ARKANSAS RIVER CORRIDOR

Appendix J: Hydraulics and Hydrology

ARKANSAS RIVER CORRIDOR, TULSA COUNTY, OKLAHOMA

Introduction

The Arkansas River is a water resource serving numerous nationally significant purposes. The river has historically served as a nationally significant resource for aquatic and terrestrial habitat of the nation's wildlife that live, breed, and migrate through the Arkansas River ecosystem. This includes federally endangered Interior Least Tern (Least Tern, *Sterna antillarum*), a nationally significant resource, and one federally threatened bird species, the Piping Plover (*Charadrius melodus*) as well as a plethora of native species and migratory waterfowl that support a healthy and functional riverine ecosystem. Keystone Lake and its dam located along the Arkansas River play vital roles in supporting the continued provision for these species, as well as many other purposes. In particular, the lake and dam provide flood risk management benefits, contribute to the eleven reservoir system operation of the McClellan-Kerr Arkansas River Navigation System, provide clean and efficient power through the associated hydropower plant, and provide a source of water for municipal and industrial uses. However, construction, operation, and maintenance of the Keystone Dam, lake, associated hydropower operations and other multi-purposes have significantly degraded the riverine ecosystem structure, function, and dynamic processes below Keystone Dam on the Arkansas River within Tulsa County, Oklahoma.

Purpose

This study is in response to the Section 3132 authorization of the 2007 WRDA. The purpose of this study is to evaluate the aquatic ecosystem restoration components of the October 2005 Arkansas River Corridor Master Plan (ARC Master Plan) and determine if there is a Federal Interest that aligns with the Corps of Engineers' ecosystem restoration mission.

Study Authority

The Arkansas River Corridor study is authorized in the Water Resources Development Act (WRDA) of 2007, Section 3132.
Section 3132. Arkansas River Corridor.

(a) IN GENERAL. – The Secretary is authorized to participate in the ecosystem restoration, recreation, and flood damage reduction components of the Arkansas River Corridor Master Plan dated October 2005. The Secretary shall coordinate with appropriate representatives in the vicinity of Tulsa, Oklahoma, including representatives of Tulsa County and surrounding communities and the Indian Nations Council of Governments.
(b) AUTHORIZATION OF APPROPRIATIONS. – There is authorized to be appropriated $50,000,000 to carry out this section.

Non-Federal Sponsor

Tulsa County is the non-federal sponsor for the Arkansas River Corridor feasibility study. An amended feasibility cost-sharing agreement was executed in May 2015.

Recommended Plan

Alternative 5 is the National Ecosystem Restoration (NER) Plan and includes construction of a pool structure at River Mile 530 to regulate flow in the Arkansas River, a rock riffle feature associated wetland plantings at Prattville Creek, and construction of a sandbar island near Broken Arrow, OK. With the implementation of the NER plan, more natural river flow would return to 42 river miles of the Arkansas River within the study area. The NER plan would provide approximately 2,144 acres of additional riverine habitat, nearly doubling the amount of currently available habitat under low flow conditions. Also five acres of restored wetlands, and three acres of reliable sandbar island habitat where none currently succeed, would be restored as part of the NER plan. Shoreline, river, backwater, slackwater, wetland, and sandbar island habitat quality would all be improved generating an overall increase in the ecosystem quality and carrying capacity of the corridor. Current operation of Keystone Dam would not be changed. Additional water and flow would remain within the existing banks of the river and would not increase the flood elevation, nor downstream or backwater flooding.

Arkansas River Flow Conditions

Flows in the Arkansas River downstream of Keystone Dam generally consists of releases based on hydropower generation and flood control operations. Releases associated with flood control operations are generally higher flow releases that may continue for an extended length of time until the water levels upstream are down to normal operating levels. Hydropower generation at Keystone Dam results in releases of approximately 6,000 or 12,000 cfs. With one unit generating power the release is approximately 6,000 cfs, and the flow is doubled when both units are in operation. Hydropower generation is typically only a few hours during weekdays when power demands are higher. When flood control and hydropower generation releases are not required, Keystone Dam does not release flow into the Arkansas River through Tulsa.

The Arkansas River Corridor project has the goal of ecosystem restoration. A minimum flow estimate of 1,000 cfs was derived from an analysis of pre-Keystone Dam minimum flows in the Arkansas River through Tulsa, and from consultation with the U.S. Fish and Wildlife Service and Oklahoma Department of Wildlife Conservation, as the level of flow that will restore the structure and function of the riverine ecosystem. Keystone Dam hydropower releases can be utilized to provide the minimum flow rate with the implementation of a pool structure. The pool structure would detain releases associated with hydropower generation and to make releases of approximately 1,000 cfs to allow for ecosystem restoration.

Corridor Historic Flow

The release data from Keystone Dam was evaluated for the years 2000 through 2014 to determine how frequently the Arkansas River downstream of Keystone Dam had flows of less than 1,000 cfs. Over the fifteen year period, an average of 228 days per year had an hourly release from Keystone Dam that was 0 cfs, and on average, there are 97 days where the minimum flow was greater than 1,000 cfs. The average daily flow was greater than 1,000 cfs for an average of 274 days per year. Therefore, on average, the daily flows could be redistributed to provide a consistent 1,000 cfs flow rate on 177 days per year. In order to provide minimum flows during the weekends when hydropower is not commonly generated, the pool control structure was sized and located to be able to provide flows over a three day period. The average three day flows were greater than 1,000 cfs on average 298 days per year.

Over the 15 year period, the daily minimum flow rate of 1,000 cfs was observed 26.7% of days. Based on a three-day average releases, with the pool control structure in place, the minimum flow rate could be achieved 81.8% of days. On an annual basis, the observed minimum flow ranged from 6.6 to 52.5% of days, and based on the three day flow average, the minimum flow could be achieved 54.4 to 98.1% of days. The minimum annual increase in days with 1,000 cfs average flow was 37.7% of days in 2012, and the maximum increase was 67.9% of days in 2002.

