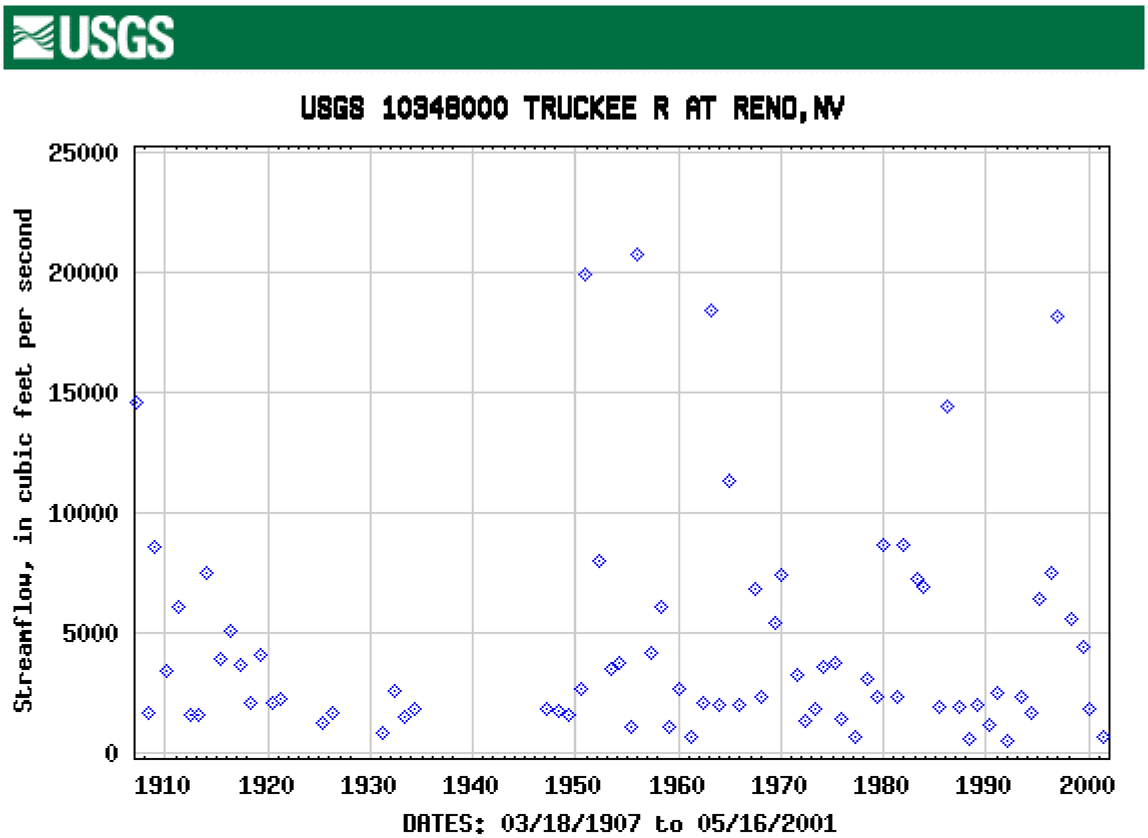

Figure 1 – Peak Flows for Truckee River at Reno, NV

The following flow exceedance values are provided in the USGS gage record.

- 80 percent exceedance flow 72.8 cfs
- 50 percent exceedance flow 238 cfs
- 20 percent exceedance flow 332 cfs

Flood Control Issues and Impacts

Alternative 1: Improve Existing Diversion Weir

Improving the existing weir structure should not significantly alter the existing flood characteristics or profiles in the vicinity of the weir. However, securing the construction materials from movement during floods better than the current condition may assist in maintaining a clear opening under Glendale Avenue Bridge to pass high flows.

Alternative 2: New Diversion Weir at Existing Location

Redesigning the diversion weir may impact flood levels upstream of the structure if the overall height is greater than the existing crest elevation, or if the discharge rating curve for the redesigned weir provides for lower discharge capacity for the same water surface elevation. In addition, if a rubber dam type crest is implemented, the consequences of rapid deflation due to damage must be considered.

