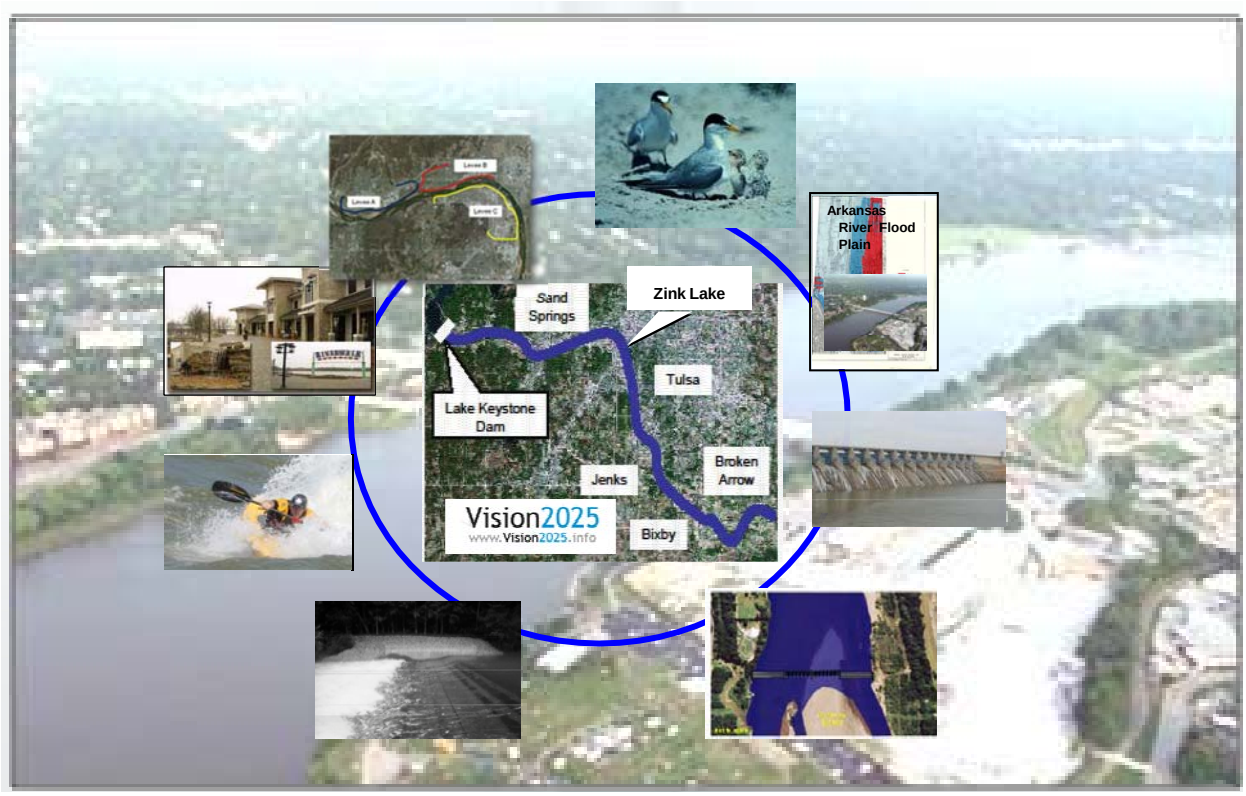
Arkansas River Corridor

Feasibility Report and Integrated Environmental Assessment



US Army Corps of Engineers ®
Tulsa District

TULSA COUNTY

Final Report

Prepared by:

U.S. Army Corps of Engineers

Tulsa District

March 2018

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EXECUTIVE SUMMARY

This is a Feasibility Report and Integrated Environmental Assessment completed by the United States Army Corps of Engineers (USACE), Tulsa District, presenting the results of a Feasibility Study on the potential for ecosystem restoration (ER) opportunities along a 42-mile corridor of the Arkansas River in Tulsa County, Oklahoma (Figure ES 1). The Arkansas River is a water resource serving numerous purposes within the City of Tulsa and surrounding communities. The river is dammed at the western Tulsa County line creating Keystone Lake which, along with the dam, provide flood risk management benefits, contribute to the eleven-reservoir-system operation of the McClellan-Kerr Arkansas River Navigation System (MKARNS), provide clean and efficient power through the associated hydropower plant, and provide a source of water for municipal and industrial uses. Historically, the river has served as an important resource for aquatic and terrestrial habitat of the nation's wildlife that live, breed, and migrate through the Arkansas River ecosystem. Construction, operation, and maintenance of the Keystone Dam, lake, associated hydropower operations, and other multi-purposes have substantially degraded the riverine ecosystem structure, function, and dynamic processes along the Arkansas River within Tulsa County. In addition to the nationally significant purposes of flood risk management, inland navigation, hydropower, and water supply, the Arkansas River ecosystem is a nationally significant resource for the Federally-listed Interior Least Tern (*Sterna antillarum*), hereafter referred to as Least Tern, as well as a plethora of other native species that support a functional riverine ecosystem.

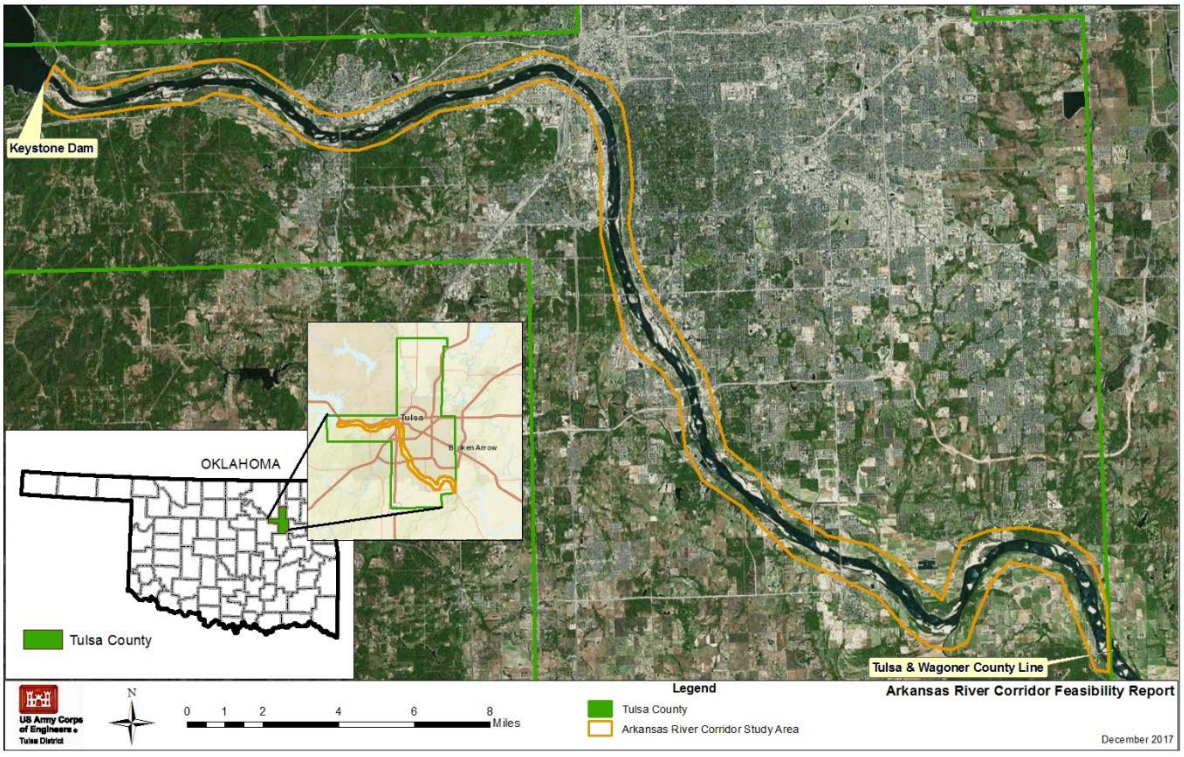

Figure ES 1: Arkansas River Corridor Study Area Location Map

Study Authority

The Arkansas River Corridor Feasibility Study was 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.

This study was conducted in accordance with *Engineering Regulation (ER) 1105-2-100, Planning Guidance Notebook,* and is organized in the framework of the ER. The study has been conducted following the six-step planning process which originated in the *1983 Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (also known as Principles and Guidelines or P&G). Implementation guidance provided for Section 3132 requires a cost-shared study be completed following the guidelines in ER 1105-2-100, Appendix H for projects authorized without a report. No project construction may be initiated until funds are specifically appropriated to accomplish the work. Pre-construction Engineering and Design is considered the next phase of this investigation.

The study identified and evaluated a suite of proposed ecosystem restoration measures and alternatives to determine the National Ecosystem Restoration (NER) plan, which became the Recommended Plan. The Integrated Environmental Assessment resulted in a Finding of No Significant Impact (FONSI) for the Recommended Plan.

Problem Identification and Existing Conditions

The impacts on the aquatic and riparian ecosystem within the study area from Keystone Dam and associated operations are dramatic. Keystone Dam is a physical barrier for natural river flow and connectivity, sediment transport, and migratory and spawning life histories of native fauna. Outside of flood pool releases, river flow in the study area relies upon hydropower operations.

The generation of hydropower at Keystone Dam, which has been in operation since 1968, has had a significant influence over the health of the ecosystem within the study corridor. The dam houses two hydropower-generating turbines with a power-generating capacity of 80 megawatts and a full-power discharge from the reservoir of 12,000 cubic feet per second (cfs). The Southwestern Power Administration (SWPA), as the region's Power Marketing Administration, is authorized to market the hydropower generation at Keystone Dam. When the Keystone lake level is in the flood pool, hydropower generation is used as the first methods of flood control release as part of the USACE flood risk management strategy. When the lake level is in the conservation pool, SWPA schedules and calls on Keystone Dam hydropower generation to meet peak electricity demand needs of Federal hydropower customers in a six-state region. Keystone Dam hydropower generation is operated as part of a system of numerous Federal hydropower projects in the region to meet the peak electricity demand. Generation schedules are subject to change due to a variety of factors.

During hydropower generation, the hydropower units can release an estimated 6,000 cfs (1 unit) or 12,000 cfs (2 units) of water that flows through the river throughout the study area. During periods of low precipitation, water levels behind the dam drop into the conservation pool. Once in the conservation pool, the only water released downstream is to meet hydropower or, occasionally, water supply demand, which is typically released via the hydropower units. As a result, the current flow regime within the study area exhibits daily bouts of brief 6,000-12,000 cfs river flow followed by extended periods of near zero river flow from Keystone Dam. Without releases from Keystone Dam, the Arkansas River within the study area is reduced from a flowing river to isolated pools and a disconnected floodplain habitat lasting from several hours during the week to several days over the weekend. This creates an incredibly disruptive, unnatural flow regime impacting all aquatic and riparian habitat types as well as the flora and fauna throughout the study area. While the drying of rivers is a naturally occurring process in the southwestern region of the United States, those conditions are generally experienced in smaller drainages and during extended severe droughts. In the study area, flooding and drought conditions are exacerbated beyond this natural drying process by the impacts of Keystone Dam and hydropower releases.

The Keystone Dam also traps a significant amount of sediment resulting in downstream sediment-starved flow causing channel and tributary incision and bank erosion. The impacted geomorphology has resulted in streambank erosion and the destruction of riverine wetlands, backwaters, and slackwater habitats that were once important fish nurseries and feeding/resting areas for resident and migrant waterfowl. As an example, the current mouth of Prattville Creek is an erosional shortcut to the Arkansas River, bypassing nearly one mile of the original Prattville Creek channel, caused in part by Arkansas River channel down cutting.

Within the study area, Federally-listed endangered Least Terns annually nest on the sandbar islands. As river flow diminishes and the river bed is exposed, the sandbar islands become connected to the shoreline. This fluctuating flow cycle coincides with peak Least Tern nesting activities in the study corridor, exposing the nesting colonies to inundation during high flows, and human and predator disturbances when low flows create land bridges to sandbar islands. The low flow conditions also induce Least Terns to nest in unsuitable low-lying areas. Hours or days later when river flows return, the low-lying nests have a higher probability of being swept into the river. Both inundation and low flow conditions contribute to the documented nesting failure in the Arkansas River Corridor.

Existing Conditions

Without river flow, the remaining shallow, isolated pools subject trapped fish, fish eggs and larvae, and aquatic invertebrates to increased predation, intolerable environmental conditions, and desiccation if river flow does not return in time. The disconnected river reaches and exposed river bed created by low flow conditions severely impact the ability of migratory fish, such as the Paddlefish (*Polyodon spathula*), Shovelnose Sturgeon (*Scaphirhynchus platorynchus*), and Sauger (*Sander canadensis*) to reach upstream spawning habitat within the backwater and slackwater habitats. These and other native fish species require continuous flows to prevent egg desiccation and to suspend larval offspring before they are fully mobile.

Along the shorelines, a variety of vegetation types including aquatic, emergent, shoreline, and moist soil dependent communities face similar challenges in a low flow condition. These habitats provide the vegetative structure necessary for refuge and critical nesting and nursery

life histories for numerous species across all fauna. In addition, these habitats supply the base of the food web throughout the study area. Seed, zooplankton, forage fish, and insect production are all dependent on the presence and function of these habitats. The low or no-flow conditions disconnect the above described habitats from the hydrologic regime they require to sustain growth. The result is a diminished food base with limited foraging opportunities, reducing the carrying capacity of the study area. Nesting Least Terns, migratory waterfowl, migratory fish, amphibians, bats and all other species that forage on small fish, seeds, zooplankton, and insects are faced with sustenance shortfalls.

Alternative Formulation

The project delivery team (PDT) through the planning process identified and assessed an array of restoration measures within the ARC Master Plan to address the specific ecological problems of the Arkansas River. These measures were combined into a suite of alternatives that address the degraded structure and function of the riverine ecosystem within the study area at varying degrees of improvement and cost.

The October 2005 ARC Master Plan is an overarching document produced by the Indian Nations Council of Governments that outlines future development of the corridor including concepts for ecosystem restoration, economic development, and outdoor recreation measures. The Master Plan identified three major categories for which measures were explored; Public Use Areas, Low Water Dams, and Natural Habitat/Ecosystem Restoration. Public use consists of mixed use development opportunities integrated with parks, trails, wildlife habitat, gateways, ball fields, boat ramps, fishing piers and marinas. The plan explores several locations for placement of low water structures, including one analyzed in this feasibility study. In the Master Plan, the low water structures are considered for habitat, flow management, aesthetics and development potential. Finally, the natural habitat/ecosystem restoration focus of the Master Plan considers native plantings, construction of wetlands, wildlife habitats, river lakes with fish passage, and stream corridor stabilization.

The ARC Master Plan did not develop measures into specific plans for implementation, but were left at a conceptual level. Conceptual plans were prepared for seven key development sites and two low water dam locations as well as conceptual plans for ecosystem restoration and floodplain management that address the corridor as a whole.

Initial screening of the elements within the Master Plan revealed potential for USACE participation in the ecosystem restoration opportunities discussed in the Master Plan. Measures identified for the ecosystem restoration of the Arkansas River Corridor to a more resilient and sustainable condition include a pool control structure to help maintain more consistent minimum flows released in the corridor, Rock Riffle and Wetland Plantings, and a Constructed Habitat Sandbar Island.

The restoration measures included two possible locations (but not both) for a pool structure; rock riffle structures; and wetland and riparian plantings at Prattville Creek and/or I-44/Riverside. These measures were combined into 11 plans, consisting of stand-alone plans and partially formed plans, for populating Institute for Water Resources (IWR) Planning Suite to generate alternatives, or combination of the plans. All plans assumed South Tulsa/Jenks low water dam is in place and functioning as the Future With Project Condition. Benefits and first costs were developed for each of the 11 partially formed/stand-alone plans. The array of plans are:

- Pool structure located at river mile 531 (former site of Lake Keystone Project reregulating dam)
- Pool structure located at river mile 530
- Constructed Least Tern Island
- Rock Riffle Structures at Prattville Creek
- Rock Riffle Structures and Wetland Plantings at Prattville Creek
- Rock Riffle Structures and Riparian Planting at Prattville Creek
- Rock Riffle Structures, Wetland Plantings, and Riparian Plantings at Prattville Creek
- Rock Riffle Structures at I-44 Riverside
- Rock Riffle Structures and Wetland Plantings at I-44 Riverside
- Rock Riffle Structures and Riparian Planting at I-44 Riverside
- Rock Riffle Structures, Wetland Plantings, and Riparian Plantings at I-44 Riverside

Cost and benefits were developed for each of the measures and partially formed plans, as described in the sections below. The information was entered into IWR Planning Suite in order to arrange the measures into all possible combinations, with the following conditions set: (1) a pool structure measure is required prior to combination with any other measure, (2) the two pool structure measures are not combinable with each other, and (3) rock riffle structures are required prior to combining any planting measures. This resulted in 101 alternatives to be further screened using Cost Effectiveness and Incremental Cost Analyses (CE/ICA). The CE/ICA identified seven "best buy" plans in addition to the No Action Alternative. The PDT added one cost effective plan, Alternative 2a, which was not a best buy plan, but includes the upstream dam location coupled with the Rock Riffle Structures and Riparian Planting at Prattville Creek and a Constructed Sandbar Island. Table ES1 lists the final array of alternative plans carried forward for analysis (the six best buy plans, Alternative 2a and the No Action Alternative).

Table ES1: Final Array of Alternatives (Best Buy Plans)

Measures	Alternatives								
	1	2	2a	3	4	5	6	7	8
No Action	X								
Pool Structure at river mile 531 (former reregulation dam site)		X	X						
Pool Structure at river mile 530				X	X	X	X	X	X
Prattville Creek Rock Riffle with Wetland Plantings			X		X	X	X	X	X
New Least Tern Island			X			X	X	X	X
Riverside/I-44 Rock Riffle with Wetland Plantings							X	X	X
Riverside/I-44 Riparian Plantings								X	X
Prattville Riparian Plantings									X

National Ecosystem Restoration Plan

The “is it worth it” analysis for alternatives in the final array includes quantitative and qualitative discussions utilizing the following selection criteria:

- Incremental benefit
- Incremental cost
- Quantity of restored riverine acres
- Quality of restored habitat
- Number of targeted habitat types restored

Alternative 5 is the recommended/National Ecosystem Restoration (NER) plan. 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 at a first cost of approximately $128.4 million (October 2017 prices). While built within the floodplain, Alternative 5 would not increase the base flood elevation of the Arkansas River and all flows would remain within the existing river banks. Figure ES 2 shows the location of individual measures that make up the NER plan as they would sit in the study area

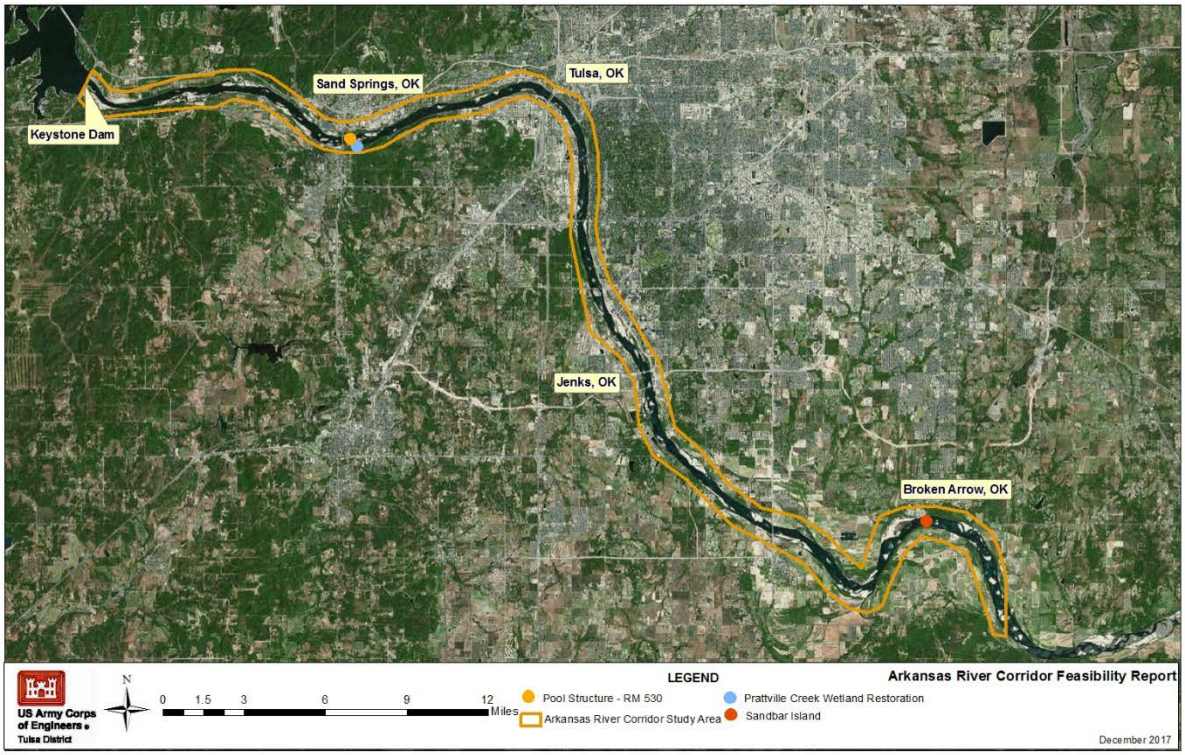

Figure ES 2: Location of NER Measures within the Study Area.

Restoration of the Arkansas River Corridor would add to the larger existing habitat complex of the Arkansas River. The current intermittent flow regime reduces the river to isolated pools dotting the 42 river mile reach. Implementation of the NER plan would increase the river's surface water from 1,591 acres to 3,735 acres and most importantly, the potential for a more continuous river flow of 1,000 cubic feet per second (cfs) from the pool structure to the Tulsa/Wagoner County line. This additional water and flow would remain within the existing banks of the river and would not increase the flood elevation, or downstream, or backwater flooding. Restoring river flow, wetlands, and sandbar habitat would greatly benefit the federally listed endangered Interior Least Tern. The sustained river flows provided by the NER plan would maintain nesting habitat and forage fish species. Restored wetlands would increase forage fish abundance to support a growing Interior Least Tern population. The constructed sandbar island would withstand the higher flow rates – with some 3 acres of island remaining available during flows as high as 20,000 cfs – providing additional nesting habitat during elevated river stages.

The restoration of connected river reaches also expands migratory routes for native fish in the Arkansas River Corridor and provides them access to side channel and backwater habitat they use for refuge, spawning, and nursery habitat. As evidenced by the numerous conservation and management cooperatives established to address adverse impacts to avian populations in North America, migratory birds are of great ecological value and contribute immensely to biological diversity. These same backwater areas and vegetated shorelines also provide food and cover for millions of waterfowl and migratory birds that utilize the Central Flyway. The study area lies along the eastern fringe of the Central Flyway and likely supports regular Mississippi Flyway migrants as well. The restored Arkansas River Corridor would provide tremendous additional habitat to support winter and summer migrants as the study area is positioned at a relative midpoint location for many species migration routes.

The riparian corridor that brackets the study area would be further supported by continuous river flow provided by the NER plan. Currently, the shorelines are subjected to frequent bouts of drying followed by high flow events. This constant shift in water levels subjects the shorelines to increased erosion and fosters invasive species encroachment. The NER plan provides a more stable flow regime to support native riparian vegetation growth. Native vegetation naturally stabilizes shorelines providing habitat and reducing the need for expensive constructed shoreline stabilizing measures that offer little habitat.

The Arkansas River Corridor NER Plan/Recommended Plan:

- fulfills the U.S. Army Corps of Engineers restoration mission,
- is in accordance with the USACE Civil Works Strategic Plan,
- is in accordance with the USACE Environmental Operating Principles,
- is in compliance with USACE restoration and recreation policies,
- is sustainable though the application of geomorphologic principles for sediment transport, hydraulic modeling, native vegetation species survivability, and synergistic effects,
- restores biological and environmental resources that were present prior to the construction of the Keystone Dam,
- restores nesting habitat for the Federally listed endangered Interior Least Tern,
- complements other Federal, state, and local restoration programs and projects,
- demonstrates ecosystem restoration co-exists effectively with the existing Keystone Dam and associated Tulsa Levee project purpose of flood risk management, and hydropower production,
- is supported by U.S. Fish and Wildlife Service, and Oklahoma Department of Wildlife Conservation, and
- has widespread local support.

Project (Recommended Plan) First Cost

Plan formulation was done using FY2016 (October 2015) price levels and a federal discount rate of 3.125 percent. Table ES2 below presents the project first cost, interest during construction, and annual cost based on FY2018 (October 2017) price levels and the federal discount rate of 2.75 percent, per Economic Guidance Memorandum 18-01. The Federal investment is capped at $50 million by the study authority. Tulsa County is identified as the non-Federal sponsor. Tulsa County and the City of Tulsa support the recommended plan and, should the plan be approved, intend to participate in its implementation. The Non Federal Sponsor will be responsible for all costs exceeding $50 million regardless of cost share percentages.

Table ES2: Project first cost, interest during construction and annual cost (FY18 prices, 2.75% Discount Rate)

Item	Ecosystem Project First Costs	Ecosystem Benefits
Investment Cost		
First Cost	$128,375,000	
Interest During Construction	$1,905,000	
Total Investment Cost	$130,280,000	
Annual Cost		
Interest and Amortization	$4,826,000	
OMRRR	$349,000	
Total Annual Cost	$5,175,000	
Annual Benefits		
Average Annual Habitat Units		875.7

Environmental Compliance

An Integrated Environmental Assessment and Finding of No Significant Impact (FONSI) were prepared and integrated into the Feasibility Report evaluating the potential environmental impacts of the Recommended Plan and demonstrating that the Recommended Plan would be in compliance with all environmental laws, regulations, executive orders, and guidance. The draft Feasibility Study with integrated Environmental Assessment and draft Finding of No Significant Impact (FONSI) were available for public review February 6 – March 06, 2017 and a public meeting was held in the study area February 27, 2017.

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FINDING OF NO SIGNIFICANT IMPACT

ENVIRONMENTAL ASSESSMENT –
ARKANSAS RIVER CORRIDOR ECOSYSTEM RESTORATION
FEASIBILITY STUDY, (March 2018)
Tulsa County, Oklahoma

In accordance with the National Environmental Policy Act of 1969, including guidelines in 33 Code of Federal Regulations, Part 230, the Tulsa District, in cooperation with Tulsa County, OK, has assessed the environmental impacts of proposed ecosystem restoration within the 42-mile Arkansas River Corridor (ARC) from the Keystone Lake Dam down to the Tulsa/Wagoner County boundary. The Water Resources Development Act (WRDA) of 2007, Section 3132 authorizes participation in ecosystem restoration components identified in the Arkansas River Corridor Master Plan dated October 2005. Tulsa County is the non-federal sponsor for the Arkansas River Corridor feasibility study.