Flood pool releases were estimated based on the average daily flows exceeding the capacity of the hydropower generation system. Over the 15 year period, there was an average of approximately 54 days of releases exceeding the hydropower generation capacity. In 2014, there were no flood releases, and 155 days of flood releases in 2007. The median for this set of data was 44 days of flood releases.

Hydraulic Analysis

The hydraulic analysis for this study was to develop a model using USACE Hydrologic Engineering Center – River Analysis System (HEC-RAS) that would provide the necessary hydraulic information to be used to evaluate the ecosystem benefits and any potential flood risks associated with the project. These benefits were developed based on several factors related to the flow in the Arkansas River. HEC-RAS provides detailed flow information at predetermined locations, which allows for a comparison of the ecosystem benefits and the ability to assess any flood risks for each of the scenarios considered.

Four models were developed to evaluate the benefits of the project. The model scenarios include existing conditions, future without project (includes other local projects being implemented within the study area), future with project at the location of the previous structure, and future with the project located downstream of the Highway 97 bridge.

The existing conditions model establishes the current conditions along the Arkansas River and provides a baseline to compute benefits associated with the project. The future without project model establishes the conditions that will exist following the implementation of ongoing Arkansas River projects downstream of the structure being studied. There are two potential locations being considered for the project structure, so a model was developed for the two locations. The two future with project models include a pool structure downstream of Keystone Dam that will hold back a portion of the hydropower releases. Once the hydropower release is completed, the pool structures will slowly release the impounded water.

HEC-RAS Model

The Tulsa District had previously developed a HEC-RAS model that was used as the base model for this project. This model was developed as a part of the Arkansas River Corps Water Management System (CWMS) effort, and had been calibrated. One of the challenges for HEC-RAS models is modeling very low flows in a very wide channel. The current flow regime in the Arkansas River is very low flows (near no flow condition), or high flows resulting from hydropower or flood control releases from Keystone Dam.

Cross-sections

Stream and valley cross-section data were developed from the detailed topographic mapping discussed in “Hydrologic Analysis”. Environmental Systems Research Institute (ESRI) ArcMap software was used to develop the three-dimensional terrain modeling.

USACE HEC-GeoRAS software was used to accomplish the following steps:

- Develop stream stationing along the Arkansas River channel.
- Develop preliminary measurements for channel and overbank reach lengths between cross-sections.
- Identify preliminary channel bank stations at each cross-section.
- Extract the cross-section data points (elevation versus section station).
- Populate each of the associated input data fields within the HEC-RAS models.

Locations and Layout Considerations

The locations for cross-sections were identified to capture the critical hydraulic features within the study reach.

- Cross-sections were spaced as necessary to model significant hydraulic features such as bridges, low water crossings, dams, or to capture expected flow change locations.
- Inline structures were used to model the low-water dams included in the system.
- Locations of tributaries that contribute to the study streams were also considered for choosing the appropriate cross-section locations.

Structures

Railroad and roadway bridges were incorporated within the HEC-RAS models in the study. The pool control structure was included as inline structure. The low-water dam impounding Zink Lake (current and proposed modification configuration) is included in the model, as well as the downstream proposed low-water dam near Jenks, Oklahoma. The Sand Springs pool structure was included at the appropriate location for the two models of future with project conditions.

Manning's Roughness Coefficients

Manning's *n* values were estimated based on the land use. Manning's *n* values varied horizontally for each cross-section, thus capturing the variation in land use along the cross-section. The flows modeled for this project are within the channel banks of the Arkansas River, so the in-channel Manning's *n* values were the critical values for this project.

Water Surface Elevations

A steady flow model was utilized to develop the water surface profiles for specified flows of interest for the ecological studies included in the project. An unsteady flow model was developed to simulate releases from Keystone Dam for the period of available record. RAS Mapper was used to prepare inundation maps for the various flows that were modeled to provide visual reference of the areas inundated.

Structure/Road Crossings

Existing bridges were included in the hydraulic models to incorporate their effect on water surface profiles.

Levees

There are several levee systems along the Arkansas River downstream of Keystone Dam. These levees protect industrial and residential areas along the river. These areas were included in the HEC-RAS model for the project.

Ineffective Flow Areas

To define the appropriate limits for the areas of effective flow, ineffective flow areas were designated around structures according to the HEC-RAS modeling standards. Ineffective flow was also designated for that portion of cross-sections where flow was not effectively conveyed downstream.

Terrain Data

Since the model needed to operate at low flow conditions in the Arkansas River, a well-defined terrain dataset was needed to closely represent the river channel. The proximity of the project to a major metropolitan area was critical for this phase of the model development. The City of Tulsa and the Indian Nation Council of Governments (INCOG) had commissioned the gathering of terrain data for Tulsa County. This information was available for use for this project. The data provided was a topographic map of contours on a two-foot interval. The contours were processed into a terrain raster using ArcGIS.

Model Calibration

The CWMS hydraulic model was calibrated using stage information at stream gages during high-flow events.

Pool Control Structure Details

The pool control structure is a critical element for this ecosystem restoration project. All other restoration components depend on the availability of the minimum flow of 1,000 cfs. The pool control structure was included in the model based on various gate types and operations. The preliminary design includes gates of various heights to accommodate minimum flow releases, sedimentation passage, and fish passage. The layout also includes a stepped outlet that addresses public safety concerns associated with the reregulation dam that was previously removed.

Sedimentation

Sediment in this segment of the Arkansas River is highly regulated by Keystone Dam. Sediment tends to drop out of the flow when it enters Keystone Lake where the velocities are much lower. As a result, there is a limited amount of suspended sediment in flows released from Keystone Dam. The hydropower and flood control releases under current conditions have little entrapped sediment, so there is little sediment that can be deposited downstream of Keystone Dam. When considering the future without project conditions, sedimentation conditions would remain unchanged. Releases from Keystone Dam would remain similar to their current conditions, and sediment deposition would remain unchanged.

