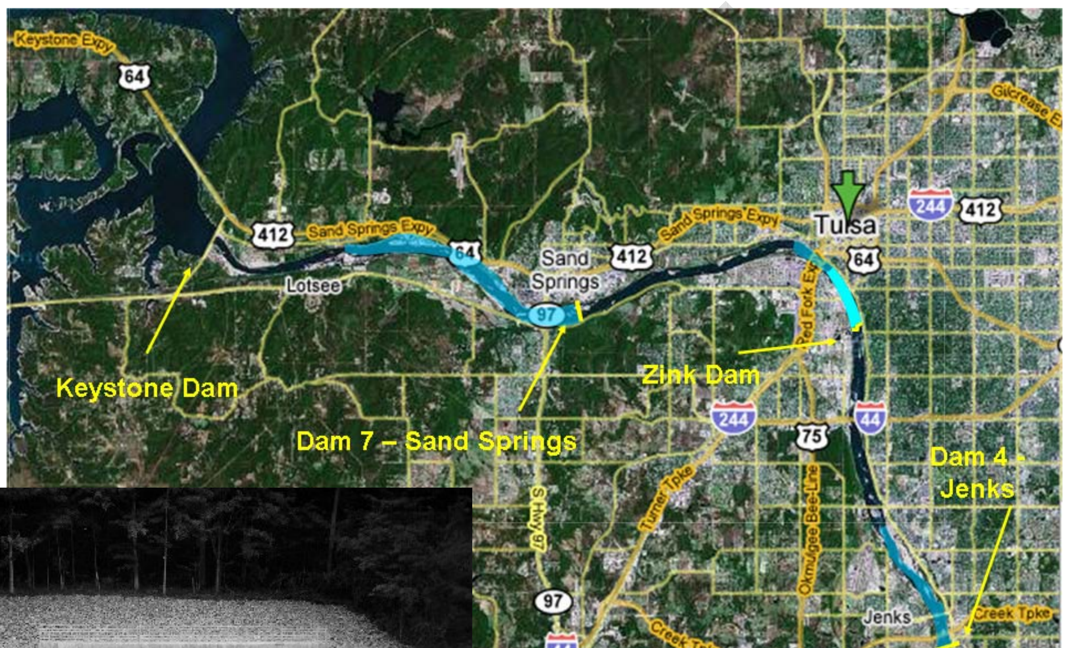
PRELIMINARY

TENNESSEE VALLEY AUTHORITY
River System Operations & Environment

Vision for the Arkansas River Corridor at Tulsa



Prepared by
William D. Proctor
Coleman Hoskins
Colleen Montgomery

Knoxville, Tennessee
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Vision for the Arkansas River Corridor at Tulsa

INTRODUCTION

In October 2006, personnel from the Tennessee Valley Authority (TVA) met with representatives from the Corps of Engineers and local officials in Tulsa, Oklahoma. TVA representatives were invited to discuss concerns and issues related to installing weirs (low-head dams) in the portion of the Arkansas River flowing through the Tulsa metro area as part of Tulsa's Vision 2025 plan. TVA was consulted due to past experience in weir designs with an emphasis on river safety for recreational users and enhancement of the aquatic environment below the weirs. Over a three-day period, meetings, discussions, and site visits were conducted to define areas of concern and to attempt to formulate some preliminary concepts for future discussion. This report is the result of those meetings.

INTEGRATED RIVER SYSTEM FROM KEYSTONE DAM TO JENKS

To achieve all of the desired objectives for the Tulsa weir project and ensure the greatest benefits for the majority of the people, an integrated river system approach is essential. The ability to control flows through a system of coordinated hydraulic structures is necessary so that the river system can provide for multiple benefits. To achieve the benefits, which include habitat enhancement and protection, economic and recreational opportunities, while still meeting floodplain development restrictions, requires thoughtful design and carefully coordinated operation. An integrated system approach offers a solution to the many conflicting interests inherent in attempting to control even a portion of a river system. Ultimately, the success of the river system depends on both appropriate design and construction of the structures, as well as their prudent operation and maintenance.

Key Issues

- Designing an Integrated River System to optimize river operations.
- Passing striped bass, sauger, shovelnose sturgeon, and paddlefish at the correct time of year to allow upstream migration, spawning, and downstream egg transport.
- Providing consistent riverine habitat for smaller non-migrating fish species; e.g., shiners, minnows, darters, and silversides are more important than their passage past low head dams.
- Protecting least tern nesting areas by eliminating land bridging that occurs when the channel is mostly dry.
- Extending the Zink Dam pool farther upstream by raising the crest elevation.
- Minimizing impacts on smaller fish species utilized as food for least terns.

- Passing the heavy sand loads through the weirs must be included.
- Complying with Federal Emergency Management Agency (FEMA) National Flood Insurance Program (NFIP) and other floodplain regulations.
- Building a weir considering the sandy nature of the channel and soil in the floodplain.

Discussion

Integrated River System

The Tulsa low-head dams (or weirs) would create a system of lakes that would be operated in an integrated manner to provide a wide range of benefits through the Arkansas River tailwater below Keystone Dam. The integrated system will include three weirs: at Sand Springs, at Jenks, and at the existing John Zink Dam, located in-between the two proposed weirs.

The benefits of these river lakes would include beautification of the water front, recreational opportunities for boaters, and additional protection of the nesting islands for least terns. In addition, minimum flows provided from the Sand Springs Weir would increase the foraging areas for the least terns, provide consistent habitat for aquatic species in the river, as well as provide flow to operate a new whitewater course at Zink Dam and possible future whitewater courses below Sand Springs and Jenks Weirs.

Operation of the system would rely on some of the daily generation from Keystone Dam being captured by the Sand Springs Weir, which will have a pool about five miles in length and a depth ranging from 9 to 11 feet at the structure. During Keystone's non generation periods, the top two feet of the Sand Springs pool would be used to provide a continuous minimum flow to the downstream channel, helping to achieve the public's desire for "water in the river" throughout the corridor. These flows would be provided by gradually releasing water through the Sand Springs Weir to maintain a consistent minimum flow.