The Recommended Plan which is the subject of this Finding of No Significant Impact (FONSI) was developed as a result of a Feasibility Study by the Tulsa District that culminated in the Arkansas River Corridor Feasibility Report and Integrated Environmental Assessment, Final Report, February 2018. The Feasibility Study evaluated a set of proposed ecosystem restoration measures and alternatives to determine the National Ecosystem Restoration (NER) plan, which became the Recommended Plan.

While the construction of the Keystone Dam in 1964 has successfully reduced the negative impacts of flooding within the ARC, and hydroelectric power components brought online in 1968 have contributed to a clean and efficient energy resource for the region, operation of the dam for flood control and hydropower generation have significantly altered the riverine corridor ecosystem downstream of the dam. Negative consequences include disrupted river connectivity, altered flooding and low flow regimes, highly variable sub-daily flows, decreased sediment loads, streambank erosion, decreased connection with riparian flood zones, and seriously altered species composition and food webs within the Arkansas River in Tulsa County. These alterations, combined with land use changes, and the construction of levees for residential, commercial and industrial flood protection, have significantly degraded the river corridor ecosystem. Sediment trapped by the Keystone Lake Dam has significantly reduced the quantity of sediment that maintains downstream sandbar island habitat for the federally endangered Interior Least Tern (Least Tern, *Sterna antillarum*), and periods of nominal flow in the river have made existing sandbar habitat vulnerable to land-bridging exposing Least Tern nesting sites to hazards including predation and disturbance. Alterations to the river corridor have created negative interruptions to fish habitats and fish assemblages in the Arkansas River Corridor with documented overall increases in abundance and diversity of intolerant species. Periods of no flow strand and limit the passage and habitat of migratory fish species. The altered flow regime and urban development within the corridor has led to the destruction of riverine slackwater, wetland, oxbow, and scrub-shrub habitats that were once important native fish nurseries and feeding and resting areas for migrant birds and waterfowl. The loss of these habitats has decreased the species diversity and overall biological productivity of the remaining downstream habitat.

Consistent with features identified in the Arkansas River Master Plan (2005), the Recommended Plan consists of a pool structure at River Mile 530, restoration of a 5.34 acre wetland at the mouth of Prattville Creek, and development of resilient and sustainable Least Tern sandbar habitat within the Arkansas River Corridor in Tulsa County. The pool structure is a flow regime management measure, fundamental to restoration within the ARC, designed to alleviate periods of nominal instream flow by capturing and slowly releasing pulsed hydropower and flood pool releases providing minimum flows in the range of 1,000 cubic feet per second. State of the art design technology will be incorporated to provide safety, seasonal fish/fry/egg and sediment passage, and connected riverine flow through the upstream riverine pool. Enhanced minimum flows will restore riverine habitat connectivity, downstream riverine ecosystem structure and function, and downstream wetland and riparian habitats. Wetland restoration at the mouth of Prattville Creek with placement of a rock riffle at the current mouth of the creek will restore a 5.34 acre wetland providing additional shallow water habitat to the Arkansas River Corridor, and area of velocity refuge, foraging, and nursery habitat for fish, restored flow to the original Prattville Creek channel, and additional habitat for insects, amphibians, mammals, and migrant birds and waterfowl. Development of sustainable and resilient sandbar habitat will enhance federally endangered Least Tern nesting habitat within the Arkansas River Corridor, a critical component for supporting the continued proliferation of the species and other migrant shorebirds.

All practicable means to avoid or minimize environmental impacts due to construction of the Recommended Plan have been considered. The hydraulic roll-over effect was a significant life safety risk in a previously existing re-regulation dam. To reduce life safety risks to less than significant, the proposed pool structure would feature sloped aprons to minimize the hydraulic roll-over effect. In addition, appropriate physical facility security measures would be utilized to limit public access near the pool structure.

Typical low water dams are often barriers to river flow, sediment, and fish movement. The proposed pool structure has been designed to operate independent full and partial height gates. These gates would be operated to increase minimum river flow in the study area during periods that would otherwise experience little to no river flow in the absence of releases from Keystone Dam. During larger releases from Keystone Dam, the gates would be fully opened, from their full height down to near river bed elevation. This operational capability allows the pool structure to maintain connected river reaches, facilitate fish and larvae/egg passage and sediment transport while avoiding impacts to Keystone Dam operations, hydropower production, and flood risk management.

As part of Tulsa County's responsibilities as the non-federal sponsor, a contaminant free work area must be provided for the construction and operation of the Recommended Plan. Any remediation of lands needed for the Recommended Plan would be the sole responsibility of Tulsa County.

The Recommended Plan has been designed with the smallest practicable footprint. In addition, a Monitoring and Adaptive Management Plan has been developed to ensure restoration goals are met by assessing performance and functionality of components of the Recommended Plan. Additional strategies minimizing implementation impacts include employment of all applicable Best Management Practices associated with construction activities and timing.

The enclosed Integrated Environmental Assessment demonstrates the Recommended Plan would have no significant impact on the quality of the natural or human environment. Based on a review of the Feasibility Report and Integrated Environmental Assessment, I have determined that the implementation of the Recommended Plan is not a major federal action which would significantly affect the quality of the human environment within the meaning of Section 102(2)(c) of the National Environmental Policy Act of 1969, as amended. Therefore, the preparation of an Environmental Impact Statement is not required.

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Christopher A. Hussin Date

Colonel, EN

Commanding

Enclosure: Environmental Assessment Integrated into the Arkansas River Corridor Ecosystem Restoration Feasibility Investigation Report

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1 INTRODUCTION

This is a feasibility report and integrated environmental assessment completed by the United States Army Corps of Engineers (USACE), Tulsa District, presenting the results of study on the potential for ecosystem restoration opportunities along a 42-mile corridor of the Arkansas River in Tulsa, Oklahoma (Figure 1). The Arkansas River is a water resource serving numerous purposes within the City of Tulsa and surrounding communities. The river is dammed at the western Tulsa County line creating Keystone Lake which, along with the dam, provide flood risk management benefits, contribute to the eleven-reservoir-system operation of the McClellan-Kerr Arkansas River Navigation System (MKARNS), provide clean and efficient power through the associated hydropower plant, and provide a source of water for municipal and industrial uses. Historically, the river has served as an important resource for aquatic and terrestrial habitat of the nation's wildlife that live, breed, and migrate through the Arkansas River ecosystem. Construction, operation, and maintenance of the Keystone Dam, lake, associated hydropower operations, and other multi-purposes have substantially degraded the riverine ecosystem structure, function, and dynamic processes along the Arkansas River within Tulsa County. In addition to the nationally significant purposes of flood risk management, inland navigation, hydropower, and water supply, the Arkansas River ecosystem is a nationally significant resource for the Federally-listed Interior Least Tern (*Sterna antillarum*), hereafter referred to as Least Tern, as well as a plethora of other native species that support a functional riverine ecosystem. The national significance of this resource will be discussed in more detail in Chapter 2 and Appendix A.

1.1 Study Purpose and Need

1.1.1 Study Purpose

The purpose of this study is to evaluate the components of the October 2005 Arkansas River Corridor (ARC) Master Plan and determine if there is a Federal interest that aligns with the USACE mission areas. The ARC Master Plan included conceptual plans to address public use areas (e.g. mixed use development areas and recreation opportunities), low water dams and natural habitat/ecosystem restoration. The specific elements of the ARC Master Plan are discussed in Chapter 3. Initially, this study assessed the ARC Master Plan for potential flood risk management and recreation elements in addition to ecosystem restoration. Early in the study process the scope was narrowed to only include analysis for potential ecosystem restoration (ER) opportunities because analysis indicated there was little to no Federal interest in pursuing flood risk management or recreation in the region. Flood risk is being adequately handled by local entities and residual risk of flood damage would remain unchanged with implementation of ER as a result of this study.

1.1.2 Study Need

While the Arkansas River has long been a significant natural resource for the surrounding land and its inhabitants, historical alterations have degraded watershed conditions and masked the river's potential. The 1964 construction of Keystone Dam for flood risk management substantially changed the natural hydrology and sediment transport patterns of the Arkansas River. The adverse impacts resulting from Keystone Dam operations for flood risk management, water supply and hydropower operations along with impacts from urbanization, flood risk management measures (levee system), constructed banks and erosion, and active sand-mining

have weakened/reduced aquatic systems. These ecosystems would continue to degrade as climate change in this region of North America is forecasted to result in more frequent and more intense droughts, heat waves, intense thunderstorms, and flash flooding. Coupled with gaps in river flow releases by flood risk management and hydropower generation, additional periods of shortages and surpluses of water released from Keystone Dam, hence the need for flexibility of the pool structure to adapt to environmental conditions to restore the ecological functions of the corridor.

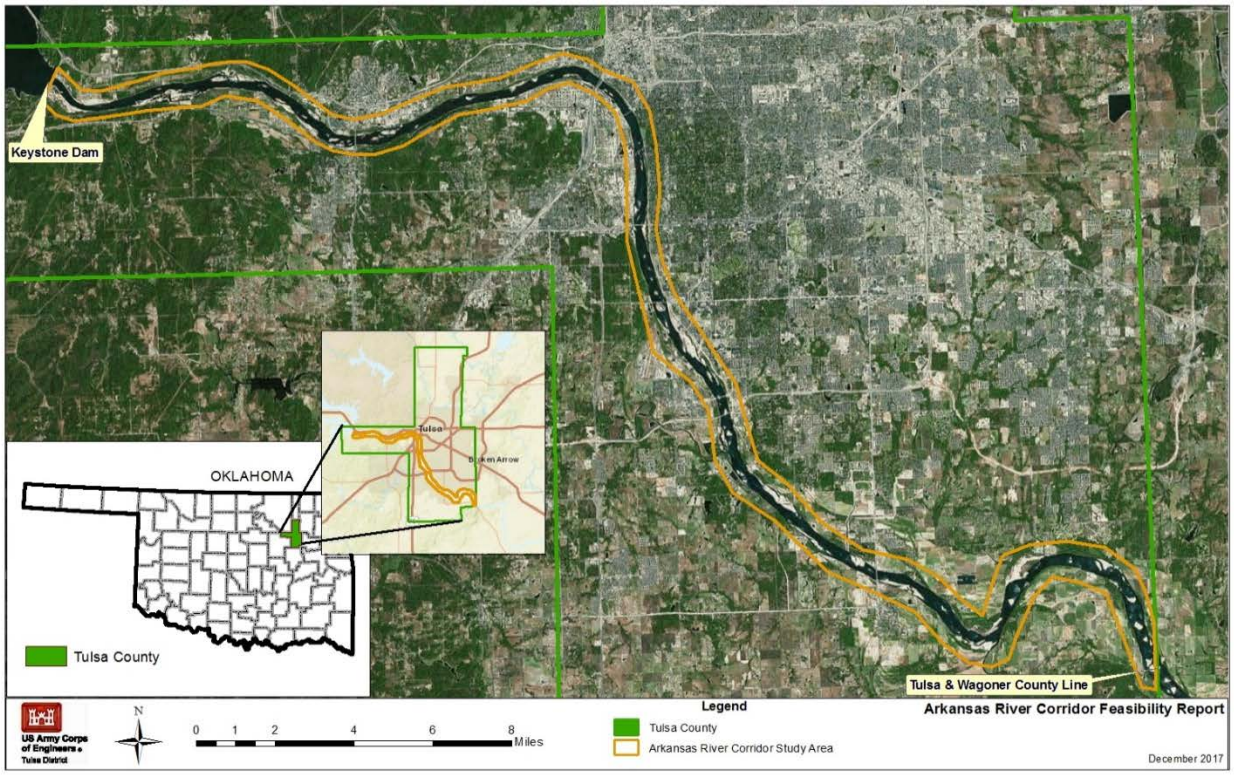

Figure 1: Arkansas River Corridor study area location map

The impacts on the aquatic and riparian ecosystem within the study area from Keystone Dam and associated operations are dramatic. Keystone Dam is a physical barrier for natural river flow and connectivity, sediment transport, and migratory and spawning life histories of native fauna. Outside of flood pool releases, river flow in the study area relies upon hydropower operations.

The generation of hydropower at Keystone Dam, which has been in operation since 1968, has had a significant influence over the health of the ecosystem within the study corridor. The dam houses two hydropower-generating turbines with a power-generating capacity of 80 megawatts and a full-power discharge from the reservoir of 12,000 cubic feet per second (cfs). The Southwestern Power Administration (SWPA), as the region's Power Marketing Administration, is authorized to market the hydropower generation at Keystone Dam. When the Keystone lake level is in the flood pool, hydropower generation is used as the first methods of flood control release as part of the USACE flood risk management strategy. When the lake level is in the conservation pool, SWPA schedules and calls on Keystone Dam hydropower generation to

meet peak electricity demand needs of Federal hydropower customers in a six-state region. Keystone Dam hydropower generation is operated as part of a system of numerous Federal hydropower projects in the region to meet the peak electricity demand. Generation schedules are subject to change due to a variety of factors.

During hydropower generation, the hydropower units can release an estimated 6,000 cfs (1 unit) or 12,000 cfs (2 units) of water that flows through the river throughout the study area. During periods of low precipitation, water levels behind the dam drop into the conservation pool. Once in the conservation pool, the only water released downstream is to meet hydropower or, occasionally, water supply demand, which is typically released via the hydropower units. As a result, the current flow regime within the study area exhibits daily bouts of brief 6,000-12,000 cfs river flow followed by extended periods of near zero river flow from Keystone Dam. Without releases from Keystone Dam, the Arkansas River within the study area is reduced from a flowing river to isolated pools and a disconnected floodplain habitat lasting from several hours during the week to several days over the weekend. This creates an incredibly disruptive, unnatural flow regime impacting all aquatic and riparian habitat types as well as the flora and fauna throughout the study area. While the drying of rivers is a naturally occurring process in the southwestern region of the United States, those conditions are generally experienced in smaller drainages and during extended severe droughts. In the study area, flooding and drought conditions are exacerbated beyond this natural drying process by the impacts of Keystone Dam and hydropower releases.

Water 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.

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.

Because river flow is vital in supporting aquatic life and completing life histories dependent on moving water in riverine systems, the no/low flow conditions that occur in the study area are considered the limiting factor to aquatic ecosystem health in the ARC.

1.2 Scope

This study evaluates the existing and future without-project conditions of the riverine ecosystem for the 42-mile Arkansas River Corridor and compares that to a series of alternative project plans to find means to potentially improve aquatic ecosystems within the corridor. Through analysis of the alternatives, this document will provide details of an assessment of the problems and opportunities, planning objectives, and constraints of the study to find an ecosystem restoration project which warrants Federal investment and meets the goals and objectives of the non-Federal sponsor.

1.3 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.

This study was conducted in accordance with *Engineering Regulation (ER) 1105-2-100, Planning Guidance Notebook,* and is organized in the framework of the ER. The study has been conducted following the six-step planning process which originated in the *1983 Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (also known as Principles and Guidelines or P&G). Implementation guidance provided for Section 3132 requires a cost-shared study be completed following the guidelines in ER 1105-2-100, Appendix H for projects authorized without a report. No project construction may be initiated until funds are specifically appropriated to accomplish the work. Pre-construction Engineering and Design is considered the next phase of this investigation.

The study identified and evaluated a suite of proposed ecosystem restoration measures and alternatives to determine the National Ecosystem Restoration (NER) plan, which became the Recommended Plan. The Integrated Environmental Assessment resulted in a Finding of No Significant Impact (FONSI) for the Recommended Plan.

1.4 Study Location

The Arkansas River is the sixth longest river in the nation originating in the eastern slopes of the Rocky Mountains in Colorado flowing through Colorado, Kansas, Oklahoma, and Arkansas until it meets the Mississippi River in southeast Arkansas. The study area includes the 42-mile long Arkansas River Corridor ecosystem downstream of the Keystone Dam to the Tulsa/Wagoner County boundary (see

Figure 1). Key tributary streams include, but are not limited to, Prattville Creek at Sand Springs, Crow Creek and Vensel Creek in Tulsa. The study area is confined to within the existing banks of the Arkansas River. Tributaries were only evaluated upstream to the extent that they were inundated when the Arkansas River is held at elevation 638 feet above mean sea level (msl).

1.5 Previously Constructed Projects

1.5.1 Keystone Dam

The Keystone Lake Dam forms the up-stream project area boundary for the Arkansas River Corridor study. Congressionally authorized purposes include flood risk management, water supply, hydropower, navigation, and ecosystem restoration. Construction began in 1957 and the project was placed in operation in September 1964. Hydropower operations began in May 1968.

In addition to the main Keystone Dam, a reregulating dam located 7.8 miles downstream of Keystone Dam was constructed for purposes of smoothing hydropower releases and providing

water quality control flows. However, due to its upstream location, it lacked the storage capacity to provide river flow throughout a weekend without hydropower generation releases from Keystone. So while this structure provided some consistency in the river flow, it did not provide the flow necessary throughout the weekend to promote a healthy ecosystem downstream. The structure also lacked the fish passage, sediment transport, and safety measures. The reregulating dam operated from 1968 to 1985, when it was removed over safety concerns. Keystone Lake also has a significant regional influence as one of 11 principle USACE reservoirs in the Arkansas River Basin in Oklahoma that regulate flows on the Arkansas River including within the MKARNS. Navigation on the MKARNS originates at the Tulsa Port of Catoosa northeast of Tulsa on the Verdigris River and runs southeast through Oklahoma and Arkansas to the Mississippi River. The Arkansas River joins the MKARNS system some 50 river miles downstream of the Tulsa/Wagner county line, near the City of Muskogee, Oklahoma.

In times of extreme low water in the MKARNS, releases can be made from Keystone Dam to supplement the flow to reach the water elevation needed to operate Webbers Falls Lock and Dam #16. As such, operation of MKARNS would not directly impact formulation in this study as any ecosystem restoration solution would be designed to withstand higher flows from hydropower generation and dam operations. Releases for MKARNS are part of established Keystone operations, do not occur frequently, and are most likely to occur when river levels are low and best able to accommodate extra flow through the area. Likewise, ER measures implemented as result of this study would not impact MKARNS function.

1.5.2 Tulsa and West Tulsa Levees

The Tulsa and West Tulsa Local Protection Project consist of levees on the banks of the Arkansas River in Tulsa County, Oklahoma. The levee project was constructed by USACE. Drainage District Number 12, Tulsa County, Oklahoma, accepted the completed project for operation and maintenance on August 7, 1945. On the left bank, the levee extends from river mile (RM) 531 near Sand Springs downstream to RM 521.4 at Tulsa. On the right bank, the levee extends from RM 526.7 downstream to RM 521.3 and is adjacent to the major portion of the business and residential districts in West Tulsa. Tulsa County Drainage District 12 is working with other local and Federal agencies to reduce risks associated with these levees. Tulsa County funds Drainage District 12 for the operation and maintenance of the Tulsa/West Tulsa Levee.

1.5.3 Zink Lake

Zink Lake Dam is located on the Arkansas River near 31st Street. It was completed in 1983 by the City of Tulsa. The low water dam is named after John Steele Zink, whose family foundation was a major private contributor to the project. Zink Lake, located adjacent to the River Parks Authority trail system is a popular area for fishing and rowing. Immediately downstream of Zink Lake Dam once was a popular spot for kayaking the “Tulsa Wave.” Tulsa County is in the process of rehabilitating the Zink Lake Dam.

1.5.4 Jenks Levee

The Jenks Local Protection Project near Jenks, Oklahoma, was completed in 1949 and associated bank protection work was completed in 1950. The levee was constructed by USACE. Drainage District Number 13, Tulsa County, Oklahoma, accepted the project for operation and maintenance on February 23, 1950. The levee extends along the right bank of the Arkansas River from RM 518 downstream to RM 514.3; then upstream on the left bank of

Polecat Creek for nearly 2 miles, and along the left bank of Hager Creek (a tributary of Polecat Creek) for another 2 miles. Tulsa County funds Drainage District 13 for the operation and maintenance of the Jenks Levee.

1.6 Projects Planned or Under Construction

1.6.1 Muskogee (Creek) Nation

The Muskogee (Creek) Nation has been actively involved in development along the Arkansas River Corridor. An existing attraction is the River Spirit Casino near 81st Street and Riverside Drive. On-going initiatives include renovation of Riverwalk Crossing and construction of the Margaritaville project that includes a 27-story, 483-room hotel and other associated amenities in the vicinity of the casino.

1.6.2 A Gathering Place for Tulsa

A project of George Kaiser Family Foundation, A Gathering Place for Tulsa is a waterfront recreation area along the Arkansas River that aims to blend nature with an urban setting. The 100 acre waterfront recreation area opened its Chapman Adventure Playground to area youth in January 2018. Several features are still under construction including restaurants, a lodge, landscaping, boathouse and water based recreation.

1.6.3 South Tulsa / Jenks Pool

Identified as a top priority low water dam location in the 2005 Master Plan, the proposed low water dam and pool at RM 514, would enhance future commercial, recreational, and residential development in the area. Public safety, sedimentation, fish passage, and habitat restoration are important considerations in development of plans at this site. Local funding for this project was approved by City of Tulsa and Jenks voters in April 2016. This project is currently seeking a permit from USACE through the Clean Water Act Section 404 process.

2 EXISTING CONDITIONS AND FUTURE WITHOUT PROJECT CONDITIONS

This chapter describes the existing conditions and future without project conditions and establishes a baseline for each of the following resources:

- air quality;
- climate;
- water resources;
- hydrology and floodplains;
- riverine resources;
- biological resources;
- threatened and endangered species;
- cultural resources;
- land use, recreation and transportation;
- socioeconomics and visual aesthetics;
- utilities;
- health and safety;
- hazardous toxic and radioactive waste, and;
- geology and soils.

In addition, it includes discussion on the affected environment as it relates to National Environmental Policy Act (NEPA). The affected environment is the natural and physical environment as well as the relationship of people with the environment. The affected environment is summarized below, greater detail can be found in Appendix B.

The planning horizon for projecting the future without project condition is 50 years. This is in alignment with the Engineering Regulation 1105-2-100 for water resources projects and is as far into the future that we can reasonable predict the most likely condition expected to exist. The 50-year period of analysis for this study begins in 2023 to allow for Congressional approval and appropriations, engineering and design prior to construction, therefore the planning horizon for this study is 2023-2073.

2.1 Future without Project Conditions

Under future without project conditions (FWOP), the Arkansas River Corridor ecosystem would continue to exist, at best, in its degraded state, but most likely worsen. While this low flow condition provides some water to the approximately 1,591 acres of wetted riverine habitat within the 42 river mile study area, the 1,591 acres consists of largely isolated pools. The total acres of riverine habitat in the future without project condition is expected to decrease to 1,422 acres, within 10 years when accounting for the anticipated size increase of Zink Lake and construction of the South Tulsa/Jenks low water dam further downstream. Other downstream projects may be required to offset impacts through compensatory mitigation. Locations of these measures is not known and therefore the measures were not included in future projects.

2.2 Air Quality

Ground-level ozone is the main criteria pollutant of concern for the Tulsa metropolitan area. Motor vehicle exhaust and industrial emissions, among other sources, emit nitrogen oxides and other volatile organic compounds, which react with sunlight to form ground-level ozone. Ozone accumulation is at its highest during warm weather months.

The U.S. Environmental Protection Agency (EPA) has the primary responsibility for regulating air quality nationwide. The Clean Air Act (42 U.S.C. 7401 *et seq*.), as amended, requires the EPA to set National Ambient Air Quality Standards (NAAQS) for wide-spread pollutants from numerous and diverse sources considered harmful to public health and the environment. The Clean Air Act established two types of national air quality standards classified as either "primary" or "secondary." Primary standards set limits to protect public health, including the health of at-risk populations such as people with pre-existing heart or lung diseases (such as asthma), children, and older adults. Secondary standards set limits to protect public welfare, including protection against visibility impairment, damage to animals, crops, vegetation, and buildings.

EPA has set NAAQS for six principal pollutants, which are called "criteria" pollutants. These criteria pollutants include carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3), particulate matter less than 10 microns (PM_{10}), particulate matter less than 2.5 microns ($PM_{2.5}$), sulfur dioxide (SO_2) and lead (Pb). If the concentration of one or more criteria pollutant in a geographic area is found to exceed the regulated "threshold" level for one or more of the NAAQS, the area may be classified as a non-attainment area. Areas with concentrations of criteria pollutants that are below the levels established by the NAAQS are considered either attainment or unclassifiable areas.

The Tulsa area was designated an attainment area for ozone in 1990 after 20 years of nonattainment designation. As of now, the Tulsa area and the State of Oklahoma remain in attainment. Although growth continues in the area and more pollutant sources may exist in the future, fuel efficient vehicles and expanding clean energy use should mitigate the increase in population.

2.3 Climate, Climate Change, and Greenhouse Gases

The climate in the Tulsa area is considered continental, characterized by abundant sunshine and rapid fluctuations in temperature. Winters are generally mild, though temperatures occasionally fall below 0 degrees Fahrenheit (°F) for brief periods of time. During the summer, temperatures often exceed 100°F from late July to early September. The average annual temperature is 60°F, with average highs ranging from 88°F to 93°F during the summer and from 46°F to 53°F during the winter. Average low temperatures in the winter months generally range between 26°F and 31°F (NWS 2011).

Average annual precipitation in the study area is 42 inches (NWS 2011). Thunderstorms account for a significant amount of the annual precipitation and are most frequent in the spring. Generally, wet weather events take place only for a day or two, followed by fair skies. Snowfall is most prevalent in January and early March, with annual snowfall amounts averaging 9.2 inches (NWS 2011). In addition to local precipitation, rain and snowfall events throughout the Arkansas River watershed can impact flow conditions in the Tulsa area.

Large hail and windstorms may occur throughout the year, but are most common in spring and early summer. Typically these storms create scattered damage. Oklahoma has a very high level of tornado activity, with an average of 53 tornadoes a year state-wide, with an average of 12 in Tulsa County per year (NWS 2011b).

Federal guidance and direction regarding climate change evaluation is currently in flux. Several Executive Orders (EO) have been issued in recent years that direct federal agencies to address climate change and Green House Gas (GHG) emissions with emission reductions and preparedness planning and implementation. President Obama issued EO 13653, preparing the U.S. for the Impacts of Climate Change in 2013, which was rescinded by President Trump's EO 13783, Promoting Energy Independence and Economic Growth in 2017. EO 13693, Planning for Federal Sustainability in the Next Decade (2015) requires federal agencies to meet emission-reducing goals associated with energy use, water use, building design and utilization, Fleet vehicles, and procurement and acquisition decisions.