Each of the project alternatives considered include a pool control structure. The two locations of the proposed pool control structure have minimal impact on sedimentation associated with the project. The channel bottom upstream of the two locations has been scoured to bedrock, so the releases being captured by the pool control structures will not have sediment to pick up as it flows downstream.

The design of the pool control structure will include full height gates, allowing any sediment that has been deposited upstream of the pool control structure to be scoured out and carried downstream as a part of the pool control structure operations. During flood releases from Keystone Dam, all of the pool control structure gates will be lowered fully. This will allow any sediment deposited within the pool control structure to be picked up by the flow and transported downstream of the structure.

The sediment balance will remain relatively unchanged as a result of this project. There will be minimal sediment introduced to the project area from Keystone Dam hydropower releases, matching current conditions. Any sediment that is deposited upstream of the pool control structure will be scoured out when full height gates are opened to channel invert elevations during normal project operations or during flood control releases from Keystone Dam. It is not anticipated that sedimentation will be an issue for the project.

Fish Passage

Fish passage is most critical during spawning season, which is triggered by increased temperatures and higher flows. These conditions are also associated with flood control releases from Keystone Dam when the gates at the pool control structure would normally be fully open. Water flow will be through the open gates and over the top of the structure providing upstream access for fish.

When there are no flood control releases, access to the river reach upstream of the pool control structure would be limited as there is essentially no flow in the river except during hydropower generation releases. The primary gate operation procedures for the pool control structure will be to provide 1,000 cfs minimum flow. Under these normal gate operations, the opportunity for fish passage will be very limited as the gates will be only partially open.

As the water level drops upstream of the pool control structure, there will be opportunities to operate the full height gates in the fully open position. This will place the gates near the channel invert elevation, and provide flow velocities within a suitable range for fish passage. To improve fish passage capabilities, boulders specifically placed in this area will provide locations for the fish to rest while making the upstream swim through this passageway. This fish passage operation would require lowering the gates for a limited time and then raising the gates to maintain a pool upstream of the control structure until the next hydropower generation cycle. This fish passage operation would likely not occur on a frequent basis as the primary focus and benefit of the project is to provide 1,000 cfs minimum flow.

In addition to allowing fish passage through the full height gates, the pool structure has a stepped downstream chute, which may allow fish to have safe passage over the structure during times when the flows are overtopping the pool structure. A constructed fish ladder is not included in the preliminary design.

Fish passage limitations are similar for both with project and without project conditions. Without the pool control structure, there is limited water for the fish to utilize in this upstream area. With the project, fish passage is limited to when specific pool conditions exist and gate operations are managed to provide fish passage opportunities. During flood pool releases, the conditions for fish passage are not impacted by the pool control structure.

Public Safety

A previous reregulation structure was removed after people lost their lives downstream of the structure. A roller effect developed as the water passed over the crest of the reregulation dam and entrapped fishermen and other members of the public that were in the water downstream of the structure. The turbulent waters immediately downstream of the structure had undercurrents that would prevent individuals from being able to exit the roller. Several people lost their lives due to this roller effect, and eventually led to the removal of the structure.

The pool control structure associated with this structure will include features to minimize the risk to the public. The final design has not been completed, but the main safety feature is a stepped rock chute similar to that shown below in Figure 1. As water flows from one step to the next, energy in the flow is dissipated allowing the flows to transition more smoothly into the river channel downstream of the structure.

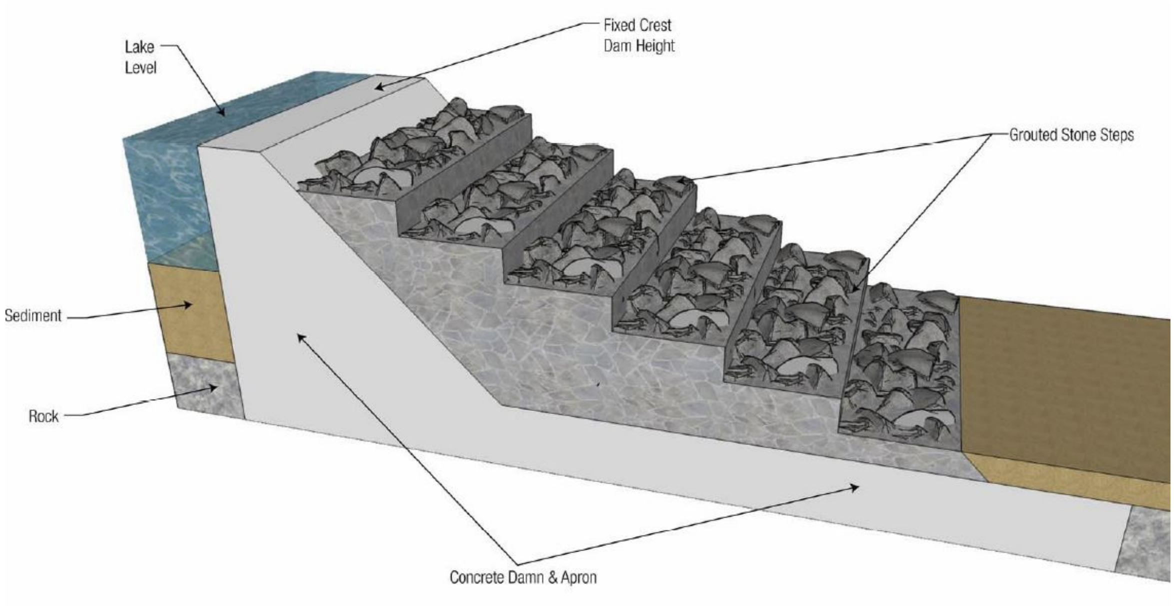

Figure 1. Stepped Rock Chute Energy Dissipation Layout.