Hydraulic Modeling Requirements

An HECRAS model was previously developed as part of the ongoing flood control studies by WRC of Reno of the portion of the Truckee River within the city of Reno. This model was developed in support of a US Army Corps of Engineers flood damage reduction study for the Reno area. Eco:Logic provided the geometry file for this HECRAS model to NHC. Review of the geometry file shows that the cross section placement in the vicinity of the Glendale and Pioneer diversion weirs is not entirely sufficient for detailed analysis of the two diversion weirs and associated appurtenant structures. Several cross sections should be added to the model, and several more should be realigned to provide for adequate evaluation of diversion weir alternative configurations. Figure 2 shows a plan view of the Glendale diversion weir with the desired additional cross sections. Figure 3 shows a plan view of the Pioneer diversion weir with the desired additional cross sections.

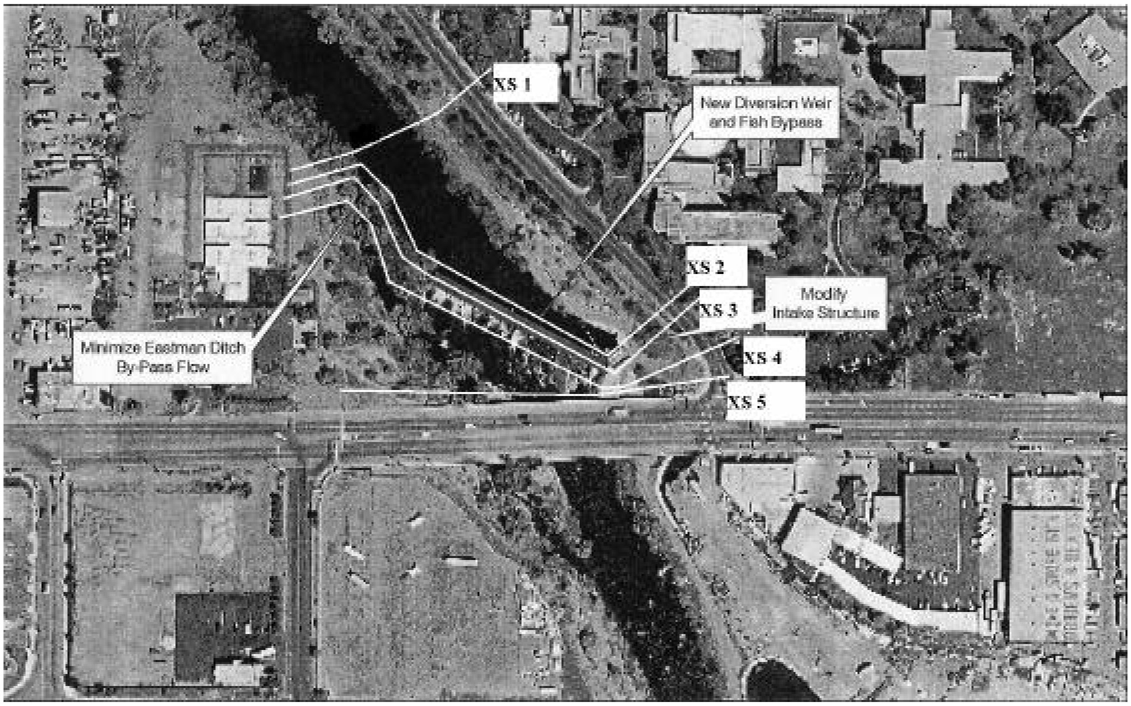

Figure 2 – Glendale Diversion Weir HECRAS Cross Sections

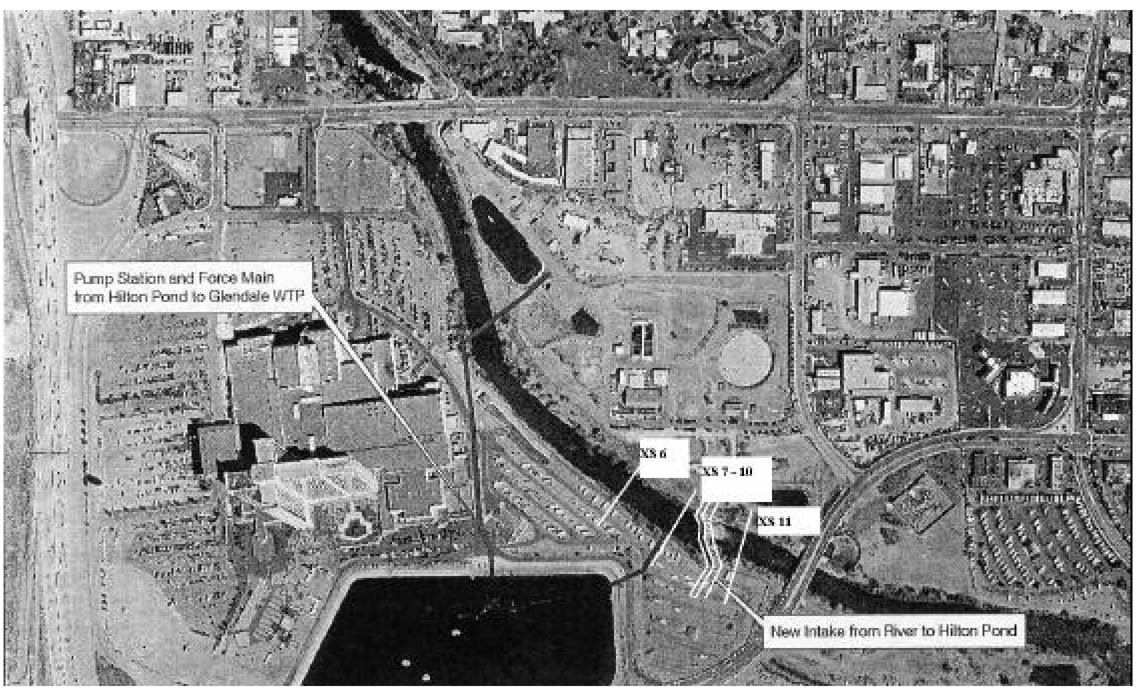

Figure 3 – Pioneer Diversion Weir HECRAS Cross Sections

Although the flow file was not supplied for review, we recommend that a series of hydrologic scenarios be evaluated with the HECRAS model of the reach in the vicinity of the Glendale and Pioneer diversion weirs.

Recommended Work Plan

The replacement of the Glendale Diversion Weir with a more reliable structure should be evaluated using a phased approach. The first phase should be an Alternatives Analysis that evaluates the relative economic and engineering feasibility of several preliminary alternatives. This phase was completed by Eco:Logic and is documented in the report cited in Section 3 above (Eco:Logic, 2001). The second phase should be a Feasibility Evaluation of the two selected alternatives. Major features of the two alternatives should be defined and the overall operation of the structure and facility must be determined at this phase. In addition, feasibility construction cost estimates must be developed to the ± 30% confidence level at this phase. A