The other two weirs, which are farther downstream, would be operated at a fixed pool elevation. The continuous minimum flow provided by reregulation releases from Sand Springs Weir could allow 400 to 1000 cfs of flow to continuously travel down the river channel, as long as their pool is refilled by Keystone Dam releases once a day. To be consistent throughout the document, plots are shown with a release rate of 600 cfs.

An additional proposal is to increase the height of Zink Dam by 2 feet (or even 3 feet) to essentially double the length of the pool. The crest of the existing dam could be retrofitted with 2-foot tall flap gates to accomplish this. These gates could be lowered in the event of a flood and should provide no additional obstruction to flood flow than the existing condition.

The following figure illustrates the extent and approximate location of the proposed weir pools, as well as the additional pool area that could be gained by raising the height of Zink Dam.

Figure 1. Conceptual Plan View of Tulsa Area Showing Existing and Proposed Weir Pools and Keystone Dam

The river bed drops approximately 35 feet between the Sand Springs and Jenks weir locations. The steepest part of this reach is between Zink Dam and the upper end of the Jenks weir pool. This area would have the opportunity for whitewater recreation with a continuous release of 400 - 1000 cfs and the construction of an artificial whitewater course. In addition, the existing whitewater attraction below Zink Dam may possibly be enhanced even further as a result with multiple areas of the tailwater that could be used for whitewater.

Figure 2 shows a profile view of the streambed with the three full weir pools and with a reregulation flow through the river channel. The figure also shows the change in size of the available weir pool from raising the height of Sand Springs Dam by 3 feet, and highlights the fluctuating top 2 feet of pool area in the Sand Springs weir pool, with a total depth of up to 11 feet when the weir pool is completely full.

A flow rate of 600 cfs is presented in Figure 2 because it was one of the design flows already present in the HEC-RAS model provided by Tulsa USACE (labeled as “Water Quality”) and it was also within the possible range of flows that could be provided by Sand Springs Dam. At the small scale of the profile in Figure 2, 600, 800, or 1000 cfs would look virtually the same.

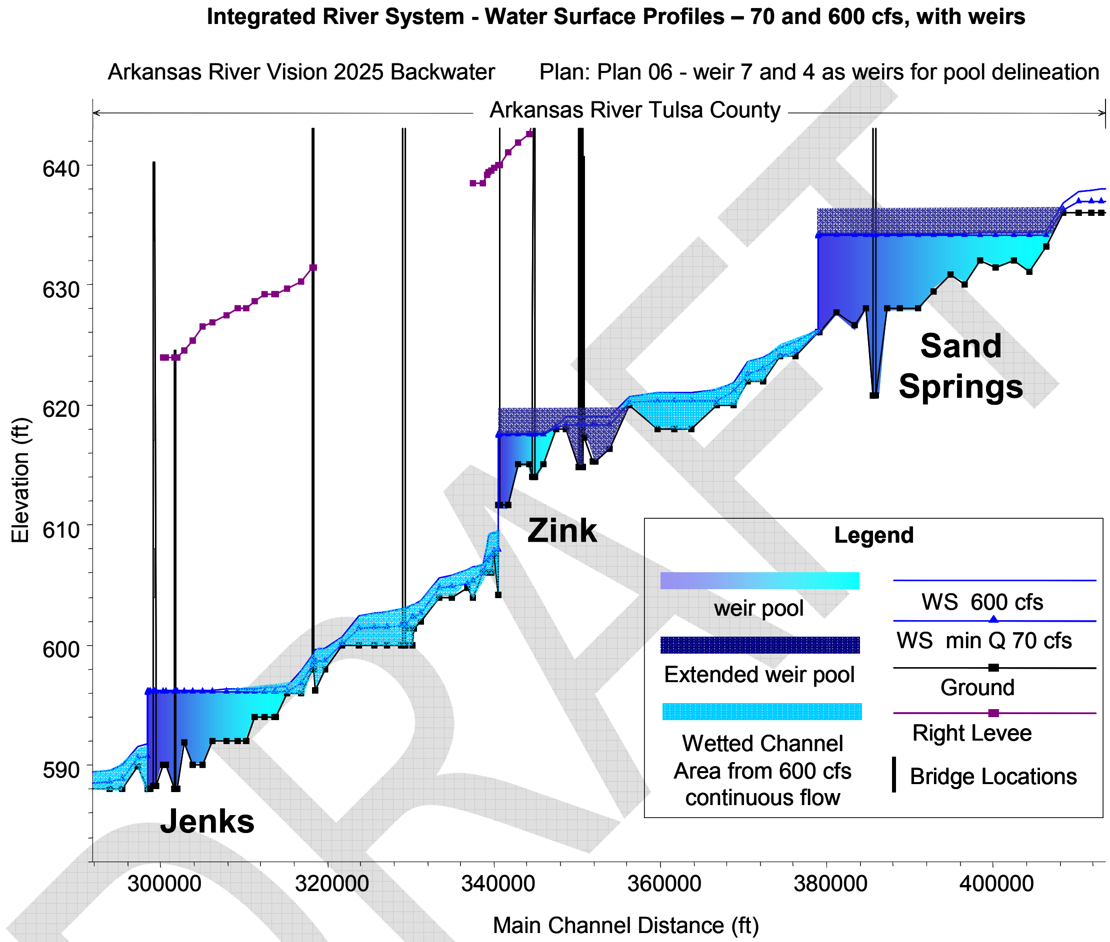

Figure 2. Water Surface Profile View Showing Weirs and integrated River System Concept

Protection of Least Tern Nesting Areas and Food Supply

A continuous flow in the river would also help provide protection for the least tern by reducing the amount of land bridging to the mid-channel islands through the river. Because least terns build their nests on the ground, they are susceptible to predation from carnivorous mammals that traverse the dry channel. A continuous flow in the channel would cut off many of these pathways and help isolate the least tern nesting areas on the islands from these predators. In addition, minimum flows, by increasing the aquatic habitat through the riverine portions of the river, should provide additional foraging opportunities for the least terns in the riverine reaches between the weir pools.