Federal agencies are required to consider GHG emissions and climate change in environmental assessment in accordance with NEPA. On August 1, 2016, the CEQ issued final guidance on the consideration of GHG emissions and climate change in NEPA review, however, EO 13783 directed the CEQ to rescind that guidance. At the same time, case law in the Ninth Circuit still requires climate change analysis: "The impact of greenhouse gas emissions on climate change is precisely the kind of cumulative impacts analysis that NEPA requires agencies to conduct" (Center for Biological Diversity v. National Highway Traffic Safety Administration, 538 F.3d 1172, 1217 (9th Cir. 2008). As the previous air quality section describes, the study area reached attainment for ozone in 1990. The state of Oklahoma, including the study area, has maintained the status to this day. Consistent with case law, an analysis of climate change impacts was conducted for this EA.

The USACE Climate Change and Hydrology Literature Synthesis for the Hydrologic Unit Code (HUC) 11 that encompasses the project area was reviewed to get a summarization of the observed and projected climate trends within the region. The climate change analysis is included as Appendix N.

Observed rainfall trends have been widely reported for the Water Resources Region within HUC 11 (Arkansas, White and Red Rivers Region 11). The literature is inclusive of the region, but not specific to it. For the general project area, rainfall trends show an increase of 0 to 20 percent. A regionally focused study over a similar time period found an increase in precipitation of 6 to 20 percent. In terms of intensity, trends in the project area show that the rainfall events have slightly increased in intensity. The overall trend in the mean projected annual maximum monthly streamflow increases over time is shown in Figure 5 of Appendix N. This finding suggests that there is potential for annual maximum monthly streamflow to increase in the future in the study area, relative to the current conditions. According to the Vulnerability Assessment, historic temperature change in the project area is minimal based on a comparison of the average temperature from 1901-1960 and the average temperature from 1991-2012. However, temperature projections show that nationwide, the average temperatures are expected to rise.

A series of climate projection models were accessed from an archive maintained as a collaboration of the U.S. Bureau of Reclamation, Climate Analytics Group, Lawrence Livermore National Laboratory, Santa Clara University, Scripps Institution of Oceanography, USACE, U.S. Geological Survey, and the National Center for Atmospheric Research to develop the projected

temperatures. The *Fifth Assessment Report of the Intergovernmental Panel on Climate Change* (Romero-Lankao et al. 2014) also indicates very likely increases in mean annual temperatures exceeding 2 degrees Celsius over North America by the mid to late 21st century. Precipitation models indicated a likely increase in precipitation over Canada and Alaska, while very few areas of the contiguous United States are expected to see significant change in mean annual precipitation. Projected climate changes are not anticipated to be a significant factor for the project area.

2.4 Water Resources

This section characterizes the surface water and groundwater resources of the study area as well as the quality of these waters.

2.4.1 Surface Water

The Arkansas River drains approximately 75,700 square miles (mi^2) upstream of the Tulsa, Oklahoma, vicinity, of which nearly 50,000 mi^2 contribute to flows through Tulsa. The headwaters originate near Leadville, Colorado. The basin upstream of Tulsa is about 650 miles long and averages 150 miles wide, draining parts of Colorado, New Mexico, Texas, Kansas, and Oklahoma (Meshek, 2009a). The river corridor is characterized by a wide channel with large meanders, point bars, and braided channels through most of the study area, except for the pool behind Zink Dam. The active channel is wide and flat-bottomed with a representative channel width of 1,500 feet and a representative depth of 20 feet (USACE, 2011).

Using the United States Geological Survey (USGS) StreamStats topographic map viewer at a scale of 1:36,112, a total of 35 tributaries, 18 named and 17 unnamed, were identified within the 42-mile study area (USGS, 2016b). Tributaries are not only important hydrologic features, but they are ecologically significant due to the habitat diversity they provide. The named tributaries are perennial streams, whereas the unnamed tributaries are typically intermittent. The total number of tributaries equates to an average of one tributary every 1.2 miles along the study area.

Zink Lake is an impoundment pool on the Arkansas River formed as a result of the construction of the John Zink Dam, a low-water dam built in 1984. Zink Lake extends from 29th Street at the dam location, upstream to the Southwest Boulevard Bridge. The pool created by Zink Dam is relatively short, a little over 2 miles in length, and is broken into two pools by a shoal area about 1.2 miles upstream of Zink Dam. Recreational activities include fishing along the banks and on fishing piers along the dam as well as non-motorized boating, primarily rowing. Construction of the dam substantially affected the deposition of sediment in the streambed, resulting in greater deposits of sand and gravel within the area. The Arkansas River channel at Zink Lake is approximately 1,500 feet wide at bank full stage. The River Parks Authority, an organization created by the City of Tulsa and Tulsa County, is currently authorized and permitted to excavate and relocate sands within the Arkansas River channel as part of the Zink Lake and Zink Dam maintenance program for the reoccurring sediment accumulation in Zink Lake.

Surface waters are further described below in sections 5.0 and 6.0 below.

2.4.2 Groundwater

Oklahoma's Groundwater Monitoring and Assessment Program (GMAP) includes a network of approximately 750 wells on Oklahoma's 21 major aquifers which would be fully integrated by

2017 and sampled on a five-year rotation (OWRB, 2017). Assessments of Oklahoma's groundwater include both a baseline monitoring network and a long-term (trend) monitoring network within each of the state's major aquifers. The study area is within the 2,223 km^2 Arkansas River aquifer (Alluvial & Terrace) which extends from north central to east central Oklahoma, has an estimated capacity of 946,000 acre-feet for which its primary uses are irrigation, public supply, domestic, and industrial (OWRB, 2015). The September to October 2014 baseline sampling included 29 groundwater quality sites and 22 water level sites. Maximum contaminant levels (MCLs), set by the EPA under the Safe Drinking Water Act, include primary MCL's to address health concerns and secondary MCL's to address concerns like taste and odor. The GMAP for the study area found some elevated MCL's for Total Dissolved Solids (mg/L), dissolved Iron (µg/L), and dissolved Manganese (µg/L) (OWRB, 2015).

The alluvial aquifer along the Arkansas River in the study area ranges in thickness from 20 to 40 feet. The alluvium consists of relatively permeable coarse sand and fine gravel overlying bedrock, which is in turn overlain by floodplain deposits of silt and fine sand (Marcher and Bingham, 1971). Bedrock is composed of low-permeability shale. It is reasonable to assume there is little groundwater transfer between the shallow alluvial aquifer and deep regional aquifers in the study area (CH2M 2010b). Based on depth-to-water data from some well completion reports in the area, the water table generally ranges from about 8 to 29 feet below grade. Of the 154 wells in the study area, 57 were identified as supply wells for commercial, domestic, industrial, irrigation, or public use. One of the wells was listed as a domestic well for a Sand Springs public school. The remaining wells were either dewatering/corrosion protection wells or monitoring wells/extraction wells, presumably installed for previous or ongoing water quality investigations in the area. Within the reach between Keystone Dam and Highway 97, a total of 20 wells were identified: 13 domestic, five irrigation, one used for soil evaluation, and one "other" (either commercial, corrosion protection, dewatering, industrial, observation well, public water supply, pump and treat, or water location).

2.4.3 Water Quality

Beneficial uses are designated to each of the state's waterbodies as a requirement of the Clean Water Act (CWA). For each waterbody, the designated beneficial uses have water quality criteria which are defined in the state's water quality standards (WQS) (Title 785 OAC). These criteria are designed to maintain a waterbody at a level necessary to meet its designated uses (OWRB 2016). The designated beneficial uses of the Arkansas River within the project area are the following (OAC 2009):

Emergency water supply

Fish and wildlife propagation – warm-water aquatic community

Agriculture

Secondary body contact recreation

Navigation

Aesthetics

If a waterbody does not meet the requirements as set forth in the state's WQS it is considered "impaired" and is listed as such on the CWA 303(d) List of Impaired Waters (OWRB 2016). The CWA requires that each state report its water quality on a biennial cycle. EPA Region 6 has approved Oklahoma's 2014 303(d) list of impaired waters. Table 1 provides a summary of the

last eight 303(d) lists for the main stem of the Arkansas River within the study area (e.g., Polecat, Bigheart, Fred, Haikey, and others).

For the river segments listed in Table 1, the "unconfirmed potential sources" of turbidity listed in the 2014 303(d) list are: grazing in riparian or shoreline areas, municipal point source discharges, rangeland grazing, and source unknown. Similarly, the potential sources of cadmium affecting the reach between Berryhill Creek and Cherry Creek are unknown. The bacteria TMDL developed for the two "Category 4a" Arkansas River reaches shown in Table 1 under the "2014 Final List" identify nonpoint sources, particularly commercially raised farm animals, to be the major origin of bacteria loading in the watershed (ODEQ 2008b).

The Indian Nations Council of Governments (INCOG) is the designated Water Quality Management Planning Agency for the Tulsa region. INCOG monitored summer flows and temperatures at eight sampling sites during extreme critical conditions in 2011, in the midst of the worst drought in Oklahoma's recorded history (INCOG 2012). The monitoring sites spanned the river reach from Highway 97 at Sand Springs to Highway 67 in Bixby. Releases from Keystone Dam were minimal to no flow for many days on end (INCOG 2012). The diurnal sampling study revealed that even under the extreme and unprecedented critical conditions during August 2011, the minimum dissolved oxygen (DO) concentrations at all eight sites measured at dawn were greater than the minimum DO WQS for summer of 5.0 milligrams per liter (mg/L). INCOG noted, "This is likely due to super-saturated water from the previous day's high DO concentrations of around 120 percent to 140 percent at most sites, along with the continuous flow of around 100 cfs of very shallow water frequently tumbling over bedrock and large rocks causing mechanical aeration from the air."

Low concentrations of carbonaceous biological oxygen demand and ammonia-nitrogen were measured during the summer 2011 diurnal study, indicating low levels of organic material from sewage and stagnant areas (INCOG 2012). INCOG reported, "This is likely because all wastewater treatment plants within the project area are performing well, and even under the extreme summer conditions of 2011 there still was a residual base flow in the river of around 100 cfs that likely prevented stagnation of pools and the consequent collection of organic materials." In the absence of typical scouring flows associated with generation, noticeable amounts of attached algae were observed at all eight sampling sites (INCOG 2012).

INCOG (2012) concluded that while their studies indicate a river that is returning to full beneficial use attainment, there are continuing indications of water quality issues that need to be addressed in the future. These indicators were identified as bacteria, metals, and nutrients. INCOG also noted that the extent of future reductions in the bacteria loading would depend upon the effectiveness of bacteria reduction programs in the watershed. Finally, INCOG's diurnal study indicated that, under prolonged periods of relatively low flows (mostly < 1,000 cfs), there is an abundance of attached algae in the river which increases DO during daylight and utilizes DO after dark.

Table 1: Summary of 303(d) Lists for the Arkansas River within the Study Area – 1998 through 2014

River Segment	Location	1998 Final List	2002 Final List	2004 Final List	2006 Final List	2008 Final List	2010 Final List	2012 Final List	2014 Final List
OK120420010130_00	Keystone Dam to Berryhill Creek	303(d) - metals, pathogens, pesticides, priority organics	Category 2	Category 2	Category 2	Category 5a - oil and grease, TDS	Category 5a - turbidity, thallium, oil and grease	Category 5a - turbidity, oil and grease Category 4a - enterococcus	Category 5a - turbidity
OK120420010010_10	Berryhill Creek to Cherry Creek	303(d) undivided - metals, pathogens, pesticides, priority organics	Not listed in 2002 Integrated Report	Category 3	Category 5a - cadmium, fecal coliform	Category 5a - cadmium, fecal coliform	Category 5a - cadmium, fecal coliform	Category 5a - cadmium	Category 5a - cadmium
OK120420010010_00	Cherry Creek to Snake Creek		Category 5 - lead	Category 5 - enterococcus, E. coli, fecal coliform	Category 5a - enterococcus, E. coli, fecal coliform	Category 5a - fecal coliform, enterococcus, TDS, lead, oil and grease	Category 5a - turbidity, thallium, oil and grease (bacteria TMDL completed)	Category 5a - turbidity, oil and grease Category 4a - Enterococcus	Category 5a - turbidity Category 4a - enterococcus
OK120410010080_10	Snake Creek to Broken Arrow Creek	303(d) undivided - pathogens, pesticides, priority organics	Category 3	Category 3	Category 5a - fecal coliform	Category 5a - fecal coliform	Category 5a - fecal coliform	Category 2 (delisted fecal coliform)	Category 2
OK120410010080_00	Broken Arrow Creek to Muskogee Creek, North		Category 5 - pathogens, TDS	Category 5 - TDS, turbidity, enterococcus	Category 5a - TDS	Category 5a - enterococcus, TDS, oil and grease	Category 5a - thallium, oil and grease (bacteria TMDL completed)	Category 4a - enterococcus	Category 4a - enterococcus

Source: INCOG 2015.

TDS = total dissolved solids
TMDL = total maximum daily load

Notes:

Category 2 = Attaining some of the designated uses; no use is threatened; and insufficient or no data and information is available to determine if the remaining uses are attained or threatened.

Category 3 = Insufficient or no data and information to determine if any designated use is attained.

Category 4a = Impaired or threatened for one or more designated uses by a pollutant(s), but a TMDL has been completed.

Category 5 = Impaired or threatened for one or more designated uses by a pollutant(s), and requires a TMDL.

Category 5a = TMDL is underway or will be scheduled.

2.5 Hydrology and Floodplains

2.5.1 River Hydrology

The study has the potential to effect the hydrology and floodplains of the Arkansas River Corridor downstream of Keystone Dam to the Tulsa County line. The river originates from headwaters near Leadville, Colorado, and flows 1,450 miles through Colorado, Kansas, Oklahoma, and Arkansas to the confluence with the Mississippi River. The Arkansas River was once an uncontrolled prairie river but over the past century has been affected by anthropogenic activities. With completion of Keystone Dam in 1964, river dynamics below the dam changed.

Based on USGS daily average discharge data following the construction of Keystone Dam in 1964, the median daily average flow is approximately 4,000 cfs at the Tulsa gage (located on the 11th Street Bridge near downtown Tulsa), and approximately 5,200 cfs at the Haskell gage (located on the State Highway 104 Bridge near Haskell, Oklahoma). The annual mean flow at these locations is approximately 8,400 and 10,100 cfs, respectively. Instantaneous annual peak flows near Haskell are typically about 3,000 cfs greater than those measured at the Tulsa gage. However, the magnitude of the difference has varied widely. For example, the peak flow rate at Haskell exceeded that at Tulsa by 29,000 cfs during the event of March 3, 1990. Conversely, during the event of October 5, 1986, the peak at Haskell was 48,000 cfs less than the peak at Tulsa.

The Federal Emergency Management Agency (FEMA) Flood Insurance Study for Tulsa County and incorporated areas lists several peak discharges associated with a probability of occurrence in any given year for the Arkansas River in the Tulsa area (FEMA, 2016a). These peak discharges are:

- 10-percent (10-year event): 90,000 cfs
- 2-percent (50-year event): 155,000 cfs
- 1-percent (100-year event): 205,000 cfs
- 0.2-percent (500-year event): 490,000 cfs

The 10-year event of 90,000 cfs is equal to the maximum lake regulating discharge normally expected from Keystone Lake. The channel capacity downstream of Keystone Dam is currently estimated at 105,000 cfs. The current release range from Keystone is 0 to 105,000 cfs. However, releases may be modified to meet requirements of the Arkansas River system operating plan. When the Arkansas River is below channel capacity, and releases from Keystone Dam are increasing, the maximum increase is 15,000 cfs, and the minimum time between changes is 2 hours. When the Arkansas River is below channel capacity, and releases from Keystone Dam are decreasing, the maximum decrease is 15,000 cfs, and the minimum time between changes is 3 hours.

Monthly mean flows in the Arkansas River are typically higher during the spring and summer months compared to the fall and winter. From March through July, the long-term average monthly mean flows exceed 10,000 cfs at both Tulsa and Haskell. From August through February, the long-term average monthly mean flows are less than 8,000 cfs. The smallest difference in a given month between the long-term maximum and minimum monthly mean flows occurred in December and was nearly 17,000 cfs. Conversely, the largest difference occurred in May and exceeded 80,000 cfs. The monthly mean flows at Arkansas City are slightly higher during the spring and summer months compared to fall and winter. However, the relative

magnitude of the flow difference between seasons is much less dramatic than observed at Tulsa and Haskell.

A significant characteristic of the river hydraulics in the study area are high-frequency, large amplitude flow fluctuations resulting from the operation of Keystone Dam. Flows within the study area regularly fluctuate up to nearly two orders of magnitude within time intervals as short as 24 hours. Flood pool and hydropower releases temporarily provide beneficial river flow in the study area. Figures 3 and 4 in Appendix J (H and H) further display the existing flow regime in the ARC.

Another significant effect of Keystone Dam on the Arkansas River has been a reduction in the downstream sediment supply. The mean annual suspended sediment concentration decreased by 82 percent from 1,970 mg/L (1931-1964) to 350 mg/L (1965-1995) at the Tulsa gage. Similarly, the mean annual suspended sediment flux decreased by 73 percent from 14.7 to 4.0 megatonnes after completion of the dam. The Haskell gage station exhibited a similar post-dam pattern of annual fluxes, with the Haskell station always having a greater annual flux than that measured at the Tulsa station.

2.5.2 Floodplains

Floodplains are the normally dry land areas adjoining surface waters that are inundated during flood events. The 100-year floodplain includes that area subject to a 1 percent chance of flooding in any given year. The 500-year floodplain of a stream is that area subject to a 0.2 percent chance of flooding in any given year. Areas within the designated floodplains may be subject to more frequent flooding than the assigned risk would indicate. FEMA Flood Insurance Rate Maps (FIRMs) were reviewed to determine the relationship between the study area and FEMA-designated floodplains. Most regions in the study area are designated as either “AE” (high risk areas) or “X” (moderate to low risk areas) (FEMA, 2011). Levees reduce the risk of flood damages in several areas throughout the study area.

2.5.3 Levees

The Levee District of Tulsa County snakes along 20 miles of the Arkansas River. It was built in the 1940s. Clay pipes and porous relief wells are buried beneath the green berms. Between 1938 and 1985, USACE constructed five levee systems along the Arkansas River and tributary creeks in Tulsa County (Tulsa-West Tulsa Levee systems). Beginning in 1945 the levees were transferred to local county governments for long-term operation, maintenance, repair, rehabilitation and replacement. The three disconnected levees are known as Levees “A,” “B,” and “C” with Levees “A” and “B” running along the left bank and Levee “C” along the right river bank. The 7.8-mile Jenks Levee is divided into two adjoining sections which make a continuous levee. The Jenks Levee is located on the right bank of the Arkansas River, immediately upstream from the confluence of Polecat Creek.

The Jenks Levee protects approximately 1,540 acres of the town of Jenks and Tulsa County from floods on the Arkansas River, Polecat Creek, and Hager Creek, which is a tributary of Polecat Creek. It is estimated that the Jenks Levee protects property valued in excess of $400,000,000; a population of 18,670; and includes numerous residences, businesses, and the Jones Riverside Airport. The Tulsa County Levee Drainage District No. 12 and the Jenks Levee District protect approximately 6,500 acres; 10,000 residents; and estimated $2 billion worth of infrastructure in Sand Springs, West Tulsa, and Tulsa County.

The Jenks Levee system includes a pump station, a sewage lift station, and a railroad opening to be closed with sandbags during flood periods. The levee provides protection with 1.5 feet of freeboard against a flood on the Arkansas River of 350,000 cfs (Tulsa County, 2016a). Tulsa County Drainage District No. 12 is responsible for providing operation and maintenance for over 20 miles of levee system. The District No. 12 levee system includes seven pump stations and five stop log structures with 11.8 miles located on the left bank of the Arkansas river and 7.9 miles located on the right bank.

2.6 Riverine Resources

Natural communities in the study area can include wetlands, intermittently and permanently inundated open water, and riverine sandbars. Detailed descriptions of these areas are provided in Appendix B.

Riverine, wetland, and sandbar habitats are difficult to quantify in the study area due to frequent changes is river flow and river morphology as described in the section 5.1. In the absence of flood pool and hydropower generation releases, the reoccurring no/low flow periods reduce the rivers extent to narrow reaches, isolated pools, largely exposed riverbeds, and land bridge sandbars islands to shoreline disturbances. Aquatic connectivity to side channel and back water wetlands is reduced as river flow and extent recedes to the lower elevations of the river channel. Backwater wetland abundance, function, and longevity are highly dependent on water regime. Without continued river flow and inundation, aquatic communities are limited. As shown in Figures 3 and 4 of Appendix J (H and H), breaks in water releases occur for several hours on week days, two to three days over weekends when no hydropower production generally occurs, and between flood pool releases as dictated by flood risk management operations at Keystone Dam.

These interruptions in water releases expose and diminish riverine resources that depend on continued inundation and river flow. The no/low flow conditions occur frequently enough, that the extent of the no/low flow conditions dictate overall aquatic ecosystem habitat extents, structure, function, and health. Figures 5 and 6 of Appendix J show the extent of remaining riverine habitat during no/low flow conditions.

Because the extent of shoreline and backwater wetlands and sandbar habitats are largely driven by river flow in the ARC, in channel aquatic habitats were mapped and modeled as riverine habitat. Two exceptions, Prattville Creek and I-44/Riverside locations, were made as they presented opportunities to restore wetland functions.

The sections below describe aquatic habitats that can be present during various stages of river flow.

2.6.1 Wetlands

The study area contains minimal herbaceous wetland communities. They can be found in limited abundance and durations along the banks of the Arkansas River and in low-lying areas in the floodplain during extended flood pool release periods that promote aquatic vegetation growth. Outside of these periods, the extent of inundation from the no/low flow conditions is limited to the Arkansas River's sandy riverbed brief stretches of shoreline as the river meanders through the ARC.

When present these communities include emergent herbaceous wetlands and riparian shrub wetlands. Emergent wetlands are characterized by rooted, herbaceous hydrophytes, typically in flooded soils. Emergent wetland habitats provide food and shelter for fish and a number of other species, including macroinvertebrates, which make up the foundation of the aquatic food chain. These wetland areas also provide habitat for a variety of amphibians, reptiles, birds, and insects. Frogs and salamanders use these wetland areas for breeding grounds and for egg-laying. Ducks and migratory birds use them for resting areas on migration routes and for nesting. Abundant aquatic insects provide a food source for fish, aquatic invertebrates, amphibians, reptiles, and birds, and break down organic material present in riverine and riparian wetland areas common throughout the study area. Since these wetland communities are found in the lower elevations of the river, or are associated with more permanent open water habitats, they have been the most susceptible to the impacts from the disruptive and unnatural flow regime regarding the construction and operation of Keystone Dam.

Riparian shrub wetlands are open, occasionally flooded areas dominated by shrub and hardwood saplings mixed with emergent herbaceous vegetation. Riparian shrub wetlands provide shelter, food, and nesting habitat for a variety of wildlife. These wetland communities are found at elevations slightly above the emergent wetland communities and adjacent to the river banks where less frequent inundation by flows and reduced scour allows for the shrub and sapling strata to become established.

While hydropower operations provide periodic river flow, without additional water releases the frequent drying of aquatic habitats has an unnatural flooding and drying cycle effect on aquatic habitats that serve as nurseries for juvenile fish and habitat for migrating waterfowl, producing an overall reduction in the diversity of the species utilizing these habitats. The periods of high flows followed by low flows further affect the geomorphology of the river producing increased streambank erosion and the destruction of riverine wetlands and oxbow habitats, further reducing the availability of productive habitats (USACE and TVA, 2009). Wetland habitats located within the active river channel are dominated by emergent herbaceous communities. These communities are more prone to structural instability from rapid changes in the flow regime making their size and placement in the river corridor more transient. Wetland soils and emergent vegetation are subject to habitat smothering from changes in river geomorphology. Frequent desiccation also reduces the formation of wetland soils and selects for early successive invasive species such as Johnson grass (*Sorghum halepense*) which impact vegetation strata.

2.6.2 Open Water

Open water habitats in the main stem of the Arkansas River channel include riffle, run and pool complexes, isolated pools, and reservoir pools (Keystone Lake and Zink Lake). The riffle, run and pool complexes are features typical of a prairie river system. They are braided and relatively nonpermanent features that become repositioned within the river channel during higher-flow conditions. Isolated pools of open water are less common throughout the study area. They include features created through natural processes such as oxbows, which are relics of meandering riffle, run and pool complexes, and those created through anthropogenic activities such as sand mining and at locations below stormwater outfalls entering the river. Many of these isolated pools are temporary as braided riffle, run and pool complexes meander under various river flow conditions and as riverine sandbars shift and are redeposited. The more persistent pools are found adjacent to the river channel banks and are connected to other

surface waters under higher river stages. Many of these have emergent and shrub wetland vegetation, creating a littoral fringe that helps to stabilize the substrate. Water quality within the more persistent pools is typically low due to stormwater inputs and little to no mixing with other surface waters. Substrates within these pools includes sand and organic sediments.

The open water habitats within the study area support a valuable recreational and subsistence fishery to area residents. Additionally, populations of smaller fishes that are suitable forage species for shore birds and wading birds are relatively abundant in these habitats. These smaller forage fishes are most abundant in pool runs, Zink Lake, and temporary and permanent isolated pools within the river channel. Their local seasonal abundance depends on river flows, connections of pools to other river channel surface waters, and water quality. Listed species that forage in the open water habitats include the Least Tern, Piping Plover (*Charadrius melodus)*, and Red Knot (*Calidris canutus rufus)*. Some listed species may forage along the sandbars and pools at the stream confluence with the Arkansas River, but use of the stream habitat further up the stream channel into the urbanized watershed is unlikely.

2.6.3 Riverine Sandbars

Riverine sandbars dominate the river channel habitats during lower-flow conditions. The riverine sandbars' size, location, and stability are a function of the controlled flow conditions of the Arkansas River through releases from the Keystone Dam. During typical river stage conditions (less than 12,000 cfs), the sandbars within the study area are dry and not inundated by surface water. During higher river stage conditions, the sandbars are partially or fully inundated by surface water.

Riverine sandbar habitats within the study area are mostly unvegetated and subject to cycles of scour and deposition. At slightly higher elevations nearer the river banks, the riverine sandbars are less frequently inundated by surface waters and become more vegetated. Vegetation where established along the banks is typically herbaceous, shrubs, or smaller trees such as black willow, sandbar willow, buttonbush, sycamore, and big bluestem The invasive species Johnson grass is abundant in these communities. The highest elevations within the riverine sandbar habitats include the bank slopes of the Arkansas River. The majority of the riverbanks are steep to near vertically sloped with areas that are sloughing and/or eroding or are reinforced with riprap or concrete rubble.

The primary ecological functions that the riverine sandbars provide within the study area include floodwater attenuation during high river stage events; source of sediments for downstream habitats; habitat for listed species; and foraging habitat for wading birds, waterfowl, and terrestrial species.