Releases from Keystone Dam

During non-flood conditions, Keystone Dam releases water through the powerhouse in order to meet hydropower generation peaking demands. This results in releases of approximately 6,000 or 12,000 cfs depending on the number of units generating power. These releases result in a hydrograph as shown in Figure 2. This hydrograph shows that the power generation typically occurs for four to six hours to meet the peak demand, and then no flow is released during the non-peak hours. There are also larger gaps in the hydrograph for weekends where no power is generated. As shown for May 2013, power generation may occur during some weekends. Power generation is also dependent on available water in the reservoir within the zone designated for hydropower. If there is a shortage of water, no hydropower generation will occur, and thus no recharge of the pool structure can take place.

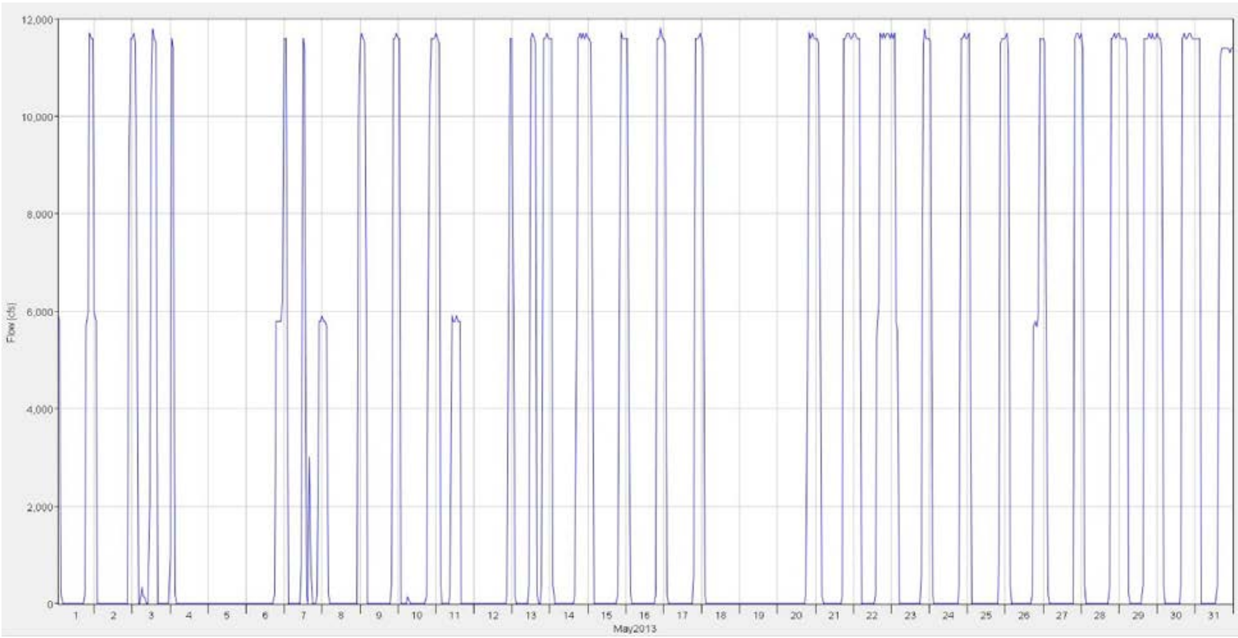

Figure 2. Example release hydrograph during hydropower generation at Keystone Dam.

As shown in Figure 2, most of the days in May 2013 had hydropower generation. However, this only lasted for a few hours during each of those day. When hydropower generation ended, the releases were shut down to essentially no flow. As shown in Figure 3, with the pool control structure in place, the flow without the structure drops below 1,000 cfs many days, but the minimum of 1,000 cfs could be achieved for every hour of the month with the pool control structure in place.