FEMA NFIP Compliance

Another key factor in the design or modification of structures such as the weirs, which are located within the 100-year floodplain, is that they would have no impact on the FEMA 100-yr flood and 100-year floodway elevations of the Arkansas River as stipulated by the FEMA NFIP. The city of Tulsa and Tulsa County both participate in the NFIP (FEMA, 2007). For an 8-foot high weir at each location, causing no increase in the 100-year flood elevations, would require an opening about 650 feet wide through the weir in the central portion of the channel during these large floods. This will be accomplished by installing gate segments in each weir in the middle portion of the channel where flood flow conveyance is the greatest. According to the Tulsa District, flood events are most likely to occur in the spring, from March to May, or during the fall.

Flow Enhancement for Migrating Fish Species

The primary fish species of concern to the state are striped bass, sauger, shovelnose sturgeon, and paddlefish. Spawning migration for these fish species occurs during the spring (March to May). It is proposed to lower the center sections of the weirs during the spring flooding/fish spawning migration season to (1) allow flood flows to pass downstream without impacting the 100-yr floodway elevations, (2) allow transport of sand loads downstream through the weirs and help avoid the need for dredging of the weir pools, and (3) allow passage of key migratory fish species upstream through the weir.

It is also important that riverine habitat is maintained through the spawning season to allow larvae and eggs of these key species to pass downstream. Striper eggs, spawning, and fry all require a steady flow of fresh water, and there must be a steady current flowing over several miles. The eggs of striped bass are semi-buoyant and are carried downstream by a flowing river. Without adequate water velocity the eggs would sink to the bottom, be smothered in sediment, and die. Early larval stages of all four species are typically swept downstream from spawning habitat (higher current velocity) to nursery habitat (lower current velocity). Furthermore, if the river lakes were kept full during this period, these eggs would likely drop out of the flow, be buried, and suffocate in the sandy bottoms of the weir pools.

In addition, several other fish species, ranging from channel catfish to river shiner, would also use the weir openings for upstream and downstream migration. The primary season for migration for these fish species is during the spring (March to May). It is proposed to lower the center sections of the weirs (essentially eliminating the river lakes) during all or part of the spring flooding and the fish migration seasons (March to May). The exact duration of lowering the weir dams can be varied to achieve the optimum balance of all the objectives as determined by the asset owners and stakeholders. The rate at which these weir pool elevations would be lowered can be also varied to avoid stranding any aquatic species within the drawdown pool.

Habitat for Small Non-Migrating Fish Species

A minimum flow is also necessary to maintain habitat for aquatic species along the riverine reaches throughout the year. After installation of weirs below several TVA projects, diversity and abundance of both macro invertebrate and fish assemblages increased dramatically downstream with improvements to aquatic habitat and adequate concentrations of dissolved oxygen. Results of biological monitoring in the Clinch River downstream of the weir below TVA's Norris Dam demonstrated the relative importance of improved minimum flows to aquatic biota, where the macro invertebrate abundance increased by 300 percent. (Bendnarek, 2002)

Fish Passage through the Weirs

Numerous fish passage designs were evaluated to allow fish passage upstream over or around the weirs. But even if fish passage upstream was provided for, biologists expressed more concern about the eggs hatching. Because the striped bass eggs rely on being carried downstream by the river currents to prevent them from being buried or caught in a stagnant pool, the opinion of biologists was that weir pools would hinder the progress of the hatching eggs. This would decrease the hatching rate for striped bass and limit the amount of fry that could be harvested downstream of the Zink and Jenks weirs. Given this concern and the hatching characteristics of the other species of concern, it was concluded that free river flow during the spawning seasons would be the best way to provide fish passage and hatching habitat for the fish eggs. Therefore, fish passage would be provided by opening up the weirs for several months of the year during the flood control and spawning period. This also allows sand to pass through the weir as well, to prevent excessive accumulation in the pool areas. Differing methods of constructing fish passage/weir openings are outlined below.

Methods to Open up the Weirs

Inflatable Rubber Dam

One attractive option to create a large gate in the weir structure was the Bridgestone Rubber Dam (see Figure 3). The inflatable dam concept allowed a large portion of the channel to be completely opened up for fish spawning runs, or to restore the river channel to essentially pre-weir conditions and not increase 100-year flood elevations as required by FEMA. The inflatable dam technology has been in existence for about 50 years.

Figure 3. Schematic of Bridgestone Inflatable Dam

Obermeyer Gate

The pneumatically operated spillway gate manufactured by Obermeyer Hydro Inc. is a much more recent innovation than a stand-alone inflatable rubber dam. This technology utilizes a combination of metal flap-gates and multiple small inflatable bladders to adjust the elevation of the gates as shown in Figure 4. The metal gate protects the inflatable bladders from debris, provides a much more predictable water surface elevation and discharge rate, and also provides a cover for the bladders when they are deflated.

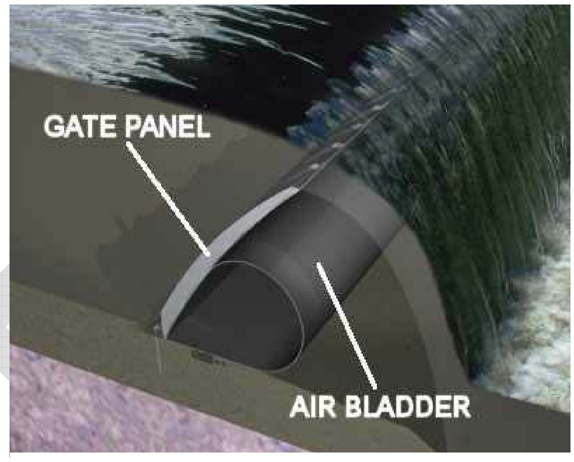

Figure 4. Schematic of Water Flow Over Obermeyer Gate and Air Bladders

Obermeyer gates are typically manufactured in 10-foot segments and each segment is controlled by its own small air bladder. Air bladders can be connected to controls individually or in banks of multiple bladders to achieve virtually any desired gate operation scenario. The bladders are constructed of several laminated layers of material, and are UV and puncture resistant.

This technology has been in use for about fifteen years and gates with heights of up to approximately 5.5 m (18 ft) have been installed. Up to now, most Obermeyer spillway gates have been installed in the United States; but, with contracts in India, Peru, and Germany under way, it is likely that its use will become as global as that of the inflatable rubber dam within a very short period (Obermeyer, 2006).