In the study area, riverine sandbars have potential to provide habitat for three federally listed species: the Least Tern, Red Knot and the Piping Plover. Although the sighting of a Red Knot or Piping Plover in the ARC would be a rare occurrence.

2.7 Biological Resources (Fish and Wildlife)

This section summarizes the fish and wildlife found in the study area based on the Biological Resources Report provided as Appendix B. Descriptions of the species designated as threatened or endangered are presented in the next section. Insects associated with open water and emergent habitats of the Arkansas River Corridor include True Flies (order Diptera), Mayflies (order Ephemeroptera), Caddisflies (order Trichoptera), Dragonflies and Damselflies

(order Odonata), and Beetles (order Coleoptera). Many species of reptiles and amphibians inhabit the riparian bottomland forests and emergent wetlands along the Arkansas River, with amphibians being more prevalent in the wetland areas and other aquatic habitats. Bird species commonly found in forested habitats surrounding the study area include Pileated Woodpecker (*Dryocopus pileatus*), Belted Kingfisher (*Ceryle alcyon*), Wood Duck (*Aix sponsa*), Herons and Egrets (*Ardea* spp. and *Egretta* spp.), Barred Owl (*Strix varia*), and Red-shouldered Hawk (*Buteo lineatus*). Birds common in the wetland areas are similar to those that occur in upland forested habitats, particularly waterfowl such as Herons, Egrets, and Cormorants (*Phalacrocorax* spp.).

A seasonal fisheries survey of the study area conducted by Oklahoma Department of Wildlife Conservation biologists from October 2006 through September 2007 reported the occurrence of 41 species of fish in 12 families (Cherokee CRC 2009). Of these reported species, four are listed as invasive exotics: Grass Carp (*Ctenopharyngodon idella*), Common Carp (*Cyprinus carpio*), White Perch (*Morone americana*), and Flathead Catfish (*Pylodictis olivaris*). The families represented by the most species were Sunfish (*Lepomis* spp.; nine species), Carp (family Cyprinidae) and Minnows (eight species), and Suckers (seven species). The principal sport fishes collected included Largemouth Bass (*Micropterus salmoides*), Spotted Bass (*Micropterus punctulatus*), Striped Bass (*Morone saxatilis*), Channel Catfish (*Ictalurus punctatus*), Flathead Catfish, White Crappie (*Pomoxis annularis*), a variety of Sunfish, and Sauger (*Sander canadensis*). Recent occurrences (2015) of paddlefish in the Arkansas River in Tulsa County have also been reported. Numerous paddlefish were observed in pools below Zink Dam in late summer and early fall 2015, following elevated river stages throughout most of the summer, which likely allowed the paddlefish to travel farther upstream than during typical river stages.

Overall native fish populations have been adversely impacted from the construction of Keystone Dam through a combination of operational changes in flows and the introduction of non-native game fish which better tolerate the altered aquatic ecosystem following the construction of Keystone Dam. Wetland and open water nursery habitats for juvenile fish have been reduced from periods of desiccation followed by higher flows which destabilize wetland soils and vegetation strata. Introduced game fish species are more tolerant of the altered in-stream aquatic habitats (USACE and TVA, 2009).

Appendix B notes that the most common aquatic macroinvertebrate species collected were Chironomids (midges), Naiads (dragonflies and mayflies), Hyalellans (amphipods), and Daphnia (water fleas). Freshwater mussels with the potential to occur within the action area of the Arkansas River and its tributaries include White Heelsplitter (*Lasmigonia complanata*), Fragile Papershell (*Leptodea fragilis*), Giant Floater (*Pyganodon grandis*), Pink Papershell (*Potamilis ohiensis*), and Mapleleaf (*Quadrula quadrula*) (Eagle Environmental Consulting, Inc. 2008). However, according to the USGS Nonindigenous Aquatic Species database, there is also an established (reproducing and overwintering) population of Zebra Mussels (*Dreissena polymorpha*) in the Polecat Snake Watershed as well as downstream within the Arkansas River Corridor (USGS 2016; ODWC 2012).

2.8 Threatened and Endangered Species

Table 2 summarizes the federally listed species that have been identified as potentially present in the study area. Summary descriptions are provided in this section and detailed descriptions of

these species are provided in the Biological Resources Report in Appendix B, and the USFWS' Information for Planning and Consultation (IPaC) Official Species List and Trust Resources Report in Appendix I. Several Federally listed species have the potential to occur in the study area. However, only the Least Tern is expected to occur in the study as is it known to annually nest on sandbar islands in the ARC.

Table 2: Potentially Occurring Federally Protected Species within the Study Area

Name	Scientific Name	Federal Protection Status	Habitat	Distribution
Birds				
Interior Least Tern	*Sternula antillarum athalassos*	Endangered	Sparsely vegetated sandbars	Major rivers within the central United States
Piping Plover	*Charadrius melodus*	Threatened	Sparsely vegetated flat sandy beaches, sandbars, and bare gravel islands	Migratory between Canada and the coast of the Gulf of Mexico
Red Knot	*Calidris canutus rufa*	Threatened	Sparsely vegetated flat sandy beaches, sandbars, and bare gravel islands	Migratory between the Canadian Artic and Tierra del Fuego, Chile
Insects				
American Burying Beetle	*Nicrophorus americanus*	Endangered	Level areas in grasslands, grazed pastures, bottomland forest, open woodlands, and riparian stream banks	Four states including Oklahoma, Rhode Island, Arkansas, and Nebraska
Mammals				
Northern Long-eared Bat	*Myotis septentrionalis*	Threatened	Roost in tree bark, tree cavities, mines, caves, and barns Forage along forested hillsides and ridges	Thirty-seven (37) states, including much of the eastern and north-central United States

Source: USFWS 2016.

2.8.1 Interior Least Tern

The interior population of Least Tern, one of three subspecies of Least Tern, is the smallest of the species in the tern family (Sternidae). The three subspecies of Least Tern are identical in appearance, morphology, habitat preferences, vocalization, and behavior and are distinguished only by their breeding ranges. The Least Tern is distinguished by being localized in the interior of the United States, where it breeds along major tributaries in the Mississippi River basin.

The U.S. Fish and Wildlife Service (USFWS) (1985a) lists the Interior population of the Least Tern as federally endangered. As of May 2015, critical habitat has not been designated for Least Tern (USFWS 2015a). Tulsa County is located within the probable migratory path for Least Terns and provides stopover habitat. Since 2005, USACE Tulsa District has annually monitored Least Terns in the Arkansas, Canadian, and Red rivers, in accordance with the USFWS 2005 Biological Opinion on the effects of USACE multipurpose projects. There are documented occurrences, including breeding and nesting activities, of the Least Tern in Tulsa County. See Appendix B for distribution of Least Tern nesting information within the Arkansas River corridor.

Least Terns nest in colonies on barren to sparsely vegetated sand and gravel bars within braided streams and rivers, as well as on man-made structures (such as inland beaches, wastewater treatment plants, and gravel mines). The terns prefer open, unobstructed areas rather than thick vegetation. The forage fish base for Least Terns is typically most abundant in shallow, flowing riverine habitats. Additionally, Least Terns tend to forage no farther than about two miles from their nest sites, although some may fly up to four miles to fish (USFWS, 1990).

The distribution of Least Terns began to decline in the early 1900s due to widespread alteration of its riverine habitat (USFWS, 1990). Much of the sandbar habitat was compromised by stream channelization, irrigation, and the construction of dams such as Keystone. Keystone Lake traps the sediments that would maintain downstream island habitat for Least Terns leading to a decline in the quantity of sandbars suitable for Least Terns (USACE and TVA, 2009).

While the species continues to breed in river systems such as the Arkansas River, its distribution has become more restricted due to widespread alteration of its riverine habitat (USFWS, 1990). The manipulation of river flow can destroy or alter sandbars, preventing the creation of new river island habitat. Increased flow can wash away nests and chicks, and sand mining within the Arkansas River Corridor has removed Least Tern habitat. The Keystone Dam has also reduced scouring stream flows and allowed for the encroachment of vegetation on sandbars, reducing the quality of the habitat for Least Tern nesting despite efforts to clear the vegetation annually.

Low flows during the nesting season (approximately April to August) contribute to terns nesting at lower elevations which increases the potential for those nests to be flooded during periods of higher flows. Lower flows result in land bridging which increases predator access to Least Tern nests.

2.8.2 Piping Plover

The Piping Plover is a migratory shorebird listed as endangered in the watershed of the Great Lakes and threatened in the remainder of its range (the Northern Great Plains, Atlantic coast, Gulf coast, Bahamas, and West Indies) (USFWS 1985b). USFWS (2016a) identifies Tulsa County as “situated within the probable migratory pathway between breeding and winter

habitats [of the Northern Great Plains population], and contain[ing] sites that could provide stopover habitat during migration." The Northern Great Plains population of Piping Plover spends up to 10 months a year on its wintering ground along the Gulf coast and arrives on prairie breeding grounds in early May. During migration periods, they utilize large rivers, reservoir beaches, mudflats, and alkali flats (Haig 1986; Schwalbach 1988). They feed on a variety of aquatic and terrestrial invertebrates. The sandbars and bare gravel islands along the Arkansas River within the study area could provide suitable habitat during the plovers' spring and fall migrations (USFWS 2011).

2.8.3 Red Knot

The Red Knot is a migratory shorebird listed as threatened wherever it is found (USFWS 2016a). Although sightings are rare, Tulsa County is listed as a location where the Red Knot is "known or believed to occur" and is located within the probable migratory path, between breeding in the Arctic tundra and winter habitats in the southern United States and Central and South America (USFWS 2015c). Red Knots forage along sandy beaches and mud flats, and this species may use the study area for temporary stopover and foraging. The sandbars and bare gravel islands along the Arkansas River within the study area could provide suitable habitat during the Red Knot's spring and fall migrations.

2.8.4 American Burying Beetle

The American Burying Beetle is a member of the family Silphidae (carrion, or Burying Beetles) and is the largest species of *Nicrophorus* in North America. USFWS (1989) lists the American Burying Beetle as Federally listed. Existing populations of this species includes eastern Oklahoma and the study area. The presence of the species has been documented in Tulsa County within the last 15 years (USFWS 2010). The American Burying Beetle is known to inhabit level areas in grasslands, grazed pastures, bottomland forest, open woodlands, and riparian areas. Wetlands with standing water or saturated soils and vegetation typical of hydric soils and wetland hydrology are listed by USFWS (2015d) as unfavorable habitats. American Burying Beetles are habitat generalists; however, it is thought that undisturbed habitat and the availability of carrion is the most likely influence on species distribution (USFWS 1991).

2.8.5 Northern Long-eared Bat

USFWS lists the northern long-eared bat threatened wherever it is found (USFWS 2016c). It was federally listed in 2015 following studies that revealed a decline in populations from the spread of white nose syndrome. USFWS service lists Tulsa County as a location where northern long-eared bats occur (USFWS 2016a). Most northern long-eared bats seasonally migrate between winter hibernacula and summer maternity or bachelor colonies. Roosting may take place in tree bark, tree cavities, caves, mines, and barns. Northern long-eared bats forage along forested hillsides and ridges near roosting and hibernating caves. They emerge at dusk and feed on various insect species such as moths, flies, leafhoppers, caddisflies, and beetles from vegetation and water surfaces (USFWS 2016c).

2.9 Cultural Resources

Cultural resources include buildings, structures, sites, districts, and objects eligible for or included in the National Register of Historic Places (NRHP), cultural items, Indian sacred sites, archaeological artifact collections, and archaeological resources. Details on the cultural history of the region and background research can be found in Appendix C.

A review of the Oklahoma Archeological Survey (OAS) maps and existing information indicates numerous known sites within a ¼ mile buffer of the 42 mile stretch of river, but also indicates significant tracts of land remain unsurveyed. The known archeological, cultural, and historical sites inventory includes artifact scatters, deeply buried deposits, historic homesteads, farms, missions, cemeteries, and a levee system. The majority of the previously recorded historic properties are not located in areas where any disturbance associated with the currently proposed measures would occur.

Table 3, Table 4, and Table 5 summarize previously recorded archaeological and architectural resources within the study area, as well as a list of reports from previous investigations within the study area.

Table 3: Archaeological Sites within 0.25 mile of the Project Area

Site No.	Site Name	Site Type	NRHP Eligibility	Date Recorded	Description
TU-200	None	Historic	Ineligible	Unknown	Twentieth Century Refuse Dump
TU-197	Holt Bison Skull	Pre-contact	Undetermined	Unknown	Bison skull with stone point embedded, dating to 5100 Before Present

Table 4: Historic-era Properties within 0.25 mile of the Project Area

Site Name	NRHP Eligibility	Date Listed	USGS Quadrangle	Report
Sand Springs Levee/Tulsa County Levee District 12	Undetermined	N/A	Sand Springs	N/A

Table 5: Cultural Resource Investigations within the Project Area

Project	Date	Area (Acres)	Resources Recorded	Report Author
A Cultural Resources Investigation of Three Low Water Dams Along the Arkansas River	October 2014	46.18	34TU200	R. Feit, B. Darnell
Archaeological Survey Report for the Creative Educational Media Corp Keystone Dam Tower Site	6/24/2014	0.91	None	J. R. Holt
Oklahoma Department of Transportation Cultural Resources Survey Report	1/7/2011, 1/20/2011	1.54	4 pre-1966 buildings, 1 pre-1966 structure	L. O'Shea, A. Eddings
Oklahoma Department of Transportation Cultural Resources Survey Report	1/7/2011	1.75	None	A. Eddings
Cultural Resources Survey of Proposed Bridge Repair on U2-64 Over Euchee Creek	4/13/2010	2.37	None	S. Sundermeyer
Archaeological Survey Report on the Cingular Wireless West Fisher Cellular Tower Project	3/30/2005	1.38	None	J. Briscoe
Emergency Bank Protection Survey by USACE	1/7/1993	0.97	Unknown	N/A
INCOG CAP Survey	7/30/1992	8.07	Unknown	N/A
Indian Electric Cooperative CAP Survey	6/12/1991	2.45	None	N/A
A Subsurface Survey […] Conducted for Indian Electric Cooperative of […] Oklahoma	3/21/1988	4.67	34PY69	D. N. Brown
Shenandoah Development Sand Springs CAP Survey	1/25-1/28/1983	318.72	34TU60, 34TU61, 34TU62, 34TU63	C. Neel, L. Neal

2.10 Land Use, Recreation, and Transportation

2.10.1 Land Use

Land use within the 42-mile study area corridor reflects the industrial history of the Arkansas River and includes Keystone Dam, the Tulsa-West Tulsa levee system, Zink Dam, multiple large refineries, steel mills, seven wastewater treatment facilities and rail/oil/ gas pipeline corridors as well as active sand-mining within the Arkansas River itself. The study area is in Tulsa County and includes the cities of Bixby, Broken Arrow, Jenks, Sand Springs, and Tulsa. A land use inventory performed in 2005 of the Arkansas River and a 0.5-mile buffer on either side of the

center of the river from Keystone Dam southward to the Tulsa/Wagoner County line, found that over one-third was used for cropland and pasture. Almost a quarter of the land was in some type of developed use such as residential or industrial (Guernsey 2005). Prime farmlands are also present in the study area, as defined by the U.S. Department of Agriculture (USDA); however, they tend to be more prevalent in the southern extent. The most recent soil survey for Tulsa County found that approximately 126,000 acres, or 34 percent of the county, meets the requirements for prime farmland (USDA 2000).

Lands adjacent to the study area are generally a mix of forests and woodlands, introduced and semi natural vegetation, or agricultural uses with the exception of those developed within the City of Sand Springs. The less developed character of the study area is partially due to the existing flowage easements and fee lands held by USACE as a result of the original reregulation dam which is still a component of the Keystone Dam Project. Notable land uses include Keystone Dam and adjacent recreation lands; recreational vehicle and mobile home parks; and the City of Sand Springs' Sand Creek Lagoon System, which is located on the northern bank of the river approximately 2.4 miles downstream of the Dam (Sand Springs 2016). Just upstream, or west, of the Highway 97 Bridge on the northern side of the river are the Sand Springs River City Park and Case Community Center, which are described in the recreational resource section. Downstream and east of the Highway 97 Bridge, the northern bank becomes substantially more developed with the Sand Springs Petrochemical and Sheffield Steel Company (now closed) sites as well as the Sand Springs Water Treatment Plant at West 21st Street. The Sand Springs Sand and Gravel Company, located on the southern side of the river just upstream of the Highway 97 Bridge is one of three sand mining operations within the study area. The balance of the southern side of the river just downstream of the bridge is initially less developed, though paralleled by the Avery Drive/Burlington Norfolk Southern Railroad corridor. The lands directly adjacent to the study area are primarily zoned for agriculture or industrial uses, with the exception of a residential single family area near West 14th Street and a mix of commercial, single family, and multi-family residential areas just south of the intersection of Highway 97 and the railroad corridor (INCOG 2013).

2.10.2 Recreation Resources

The 42-mile-long study area offers a wide range of existing water-based and land-based recreational opportunities. Lake Keystone, just upstream of the study area, is a regional recreation destination operated by USACE with 16 recreation areas, 11 boat ramps, 3 marinas, 2 off-road vehicle areas, 5 short distance trails, beaches, a waterfowl refuge, and thousands of acres of land open to public hunting. Within the study area, recreation is managed by three separate public agencies: the River Parks Authority (RPA), the City of Tulsa Parks Department, and the Tulsa County Park Department. RPA, which is a public trust created by the City of Tulsa and Tulsa County, manages and oversees the River Parks system of approximately 800 acres of land, including 41 miles of riverfront.

The Arkansas River, and the Keystone and Zink dam tailrace areas in particular, are popular destinations for fishing. Within the study area, access to the tailrace of Keystone Dam is provided from the shorelines of the White Water Off-road Vehicle (ORV) Park and the Brush Creek Recreation Area on the northern and southern shores, respectively. Swift Park, a Tulsa County day-use park, provides boat access from the southern side of the river approximately 0.5-mile downstream from Keystone Dam on Old Highway 51, while River City Park in Sand Springs offers a boat ramp on the northern side of the river. Brush Creek, a USACE-owned-and-

operated campground, is located directly downstream of Keystone Dam on the northern bank of the river, while the White Water ORV Park is located on USACE lands across the river on the southern bank. River City Park is located on the northern side of the river, just upstream of the Highway 97 Bridge, and is the community park for Sand Springs. It offers a wide range of recreational opportunities, including the River City Trail (bicycle/pedestrian), sports fields, a skate park, disc golf, and rodeo facilities. Chandler Park, a Tulsa County park, is located just downstream of the study area on the southern side of the river and provides scenic views of Tulsa and Sand Springs; it also offers rock formations for climbing, a swimming pool, trails, baseball complex, two large playgrounds, restrooms, picnic shelters, an 18-hole disc golf course, and a community center, as well as a large green space (Tulsa County 2016).

The Keystone Ancient Forest, a Sand Springs nature preserve, is located just to the northeast of the dam and offers hiking trails, while Keystone State Park is located just to the west of the dam on Keystone Lake. The wooded areas along the river within the vicinity of the study area provide public-access recreational opportunities in multiple parks and recreation sites with various amenities: picnic grounds, fountains, water splash pads, bicycle-rentals, skateboarding ramps, playgrounds, gathering plazas, parking, arts, restrooms, and a disc golf course. Zink Lake is located near the center of the study area near 29th Street downstream of the study area, and is the only existing impoundment. It is used for non-motorized boating, primarily rowing, with a public boat ramp offered at the River West Festival Park; however, “primary body contact” water activities such as swimming are prohibited. The “Tulsa Wave” offers kayaking opportunities downstream of Zink Dam on the western bank (RPA 2016). In the southern portions of the river in Tulsa, the terrain is varied and includes urban wilderness recreational areas such as Turkey Mountain, with 15 miles of maintained dirt trails for trail-running, hiking, horseback riding, and mountain biking. The popular Riverside Drive trails on the northern and eastern side of the river include a total of 30 miles of paved recreational trails that connect the study area to downtown, through neighborhoods, and to the nearby communities of Sand Springs, Jenks, Broken Arrow, and Bixby. In the study area, the Pedestrian Bridge, which was formerly used by the Midland Valley Railroad, spans the river’s 1,400-foot channel at 29th Street and Riverside, creating pedestrian/cyclist access from the eastern side of the river to the western side.

2.10.3 Transportation

There are seven major highways transecting Tulsa County. The Mingo Valley Expressway (at S. 71st Street) in southern Tulsa County has the highest daily traffic count, followed by Interstate 44. U.S. Highway 64 roughly parallels the northern side of the Arkansas River from Keystone Dam to its intersection with Interstate 44. The study area is crossed, going downstream, by Highway 97 (Wilson Avenue), Interstate 244, Southwest Boulevard, West 23rd Street, Interstate 44, Mingo Valley Expressway, Creek Turnpike, Broken Arrow Expressway, and U.S. Highway 64 in southeastern Tulsa County. Due to its extensive history with refining, there are multiple rail lines crossing the study area. Burlington Northern Santa Fe (BNSF) is the major rail carrier in the county and tends to carry coal, agricultural and forest products, chemicals, metals, and consumer goods. Union Pacific Railroad Road (UPRR) operates over the old Midland Valley line which parallels the Broken Arrow Expressway. The Tulsa-Sapulpa Union Railway is a Class III short line railway operating between Tulsa and Sapulpa and between Tulsa and Jenks.

2.11 Socioeconomics and Visual Aesthetics

The study area for socioeconomics extends from Keystone Dam to Tulsa County line, and extends 0.5 miles from the river.

2.11.1 Demographics

This section briefly discusses the socioeconomic conditions, primarily population and employment, for the Tulsa Metropolitan Statistical Area (MSA) which includes the study area (Tulsa County) as well as the following six adjacent counties: Creek, Okmulgee, Osage, Pawnee, Rogers and Wagoner. The total population of the MSA was estimated to be 969,224 in 2010, or one-quarter of Oklahoma's total. By 2015, it was estimated that the Tulsa MSA had grown to 975,666, of which 633,152, or 65 percent, were located in Tulsa County (Tulsa Chamber, 2015). As of September 2015, there were 472,318 workers in the Tulsa MSA labor force and an unemployment rate of 4.3 percent (Tulsa Chamber, 2015). Tulsa's major industries are aerospace, including aerospace manufacturing and aviation; health care; energy; machinery and electrical equipment manufacturing; transportation; distribution; and logistics (Tulsa Chamber, 2014). The 2010 Census population of the study area corridor (i.e., people residing within 0.5-mile of the study area corridor), as approximated by the EPA's Environmental Justice Screen (EJSCREEN) tool, was 27,876 (USCB, 2010a).

2.11.2 Environmental Justice

Executive Order 12898 (E.O. 12898), *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*, directs Federal agencies to provide opportunities for minority and low-income populations to actively participate in the planning process and to determine whether Federal actions would result in any disproportionately high and adverse effects on individuals in these populations. EPA released EJSCREEN, a mapping and screening tool, in June 2015 for use by agencies and the public in identifying potential environmental justice concerns. It defines low-income populations as the percent of an area's population in households where the household income is less than or equal to twice the Federal "poverty level." Minority is defined as the number or percent of individuals in an area who list their racial status as a race other than white alone and/or list their ethnicity as Hispanic or Latino (EPA 2015). The EJSCREEN tool was used to proportion 2008-2012 American Community Survey 5-year block group data within 0.5-mile of the Arkansas River within the study area and then to identify areas of potential concern through comparison with Tulsa County overall (Table 6). The minority population living within 0.5-mile of the 42-mile-long study area was comparable to that of Tulsa County; however, it did have a higher percentage of low income residents, 42 percent, versus that of the county (30 percent). The percentage of minority and low income residents in the 9-mile-long project area was lower than both the study area and county. Approximately 10 percent of Sand Springs' population is considered a minority.

Table 6: Socioeconomic and Environmental Justice Factors (Source: U.S. Census Bureau, 2008-2012)

	Project Area	Study Area	Tulsa County
Population	3,022	27,133	633,162
Percent Minority	21%	32%	30%
Percent Low-income	25%	42%	30%

2.11.3 Visual Aesthetics

The visual resources of the study area refer to those components of the environment perceived through the visual sense only, while esthetic resources specifically refers to beauty in both form and appearance. Due to the intensity of adjacent land uses, these resources are also informed by the biological, land use, and recreation sections of this document. Considered a "prairie river," the undeveloped portions of the Arkansas River corridor include a mix of woodlands and grasslands and more open areas with cottonwoods, willows, sedges, and rushes. However, the visual and esthetic character of the study area has been substantially changed due to its long history of use for navigation and trade.

The visual and esthetic character of the study corridor varies and is described via the three sub-reaches used in the 2005 Master Plan. Notable visual and esthetic features within the study area, located within the upper sub-reach, include views of Keystone Dam, views from West 11th Street, just upstream of the river's confluence with Shell Creek, as well as from River City Park and State Highway 97.

2.12 Utilities

The project area is crossed by three major interstates, I-244, I-44, and the Creek Turnpike, as well as bridges at State Highway 97 (within the project area), 23rd Street, East 96th street and South Memorial Drive. A dense network of utilities is present throughout most of the corridor and includes distribution systems for electricity, water, and natural gas. A railroad corridor parallels the entire southern/western side of the river (BNSF Railway/Midland Valley/Missouri Pacific), while a rail spur parallels the northern bank of the river from Sand Springs downstream to tie in to a rail corridor that generally follows I-244. Numerous power transmission lines and oil/gas pipelines traverse the area supporting corresponding operations along the river (Guernsey, 2005). This includes a gas pipeline that crosses the river within the project area approximately 2 miles west of the Highway 97 Bridge, while a large electrical transmission line crosses the river just east of the bridge near the confluence of Prattville Creek (CH2M, 2009).

The City of Tulsa has two water treatment plants that supply drinking water to more than 139,600 metered accounts in the city and more than 500,000 people in the Tulsa metropolitan area (City of Tulsa, 2017a). The Environmental Operations Division of the Public Works & Development Department operates the city's water supply lakes, water treatment plants, and water pipelines. There are seven wastewater treatment facilities with their corresponding collection systems within the project area. The City of Tulsa wastewater treatment system includes four treatment plants: Northside, Southside, Haikey Creek, and Lower Bird Creek (City of Tulsa, 2017b). The City of Bixby also provides wastewater services via the Bixby North and

South Lagoons; the City of Bixby plans to remove the Bixby North Lagoons and to either convert the Bixby South lagoons into a Waste Water Treatment Plant (WWTP) or decommission the lagoons. Additionally, the Haikey Creek WWTP is located just south of East 151st South Street on the north side of the river.