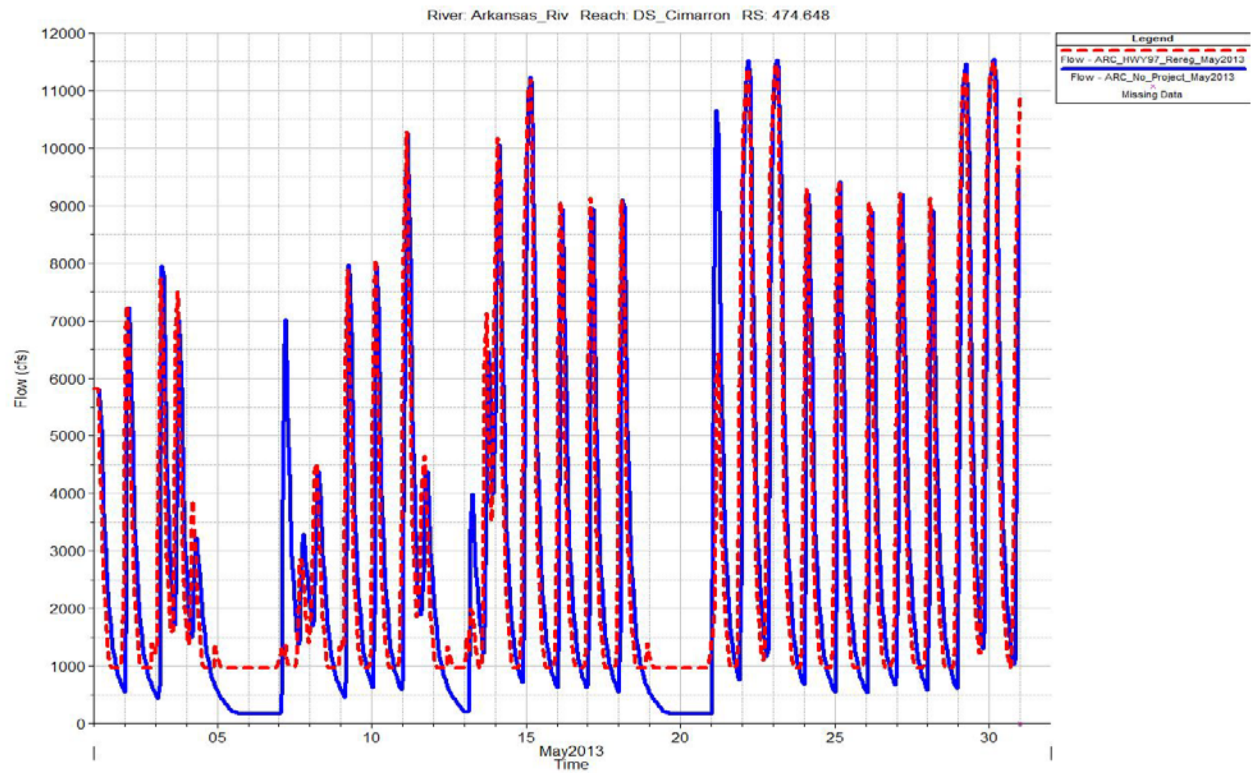

Figure 3. May 2013 Comparison of Existing and With Project Conditions.

As seen in Figure 3, there are hours and days where flows were less than 1,000 cfs. The hydraulic model has a limitation that prevents modeling of extreme low flows, so a minimal flow of 100 cfs was used to allow the model to run when flows were near zero. This is the case when hydropower is not being generated at Keystone Dam, releases from the dam approach a no flow condition.

When the water rises behind Keystone Dam, releases are not always limited to the capacity of the power generation system. As shown in Figure 4, releases are limited to the power generation capacity for much of May 2015, but when the pool behind Keystone Dam rises, flood control releases are made through the Tainter gates. These flood control releases will flow downstream to the pool control structure. During extended periods of flood control releases, flows will exceed the minimum 1,000 cfs flow, so the gates on the pool control structure will remain in the open position. This allows flows to pass through the pool control structure with minimal change to the water surface elevation compared to existing conditions.

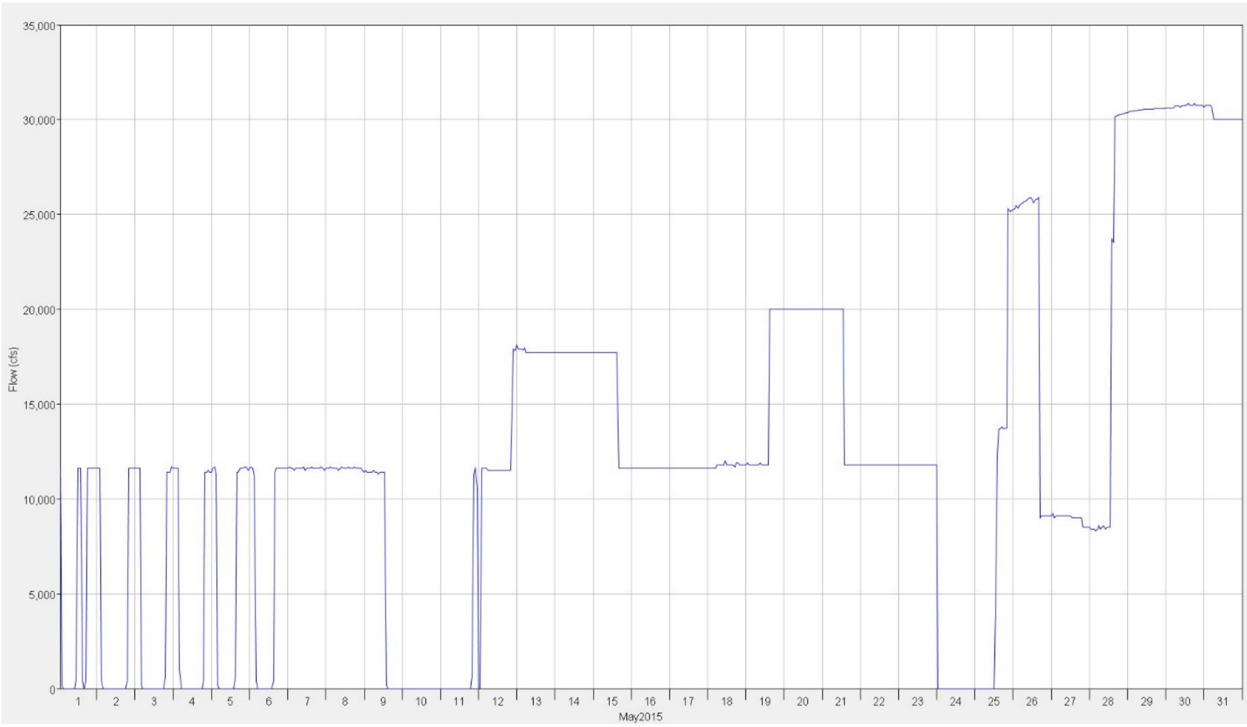

Figure 4. Typical release hydrograph including flood operations at Keystone Dam.

Impacts to High Flow Releases

The pool structure is intended to detain releases resulting from hydropower generation during normal operations. During flood control operations at Keystone Dam, the pool structure will not need to impound any water, and the system will be operated as a run of river system. Gates in the pool structure will be open to allow flows to continue downstream without impoundment.