Mechanical Gates

Conventional mechanical gates similar to the ones currently installed at John Zink Dam could also be used. This would require many additional abutments (as compared to the other two technologies) to support the mechanical gates and to hoist the motors or drives used to raise and lower the gates. This would increase the expense of the project and probably would have higher operation/maintenance costs.

Fusegates

Fusegates are a tipping-bucket-type gate design, where the gate falls down at preset water elevations to allow the excess flow to pass. The system owes its versatility to the simple design and to the various configurations that can be set up to address specific operational needs, which may include safety, storage capacity, and the flood recurrence interval linked to the first fusegate tip-over, and complete tip-over of all gates for the ultimate design flood.

Hydroplus, the designer of this type of gate, has recently developed a new system: folding fusegates. As opposed to the normal type of fusegate, folding fusegates do not overturn in the event of flooding. The gates stay in place and fold away, allowing discharge to flow over the crest. Post flooding, the folding fusegates are raised up to their initial position. According to Hydroplus, the implementation of a fusegate solution requires an investment that is normally significantly lower than that of conventional systems (mechanical gates, inflatable dams, and similar solutions). In addition, lifecycle maintenance costs for fusegates are reported to be five to ten times lower than that of alternative systems. The systems are made of very large, heavy gate units constructed of steel or concrete. They are nearly impossible to vandalize, other than perhaps by spray-painting. Figure 5 shows a typical tipping Fusegate installation at McClure Dam in New Mexico, and how the tipping fusegate system works (Hydroplus, 2006).

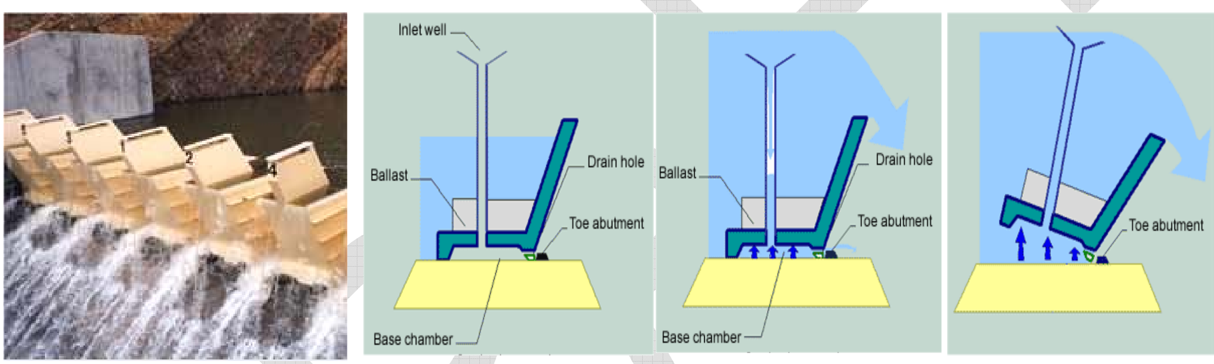

Figure 5. Fusegate Installation and Operation Diagrams

Fusegates would be an alternative to raise the height of Zink Dam, as well as for the open section of the Jenks weir. Advantages of this system include that they appear to be reliable and resistant to damage from vandalism, other than spray-painting; and there is no instrumentation to install or worry about actuating, as they are actuated by buoyant forces. Disadvantages of the system are that, when tipped the gates are heavy and may require some heavy equipment to reposition them; and they are rather unsightly, but are an alternative worth considering, nonetheless.

Each of these alternatives can be investigated. The River Parks Authority has emphasized that resistance to vandalism and ease of maintenance will be very important design considerations. Each of the proposed alternatives can be examined in light of these concerns during the final design process. At present time, however, the preferred concept is the Obermeyer gate system and its usage will be assumed through the remainder of the report.

SAND SPRINGS DAM

Key Issue

- Adjusting the height of the weir to meet all of the operational objectives.
- Providing continuous releases to the downtown river reach through Jenks and beyond.
- Preventing erosion in the top portion of the weir pool that will be used for reregulation of Keystone Dam releases.
- Providing a safe recreational venue at this location.
- Constructing the weir in the best location.
- Providing for passage of the heavy sand loads.
- Avoiding the badly eroded area near the 4H hog farm.
- Setting weir foundations and abutments given the sandy nature of the soil.
- Minimizing any other issues such as impacts on tributary streams or changes in ground water conditions.
- Providing a pedestrian bridge over the river at this location.

Discussion

Description of the Weir

In the original design concept of the Sand Springs weir, the 1400-foot long structure would consist of two 350-foot fixed-elevation, stepped crib weir segments on each end, with a 700-foot adjustable section in the middle, and an 8-foot weir height. However, TVA proposes to make the weir taller, and if that occurs, the center gated section would need to be wider and the stepped sections on the end would be correspondingly shorter. For an 11-foot height, the gated adjustable section would need to be 925 feet wide, and if the weir was designed at a 10-foot height the gated section would need to be 850 feet wide. The additional width of the gated section is required for the taller weir heights to comply with FEMA NFIP regulations during the 100-year flood event. The weir will also cause no rise in the 1986 flood elevations, which the city of Tulsa also uses for regulatory purposes. The 1986 flood was at a recurrence interval between 100 and 500 years. In addition, the impacts of the increase in pool elevations would need to be evaluated on the surrounding area.