Within the vicinity of the Highway 97 bridge at Sand Springs are two industrial and one municipal waste water treatment facilities. The Sand Springs WWTP treats nearly all of the city's wastewater and has a capacity of 3.1 million gallons per day, while the lagoon system has a capacity of 50,000 gallons per day. As mentioned earlier, an existing Public Service Company (PSO) electrical transmission corridor (200 to 300 feet wide) crosses the River approximately 2000 feet downstream of the bridge. Related, supporting PSO infrastructure includes a tower in the river 2,300 feet downstream of the Highway 97 bridge as well as a tower less than 100 feet from the southern bank of the Arkansas River and 200 feet from the western bank of Prattville Creek on the 4-H and FFA livestock area. The two PSO transmission towers that tie in on the northern side of the Arkansas River are located 500 to 600 feet from the top of its banks.

An extensive field investigation and survey performed in 2009 identified a total of 266 storm sewer outfalls and drainage structures located along the Arkansas River in the vicinity of the corridor study (Meshek 2009). More recently, the 2015 Schematic Design and Cost Estimates Report located 159 adjacent outfalls within the project area and classified them into three groupings: (1) those with inverts below the new pool elevations (18 total outfalls), (2) those with inverts within 2 feet of the new pool elevations (23 outfalls), and (3) those with invert elevation greater than 2 feet above the new pool (118 outfalls). There are 20 outfalls located between Keystone Dam and the downstream side of the Highway 97 Bridge; of these, three are below the proposed pool elevation of 638.00, three outfalls are within 2 feet of the pool, while the remaining 14 are more than 2 feet above pool elevation (CH2M, 2015).

2.13 Health and Safety

This section describes the health and safety aspects of the study area by first characterizing the existing safety concerns associated with low water dams and then briefly describing potential health issues related to the Protection of Children under EO 13045. Due to historical incidents with the former reregulation dam as well as below Zink Dam during high river flows, public safety is one of the major design considerations for any new structure in the Arkansas River. While subsurface currents created below a dam are often responsible for accidents, the design of flow regime measures have improved greatly, allowing for a greater degree of public safety (Guernsey, 2005).

EO 13045 directs Federal agencies to analyze their policies, programs, activities, and standards for any environmental health or safety risks that may disproportionately affect children, including risks to health or safety that are attributable to products or substances that a child is likely to come in contact with or ingest, such as air, food, water, recreational waters, soil, or products they might use or be exposed to. As it relates to the study area, while there are multiple schools and daycare facilities along the corridor, "primary body contact" water activities such as swimming are currently prohibited.

2.14 Hazardous, Toxic and Radioactive Waste

In accordance with Resource Conservation and Recovery Act (RCRA), facilities that generate, transport, treat, store, or dispose of hazardous waste must provide information about their

activities to state environmental agencies. There were over 100 waste sites identified by EnviroMapper located adjacent to Arkansas River within the project area. The types of waste that may exist in the proposed project area include those from facilities such as oil and petroleum industries, utilities, electronic manufacturing, rubber manufacturing, recycling, concrete services, automobile service centers and tire shops, and gasoline service stations (EPA, 2016d). Most of the sites were identified as RCRA sites. According to the 2014 Toxics Release Inventory (TRI), there were 19 RCRA facilities that had releases in 2014. There were two facilities, Petroleum Electronics Mfg, Inc. and Power Electronics Mfg. Inc., which were identified by EnviroMapper as Superfund facilities. Both facilities are located approximately 3.5 miles upstream of the Zink Dam.

In the vicinity of proposed pool control structure and Prattville Creek restoration measures is the Webco Industry Star Center (pipe bending and fabrication) (permitted facility) with an individual National Pollutant Discharge Elimination System permit for noncontact cooling water that is in compliance (USACE Tulsa, 2016). The Mohawk Material-Ready-Mixed Concrete is also upstream from the site but doesn't have surface water discharges. There are several secondary nonferrous metal fabrication facilities north of the proposed pool control structure and Prattville Creek restoration sites such as Sheffield Steel and Gerdau Ameristeel but none have permitted discharges to the river or storm drains.

An initial survey for HTRW sites was undertaken as part of this study in accordance with ER 1165-2-132 "HTRW in Civil Works Projects" (Appendix D). The survey identified the Sand Springs Petrochemical Complex (SSPC), located adjacent to the north bank of the Arkansas River less than one mile below Highway 97 (

Figure 2). The SSPC site was listed on in the National Priority List (NPL in 1986. In 1995, potentially responsible parties dug up, stabilized and disposed of petroleum waste material in an onsite landfill. The landfill area associated with the site is 0.37 square miles (235 acres). EPA removed the site from the NPL in 2000 (EPA, 2016e). Between 2004 and 2006, parties dug up and removed sludge material along the banks of the Arkansas River. Operation and maintenance activities at the site continue. Fencing has been placed around the landfill, and operation and maintenance activities at the site continue today. A portion of the north bank of the Arkansas River has also had rip-rap placed (rock used to armor shorelines) to prevent erosion by the Arkansas River (ODEQ, 2016). A series of 5-year review for the SSPC found the remedies in place to be protective of human health and the environment.

Figure 2: Location of EPA Superfund site near proposed water control structure at RM 530.

2.14.1 Toxic Substances

In accordance with Emergency Planning and Community Right-To-Know Act of 1986 and Toxic Substances Control Act of 1976, facilities that release toxic substances into the environment are required to report such releases, including compliant and potentially noncompliant releases. Data regarding releases are maintained in the TRI database and contain information about more than 650 toxic chemicals that are being used, manufactured, treated, transported, or released into the environment. Facilities identified in the database search conducted for this study may have reported one or more toxic releases, such as air emissions, water surface water discharges, releases to land, underground injections, or transfers to offsite locations. There were approximately 20 sites identified as toxic sites adjacent to the Arkansas River Corridor study area. Businesses included oil and petroleum facilities, concrete, steel, and chemical companies, as well as a cola bottling facility (EPA, 2016d).

2.15 Geology and Soils

The regional geology provides context for the past and current geomorphic processes that shape the Arkansas River and floodplain. Rocks in the study area were formed from ancient river and sea deposits. Rock outcrops in the hills adjacent to the Arkansas River in the study area are of Pennsylvanian age and consist of Dewey Limestone and Nellie Bly Formation shale. Sediments washed into the region from the Rocky Mountains during the Tertiary. The broad Arkansas River floodplain is composed of Quaternary alluvium. The alluvium consists of unconsolidated gravels, sands, silts, and clays (Bennison et al. 1972; Marcher and Bingham 1988; Heran et al. 2003).

2.15.1 Sands

Bedrock at the proposed dam sites consist of shales and sandstones of the Coffeyville formation. The strata strike along a northeast plane (about N45E) and dip 2 degrees in an upstream direction. The overall river valley is about 1-1/2 miles wide.

Based on the investigations performed during design of the original Reregulation dam at River Mile 531, the soils within the river channel at the proposed dam site at River Mile 531 are mainly medium to coarse sands (SP), about 16 feet in thickness. On the left bank of the channel, the bank soils vary from 27 to 31 feet in thickness and are generally capped by 10-15 feet of sandy silts or silty sands underlain by medium to coarse sands (SP) with a thin stratum of pea sized gravel immediately above rock.

Based on the 2008 investigations performed near the proposed dam site of River Mile 530 (pool control structure and rock/riffle site), the soils within the river channel are approximately 10 feet thick and consists predominantly of loose fine to coarse grains sand with occasional gravel and clay lenses. On the left bank, soils are typically 18 feet thick and consists of silty sand with little gravel and occasional clay lenses. On the right bank, soils are approximately 35 feet thick and consist of 25 feet of sandy silt with some red clay lenses underlain by 10 feet of fine grained silty sand.

2.15.2 Soils, Including Prime Farmlands

The Choska-Severn soil series is the predominant soil series in the area, according to the Natural Resources Conservation Service (NRCS) Soil Survey of Tulsa County, Oklahoma (Cole 1977). These soils are characterized as deep, well-drained sandy to silty loam overlying loamy and sandy floodplain alluvium.

Widespread bank erosion is evident throughout the river corridor along the study area. The river banks throughout and upstream of the study area are generally sandy and highly erodible. The channel downstream of Keystone Dam has experienced incision and bank erosion as it has been scoured of sediment to regain the sediment load of the river that is trapped upstream in Keystone Lake. The rapid fluctuation in river flow has reduced native wetland habitats and has reduced the stability of rooted vegetation along river banks and increased erosion. This erosion would likely continue until the banks of the channel are armored.

The major changes in sandy substrate (sediment fluxes) in the corridor occur during high flow events when major sediment transport happens (USGS 2011). The 2011 USGS report concluded that there has been an 82 percent documented reduction of sediment concentrations since the construction of Keystone Dam in 1964.

2.16 Resource Significance

In compliance with the Council of Environmental Quality (CEQ) NEPA regulations (40 CFR 1500.1(b), 1501.7(a) (2) and (3), and 1502.2(b)), guidance for USACE ecosystem restoration projects require the identification of significant resources and attributes that are likely to be affected by one or more of the alternative plans (U.S. Water Resources Council, 1983). This section summarizes the expanded Resource Significance discussion included in Appendix A.

2.16.1 Institutional Recognition

Significance based on institutional recognition means that the importance of the environmental resource is acknowledged in the laws, adopted plans, and other policy statements of public agencies or private groups. The institutional recognition of resource significance for the Arkansas River Corridor Study area is demonstrated by the following laws, policies, plans, and cooperative agreements established for the conservation and protection of these environmental resources.

- The Endangered Species Act of 1973 (ESA), as amended
- Oklahoma Administrative Code Title 800 (Department of Wildlife Conservation) - Chapter 25 (Wildlife Rules) - Subchapter 19 (Oklahoma Endangered Species)
- The Fish and Wildlife Conservation Act (FWCA) of 1956
- The Fish and Wildlife Coordination Act
- The Migratory Bird Treaty Act
- The Bald and Golden Eagle Protection Act
- America's Watershed Initiative
- U.S. EPA's Healthy Watersheds Initiative
- USACE-Nature Conservancy Sustainable Rivers Project
- Water Resources Development Act of 1986
- Water Resources Development Act of 1990
- WRDA 2007 Section 3132 Arkansas River Corridor, Oklahoma
- Executive Order 11990 (Protection of Wetlands)
- Executive Order 13112 (Invasive Species)

2.16.2 Public Recognition

Significance based on public recognition means that some segment of the general public recognizes the importance of an environmental resource. Public recognition is evidenced by people engaged in activities that reflect an interest in or concern for a particular resource. The citizens of Tulsa County, have recognized the Arkansas River as "…a resource of paramount

importance to the Greater Tulsa community" (C.H. Guernsey & Company, 2005), and the need to address its declining aquatic habitats. An extensive regional planning effort including the 2005 Arkansas River Corridor Master Plan, Phase II Master Plan and Pre-Reconnaissance Study (2005), was focused on improving 42 miles of the ARC between Keystone Dam and the Tulsa County/Wagoner County line. The INCOG began a comprehensive public involvement and planning effort which culminated in the Final ARC Master Plan. The Master Plan includes a comprehensive ecosystem restoration plan to improve riverine, riparian corridor, and open water habitats. In response to multi-community support for the Master Plan concepts, the U.S. Congress demonstrated institutional recognition of the Arkansas River Corridor by creating special authorization language in Section 3132 of WRDA 2007. Section 3132 authorizes construction of ecosystem restoration, recreation, and flood risk management components identified in the Master Plan.

2.16.3 Technical Recognition

Significance based on technical recognition requires identification of critical resource characteristics such as scarcity, representativeness, status and trends, connectivity, critical habitat, and biodiversity. Therefore, technical recognition of resources varies across geographic areas and spatial scale. Least Tern populations in the ARC are technically significant based on range-wide surveys of the species that found nearly 12 percent of the total number of Least Terns in North America were counted in the Arkansas River System in Oklahoma. Habitat of the Least Tern found in the system, is negatively impacted within the Arkansas River Corridor through diminished sediment transport affecting development and maintenance of existing nesting habitat. Declining populations of native or suitable small fish species, and increasing numbers of introduced and unsuitable forage species, reduce the terns' ability to acquire small fish. Alterations to the river corridor have created negative interruptions to fish habitats and fish assemblages in the study area. Disruptions to the fisheries complicate the complex food web within and surrounding the river. The Oklahoma Comprehensive Wildlife Conservation Strategy (OCWCS) is a means to articulate and rank conservation strategies necessary to conserve the State's rare and declining wildlife species. Fish Species of Greatest Conservation Need occurring within the ARC include the Shovelnose Sturgeon (*Scaphirhynchus platorynchus*, Tier I), the Paddlefish (*Polyodon spathula*, Tier III), and the Shorthead Redhorse (*Moxostoma macrolepidotum*, Tier III). Bird species include the Least Tern (Tier I), the Piping Plover (Tier II), and the Bald Eagle (Tier III).

3 PLAN FORMULATION

Plan formulation and evaluation of alternatives used for this study are conducted in accordance with the USACE Planning Guidance Notebook (Engineer Regulation 1105-2-100) which emanates from the Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies, which were approved by the U.S. Water Resources Council and the President in 1983, pursuant to the Water Resources Planning Act of 1965 (P.L. 89-80).

Based on guidance and policy, USACE has a well-defined six-step process used to identify and respond to problems and opportunities associated with Federal water resources planning objectives, and specific state and local concerns:

1. Identify Problems and Opportunities
2. Inventory and Forecast Conditions
3. Formulate Alternative Plans
4. Evaluate Alternative Plans
5. Compare Alternative Plans
6. Select Recommended Pan

This chapter describes the development of measures and alternatives to address the problems and achieve the study objectives. Alternatives, including the no action, were compared to one another to determine which plans were cost effective and which plans provided the least incremental cost per output. An "is it worth it" analysis of the cost effective plans allowed the team to identify the plan that reasonably maximizes ecosystem restoration benefits compared to costs. The “is it worth it” analysis included consideration of non-measured benefits.

3.1 Problem Identification

The WRDA 2007 authorization allows USACE to participate in the ecosystem restoration, recreation, and flood risk management components of the Arkansas River Corridor Master Plan dated October 2005.

3.1.1 Ecosystem Losses in the Study Area

The generation of hydropower at Keystone Dam, which has been in operation since 1968, has had a substantial influence over the health of the ecosystem within the study corridor as it is the only reoccurring water release mechanism from Keystone Dam that provides river flow in the ARC other than flood pool releases. The dam houses two hydropower-generating turbines with a power-generating capacity of 80 megawatts with a full-power discharge from the reservoir of 12,000 cfs. The Southwestern Power Administration (SWPA), as the region’s Power Marketing Administration, is authorized to market the hydropower generation at Keystone Dam. When the Keystone lake level is in the flood pool, hydropower generation is used as the first methods of flood control release as part of the USACE flood risk management strategy. When the lake level is in the conservation pool, SWPA schedules and calls on Keystone Dam hydropower generation to meet electricity demand needs of Federal hydropower customers in a six-state region. Keystone Dam hydropower generation is operated as part of a system of numerous Federal hydropower projects in the region to meet that electricity demand. Generation schedules are subject to change due to a variety of factors.

The impacts on the aquatic and riparian ecosystem within the study area from Keystone Dam and associated operations are dramatic. Keystone Dam is a physical barrier for natural river flow and connectivity, sediment transport, and migratory and spawning life histories of native fauna. During hydropower generation, the hydropower units can release an estimated 6000 cfs (1 unit) or 12,000 cfs (2 units) of water that flows through the river throughout the study area. During periods of low precipitation, water levels behind the dam drop into the conservation pool. Once in the conservation pool, the only water released downstream is to meet hydropower or, occasionally, water supply demand, which is typically released via the hydropower units. As a result, the current flow regime within the study area exhibits daily bouts of brief 6,000-12,000 cfs river flow followed by extended periods of near zero river flow from Keystone Dam. Without releases from Keystone Dam, the Arkansas River within the study area is reduced from a flowing river to minimally flowing river reaches with stagnant isolated pools and a disconnected floodplain habitat lasting from several hours during the week to several days over the weekend. This creates an incredibly disruptive, unnatural flow regime impacting all aquatic and riparian habitat types as well as the flora and fauna throughout the study area. While the drying of rivers is a naturally occurring process in the southwestern region of the United States, those conditions are generally experienced in smaller drainages and during extended severe droughts. In the study area, flooding and drought conditions are exacerbated beyond this natural drying process by the impacts of Keystone Dam and hydropower releases.

The Keystone Dam also traps a substantial amount of sediment resulting in downstream sediment-starved flow causing channel and tributary incision and bank erosion. The impacted geomorphology has resulted in streambank erosion and the destruction of riverine wetlands, backwaters, and slackwater habitats that were once important fish nurseries and feeding/resting areas for resident and migrant waterfowl. As an example, the current mouth of Prattville Creek is an erosional shortcut to the Arkansas River, bypassing nearly one mile of the original Prattville Creek channel, caused in part by Arkansas River channel down cutting.

Within the study area, Federally-listed endangered Least Terns annually nest on the sandbar islands. As river flow diminishes and the river bed is exposed, the sandbar islands become connected to the shoreline. This fluctuating flow cycle coincides with peak Least Tern nesting activities in the study corridor, exposing the nesting colonies to inundation during high flows, and human and predator disturbances when low flows create land bridges to sandbar islands. The low flow conditions also induce Least Terns to nest in unsuitable low-lying areas. Hours or days later when river flows return, the low-lying nests have a higher probability of being swept into the river. Both inundation and low flow conditions contribute to nesting failure in the Arkansas River Corridor.

3.1.2 Existing Conditions

Without river flow, the remaining shallow, isolated pools subject trapped fish, fish eggs and larvae, and aquatic invertebrates to increased predation, intolerable environmental conditions, and desiccation if river flow does not return in time. The disconnected river reaches and exposed river bed created by low flow conditions severely impact the ability of migratory fish, such as the Paddlefish (*Polyodon spathula*), Shovelnose Sturgeon (*Scaphirhynchus platorynchus*), and Sauger (*Sander canadensis*) to reach upstream spawning habitat within the backwater and slackwater habitats. These and other native fish species require continuous flows to prevent egg desiccation and to suspend larval offspring before they are fully mobile.

Along the shorelines, a variety of vegetation types including aquatic, emergent, shoreline, and moist soil dependent communities face similar challenges in a low flow condition. These habitats provide the vegetative structure necessary for refuge and critical nesting and nursery life histories for numerous species across all fauna. In addition, these habitats supply the base of the food web throughout the study area. Seed, zooplankton, forage fish, and insect production are all dependent on the presence and function of these habitats. The low or no-flow conditions disconnect the above described habitats from the hydrologic regime they require to sustain growth. The result is a diminished food base with limited foraging opportunities, reducing the carrying capacity of the study area. Nesting Least Terns, migratory waterfowl, migratory fish, amphibians, bats and all other species that forage on small fish, seeds, zooplankton, and insects are faced with sustenance shortfalls.

Additionally, the lack of adequate water promotes the desiccation of aquatic and riparian vegetation communities that naturally stabilize the riparian corridor. Without the vegetation communities, erosion, and marginalization of the remaining habitat would continue when higher river flows return.

In compliance with the Council of Environmental Quality (CEQ) National Environmental Policy Act (NEPA) regulations (40 CFR 1500.1(b), 1501.7(a) (2) and (3), and 1502.2(b)), guidance for USACE ecosystem restoration projects (P&G) require the identification of significant resources and attributes that are likely to be affected by one or more of the alternative plans (U.S. Water Resources Council, 1983). “Significant environmental resources are defined as those that are institutionally, publicly, or technically recognized as important.” (Apogee Research, Inc., 1997). Resource significance is determined by the importance and non-monetary value of the resource based on institutional, public, and technical recognition in the study area.

The USFWS has identified one federally endangered bird species, the Interior Least Tern (ILT, *Sterna antillarum*), and two federally threatened bird species, the Piping Plover (*Charadrius melodus*), and the Red Knot (*Calidris canutus rufa*), that utilize, or potentially utilize, the ARC in the project area in Tulsa County, Oklahoma. Also listed for the ARC project area is the endangered American Burying Beetle and the threatened Northern Long-eared Bat. Appendix A presents a detailed description of the significance criteria and the resources that utilize the project area, their habitat needs and how they have been effected by the current conditions within the ARC.

3.1.3 Flood Risk Management

An early assessment during the study shows that the flood risks along the Arkansas River Corridor in the study area are being adequately addressed by various local governments, non-government organizations, professional organizations and other Federal programs. Although the study focus is on ecosystem restoration, the computer model Hydrologic Engineering Center’s River Analysis System (HEC-RAS) developed to aid the assessment of restoration flow regime alternatives would also serve as a regional hydrology and hydraulic model. This regional model would provide information to help local leaders make informed Flood Plain Management decisions regarding sustainable development along the Arkansas River in Tulsa County.

3.1.4 Recreation

The USACE policy (ER 1105-2-100 Appendix E) on recreation development at an ecosystem restoration project is that recreation features must be totally ancillary to the primary purpose,

appropriate in scope and scale, and shall not diminish the ecosystem restoration outputs used to justify the project. For these reasons, the recreation elements of the ARC Master Plan are not in the Federal interest for investment.

3.2 Problems and Opportunities

The first step in the planning process is to identify problems and opportunities. Problems are undesirable, negative conditions that the study will assess. Opportunities are desirable conditions that could be achieved in the future. The "conditions" to be considered are those forecast to exist during a forecast period of analysis. The problems are forecast for conditions expected to exist in the absence of a federally constructed project as a result of the current study. The opportunities are forecast for conditions expected to exist in the presence of a federally constructed navigation project. Plan formulation is based on a 50 year period of analysis. The period of analysis is considered to be 2023 through 2073, allowing time for construction of proposed structures and ecosystem plantings after project authorization. Benefits will not begin to accrue until the proposed structures and plantings are completed.

The severe flow regime fluctuations resulting from Keystone Dam and associated flood risk management and hydropower operations have altered the aquatic structure of the Arkansas River within the study area. This degraded aquatic structure has resulted in severely degraded and in some cases almost complete loss of aquatic functions necessary to sustain a riverine ecosystem. Other stressors of the system serve to compound the ecological losses and resulting impacts. These additional stressors are primarily associated with additional flood risk management features such as levees, as well as, industrial and urban development and agricultural practices. The Arkansas River's carrying capacity has been severely degraded for all the native wildlife that depend on this particular ecosystem for survival. The reoccurring low/no flow conditions limit aquatic ecosystem development, structure, and function. The low/no flows occur throughout the year in the absence of flood pool releases, disconnecting river reaches and interrupting life histories. From 2000-2014, an average of 228 days per year had an hourly release from Keystone Dam that was 0 cfs. The aim of the study is to increase the number of days with a minimum flow rate annually to a level that would continuously sustain a thriving ecosystem. Specific problem statements associated with this degradation are listed below.

3.2.1 Problem Statements

1. The extreme low to no-flow conditions occurring between flood pool and hydropower operations creates numerous hydrologically disconnected river segments and aquatic ecosystem structure degradation and loss.
2. Critical seasonal riverine functions have been altered causing degradation of habitat and loss of life requisites for native aquatic dependent species.
3. Frequent high flow pulses associated with Keystone Dam and hydropower operations create erosive forces that affect numerous components of the riverine environment (aquatic and terrestrial); many of these degraded riverine components are associated with successful breeding, nesting, and brooding for the Least Tern.
4. The Arkansas River within the study area has been constrained to the point of having limited association with or being fully disconnected from the floodplain component of the riverine ecosystem.

3.2.2 Opportunity Statements

1. Restoration of a more natural flow regime which helps sustain Least Tern habitat is consistent with and supported by the USACE-Nature Conservancy Sustainable Rivers Project Memorandum of Understanding (USACE IWR 2016).
2. Restoration of the Arkansas Riverine ecosystem supports the ecosystem component of the America's Great Watershed Initiative.
3. Restoration of the riverine ecosystem along the Arkansas River within the study area would support the larger community vision of the citizens of Tulsa County and surrounding communities.

3.3 Planning Goals and Objectives

Objective statements provide a qualitative or quantitative metric used to evaluate the measures and alternatives that will be identified to achieve the desirable conditions described by the opportunity statements.

3.3.1 Study Objective:

Restore the overall aquatic habitat and substantial aquatic-related terrestrial resources to a more sustainable riverine ecosystem for the Arkansas River within the study area to support threatened and endangered and native species dependent on the riverine environment.

3.4 Planning Constraints

Constraints are characterized as *universal constraints* that would apply to similar categories of studies and *study specific constraints* that are relatively unique for an individual study. Alternatives are formulated to achieve the objectives and avoid the constraints. Universal constraints (not listed below) include all of the applicable laws, policy, guidance, and other federal government requirements.

Because planning was limited to elements included in the ARC Master Plan as per Section 3132 of WRDA 2007 and subsequent USACE implementation guidance, constraints identified in the ARC Master Plan were carried forward into formulation for the current study. Constraints identified in the ARC Master Plan include:

- FEMA 100 year floodplain and floodway cannot be changed;
- Impacts to areas with historical environmental activities (primarily hazardous waste and petroleum issues) must be avoided unless the non-federal sponsor removes any discovered contaminants prior to construction;
- Impacts to existing utilities and pipelines in the project area must be avoided;
- Impacts to wastewater treatment facilities must be avoided, and;
- Impacts to active railroads must be avoided.

  Two additional constraints set by the team for the study are:

- No measure or combination of measures can increase the risk to life safety, and;
- No Plan can increase residual flood risk within or downstream of the study area.

3.5 Initial Screening of Measures

The project delivery team (PDT) through the planning process identified and assessed an array of restoration measures within the ARC Master Plan to address the specific ecological problems

of the Arkansas River. These measures were combined into a suite of alternatives that address the degraded structure and function of the riverine ecosystem within the study area at varying degrees of improvement and cost.

3.5.1 Arkansas River Corridor Master Plan

The October 2005 ARC Master Plan is an overarching document produced by the Indian Nations Council of Governments (INCOG), adopted by Tulsa County and the City of Tulsa, that outlines future development of the corridor including concepts for ecosystem restoration, economic development, and outdoor recreation measures. The Master Plan identified three major categories for which measures were explored; Public Use Areas, Low Water Dams, and Natural Habitat/Ecosystem Restoration. Public use consists of mixed use development opportunities integrated with parks, trails, wildlife habitat, gateways, ball fields, boat ramps, fishing piers and marinas. The plan explores several locations for placement of low water structures, including one analyzed in this feasibility study. In the Master Plan, the low water structures are considered for habitat, flow management, aesthetics and development potential. Finally, the natural habitat/ecosystem restoration focus of the Master Plan considers native plantings, construction of wetlands, wildlife habitats, river lakes with fish passage, and stream corridor stabilization.

The ARC Master Plan did not develop measures into specific plans for implementation, but were left at a conceptual level. Conceptual plans were prepared for seven key development sites and two low water dam locations as well as conceptual plans for ecosystem restoration and floodplain management that address the corridor as a whole. The seven conceptual plans are identified within the Master Plan as:

1. Sand Springs Main Street Low Water Dam and Riverfront
2. Jenks/South Tulsa Low Water Dam and River Front
3. Zink Lake Riverfront
4. Crow Creek Corridor
5. 71st Street Low Water Dam and Riverfront
6. Bixby Low Water Dam and Riverfront
7. Broken Arrow Low Water Dam and Riverfront

Areas described as a “Riverfront” refer to mixed use economic development. Sample conceptual drawings are displayed in Figure 3.