Unsteady flow model scenarios were run to determine the potential impacts downstream of Keystone Dam. A flow rate of 205,000 cfs is the peak flow associated with the 1% (1/100) Annual Chance of Exceedance (ACE). This peak flow rate was utilized in the HEC-RAS model to determine the water surface changes near the upstream end of the levee system for this event. Based on the conceptual design, the location of the project structure at the original location results in a minimal change in the 1% (1/100) ACE water surface, while the location of the project structure downstream of the Highway 97 Bridge resulted in a minimal water surface increase. These results are similar to published studies developed for the Arkansas River Corridor Study associated with the Master Plan. Final project configuration and operations will need to be evaluated to ensure project impacts are acceptable. As shown in Figure 5, the pool control structure (located at station 474.8 in the model), there is a small increase in water surface elevation. This increase in water surface elevation could be eliminated to produce a no rise scenario during the final design of the pool control structure. The pool control structure would be built in the river channel and not increase the flood risk for the downstream area while allowing for the improved ecological conditions associated with the results of this project.

HEC-RAS River: Arkansas_Riv Reach: DS_Cimarron Profile: Max

Reach	River Sta	Profile	Plan	W.S. Elev (ft)	Q Total (cfs)
DS_Cimarron	474.909	Max WS	ARC_HWY97_Rereg_205k	649.33	205015
DS_Cimarron	474.909	Max WS	ARC_NoProj_205k	649.25	205016
DS_Cimarron	474.8			Inl Struct	
DS_Cimarron	474.648	Max WS	ARC_HWY97_Rereg_205k	649.09	205017
DS_Cimarron	474.648	Max WS	ARC_NoProj_205k	649.08	205017
DS_Cimarron	474.254	Max WS	ARC_HWY97_Rereg_205k	648.64	205016
DS_Cimarron	474.254	Max WS	ARC_NoProj_205k	648.64	205018
DS_Cimarron	473.836	Max WS	ARC_HWY97_Rereg_205k	647.65	205022
DS_Cimarron	473.836	Max WS	ARC_NoProj_205k	647.65	205021
DS_Cimarron	473.80			Lat Struct	
DS_Cimarron	473.316	Max WS	ARC_HWY97_Rereg_205k	645.88	205021
DS_Cimarron	473.316	Max WS	ARC_NoProj_205k	645.88	205020
DS_Cimarron	472.958	Max WS	ARC_HWY97_Rereg_205k	645.08	205026
DS_Cimarron	472.958	Max WS	ARC_NoProj_205k	645.08	205026
DS_Cimarron	472.95			Lat Struct	
DS_Cimarron	472.578	Max WS	ARC_HWY97_Rereg_205k	644.51	205025
DS_Cimarron	472.578	Max WS	ARC_NoProj_205k	644.51	205025
DS_Cimarron	472.242	Max WS	ARC_HWY97_Rereg_205k	644.18	205025
DS_Cimarron	472.242	Max WS	ARC_NoProj_205k	644.18	205025
DS_Cimarron	472.142	Max WS	ARC_HWY97_Rereg_205k	644.15	205025
DS_Cimarron	472.142	Max WS	ARC_NoProj_205k	644.15	205026

Figure 5. Comparison of Existing and With Project Water Surface Elevations for the 1% (1/100) ACE flow.

As shown in Figure 5, the 1% (1/100) ACE flow of 205,000 cfs results in a minimal increase in the water surface profiles near the pool control structure. Shortly downstream of the pool control structure, the water surface profile for the with pool control structure is equal to the no project water surface elevation.

In order to further evaluate the impact to water surface elevations for a full range of higher flows, flood releases were modeled. The standard project flood release hydrograph obtained from the 2012 Keystone Lake Water Control Manual was scaled to result in peak releases corresponding to the 20% (1/5), 10% (1/10), 2% (1/50), 1% (1/100), 0.4% (1/250), and 0.2% (1/500) ACE. The Flood Insurance Study (FIS) for Tulsa County, Oklahoma and Incorporated Areas was used to determine the peak releases for this modeling effort. The FIS provided the 10% (1/10), 2% (1/50), 1% (1/100), and 0.2% (1/500) ACE flow values. Flows were approximated for the 20% (1/5) and 0.4% (1/250) ACE. The flows included in this model are shown in Table 1.

Table 1. Annual Chance Exceedance for Peak Flow Release Rates from Keystone Dam

ACE	20% (1/5)	10% (1/10)	2% (1/50)	1% (1/100)	0.4% (1/250)	0.2% (1/500)
Peak Flow (cfs)	40,000	90,000	155,000	205,000	300,000	490,000

The flow profiles for each of the above flows are shown in Figure 6. Similar to the 0.01 ACE flow profiles described in Figure 5, the profiles for the with pool control structure and without project are very similar. Since the difference in two profiles would be minimal, only the flow profiles for the with pool control structure are shown in Figure 6.