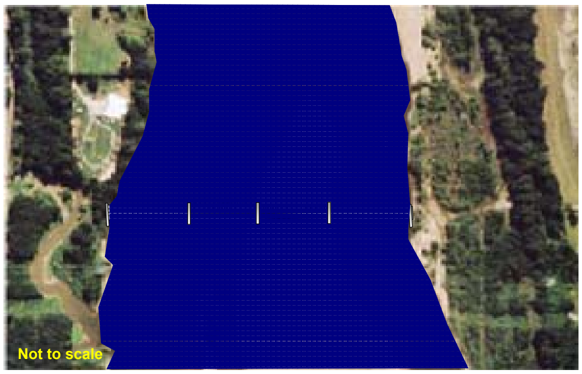

Figure 6a. Conceptual of Sand Springs Weir Passing Flood Flows

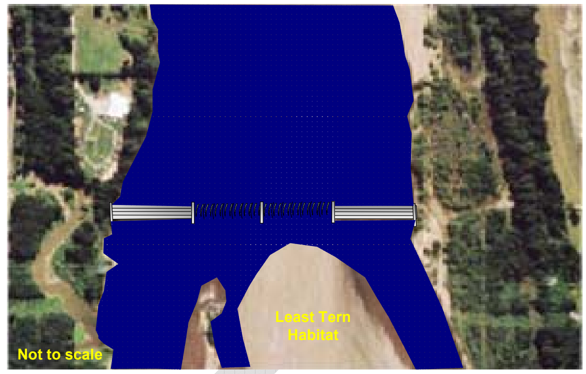

Figure 6b. Conceptual of Sand Springs Weir Passing Reregulating Flows

During normal Keystone turbine generation (12,000 cfs) and in flood operations, flows would pass over the stepped crib sections of the weir and the gate sections (Figure 6a). During larger flood operations, or to pass sand that has accumulated on the upstream side of the weir, part or all of the center section of the weir would be lowered and flow would still pass over the entire length of the weir. During reregulation releases, the stepped side sections of the weir would become dry and water would pass over the gated sections in the center or through pipes through the weir, maintaining a downstream minimum flow.

Instead of mechanically operated gates, it is proposed to install OBERMEYER pneumatically operated spillway gates (www.Obermeyerhydro.com). According to Obermeyer Hydro, its spillway gate system is most simply described as "*a row of steel gate panels supported on their downstream side by inflatable air bladders. By controlling the pressure in the bladders, the pond elevation maintained by the gates can be infinitely adjusted within the system control range (full inflation to full deflation) and accurately maintained at user-selected set-points*," (www.obermeyerhydro.com/info.htm). Some of the many advantages of this system are that bank side or remote control of the spillway gates is easily accomplished by controlling the air bladders, the air bladders are small and therefore easier to control, they are protected on the upstream side by the steel gate panels, can be hidden on the downstream side by a constant flow of water over the top of the gates, and are hidden when the gates are completely dropped.

When water is passing over the gate sections, the nappe is aerated by nappe breakers installed on the tops of the weir gates (Figure 7). The water curtain flowing over the gates will be designed to be thin enough to be safe for recreation in the downstream river channel.

Figure 7. An Obermeyer Gate installation Showing Steel Panels, Air Bladders and Stabilizers

Weir Height

The original proposal was for the weir to be 8 feet tall; however, in reviewing the extent of the weir pool and the shallow water depth near the upstream end of the pool, increasing the height of the weir by one foot would help provide protection to the least tern nesting islands in that part of the channel.

Additionally, because the streambed at the upper extent of the pool slopes upward fairly steeply just upstream of the weir pool, a further increase of two feet to the weir height would not increase the pool length by any significant amount, but it would provide a significant amount of storage to provide a continuous release to the downstream channel. Therefore, it is proposed to extend the weir height by a total of three feet, one foot for additional protection to the bird habitat, and the top two feet of the pool to hold enough volume to draw down gradually and provide the target continuous minimum flow to the downstream channel. Based on the available storage volume in the top 2 feet (5 miles x 2 feet deep x 1300 ft wide) which equals about 1575 acre-feet, 800 cfs could be continuously provided for 24 hours from this volume. If the Keystone Dam leakage and local inflows are also accounted for, the amount of flow provided to the downstream channel would be closer to 900 to 1000 cfs. This pool volume could be refilled by about 1.6 hours of two-unit generation from Keystone Dam each day.

If the Keystone Dam hydro units were not operated during the weekend, with an 11-foot weir height, the gates on Sand Springs Dam could be adjusted to release about 400 cfs instead of 800, which would draw the pool down about 3 feet in the 3-day period from Friday to Monday, allowing river-based and weir pool-based recreational activities to continue.

The continuous release over the gates at Sand Springs should keep that part of the channel immediately downstream of the gates relatively free of sand, so that when the gates are completely lowered for a flood or fish passage event, there should be no accumulated sediment debris to prevent them from being lowered.

It may be desirable to armor the shoreline with riprap or other protective materials in key places along the Sand Springs weir pool to prevent erosion from the fluctuating pool level, and for aesthetic impacts.

Recreation

The continuous release from Sand Springs, besides providing aquatic habitat improvements and least tern protection, could also provide flow for the proposed whitewater course at Zink Dam and possibly even future whitewater courses at the other two weir sites. NOTE: TVA provides a very heavily utilized whitewater rafting run below Ocoee 2 Dam with 1400 cfs. Thus, minimum flows of even half that amount could provide sufficient flow for a very good kayak course, if sufficient drop height is available. In addition, if sufficient funding is available, a bridge could be built above or near the weir structure to allow pedestrian traffic to move freely across the river.

Hydraulic Roller

Preventing the development of hydraulic rollers under normal operating conditions is also a critical part of the proposed projects. TVA conducted extensive testing to ensure that its weir installations did not create unsafe hydraulic rollers. For the Tulsa weirs, such as Sand Springs, the overflow section of the weir would be constructed similarly to the Norris weir (Figure 8) to help eliminate any potential for dangerous hydraulic roller conditions. The Norris weir breaks up the water flow using a two-fold approach of stair stepping down the elevation of the water, and also having a porous weir surface which diverts some of the flow downward through and out of the weir, eliminating the roller. The timber crib weirs are usually formed using pressure treated timbers, but a method using concrete sections could be investigated as well.

Figure 8. TVA Norris Weir's Stepped Weir Deck

For the Obermeyer gated section of the weir, there would be a free overfall of water in a classic aerated nappe during minimum flow operations. TVA research in laboratory flumes and field installations of recirculation produced by free overfall nappes has indicated that a weir overflow of 1.2 cfs/ft is generally safe for a child with some swimming skills and wearing a life jacket, and does not produce a strong enough roller to entrain a healthy child under these conditions. Overflow of 1.5 cfs/ft was very negotiable for a healthy adult, but 2 cfs/ft was trickier and the test subject became winded after several cycles of entering and exiting the recirculation zone at these flows. It was easier to exit the recirculation area when the water was shallow enough for the subject to get their feet on the ground, and trickier if just swimming was involved (Hauser, 1991). The 800 cfs over a 700-foot Obermeyer gate section is equivalent to 1.15 cfs/ft. This is less than the 1.5 cfs/ft target for an adult test subject and less than the 1.2 cfs/ft that appeared to be safe for a child in a life jacket. If the discharge were 1000 cfs instead of 800, the discharge per foot over the gated section would be 1.4 cfs/ft, which is still below the 1.5 cfs/ft that the adult TVA subject found negotiable. During turbine generation, the gates could respond to the rise in pool elevation and adjust to maintain the same pool height over the gates to provide the same safe flow rate.