Initial screening of the elements within the Master Plan revealed potential for USACE participation in the ecosystem restoration opportunities discussed in the Master Plan. Analysis indicated there was little to no Federal interest in pursuing the flood risk management. Flood risk is being adequately handled by local entities. However, formulation for ER would be constrained such that residual risk of flood damage would remain unchanged with implementation of a recommended project. USACE guidance allows for recreation features to be considered in a federal ER plan as long as they are consistent with the restoration and do not negatively impact the proposed restoration. Numerous outdoor recreation features are described in the Master Plan. While not part of the Federal study, outdoor activities that are compatible and supported by the proposed plan and that fit within the existing infrastructure in the Tulsa area including wildlife viewing, fishing, hiking, and biking can be pursued by cities, counties, and other entities.

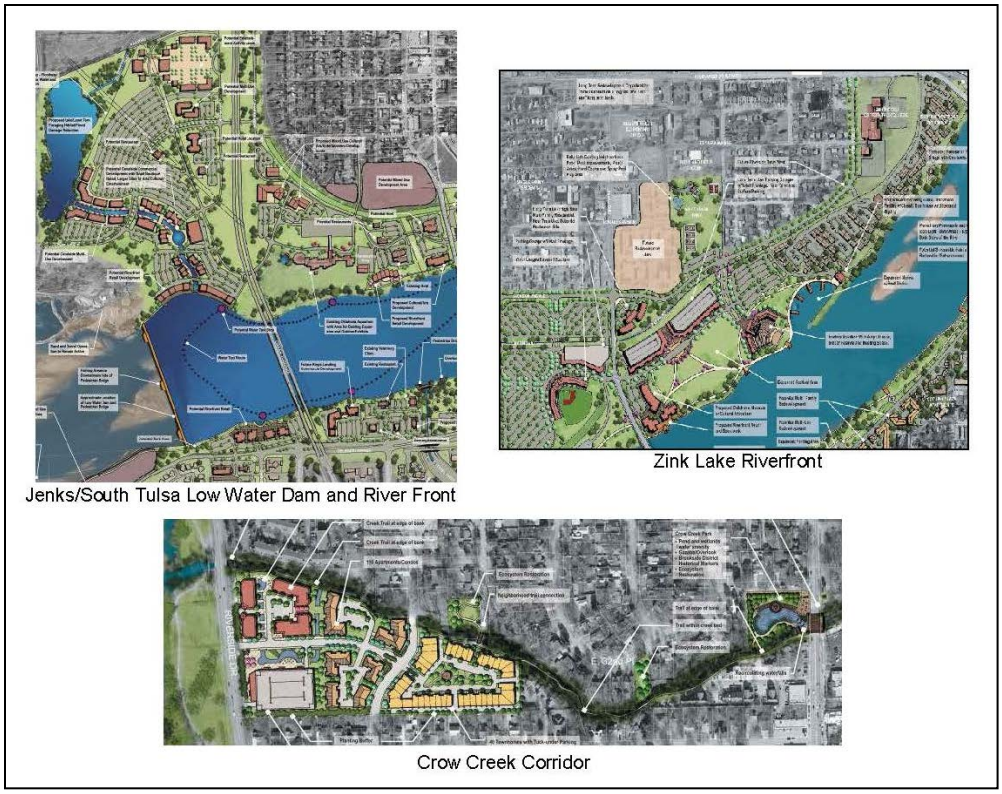

Figure 3: Sample conceptual drawings of riverfront development in the ARC Master Plan

3.5.2 Reallocation

The current study authority requires that USACE only look at measures developed in the ARC Master Plan. However, a preliminary assessment of a reallocation of reservoir storage space alternative was conducted to determine if reallocation should be considered under a modified Section 3132 authority or another authority such as Section 216 of the Flood Control Act of 1970. Reallocation entails changing how the stored water in Keystone Lake is used from one purpose to another. There are two paths to reallocation, raise the dam and conservation pool to create extra storage for use, or reallocation from the existing storage allocation uses.

Reallocation through a pool raise was eliminated from the study due to the Dam Safety Action Classification (DSAC) rating of 2 (High Urgency) on Keystone Dam. This requires a waiver to study a reallocation, and implementation would have to wait until the rating is a DSAC 4 (Normal). Additionally, the team determined that reallocation of existing storage would not meet the needs of the study. Based on a preliminary assessment, approximately 110,000 acre-feet (ac-ft.) of storage would be required from Keystone Lake to provide reasonably effective river flow of 1,000 cfs during periods of low flow. Currently, 2,000 ac-ft. are available from uncontracted municipal and industrial storage. The remaining 108,000 ac-ft. would have to come from storage allocated for hydropower generation.

The Tulsa District has completed reallocations from hydropower in the past. The cost of annual hydropower benefits foregone have been calculated using both USACE policy and by the Southwest Power Administration (SWPA), the agency with the authority to produce and sell the

hydropower generated at Keystone Dam. SWPA estimated the cost of benefits foregone for three potential scenarios that could result in the necessary minimum flows required to support ecosystem restoration: Turbine pulsing for an hour every six hours; Turbine pulsing for four hours every day, and; Use of smaller hydropower units releasing 1000 cfs.

SWPA has the authority for peak power production only (5:00 PM – 10:00 PM daily) and has no existing authority to pulse power or to put smaller hydropower units into operation, but assuming authority could be attained, these measures were considered. SWPA's analysis showed that the average annual hydropower benefits foregone for the three scenarios ranged from $ 8.5M – $8.9M. The USACE Hydropower Analysis Center (HAC) was also engaged to estimate the cost of benefits foregone following USACE policy for calculations. It is widely accepted that the hydropower benefits foregone estimates provided by SWPA are much higher than those yielded following USACE policy. While HAC did not do a detailed analysis, in their professional judgment, the annual benefits foregone costs calculated under the USACE process, while less than those estimated by SWPA, would still be higher than the annual costs of a plan that does not rely upon reallocation to achieve the ecosystem restoration benefits sought by this study. For this reason, reallocation was screened from further evaluation.

3.5.3 Change in Operations at Keystone Dam

While changes to the operation of Keystone Dam are not explicitly authorized in Section 3132 of WRDA of 2007, the PDT looked at the ways for solving the ecosystem problems within the corridor through changes in dam operations as a potential low cost alternative within the general authority of USACE's responsibilities. The PDT concluded that changes to the Dam Operations would not solve the problems identified as the source for ecosystem degradation. The problem is not dam operation, but rather it is hydropower releases that create the large pulse flows followed by periods of little to no flow that prevent a natural riparian sustainability. Currently, there is not enough unallocated water in the pool at Keystone to release at a steady 2000 cfs, and as detailed above, reallocation would be costly and would not effectively solve the ecosystem concerns of the corridor. Further, if a change to dam operations could provide a regular flow of 2000 cfs, there would still be the pulses of water released from the hydropower operations. When the pulse of water is released from hydropower generation, the river system would have too much water for a period of time, which would drown or scrub any riparian habitat that had managed to take hold rather than support or promote it. For these reasons, changes in dam operations were not considered to meet the purpose and need of the current study and screened from further evaluation.

3.5.4 Ecosystem Restoration Measures

This study is limited to those items of restoration addressed in the ARC Master Plan. The PDT reviewed the ARC Master Plan and developed a list of potential categories or types of management measures that could address the identified problems (Table 7). Simultaneously, the PDT considered the following items in relationship to identified measures.

- Does the measure address a stated problem and help achieve the objective?
- Can the measure be treated as a stand-alone measure or is it required to be in combination with other measures?

The measure types above were then developed into more specific measures for consideration within the project area. Management measures considered and screened out are listed in Table

8. Ultimately, all measures carried forward for use in the development of alternatives are also components of the ARC Master Plan.

Ecosystem restoration at Franklin Creek, Joe Creek, Fred Creek, and Vensel Creek tributaries would not be compatible with local plans for future recreation and economic development features in the vicinity of these sites. Restoration at the Cherry Creek tributary would produce relatively small benefits to a limited number of species and may require a higher level of maintenance than what the local sponsor could provide. It is anticipated that aquatic ecosystem restoration features at the Polecat Creek confluence would be accomplished by others. Restoration at the Haikey Creek tributary is not currently a high priority and could be addressed in the future under the USACE Continuing Authorities Program.

Table 7: Management Measure Types

Management Measure Types	Description
Flow Regime Management	Restores aquatic and riparian vegetation habitats and improves conditions for the Least Tern.
Constructed Least Tern Islands	Provides habitat for Least Tern and other species
Rock Riffle	Creates wetland/slackwater habitat and reduces downgrading erosion in the upstream tributary. Wetland functions include fish and wildlife habitat, biological productivity and water quality improvement,
Wetland Plantings	After being slowed by a wetland, water moves around plants allowing the suspended sediment to drop out and settle to the wetland floor. Plants also function as fish and wildlife shelter and food.
Wing Deflectors	Directs flows away the stream bank, creates scour pools, and creates a riffle or bar a short distance downstream
Rock Cross Vanes	Reduces streambank erosion, facilitates sediment transport, and provides aquatic habitat
Floodplain Bench	Restores the interactions between the stream and its floodplain
Joint Plantings	Establishes riparian vegetation in existing riprap
Longitudinal Peaked Stone Protection	Stabilizes and vegetates degraded streambanks
Riparian Plantings	Provides streamside native vegetation to lower water temperatures, improve, habitat, and reduce pollutants migrating to the stream

Table 8: Management Measures Considered and Screened Out

Management Measure	Reason for Elimination from Further Consideration
Keystone and/or Kaw Lakes Reallocation.	This measure is outside the scope of the Section 3132 of the WRDA of 2007 authorization. A cost-effectiveness analysis indicated that reallocation under another authority would neither warrant investment nor address the problems of this study.
Rock Riffle and Joint Plantings at mouth of Franklin Creek	Uncertainty due to local conceptual plan to create a "Lazy River" along Franklin Creek for recreation use.
Floodplain bench near the mouth of Crow Creek with rock cross vanes.	The George Kaiser Family's "A Gathering Place for Tulsa" project Section 404 permit includes provisions that would improve conditions for the scrub shrub wetlands. The floodplain bench measure is dropped due to uncertainties of future phased work in that area.
Joint Plantings at the Cherry Creek confluence.	The thickness of the existing riprap and the anticipated need for special equipment to establish pilot holes along with concerns about low plant survival rates would combine to result in undesirable high operation and maintenance cost. Benefits gains were very low for the high operation and maintenance costs.
Stabilization, native plantings, and instream aquatic habitat at the Joe Creek confluence.	Uncertainties due to Creek Nation River Spirit Casino economic development in this area, sand mining, and non- economic development/recreation pool.
Stabilization, native plantings, and instream aquatic habitat at the Fred Creek confluence (between 71st Street and Jenks/South Tulsa Riverfronts).	Uncertainties due to Creek Nation River Spirit Casino economic development in this area, sand mining, and non- economic development/recreation pool.
Streambank stabilization at mouth of Vensel Creek.	Uncertainties due to local plans to create a recreation feature associated with the future Jenks South Tulsa pool.
Instream aquatic habitat in the vicinity of the Polecat Creek confluence	Uncertainties associated with potential future environmental mitigation features by Public Service Company of Oklahoma and sand mining.
Streambank stabilization, native plantings, and aquatic habitat at the mouth of Haikey Creek.	The Broken Arrow Riverfront development and associated non-interest in ecosystem restoration would likely be a future long-term initiative that could be addressed by the USACE Continuing Authorities Program.

3.6 Final Array of Management Measures

After this first screening, the following management measures were carried forward for further analysis:

- Flow Regime Management – Pool Control Structure at RM 531
- Flow Regime Management – Pool Control Structure at RM 530
- Rock Riffle Complexes – at Prattville Creek and/or I-44 Riverside
- Wetland Plantings – at Prattville Creek and/or I-44 Riverside
- Riparian Plantings – at Prattville Creek and/or I-44 Riverside
- Constructed Least Tern Island

Table 9 below illustrates how the management measures carried forward address the identified problems of structure and function loss within the study corridor.

Table 9: Potential Ecosystem Restoration Management Measures to Address Problems and Associated Structure and Function Losses.

● Most Successful ○ Least Successful

Problem Statements						
1. The extreme low to no-flow conditions between Keystone Dam and hydropower operations creates numerous hydrologically disconnected river segments.						
	Restoration Measures					
Associated Structure and Function Losses	Pool Structure at RM 530	Pool Structure at RM 531	Rock Riffle Complexes	Wetland Plantings	Riparian Plantings	Sandbar Construction
Natural River Flow	●	●	○	○	○	○
River Connectivity	●	◕	○	○	○	○
2. Critical seasonal riverine functions have been altered therefore causing degradation of habitat and loss of life requisites for native aquatic dependent species.						
Native Fish Migration	●	●	○	○	○	◔
Floodplain Connectivity	●	●	○	○	○	○
Native Fish Reproduction	●	●	◑	◑	◔	◔
3. Extreme non-historically frequent high flow pulses between Keystone Dam and hydropower operations create erosive forces that affect numerous components of the riverine environment (aquatic and terrestrial); many of these degraded riverine components are associated with successful breeding, nesting, and brooding for the Least Tern.						
Sandbar Abundance	●	●	○	○	○	●
Sustainable Sandbar Nesting Habitat	◕	◕	○	○	○	●
Sediment Transport	●	●	○	○	○	○
Trophic Inter-Relationships	◕	◕	◑	◑	◑	◔

Table 9: Potential Ecosystem Restoration Management Measures to Address Problems and Associated Structure and Function Losses (continued).

● Most Successful ○ Least Successful

Problem Statements						
4. The Arkansas River within the study area has been constrained to the point of having limited association with or being fully disconnected from floodplain component of the riverine ecosystem.						
	Restoration Measures					
Associated Structure and Function Losses	Pool Structure at RM 530	Pool Structure at RM 531	Rock Riffle Complexes	Wetland Plantings	Riparian Plantings	Sandbar Construction
Wetland Diversity	◕	◕	◕	●	◔	○
Wetland Abundance	◕	◕	●	●	◔	○
Riparian Diversity	◕	◕	◔	○	●	○
Riparian Abundance	◕	◕	◔	○	●	○
Aquatic Vegetation Stability	◕	◕	●	●	●	◔
Riparian Vegetation Stability	◕	◕	◑	◑	●	◔
Shoreline Erosion	◕	◕	◑	◑	◑	○
Allochthonous Material	◕	◕	●	●	●	○
Slackwater Habitat Diversity	●	●	◑	○	○	◑
Tributary Habitat Diversity	●	◕	◕	○	○	○

3.7 Description of Each Measure Carried Forward

3.7.1 Flow Regime Management – Pool Control Structure (2 candidate locations)

A primary concern in the study area is the unnatural flow regime, therefore the team identified the need to implement a flow regime management measure as the basis for all restoration efforts. As such, an instream pool control structure is a prerequisite for all other management measures. The PDT determined that the most effective flow regime management measure would be to construct a pool control structure using state-of-the-art technology. The pool control structure would be designed to alleviate periods of no instream flow between hydropower generation pulses and during extended periods of no hydropower generation. A more natural flow regime is fundamental to the restoration of the overall aquatic habitat. Restoration success of a more natural river flow regime would entail the pool structure providing 1,000 cfs river flow throughout the downstream reaches of the study area between hydropower generation cycles. The pool structure would function similarly to a reregulation dam removed in 1985 which was

designed to provide controlled seasonal minimum flows ranging from 300 to 1,110 cfs, and to smooth hydropower releases from Keystone Dam. The proposed pool structure would capture a portion of the hydropower and flood pool discharge pulses and slowly release the water. The structure would include additional design features addressing safety concerns, and sediment and fish passage. Consultation with resource agencies identified full height gates that would lay down to near river bed as most effective design feature for fish, fish egg, and sediment passage. This feature was included in the pool structure design.

The combination of full and partial height gates provides adaptability of the pool structure to allow near seamless river reach connectivity during the monsoon season when larger, extended flood pool releases can occur and pass freely through the full height gate sections. Monsoon season also triggers fish migration, spawning, and the regeneration of sandbar islands in the study area. The full height gates allow for all riverine processes to continue. Partial height gates would operate to slowly capture and release water between hydropower generations. This allows for more consistent minimum river flows that maintain braided river channels, sandbar islands, and backwater wetland and riparian habitat connectivity.

The hydraulic roll-over effect was a significant life safety risk in a previously existing re-regulation dam. To reduce life safety risks to less than significant, the proposed pool structure would feature sloped aprons and full height gates to minimize the hydraulic roll-over effect. In addition, appropriate physical facility security measures would be utilized to limit public access near the pool structure.

On September 11, 2017 a 1,000 cfs test release from Keystone Dam was conducted to verify modeling outputs and the extent of river flow throughout the study area. USACE, FWS, ODWC, SWPA, and the representatives of the non-federal sponsor staff were able to view river flow from various locations throughout the study area. The general consensus was that the 1,000 cfs river flow would provide the expected environmental benefits throughout the study area. Pictures and general observations are included in Appendix M.

Proposed pool structure storage capacity was developed (at each location) through modeling using the Hydrologic Engineering Center River Analysis System (HEC-RAS) and geographic information system analysis. Modeling analysis of proposed pool structure function and downstream flow was compared to historical post-Keystone Dam downstream discharge to estimate the potential to alleviate periods of no flow. The pool control structure storage would have a capacity that could provide a flow of 1,000 cfs approximately 80 percent of the time between periods of hydropower releases. The 1,000 cfs minimum flow estimate was derived from analysis of pre-Keystone Dam minimum flows in the Arkansas River through Tulsa, and from consultation with USFWS and Oklahoma Department of Wildlife Conservation (ODWC) identifying minimum flow that would restore the structure and function of the riverine ecosystem. Two sites were considered for pool control structures. RM 531 is the site of the Lake Keystone Project reregulating dam that was removed in 1985. Another potential site is at RM 530. This site was identified during development of the ARC Master Plan. Sites further downstream from the RM 530 location were screened out due to potential HTRW concerns along the river bank. Potential sites upstream of RM 531 were screened because sites further upstream could not provide the storage needed to maintain flows downstream. Locations between these two sites were screened out as unsuitable due to the proximity of a railroad and highway bridges close to the river bank, which would constrain construction of the necessary structure.

Finally, the pool structure would be designed to allow for fish passage through the system. The Arkansas River is a relatively low gradient river, fish species in the study area are not equipped to jump or swim up steep fish ladders commonly used in the Pacific Northwest. Fish passage will likely be accomplished using a sloped spillway on the downstream side to overcome the height of the structure, and sized rock within the spillway would provide velocity refuge as fish move up the spill way. This sloped spillway also serves as a safety measure to minimize the roller effect that vertical gated structures create, which, as mentioned above, was the key safety reason for removing reregulating dam. Detailed design of the fish passage will be completed during PED, however as much detail as possible would be developed in the feasibly level design to ensure costs are adequately captured.

3.7.2 Pool structure at River Mile 531 (Old reregulation dam site)

The design of the proposed structure would capture and slowly release peaking hydropower and flood pool releases from the Keystone Dam, and, with design input and advice from resources agencies, provide sediment passage, and at least seasonal fish passage (upstream migration and spawn/fry movement downstream). A regulated flow regime is fundamental to the restoration of the overall aquatic habitat. At a maximum pool elevation of 638 feet, the pool volume capacity is approximately 4,860 acre-feet with a pool surface area of 1,112 acres. This full volume could provide downstream flows of 1,000 cfs for 2.5 days, 750 cfs for 3.3 days, or 500 cfs for 4.9 days. The maximum pool volume would remain entirely within the existing river bank.

3.7.3 Pool structure at River Mile 530 (Below Hwy. 97 Bridge)

The design of the proposed structure would capture and slowly release peaking hydropower and flood pool releases from the Keystone Dam, and, with design input and advice from resources agencies, provide sediment passage, and at least seasonal fish passage (upstream migration and spawn/fry movement downstream). At a maximum pool elevation of 638 feet, the pool volume capacity is approximately 6,730 acre-feet with a pool surface area of 1,321 acres (Figure 4). This full volume could provide downstream flows of 1,000 cfs for 3.4 days, 750 cfs for 4.5 days, or 500 cfs for 6.8 days. Again, the maximum pool volume would remain entirely within the existing river bank. Comparison of riverine habitat extents at the existing 100 cfs low flow condition and the 1,000 cfs future with project condition are shown in Figure 5 and Figure 6.

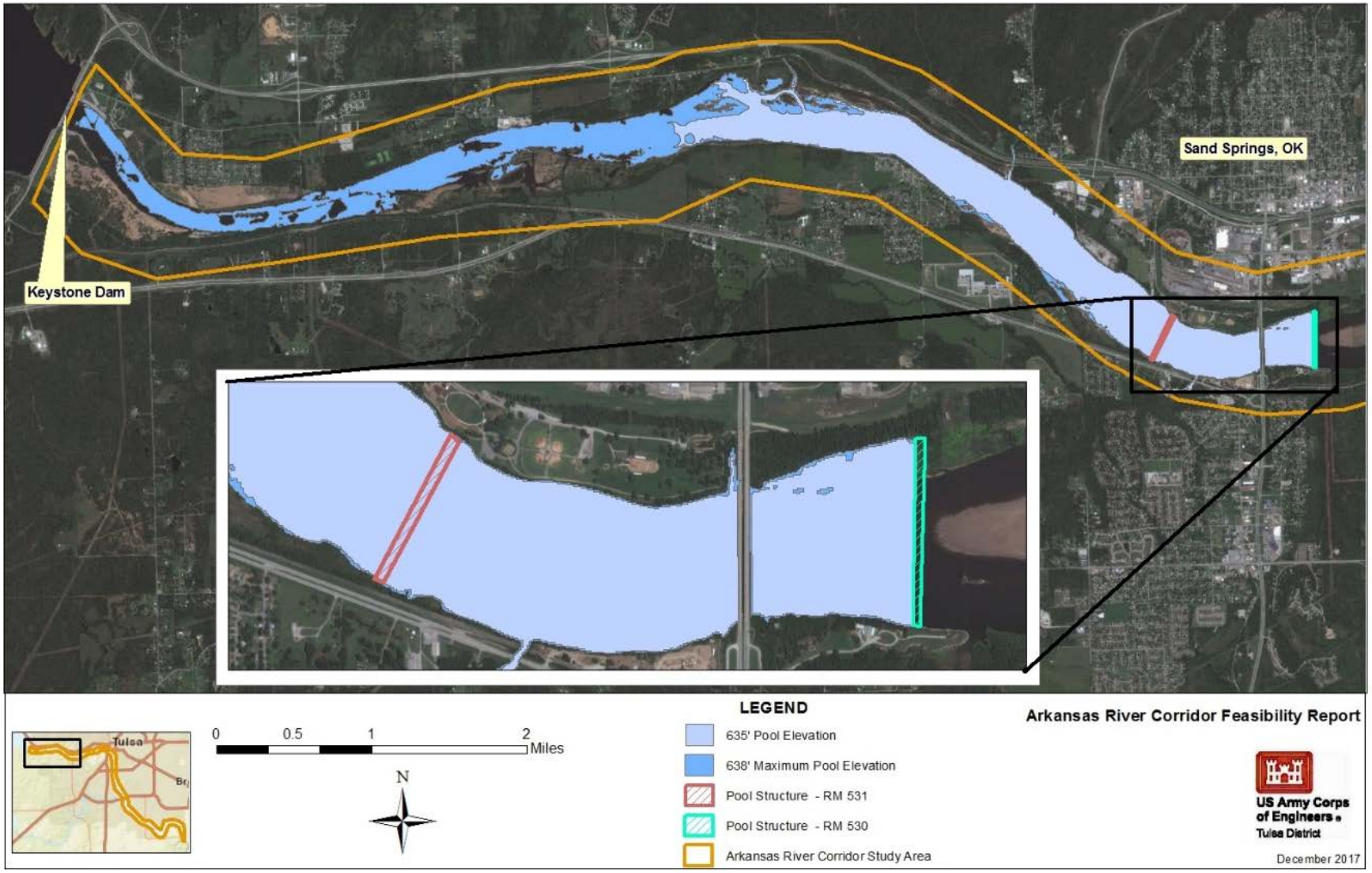

Figure 4: Pool structure location option at RM 530 (Old reregulation Dam [removed in 1985] site) and RM 531 (Sand Springs).

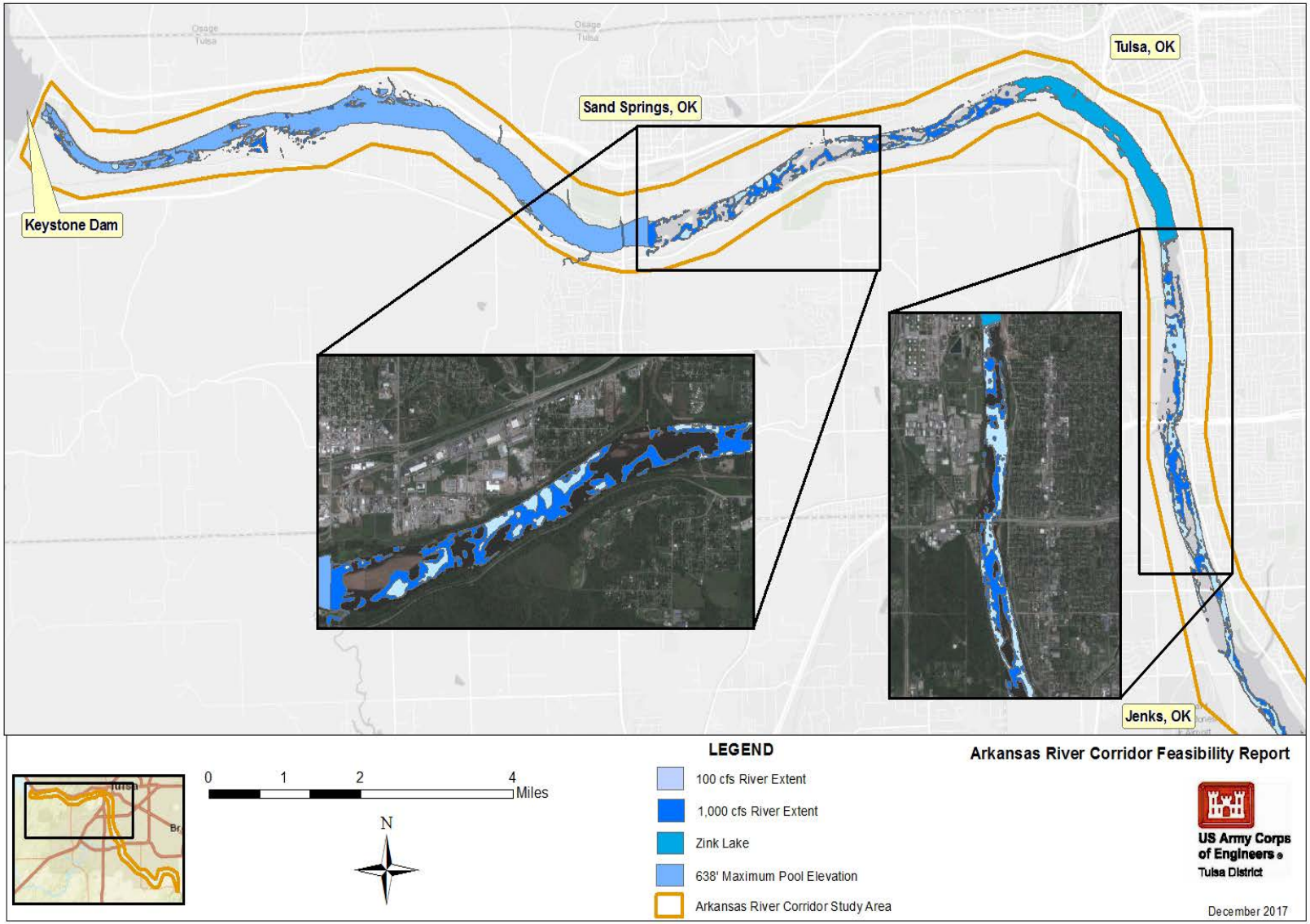

Figure 5: 100 cfs (FWOP) vs 1,000 cfs (FWP) comparison of riverine habitat extents in the upper region of the ARC.