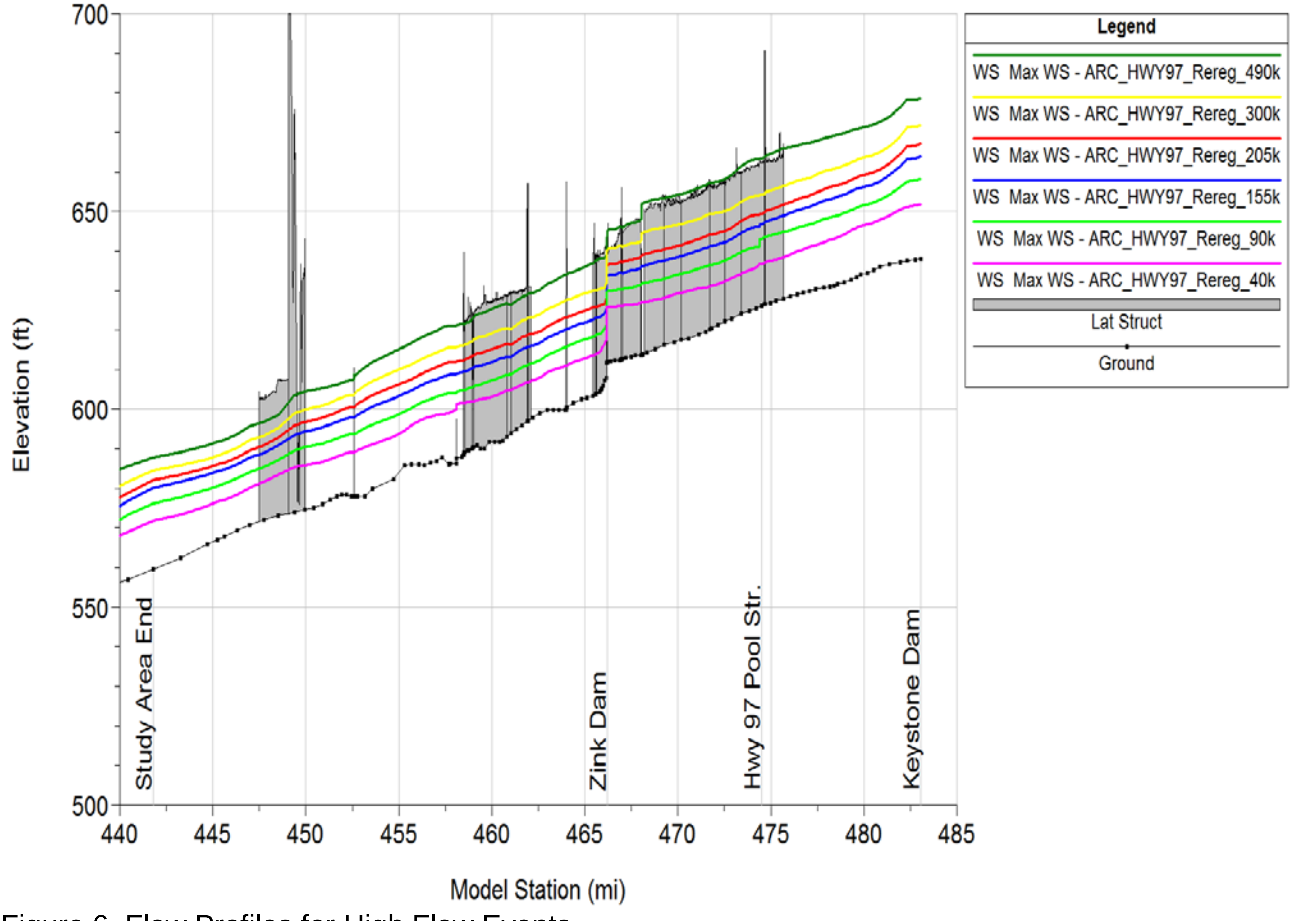

Figure 6. Flow Profiles for High Flow Events.

As shown in Figure 7, the Tulsa West Tulsa Levee System and the Jenks Levee are along the Arkansas River within the study area. These levees provide protection from flood control releases from Keystone Dam. The design flow for these levees was 350,000 cfs. The impacts of the pool control structure on flood control releases from Keystone Dam is less than 0.1 feet and can be addressed during the final design of the pool control structure.

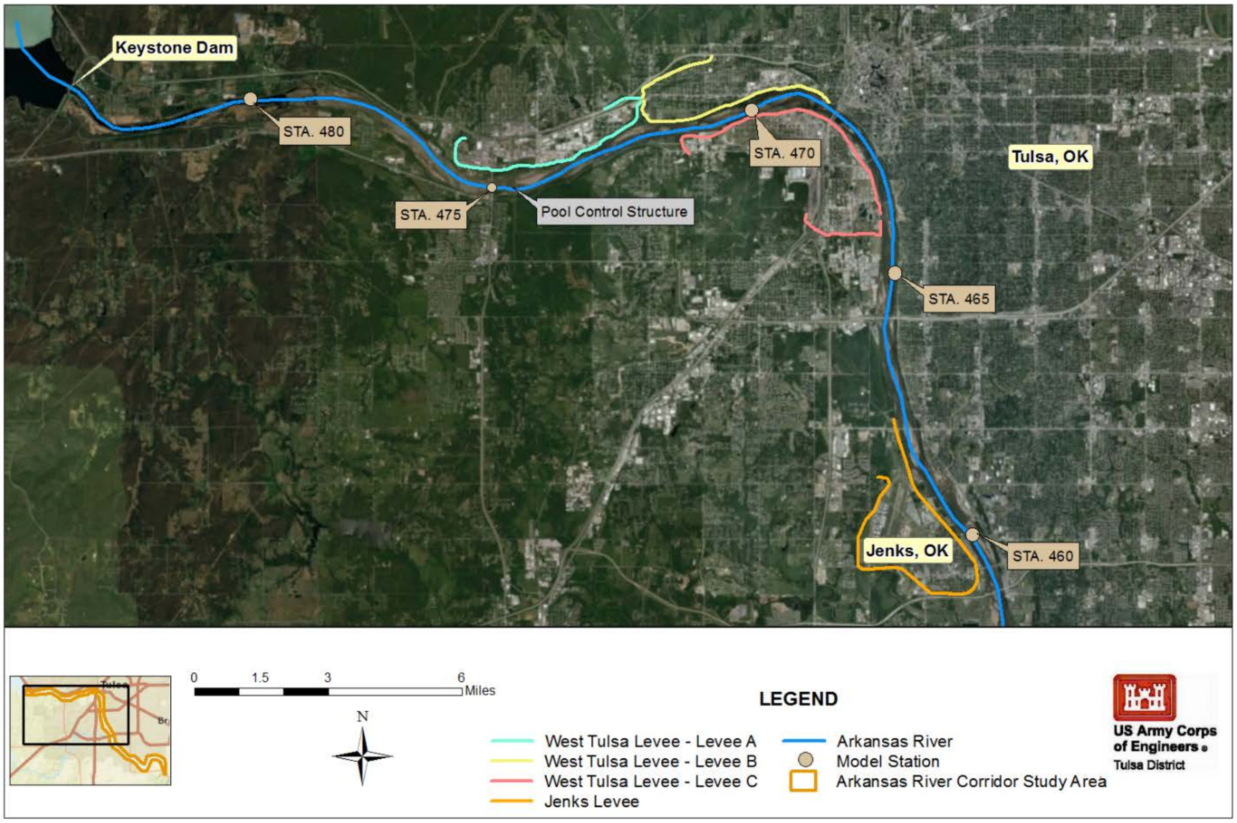

Figure 7. Location of Levees along the Arkansas River in the Study Area.