Location

The current preference is to locate the weir just downstream of the Highway 97 bridge near the 4-H hog farm. This location could create problems for construction of the Sand Springs Weir as at the right abutment there exists a 30' deep bank cut from a small inflowing stream. To deal with this issue, the weir location would need to be adjusted or the small stream rerouted along with the construction of a more extensive weir abutment.

Pool Drawdown for Fish Passage

Unlike the downstream dams (Zink and Jenks), Sand Springs would not necessarily be lowered on the same schedule as the other weirs for fish passage upstream because it will be providing the minimum flows for the river. However, the Sand Springs pool would need to be dropped during part of the year to allow passing of floods and to allow passing of the heavy sand loads downstream. Barring floods, the movable portions of the Sand Springs weir would be lowered only to keep sand from accumulating on the upstream side of the weir (maybe January through early March). The goal is for this open-gate free-flow period to be shorter than the downstream weir pools' open gate periods as part of the trade-off for providing the continuous flow. Drawdown at this weir, when it occurs, would be accomplished by having a 700-foot section in the middle of the weir open to allow for sand/flood passage downstream (as shown above in Figure 6).

Foundation and Abutment Issues

Available soils information indicates that deep, rapidly permeable soils are located along the embankments in the general area identified as desirable for construction of both the proposed Sand Springs and Jenks weirs. Soils of this type are certainly a concern for weir construction and will increase the cost of weir installation. While various methods are available to address this situation, construction costs can escalate very rapidly. Final site selection must consider all aspects of the installation including foundation concerns, which may be the overriding consideration. Thorough soils investigations must be performed to determine the best course of action.

Other Issues

During future engineering analysis, the impacts that increased pool elevations might have on inflowing tributary streams would need to be investigated. In addition, the stream banks would need to be analyzed to assess the effects of higher pool elevations on ground water flows and stream bank stability.

ZINK DAM

Key Issues

- Modifying Zink Dam to eliminate the hydraulic roller.
- Enhancing recreation by adding a whitewater course downstream of dam.
- Providing extra height at Zink Dam to double the length of the weir pool for rowing, and possibly provide additional drop for an improved kayak course.
- Passing striped bass, sauger, shovelnose sturgeon, and paddlefish at the correct time of year to allow upstream migration, spawning, and downstream egg transport.
- Replacing or modifying the existing bascule gates as some or all of them may need extensive maintenance.
- Providing for passage of the heavy sand loads.
- Passing the heavy sand loads through the weirs will need to be included – the long ogee section has a significant amount of sand built up behind it with no way to remove it besides dredging.

Discussion

Hydraulic Roller

Ensuring elimination of the hydraulic rollers that have been produced by flow over the ogee-style spillway sections on this dam is a critical part of the proposed project. This is of increased importance now, due to the proposed kayak/whitewater course which could place people near the existing hydraulic roller. For Zink Dam, a stepped crib weir filled with rock would be added to the downstream face of the weir and might possibly fit on the existing spillway apron (see Figure 9). The overflow section of the weir would be constructed similarly to the TVA Norris weir (Figure 8) to help eliminate any potential for dangerous hydraulic roller conditions. Both the porosity and the stepped design of the Norris weir work toward breaking up the water flow and diverting it downward through and out of the weir, which eliminates the roller.

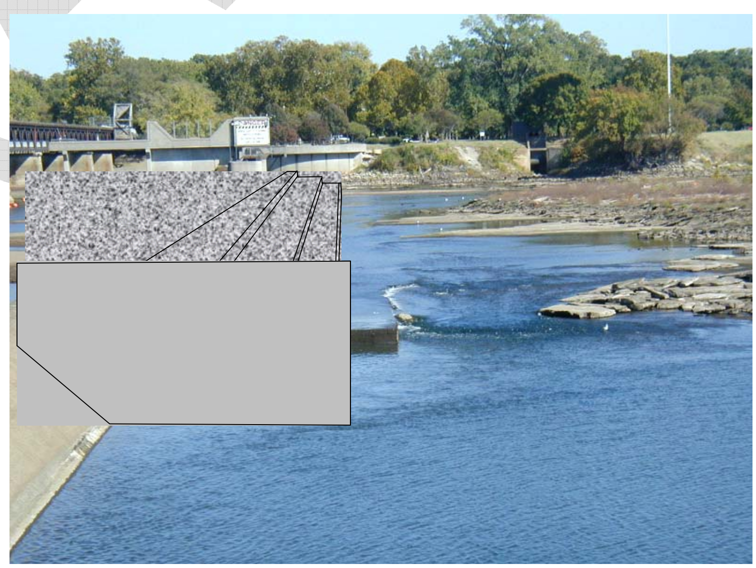

Figure 9. Conceptual of Zink Dam Retrofit with Stepped Weir to Eliminate the Hydraulic Roller

Enhancing Recreation in Zink Dam Pool

The pool created by Zink Dam is relatively short, as it is a little over 2 miles in length, but broken into two pools by a shoal area about 1.2 miles up upstream of Zink Dam. If the height of Zink Dam is increased by 2 or 3 feet using Obermeyer gates (Figure 10b) or similar feature, the extended pool created by this height increase would drown the shoal and merge the two pool areas, allowing for additional recreational opportunities for rowers and other low-draft watercraft as shown in Figure 10a. The future cost estimate will include the option of using two-foot high Obermeyer gates to raise the height of Zink Dam.