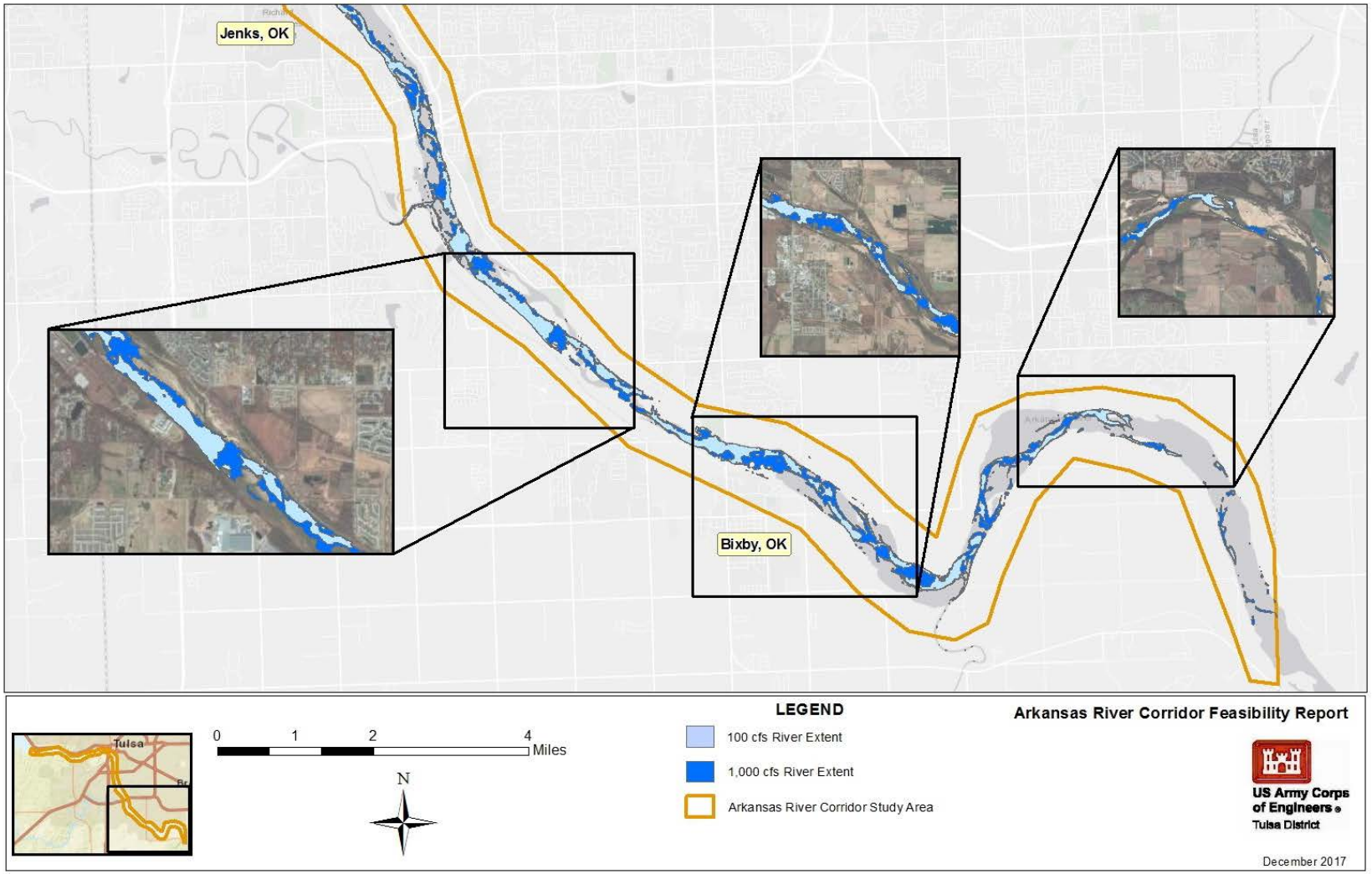

Figure 6: 100 cfs (FWOP) vs 1,000 cfs (FWP) comparison of riverine habitat extents in the lower region of the ARC.

3.7.4 Prattville Creek Measures

Prattville Creek is a right-bank tributary to the Arkansas River downstream of the Highway 97 Bridge at Sand Springs, Oklahoma. The fundamental measure consists of a rock riffle at the current confluence of Prattville Creek with the Arkansas River to restore a 5.34-acre wetland area (Figure 7). In the absence of more consistent river flow, backwater wetlands in the study often lack the hydrologic connectivity to support native aquatic vegetation communities. Restoring the hydrologic connectivity into Prattville Creek would allow for the return of this lost function.

An engineered rocked riffle with weighted toe would be placed at the mouth of Prattville Creek at an elevation of approximately 640 feet. The structure would impound flows from Prattville Creek, and would be over-topped by high flows in the Arkansas River. An engineered rocked riffle placed at the mouth of Prattville Creek would create a wetland providing additional shallow water habitat to the Arkansas River Corridor system, and an area immediately upstream of the rock riffle conducive to velocity refuge, foraging, and nursery habitat for fish. The wetland increases the area of open water and provides an opportunity for the incorporation of additional management measures consisting of aquatic and riparian plant communities. The structure would divert some Prattville Creek flow into the original Prattville Creek channel that parallels the right bank of the Arkansas River to the original confluence, approximately 1 mile east (downstream) of the current mouth.

The north peninsula forming the current mouth of the Prattville Creek confluence has already received shoreline protection both on the Arkansas River side and on the Prattville Creek side. Considering the potential for erosive high flows moving down Prattville Creek directed into the south bank of the mouth area, longitudinal peaked stone toe protection for approximately 600 feet of the south bank of the proposed wetland area would maintain bank stability.

The rock riffle structure is a prerequisite for riparian and wetland plantings. Those plantings within the existing PSO electrical transmission corridor would generally be under 15 feet in height at maturity to limit the potential for vegetation to interfere with the operation of the line (PSO, 2016). Wetland Plantings around the perimeter of the created wetland (approximately 3,000 feet excluding the rock riffle) include sedges (*Carex sp.)* and bulrushes (*Schoenoplectus spp.*) randomly planted and spaced approximately 1.5 feet on center. Wetland plantings would help stabilize banks of the wetland area, and provide forage and cover for insects, amphibians, mammals and waterfowl.

Riparian areas bounding the wetland include 2.24 acres in two sections (0.88 ac and 1.36 ac). Plantings proposed are live-staked Sandbar (*Salix interior*) and/or Prairie (*Salix humilis*) Willow, (approximately 5 feet on center). Riparian planting would provide additional bank/slope stabilization, shading for wetland area edge zones, allochthonous organic input into the wetland system, and would provide forage and cover for insects, amphibians, mammals, and birds.

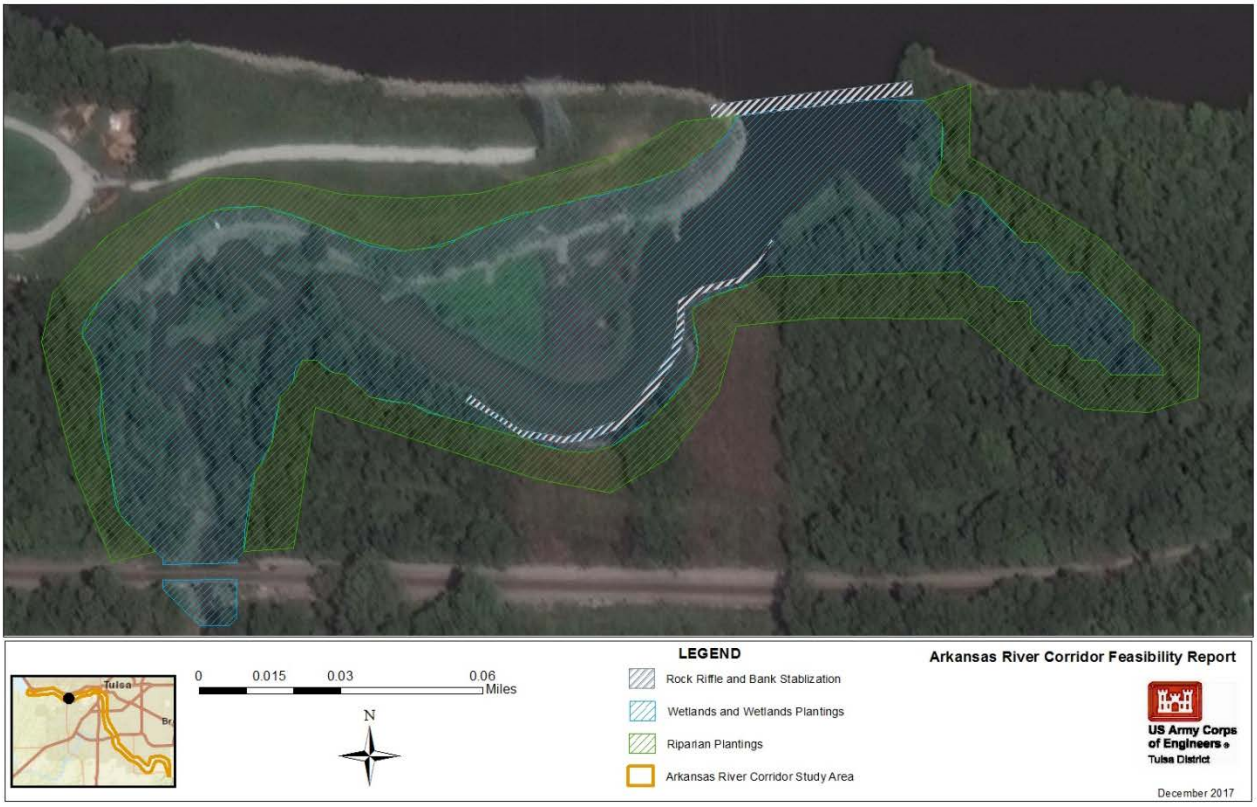

Figure 7: Prattville Creek Rock Riffle & Wetland

3.7.5 I-44/Riverside Measures

The primary measure at this location consists of two rock riffle (grade control) structures and three wing deflectors to restore wetlands and sustainable slackwater habitat on the left bank of the Arkansas River just upstream of I-44 Bridge (Figure 8). Rock riffle features would be composed of sized rock and designed to pool water at an elevation of approximately 612 feet at the mouths of two stormwater outfalls restoring two wetland areas of 0.22 and 0.33 acres. Wing deflectors providing erosion protection for the rock riffle features, would be composed of sized rock able to withstand anticipated maximum velocities in the Arkansas River. Each wing deflector would extend into the stream bank for stability at an elevation comparable to existing bank elevations, and extend into the river channel approximately 250 feet, at a slight downstream angle (approximately 10-20 degrees). The design would have to account for the downstream road bridges and avoid impacts to its piers. Instream elevations of the wing deflectors (approximately 607.1 feet) would be overtopped by stream discharge in excess of approximately 12,000 cfs (maximum two-turbine hydropower release). In addition to providing high flow erosion protection for the restored wetland areas, the wing deflectors would generate instream slackwater areas. The measure would provide additional resilient wetland areas totaling 0.55 acres, and velocity refuge zones for fish and wildlife within the Arkansas River Corridor.

Similar to the Prattville Creek site, restoring of backwater wetland, velocity refuge, and nursery habitat functions to this area would achieve wetland restoration success.

Rock riffle structures are a prerequisite for wetland and riparian restoration planting. Wetland area plantings immediately downstream and adjacent to wing deflectors, and around the perimeters of two pooled wetland areas generated by rock riffle features (380 feet and 420 feet, excluding rock riffle structures), would stabilize banks of the wetland areas, and provide forage and cover for insects, amphibians, mammals and waterfowl. Proposed plantings include a combination of Common Reed and bulrushes 1.5 feet on center. Riparian restoration plantings proposed for the area include three areas of 0.67, 0.35, and 0.57 acres. Riparian plantings proposed include live-stake plantings of Sandbar/Prairie Willow and Redosier Dogwood (5 feet on center). Riparian planting would provide additional bank/slope stabilization, shading for wetland area edge zones, allochthonous organic input into the wetland systems, and provide forage and cover for insects, amphibians, mammals, and birds.

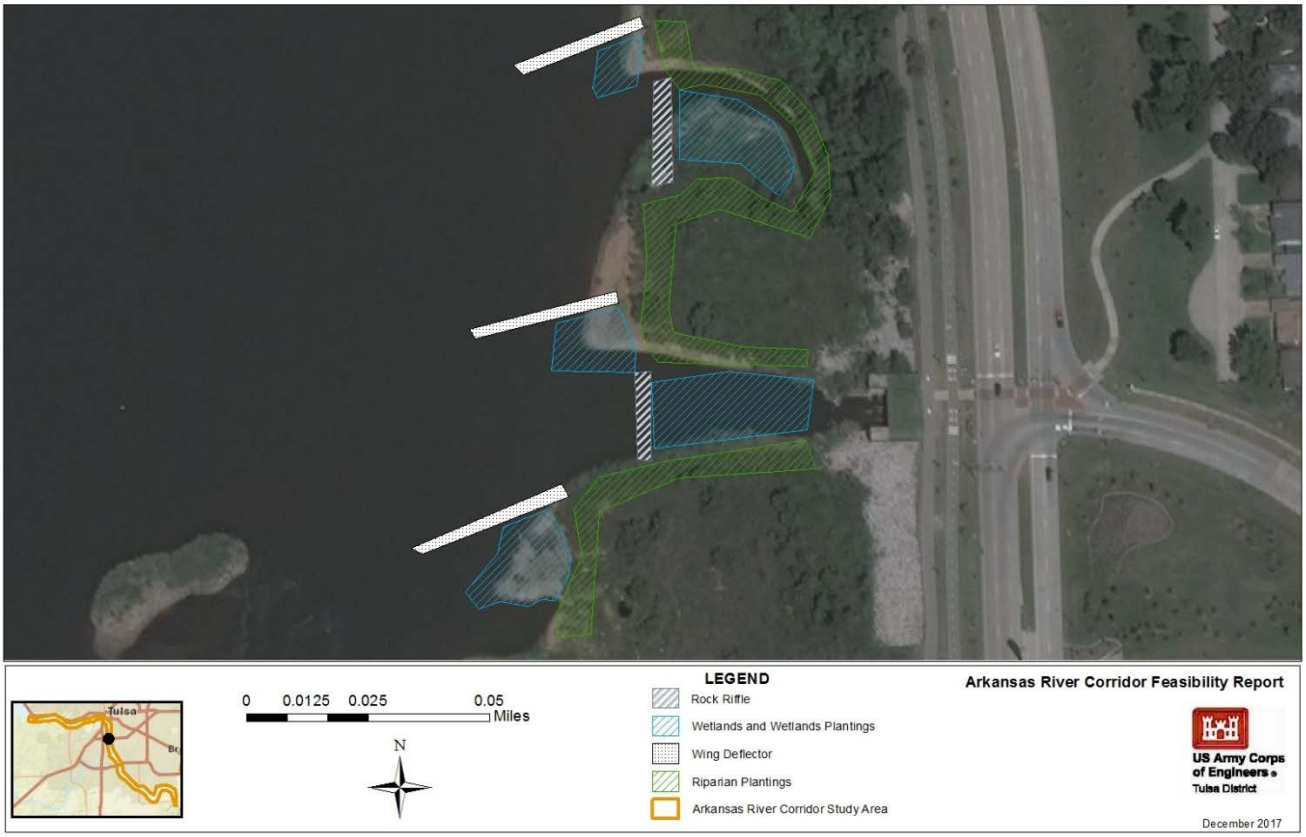

Figure 8: I-44/Riverside Rock Riffle, Wetlands and Slackwater.

3.7.6 Constructed Sandbar Island

This management measure increases nesting habitat for the Least Tern. Ideal nesting habitat for Least Terns consists of sandbar islands isolated by river flows. While normal hydropower releases reach up to 12,000 cfs, typical mid-late summer rain events can increase river height and flow to 20,000 cfs and above. Sandbar islands that remain unsubmerged during flows reaching 20,000 promote more reliable, sustainable Least Tern nesting habitat. Thus, restoration success for this measure would be quantified by its ability to provide nesting habitat at flows up to 20,000. The constructed sandbar would be approximately five acres in size

(Figure 9). Approximately three acres of which would sustain nesting habitat during flows reaching 20,000 cfs. The sandbar island would be circular to oblong in shape, with maximum surface area and a surface height above water to exceed 18 inches at nest initiation (May or June). The nesting substrates for the constructed island consist of well-drained particles ranging in size from fine sand to small stones. The anticipated design would be similar to that developed by Oklahoma State University for the USACE-Tulsa District in May 2003. The Oklahoma State University design consists of placement of a rectangular riprap structure and a downstream chevron riprap structure to promote mid-stream sediment deposition resulting in habitable sandbar development. Sediment transporting high and flood flow releases from Keystone Dam would promote sandbar development about the riprap structures, and provide scour to limit vegetative growth on sandbars when developed. Based on consultation with the USFWS and information from USACE Least Tern surveys, the most desirable reach in the study area is upstream of the Tulsa/Wagoner County line where the river more closely resembles a braided prairie stream. The current proposed location is in the Arkansas River just south of the Indian Springs Sports Complex in Broken Arrow, Oklahoma. Either of the pool structures described above would be necessary to maintain river flow around the sandbar island, protecting it from predator and public use disturbances.

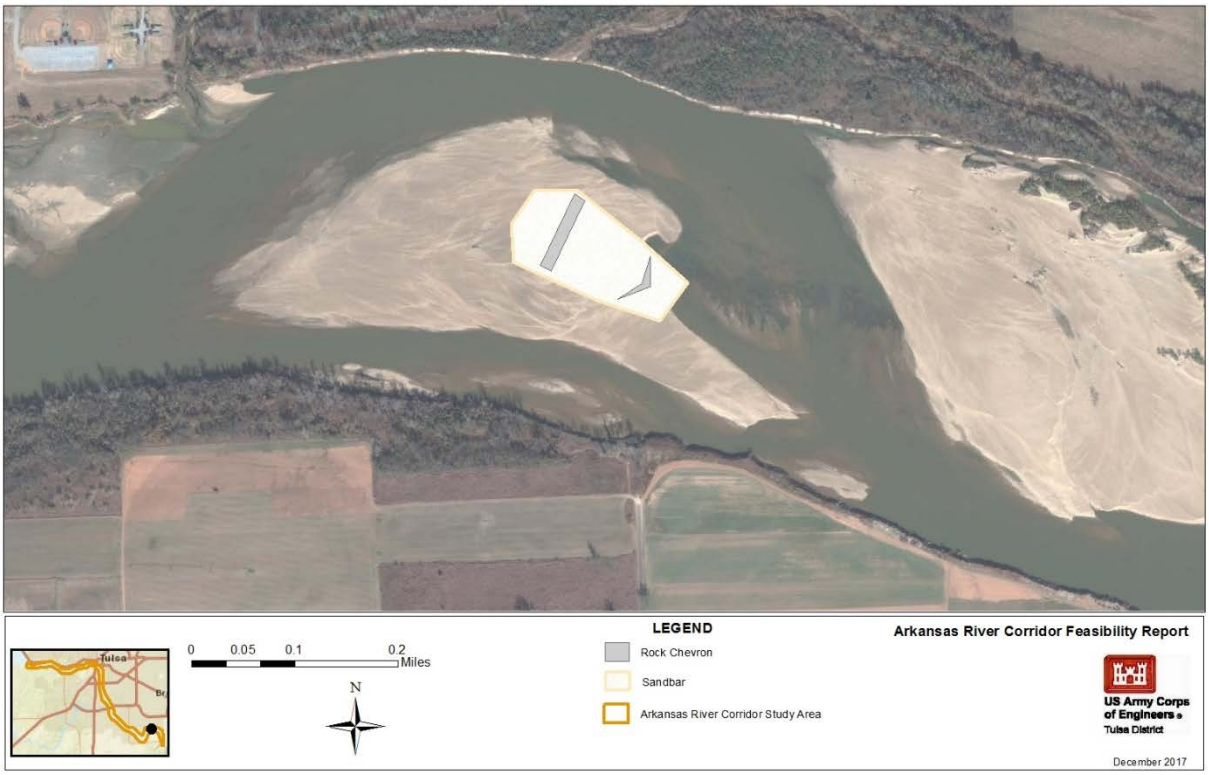

Figure 9: Broken Arrow Least Tern Island.

3.8 Alternative Comparison

3.8.1 Array of Partially-formed Alternatives

The management measures included two possible locations (but not both) for a pool structure, rock riffle structures, and wetland and riparian plantings at Prattville Creek and/or I-44/Riverside.

These were combined into 11 plans, consisting of stand-alone plans and partially formed plans, for populating Institute for Water Resources (IWR) Planning Suite to generate alternatives, or combination of the plans. All plans assumed South Tulsa/Jenks low water dam is in place and functioning as the Future With Project Condition. Benefits and first costs were developed for each of the 11 partially formed/stand-alone plans. The array of plans are:

- Pool structure located at RM 531 (former site of Lake Keystone Project reregulating dam)
- Pool structure located at RM 530
- Constructed Least Tern Island
- Rock Riffle Structures at Prattville Creek
- Rock Riffle Structures and Wetland Plantings at Prattville Creek
- Rock Riffle Structures and Riparian Planting at Prattville Creek
- Rock Riffle Structures, Wetland Plantings, and Riparian Plantings at Prattville Creek
- Rock Riffle Structures at I-44 Riverside
- Rock Riffle Structures and Wetland Plantings at I-44 Riverside
- Rock Riffle Structures and Riparian Planting at I-44 Riverside
- Rock Riffle Structures, Wetland Plantings, and Riparian Plantings at I-44 Riverside

Cost and benefits were developed for each of the measures and partially formed plans, as described in the sections below. The information was entered into IWR Planning Suite in order to arrange the measures into all possible combinations, with the following conditions set: (1) a pool structure measure is required prior to combination with any other measure, (2) the two pool structure measures are not combinable with each other, and (3) rock riffle structures are required prior to combining any planting measures. This resulted in 101 alternatives to be further screened using Cost Effectiveness and Incremental Cost Analyses (CE/ICA).

3.8.2 Benefits calculation

In order to determine benefits of an environmental restoration plan, future with-project environmental outputs are compared to future without-project outputs. The benefits are expressed as Average Annual Habitat Units (AAHU). The difference between the two represents the benefits from project implementation. The resulting benefits are then used, along with annualized costs, to identify cost effective plans and perform incremental cost analysis. For this study, future without-project conditions are expected to persist and even deteriorate further from the reoccurring low/no flow conditions that limit ecosystem function, and through the future implementation of locally funded projects including refurbishment of the Zink Dam, and construction of South Tulsa/Jenks Dam that will likely convert existing riverine habitat to lake habitat. Given the expected reoccurrence of limiting conditions for existing habitat, there is a lack of foreseeable positive change in that quality without intervention. The calculation of benefits (AAHU outputs) are shown in Table 10.

Table 10: Calculation Annual AAHU Benefits

Management Measure Area	Incremental Partially-formed Alternative	Future Without Project AAHU	With Project AAHU	Annual Benefits AAHU	Future With Project Acres
Flow Regime	Pool structure located at Keystone Lake Project reregulating dam (RM 531)	481.8	1305.8	824.1	3,614
	Pool structure located at RM 530	481.8	1349.4	867.6	3,735
Nesting Habitat	Constructed Least Tern Island	2.0	5.0	3.0	3
Prattville Creek	Rock Riffle Structures	0.002	2.6	2.6	5.34
	Rock Riffle Structures + Wetland Plantings	0.002	5.1	5.1	5.34
	Rock Riffle Structures + Riparian Plantings	0.002	2.6	2.6	7.58
	Rock Riffle Structures + Wetland Plantings + Riparian Plantings	0.002	5.3	5.3	7.58
I-44 / Riverside	Rock Riffle Structures	0.1	0.3	0.20	0.55
	Rock Riffle Structures + Wetland Plantings	0.1	0.5	0.5	0.55
	Rock Riffle Structures + Riparian Plantings	0.1	0.3	0.2	2.13
	Rock Riffle Structures+ Wetland Plantings + Riparian Plantings	0.1	0.7	0.6	2.13

3.8.3 Costs

First costs for the flow regime pool structures were adopted from similar structures presented in the Arkansas River Low Water Dams and Public Access/Recreational Improvements (April 2015) prepared for Tulsa County. The Tulsa District Cost Engineering section prepared independent government estimates for the measures, including contingencies, and the Tulsa District Real Estate Division prepared the real estate acquisition cost estimates.

Table 11 shows the derivation of annual costs for the plans. OMRRR costs were estimated for both annual operations and maintenance and periodic repairs, rehabilitation and replacement. The OMRRR costs were annualized and presented in the table. Additionally, interest during construction (IDC) were estimated for each plan using the IWR Planning Suite. First costs were annualized using IWR Planning Suite with a 50 year period of analysis and a discount rate of 3.125% (per Economic Guidance Memorandum 16-01 dated 14 OCT 2015). Prices are expressed in October 2015 dollars. The 50 year period of analysis begins in 2023 and runs through 2073.