Impacts to Hydropower Generation

Hydropower generation is the source of water that will fill the pool control structure to provide the minimum flow during times non-generating times. The amount of hydropower generated decreases when the tailwater water surface elevation increases. While hydropower generation is the key to providing the 1,000 cfs minimum flow, it also has potential costs associated with reduced power generated if tailwater increases. Keystone Dam operates one or two generating units, providing approximately 6,000 cfs or 12,000 cfs respectively.

HEC-RAS model scenarios were developed to evaluate the impacts to tailwater with one or both hydropower units generating. For both generating conditions, the tailwater was increased less than 0.1 feet. Figure 8 shows the water surface profiles for tailwater conditions for operating one or both hydropower generating units. Profiles are provided for the condition of no pool control structure (identified as ARC NoProj), as well as profiles with the pool control structure downstream of the Highway 97 Bridge location.

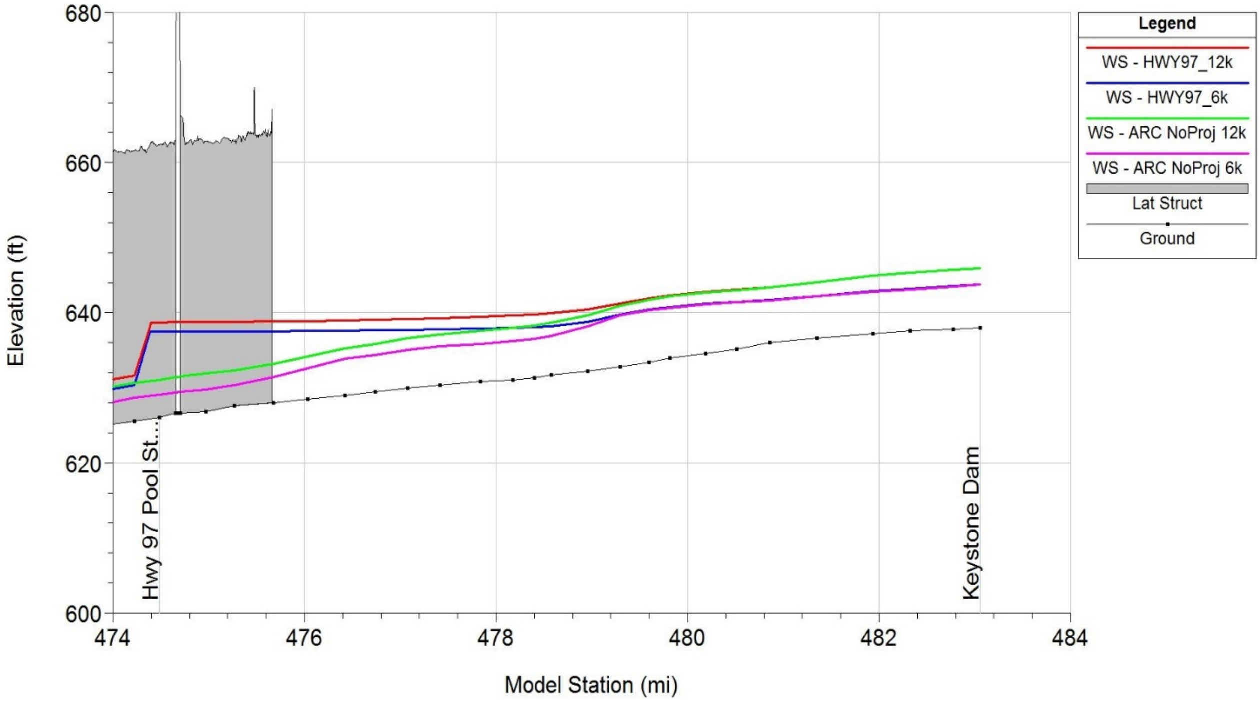

Figure 8. Hydropower Generation Water Surface Profiles.

Final design parameters for the pool control structure and gate operation procedures can be utilized to ensure there are no negative impacts to hydropower generation at Keystone Dam.

Steady Flow Model Scenarios

A steady flow HEC-RAS model was developed to establish water surface profiles for flow rates of 50, 100, 200, 300, 400, 500, 750, 1,000, 6,000, 12,000, 15,000, and 25,000 cfs. Inundation boundaries were developed for the 100 and 1,000 cfs flows rates. A flow rate of 100 cfs was utilized to estimate the inundated area associated with no releases from Keystone Dam and the 1,000 cfs inundation area is associated with the targeted minimum flow.

These inundation areas were utilized to determine the areal estimates of project area riverine, pool (created by the pool structures), and backwater acreages. The Arkansas River water surface area within the project area was also determined using the steady flow modeling for the 100 and 1,000 cfs flow conditions. The processed HEC-RAS model output was used as input data for the Habitat Evaluation and Assessment Tools.

Water Surface Delineation

Water surface delineation was completed in HEC-RAS using the RAS Mapper tool. Steady flow model simulations were completed for various flow conditions including 100 and 1,000 cfs. The steady flow models provided inundation boundaries that were used to compute areal estimates of the project area riverine, pool (created by the pool structures), and backwater acreages. These computed areas were utilized in the habitat analysis to determine the benefits associated with project implementation.