Recreation in Zink Dam Tailwater

The minimum flow from Sand Springs Dam could provide sufficient continuous flow (400 to 1000 cfs) to allow for operation of a whitewater course at Zink Dam. To further enhance the whitewater course, an increase in the Zink Dam elevations would provide even more headwater elevation to drive the whitewater course and to provide additional depth and pool length for rowing skulls at Zink Lake. This dam elevation increase could be accomplished by using 2-ft or 3-ft tall Obermeyer gates (www.obermeyerhydro.com). These gates would normally remain in the fully raised position, allowing higher pool elevations; but during floods, the gates could be signaled to be dropped, reducing the weir crest elevations back to the present height and providing no additional obstruction to the flood flows to be in compliance with FEMA regulations. The design of the stepped weir below Zink Dam would need to consider the impact that these flap gates would have on the hydraulic roller to ensure that the roller hazards are minimized under both crest gates open and crest gates closed operating conditions.

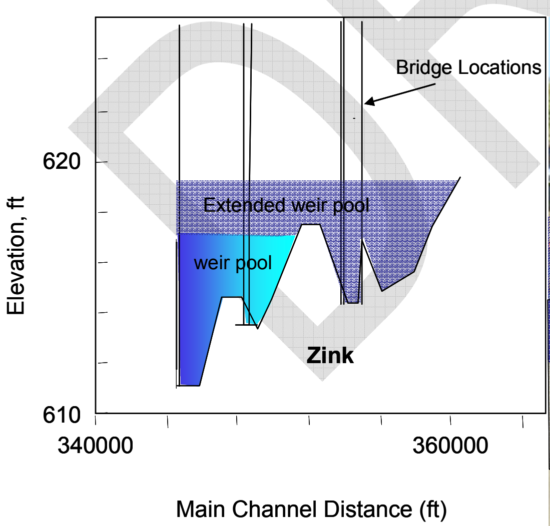

Figure 10a. Extension of Zink Dam Pool by Raising Crest Elevation Two Feet

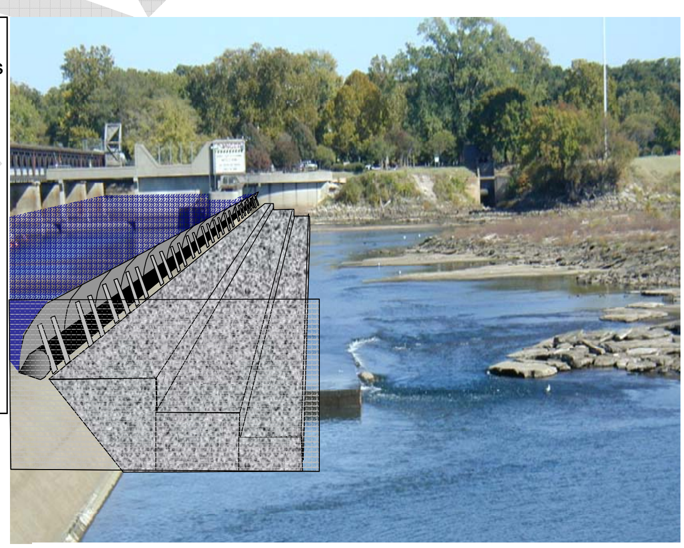

Figure 10b. Conceptual Sketch of Zink Dam with Stepped Deck and Obermeyer Gate Retrofits

Pool Drawdown

During the flood, sand passage, and fish migration seasons, the pool at Zink Dam will be dropped to produce essentially riverine conditions from Sand Springs Dam all the way through Jenks Dam. This would probably be in effect periodically from March through May. This would occur by lowering the crest gates and opening the other mechanical gates that are presently installed along the weir, allowing flood flows and sand to pass downstream. There would need to be sufficient openings through the weir and minimum flows would need to be set to provide the required velocity regimes to encourage the passage of the four targeted fish species.

Bascule Gate Condition

The bascule gates in Zink Dam are in need of maintenance. There are three bascule gates installed in Zink Dam. One is on the west end of the long, straight spillway section, and the other two are on the east end of that same section. Each gate is 50 feet wide, 5 feet tall, and operated with hydraulic lines. Their base elevation when lowered is 612.0 feet (as shown in Figure 11) and they lay flat on the spillway apron when lowered.

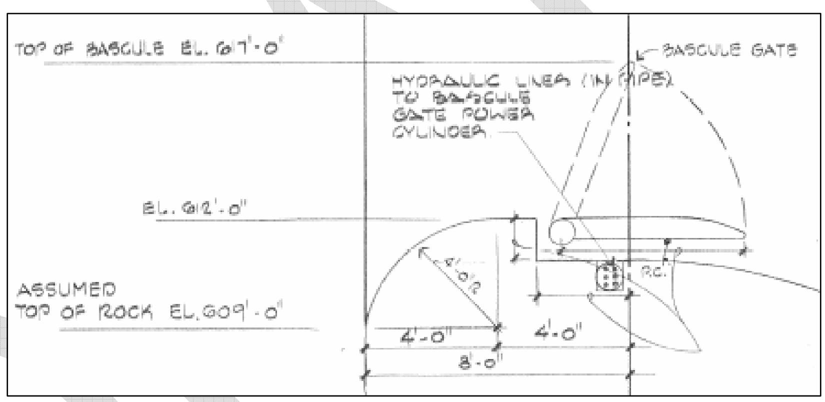

Figure 11. Diagram of Bascule Gate

Because these gates are only installed at each end of the spillway, there is significant sand accumulation behind the dam. Additional gates may need to be added to the center of the weir to help ensure passage of the heavy sand loads associated with the Arkansas River.

The channel invert is approximately elevation 610, while the current gates lower to about elevation 612. To ensure passage of the fish upstream and over the barrier, sufficient flows through the gates would be necessary for the fish to pass over the sills and through the gates. Another alternative is to increase the downstream rating curve elevations to enable the fish to pass over the Zink Dam sills.

JENKS DAM

Key Issues

- Constructing the Jenks weir between the existing bridge and sand mining operations.
- Providing a safe recreational venue at this location.
- Providing a pedestrian bridge over the river channel at this location.
- Providing for passage of the heavy sand loads
- Passing striped bass, sauger, shovelnose sturgeon, and paddlefish at the correct time of year to allow upstream migration, spawning, and downstream egg transport (especially important at this location).
- Designing and building a weir considering the sandy nature of the channel and soil in the floodplain
- Designing the weir abutments to avoid water circumventing or piping in the sandy soil.