decision to implement one or the other of the two remaining alternatives should follow the feasibility phase. The final selected alternative will be developed and refined further during the next Detailed Design phase. During this phase, miscellaneous details for the design of the intake, weir, trashracks, screens, channel, fishways, boat passage, and mechanical features will be completed. Physical hydraulic modeling of the proposed weir structure and diversion should be completed to refine project design and ensure adequate hydraulic performance for fish passage, debris management, sediment deposition and passage, and flood passage. Construction cost estimates to the ± 10% confidence level should be developed using the design details determined at this phase. Following the detailed design phase, a Construction Plans and Specifications phase should follow. During this phase, the bid documents will be prepared for construction of the entire facility.

Specific hydraulic engineering tasks to be completed during the Feasibility phase design include development of a detailed water surface profile model in the vicinity of the diversion weir, and determination of design river discharges for use in sizing various features of the project. A sediment transport analysis to determine maintenance requirements and refine the alignment of the diversion and intake structure in order to minimize sediment deposition at the intake would be necessary. In addition, hydraulic design of trashracks, boat passage features, fish passage features, and fish screen and bypass systems would be accomplished. Operational requirements and limitations as a function of stage, flow velocity, and discharge should be determined for both alternatives as well. A physical model study of the diversion weir, intake, and fish bypass features would be used to refine design configurations and to determine sediment deposition and movement characteristics in the vicinity of the intake. Numerical modeling (i.e. computational fluid dynamics, CFD) of the intake may be required to quantify detailed hydrodynamic characteristics of fish screening, bypass, and passage facilities.