Discussion

Project Description

Construction would be similar to the Sand Springs weir. The 1400-ft long Jenks weir would consist of two 350-ft stepped crib weirs on each end with a 700-ft adjustable section in the middle. During normal turbine operations or small floods (less than 22,000 cfs *for example*) flows would pass over the stepped crib sections of the weir and the gates in the raised position. During larger flood operations or to pass sand that has accumulated on the upstream side of the weir, part or all of the center section of the weir would be lowered. Instead of mechanically operated gates for the center section of the weir, it is proposed to install OBERMEYER pneumatically operated spillway gates (www.Obermeyerhydro.com) as previously described in this report.

Recreation

Primary recreation uses at Jenks would be encouraged by waterfront development along the river lake. In the future, a whitewater course could be added below this project if usage for whitewater courses is sufficiently high at Zink and Sands Springs. In addition, as with the Sand Springs project, if sufficient funding is available, a bridge could be built above or near the weir structure to allow pedestrian traffic to move freely across the river and could possibly be integrated into the weir structure.

Hydraulic Roller

Ensuring elimination of the potential for hydraulic rollers is also a critical aspect of this installation as well. As with the Sand Springs weir, the end sections will be constructed similarly to the TVA Norris Dam Reregulation Weir (Figure 8) to help eliminate any potential for dangerous hydraulic roller conditions. The Norris weir breaks up the water flow by both stepping down the elevation of the water along with having a porous weir surface, which diverts some of the flow down through and out of the weir, which eliminates the roller. The central section would be an Obermeyer gate, which is safe on the downstream side when the water curtain passing over it is thin (flows less than 1.5 cfs/foot), as under typical recreational flow conditions. The area below the Obermeyer gate is the section of greatest concern, but the overflow is in the range of 1.15 cfs /ft for the 800 cfs discharge rate, which according to TVA experience, appears to be safe for healthy adults and children wearing life jackets (TVA, 1991).

Location

Due to other variables, the Jenks weir needs to be located just downstream of the Creek Turnpike Bridge and upstream of the sand quarry operations. A major concern and potential variable in the construction costs is the sandy composition of the river banks which could require extensive preparation to ensure that piping does not occur around or under the weir structure.

Pool Drawdown

During the flood, sand passage, and fish migration seasons, the pool at Jenks Dam will be dropped to where the river is essentially a river without weirs from the Sand Springs Dam all the way through Jenks Dam. This would probably be in effect from March to May. Drawdown would be accomplished by dropping all or part of the 700-ft gate section in the middle of the weir. This open period would allow for sand/flood passage downstream, as well as migratory fish species to pass upstream through the weir (see Figure 12).

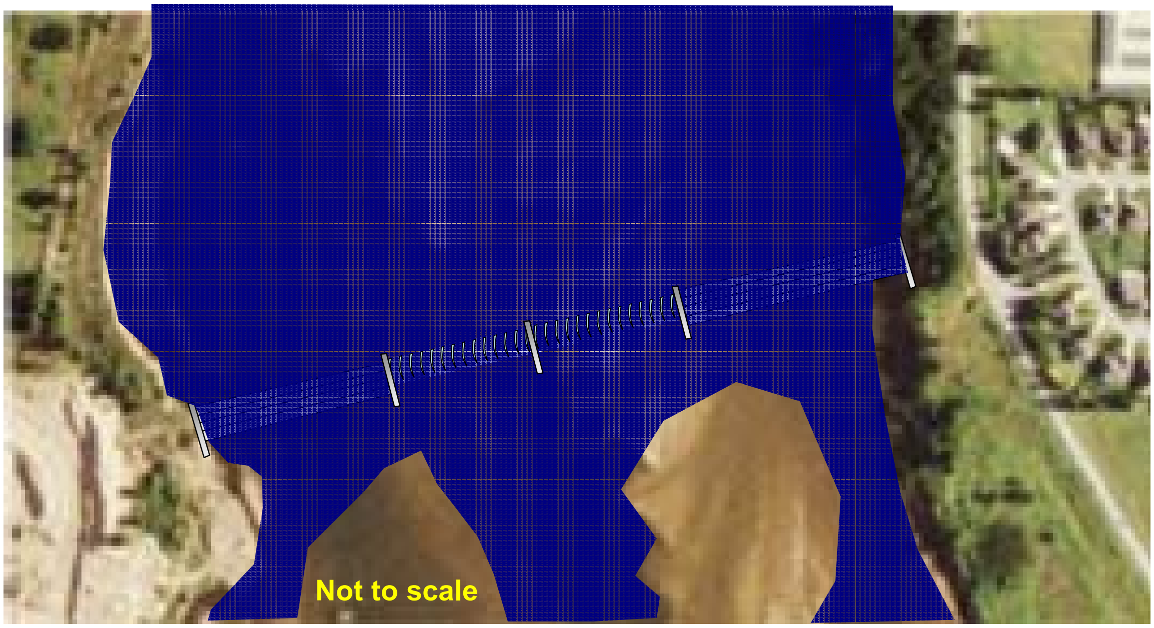

Figure 12. Visualization of Jenks Weir with Obermeyer Gate Sections and stepped Weir Sections Under Reregulation Flow Conditions

CONCLUSIONS

The proposed integrated river system outlined in this document offers many advantages to the Tulsa area, such as shoreline beautification, recreational opportunities, and improved habitat for native species. It also offers numerous challenges, such as integrating an aesthetically pleasing structure with a design that is structurally sound, and it addresses issues such as FEMA NFIP guidelines and recreational safety issues.

One consideration is the numerous benefits that can be gained from making the Sand Springs weir 11 feet tall instead of the originally proposed 8 feet. The extra height will allow up to 1000 cfs continuous flow to be provided from weir pool storage to the downstream channel even though Keystone Dam is only operated for a short time each day. The continuous flow will provide the aforementioned habitat and recreational benefits, and will also serve to protect the gated portion of the structures from vandalism.

We encourage and welcome your thoughts and questions related to the TVA vision for your river corridor.

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