The pool structure costs developed for CE/ICA included a sloped spillway to account for the known safety precautions, which doubles as a fish passage measure. In addition, the structure costs also accounted for a gated design to augment flows as needed, which also facilitates fish passage as a method of reducing head differential heights and adjusting velocity flow fields. Costs for maintenance, fish passage, and safety were applied to the pool structures at both locations, therefore, the parametric costs would have not impacted plan formulation, CE/ICA analysis, or plan selection.

Table 12 provides the inputs used for CE/ICA including average annual costs and benefits for the measure combinations. Costs used in the CE/ICA analysis in 2015 were not updated to the current discount rate as this change would affect the measures/plans equally and would not change the basis for plan selection (the planning decision).

3.8.4 Cost Effective Incremental Cost Analysis

3.8.4.1 Cost Effectiveness

Cost effective plans are defined as the least expensive plan for a given level of benefits. A more expensive plan could only be cost effective if it also provided more benefits. Of the 101 alternatives generated for this study, 22 were identified as cost effective plans (including No Action). Note that cost effective plans (those identified as blue triangles in Figure 10 below) include those identified as “best buy” plans (red squares). It should be noted that Figure 10 was modified to make the differences among with-project alternatives more visible, which necessitated the No Action alternative to be cropped out. Figure 11 displays a zoomed in view of the clusters of plans, more clearly showing the cost effective and best buy plans. Since the CE/ICA analysis was made with a flow regime (pool structure) measure as a prerequisite, it can be seen in the figure that the plans are grouped into two clusters, the left most cluster representing the less expensive pool structure at the old reregulating dam site at Rm 531 and the right most cluster representing the more expensive pool structure downstream at RM 530. The frontier, or leading edge of these two clusters represent the collection of cost effective plans – that is no plan provides greater benefits at the same cost. As with Figure 10, the graphic was modified, resulting in the No Action alternative to be cropped out.

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Table 11: Annual Costs for Plans (October 2015 prices, 3.125% Federal Discount Rate)

Management Measure Area	Plans	Construction Cost	Real Estate Cost	First Cost	Interest During Construction	Investment Cost	Annual Investment Cost	OMRRR	Total Annual Cost
Flow Regime	Pool structure located at Lake Keystone Project reregulating dam (river mile 531)	$78,722,700	$11,206,000	$89,928,700	$1,515,776	$91,444,476	$3,638,850	$235,672	$3,874,522
	Pool structure located at river mile 530 (Sand Spring)*	91,075,312	13,533,000	104,608,312	1,763,205	106,371,517	4,232,842	235,672	4,468,514
Nesting Habitat	Constructed Least Tern Island	1,025,185	336,000	1,361,185	3,497	1,364,682	54,305	34,500	88,805
Prattville Creek	Rock Riffle Structures	726,762	1,002,000	1,728,762	6,668	1,735,430	69,058	35,000	104,058
	Rock Riffle Structures + Wetland Plantings	1,056,934	1,002,000	2,058,934	7,941	2,066,875	82,247	43,000	125,247
	Rock Riffle Structures + Riparian Planting	1,703,529	1,002,000	2,705,529	13,925	2,719,454	108,215	107,200	215,415
	Rock Riffle Structures + Wetland Plantings + Riparian Plantings	1,871,907	1,002,000	2,873,907	25,950	2,899,857	115,394	130,000	245,394
I-44 / Riverside	Rock Riffle Structures	158,379	3,155,000	3,313,379	4,254	3,317,633	132,019	7,200	139,219
	Rock Riffle Structures + Wetland Plantings	507,367	3,155,000	3,662,367	18,849	3,681,216	146,487	40,000	186,487
	Rock Riffle Structures + Riparian Plantings	935,030	3,155,000	4,090,030	26,335	4,116,365	163,803	77,000	240,803
	Rock Riffle Structures + Wetland Plantings + Riparian Plantings	1,339,289	3,155,000	4,494,289	46,418	4,540,707	180,688	82,481	263,169

Table 12: Inputs for CE/ICA Analysis

Management Measure Area	Incremental Partially-formed Alternative	Annual Benefits AAHU	Annual Cost ($1,000) October 2015 Prices
Flow Regime	Pool structure located at Keystone Lake Project reregulating dam (RM 531)	824.1	$3,875
	Pool structure located at RM 530	867.6	$4,469
Nesting Habitat	Constructed Least Tern Island	3.0	$88
Prattville Creek	Rock Riffle Structures	2.6	$104
	Rock Riffle Structures + Wetland Plantings	5.1	$125
	Rock Riffle Structures + Riparian Plantings	2.6	$215
	Rock Riffle Structures + Wetland Plantings + Riparian Plantings	5.3	$245.4
I-44/Riverside	Rock Riffles Structures	0.2	$139.2
	Rock Riffles Structures + Wetland Plantings	0.5	$186.5
	Rock Riffles Structures + Riparian Plantings	0.2	$240.8
	Rock Riffles Structures + Wetland Plantings + Riparian Plantings	0.6	$263.2

3.8.4.2 Incremental Cost Analysis and Best Buy Plans

While cost effective analysis identifies the least expensive plan for a given level of benefits, it is important to also consider the incremental increase in cost per additional unit of habitat one alternative has over another. The analysis results in a final array of the cost effective alternatives that have the lowest incremental cost per additional unit of benefit, which are called “best buy” plans. These best buy plans are those that, incrementally, provide the next unit of benefit at the lowest cost, compared to any other alternative. Starting with the No Action plan, the incremental cost per incremental benefit is calculated from the No Action for each cost effective plan. The plan with the least incremental cost per incremental output is identified as the first of the “with-project” best buy plans. Then starting with that plan, the incremental cost per incremental benefit is calculated between that plan and each remaining cost effective plan, and the one with the least incremental cost per incremental benefit is identified as the next plan in the array of best buy plans. This iteration continues until there are no remaining plans. The last plan in the best buy array, is typically the “kitchen sink” plan, or the plan that contains all of the management measures being analyzed. From the cost effective alternatives, eight (including the No Action plan) were identified as “best buy” plans.

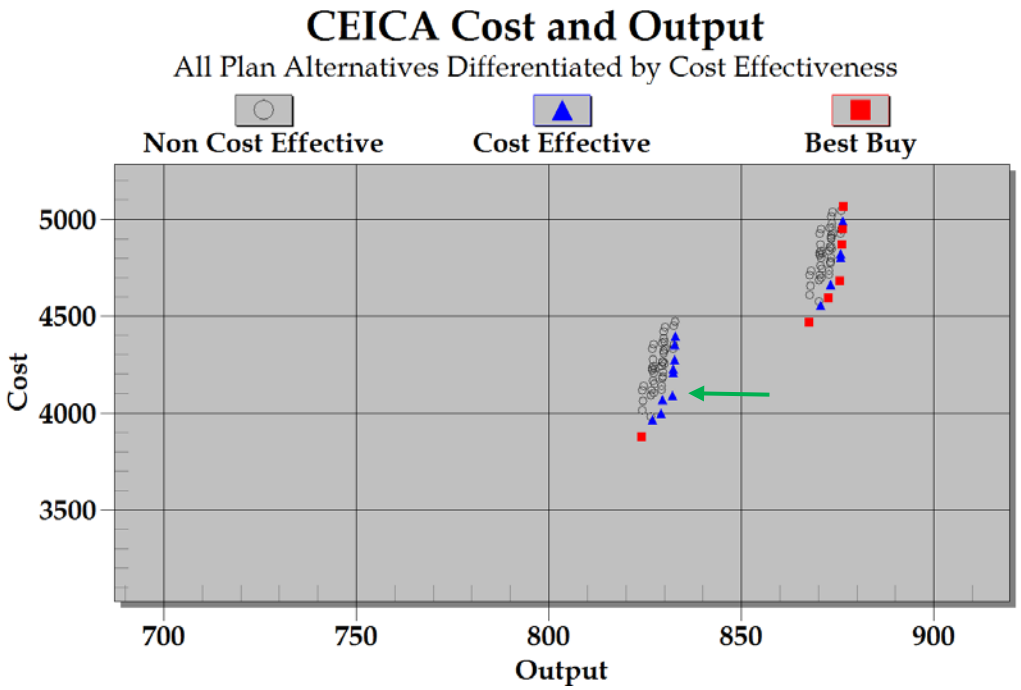

Figure 10: Cropped Graphical display of Best Buy Array (arrow indicated Cost Effective plan carried forward as 2a) (Costs expressed in $1,000, Outputs in AAHUs)

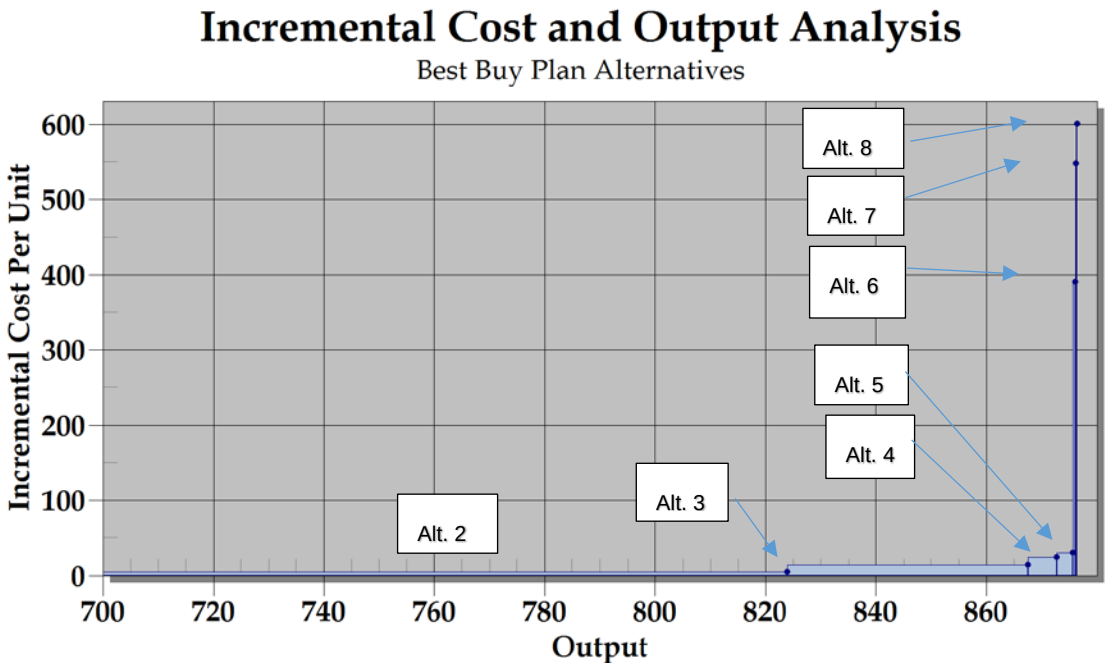

Figure 11: Cropped Graphical Display of the Incremental Cost Analysis Results (Costs are annual incremental costs per output in $1,000, Output in AAHUs)

3.8.5 Evaluation and Comparison of Array of Alternative Plans

From the 22 cost effective plans, eight plans were identified as “best buy” plans. Upon reviewing the best buy array, the PDT decided an additional cost effective measure should be evaluated alongside of the best buy array in the “is it worth it” analysis below. In order for a plan to be considered a National Ecosystem Restoration (NER) plan, it must be cost effective, but does not have to be a best buy plan. In reviewing the best buy plans, only one plan that includes the pool structure at RM 531 was included. This occurs because the two pool structures are mutually exclusive, and not additive, along with their significant cost and benefits, compared to the other measures. Once the incremental cost analysis moves to the pool structure at RM 530, there is no further consideration of any plan based on the upstream structure. By restricting the array of plans to be evaluated to the best buy plans, should the cost or any other issues related to the pool structure at RM 530 screen out plans that include it, the only remaining plan would be the structure at RM 531, without additional measures. This could leave some of the planning objectives and benefits unaddressed. The added cost effective plan is called Alternative 2a. The “best buy” plans, plus Plan 2a, represent the final array of alternative plans and are shown in Table 133 below.

Table 13: Final Array of Alternatives (Best Buy Plans)

Measures	Alternatives								
	1	2	2a	3	4	5	6	7	8
No Action	X								
Pool Structure at RM 531 (former reregulation dam site)		X	X						
Pool Structure at RM 530				X	X	X	X	X	X
Prattville Creek Rock Riffle with Wetland Plantings			X		X	X	X	X	X
New Least Tern Island			X			X	X	X	X
Riverside/I-44 Rock Riffle with Wetland Plantings							X	X	X
Riverside/I-44 Riparian Plantings								X	X
Prattville Riparian Plantings									X

3.9 Key Uncertainties

The presence of an EPA designated Superfund site within the study area could impact final site selection of some measures. The site boundary is within ¼ mile downstream of the potential pool control structure measure at RM 530. Risk is considered low because the likelihood of encountering HTRW is considered low. The potential exists to encounter a number of chemicals in the subsurface or possibly in leachate (drainage) associated with excavations. These could include any of the previously identified contaminants of concern, most probably lead, zinc, barium, copper, and organic compounds such as benzene, toluene, and chlorinated hydrocarbons. In addition, the possibility exists to encounter sulfuric acid sludge.

Potential Impacts: Should construction of the pool structure at RM 530 occur and contaminants extend beyond the EPA site boundary, the non-Federal Sponsor (NFS) would have to provide a clean project site prior to implementation of any measures in proximity. While

the sponsor is willing to take that risk, the risk to the government is that USACE could commit to a plan at a contaminated location.

Uncertainties: The full lateral extent of the contamination and its nature is unknown. Construction of a measure near the Superfund site boundary could encounter extensive HTRW, material that just requires a specific disposal location, or could encounter no hazardous materials at all. Tulsa County will begin investigations into the nature and extent of potential hazardous materials in proximity to the proposed dam location concurrently with completion of the feasibility study to inform the pre engineering and design phase of the study.

Planning Decisions: Project contingencies for the Recommended Plan would cover additional non-remediation costs (e.g. construction delays, design changes) that may be incurred as a result of encountering HTRW. The team recommends leaving the structure at RM 530 in the array of measures considered in the plan formulation to obtain maximum measureable and non measureable benefits.

3.10 National Ecosystem Restoration Plan

3.10.1 Selection Criteria for the National Ecosystem Restoration Plan

Comparing benefits and costs for ecosystem restoration provides a challenge to planners and decision makers because benefits and costs are not measured in the same units. Environmental restoration benefits can be measured in habitat units or some other physical unit, while costs are measured in dollars. Therefore benefits and costs cannot be directly compared. While cost effective analysis and incremental cost analysis are conducted to help planners and decision makers identify plans for implementation, these analyses themselves do not identify a single ideal plan.

Each alternative plan within the final array represents an incremental increase in the level of restoration which can be viewed from two perspectives – quality of restoration achieved and quantity of acres restored. Because all of the action plans in the final array of alternatives represents some level of restoration and provide habitat for a diverse community of fish and wildlife species, additional criteria need to be considered through an “is it worth it” analysis to help differentiate each alternative from the others in selecting the NER plan.

The “is it worth it” analysis for alternatives in the final array includes quantitative and qualitative discussions utilizing the following selection criteria:

- Incremental benefit
- Incremental cost
- Quantity of restored riverine acres
- Quality of restored habitat
- Number of targeted habitat types restored

Table 144 displays the AAHU outputs, average annual and incremental costs per AAHU and total first costs of each alternative and Figure 12 displays the incremental cost per incremental output for each alternative. Note, while AAHUs are presented as the sum of each alternative’s environmental benefits, not all AAHUs are equal or of the same habitat type. For example, the numeric AAHU output for the Prattville Creek restoration measures can be considered small when compared to the numeric AAHU output of one of the pool structures. However, the restored function and productivity of a wetland or other type of niche habitat, especially in a

hydrologically stressed system as the ARC, must be taken into consideration when evaluating the final array of alternatives. Increments of environmental benefits, while sometimes appearing small in term of AAHUs, were also taken into consideration as they relate to habitat type restoration (wetlands, sandbars, etc.) in the "*Is It Worth It?"* analysis. This ensured restoration opportunities, where comparatively small in AAHU output but instrumental in ecosystem recovery, received full consideration as they relate to the study's ecosystem-wide restoration goals.

Table 14: Final Array of Plans for Selection of the NER Plan

No	Plan Alternative	Output (AAHU)	Annual Cost ($1000)	Average Annual Cost ($1000/AAHU)	Incremental Annual Cost ($1000)	Incremental Output (AAHU)	Incremental Annual Cost per Output ($1000)	Alternative First Cost	Acres
1	No Action	0	0						1,422
2	Pool structure located at Keystone Lake Project reregulating dam (RM 531)	824.05	$3,875	5	$3,875	824.05	$5	$89,928,700	3,614.00
2A	Pool structure located at Keystone Lake Project reregulating dam (RM 531) + Prattville Rock Riffle and Wetland Plantings +New Least Tern Island	832.136	$4,089	5	$214	8.086	$26	$93,348,819	3,622.34
3	Pool structure located at RM 530	867.57	$4,469	5	$380	35.434	$11	$104,608,312	3,735.00
4	Pool structure located at RM 530 + Prattville Rock Riffle and Wetland Plantings	872.69	$4,594	5	$125	5.116	$24	$106,667,246	3,740.34
5	Pool structure located at RM 530, Prattville Rock Riffle and Wetland Plantings +New Least Tern Island	875.66	$4,683	5	$88	2.97	$30	$108,028,431	3,743.34
6	Pool structure located at RM 530, Prattville Rock Riffle and Wetland Plantings, New Least Tern Island + Riverside Rock Riffle and Wetland Plantings	876.13	$4,869	6	$186	0.477	$391	$111,690,798	3,743.89

Table 14: Final Array of Plans for Selection of the NER Plan (Continued)

No	Plan Alternative	Output (AAHU)	Annual Cost ($1000)	Average Annual Cost ($1000/AAHU)	Incremental Annual Cost ($1000)	Incremental Output (AAHU)	Incremental Annual Cost per Output ($1000)	Alternative First Cost	Acres
7	Pool structure located at RM 530, Prattville Rock Riffle and Wetland Plantings, New Least Tern Island, Riverside Rock Riffle and Wetland Plantings +Riverside Riparian Plantings	876.27	$4,946	6	$77	0.14	$548	$112,522,720	3,745.47
8	Pool structure located at RM 530, Prattville Rock Riffle and Wetland Plantings, New Least Tern Island, Riverside Rock Riffle and Wetland Plantings, Riverside Riparian Plantings + Prattville Riparian Plantings	876.47	$5,066	6	$120	0.2	$601	$113,337,693	3,747.71

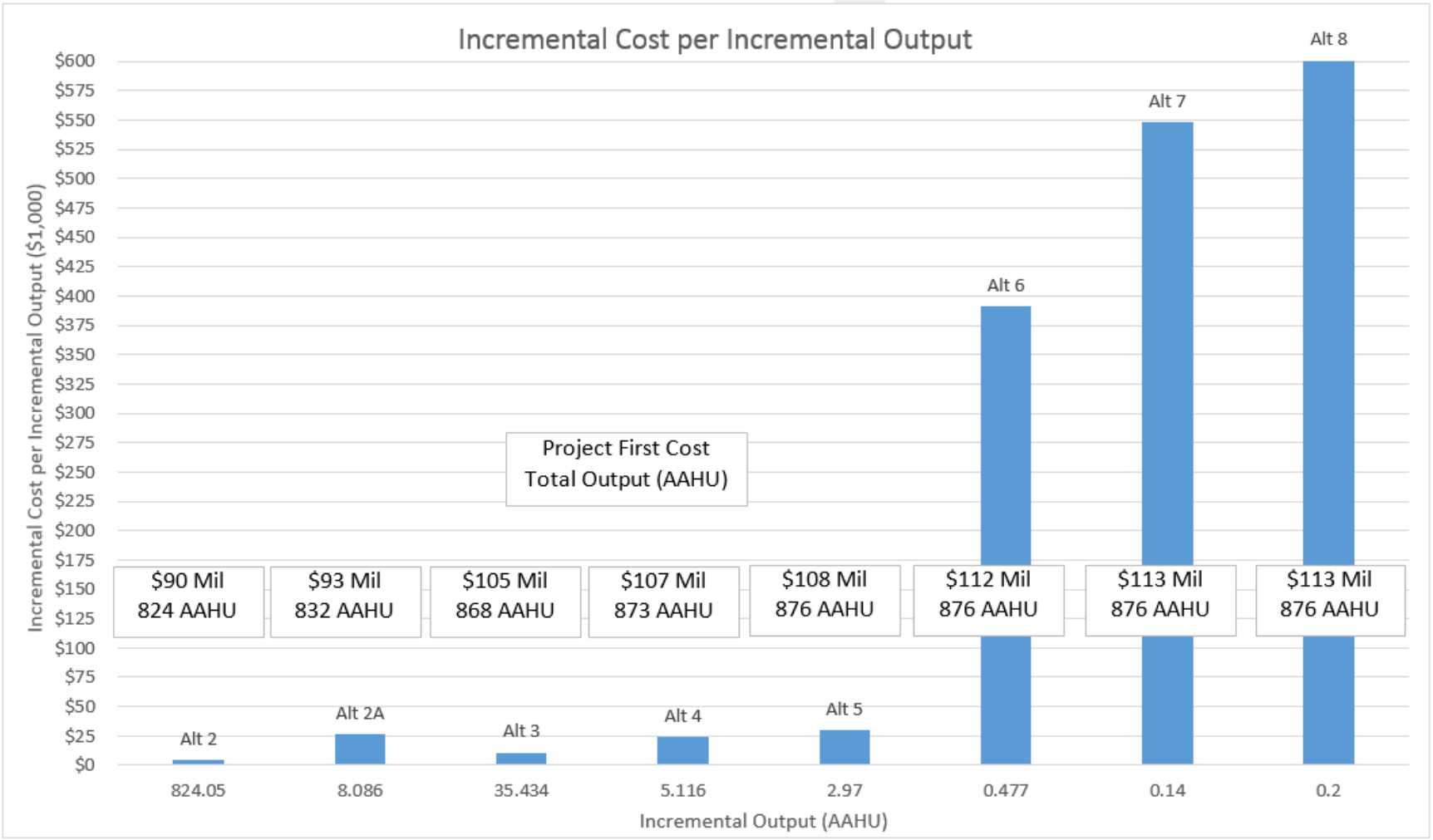

Figure 12: Comparison of the Final Array of Alternatives

3.10.2 Is It Worth It Analysis on Final Array of Alternatives

Is It Worth It? – Alternative 1(No Action)

The PDT believes that the No Action plan does not meet the study objectives and is not acceptable. The No Action plan presumes no management measure would be taken to address the planning objectives. The existing low flow condition largely disconnects the floodplain habitat, desiccates aquatic and terrestrial riverine vegetation, minimizes seed and invertebrate production for migratory waterfowl foraging, disrupts migratory and reproductive life histories of native fishes, promotes sandbar and bank erosion, and reduces Least Tern nesting opportunities and success. Existing urban, rural, agricultural, levee, and industrial development along the study corridor confines the floodplain to a narrow remnant of its historical extent. This limits the available area for fish and wildlife habitat abundance and diversity. In the No Action plan there would be no restoration of riverine habitat, connectivity for migratory fish, nesting habitat for Least Terns, or habitat diversity. The decline in overall ecosystem health is expected to continue with the No Action plan.

Is It Worth It? –Alternative 2

Alternative 2 is worth the Federal and local investment. This alternative entails constructing an instream structure at RM 531, the location of the once-existing reregulating dam. Alternative 2 restores a more natural pre-dam flow regime, restoring riverine habitat spanning 42 river miles from just below Keystone Dam to the Tulsa-Wagoner County Line that would otherwise remain degraded by reoccurring low flows. The instream structure captures portions of high flow releases from hydropower generation, then time releases that water at approximately 1,000 cfs to supplement riverine flows between hydropower generations. Under current conditions, the river would go almost completely dry until hydropower flows return the following day. The approximate 1,000 cfs release maintains a connected river system, avoiding isolated stagnant pools and interrupting life histories of migratory pelagic spawning fish species.

This alternative also maintains existing sandbar nesting habitat by reducing the occurrence and effects of land bridging. Land bridging occurs when water levels recede exposing river bed that connects the island to the shoreline. This allows for easier access to nesting colonies for predators and increases the occurrence of recreation disturbance. Alternative 2 also restores continuous water flow and connectivity to numerous backwater areas and tributaries throughout the study area. Restoring more natural flows to the Arkansas River Corridor reconnects floodplain habitats, restoring the function of remaining aquatic and terrestrial riverine vegetation. This allows aquatic and riparian vegetation communities to naturally stabilize shorelines, improve foraging and nursery habitat for aquatic insects, amphibians, fish, migratory waterfowl, and shore birds. With Alternative 2, restored riverine habitat in the study area increases from the baseline of 1,422 acres to 3,614 acres within 10 years, an approximate 154 percent increase in available riverine habitat over the No Action alternative. Approximately 824 AAHUs are gained for the four riverine model species with an incremental cost per incremental output of $5,000.

Alternative 2 is worth the Federal and local investment. Given that the largest plan in the array would restore a total of 876.5 AAHUs and 3,748 acres, this plan restores 94 percent of the possible AAHUs and 96 percent (3,614 acres) of the possible acres. The addition of 2,192 acres of riverine habitat from the No Action plan increases the carrying capacity of the study area, adds to the resiliency of the ecosystem, and most importantly reconnects and restores distant

river reaches and valuable habitats within the floodplain for native and Federally and state listed species. While this alternative targets riverine habitat, it does not address the overall net loss of wetland, sandbar, and riparian habitat types in the study corridor. The pool structure in Alternative 2 restores the function of existing sandbars that, currently, only minimally meet the Least Tern nesting needs. While the pool structure would restore connectivity to wetlands and buffering riparian habitat, these habitat types have been degraded to the point that without additional management measures, no restored ecological function can be expected. The alternative's first cost is approximately $90 million, an annual cost of $3.9 million.

Is It Worth It?—Alternative 2a

Alternative 2a is worth the Federal and local investment. The additional cost-effective plan chosen to be considered alongside the best buy array includes building the upstream pool structure at RM 531 as described in Alternative 2, plus a rock riffle complex and wetland plantings at Prattville Creek, and a nesting island for Least Terns near Broken Arrow, Oklahoma. Because the two pool structures were treated as mutually exclusive in the CE/ICA analysis, this alternative did not land in the best buy array, however it represents the most practicable, restorative alternative that includes the pool structure at the upstream location. This alternative restores riverine, wetland and sandbar habitat types throughout the study area. The additional rock riffles and wetland plantings address the loss of habitat diversity and associated functions through the restoration of 5.34 acres of wetlands at the mouth of Prattville Creek. The 5.34 acre wetland is the largest area available for wetland restoration throughout the study area due to floodplain constriction and land development along the river for multiple purposes. Aquatic insects, migratory waterfowl, shorebirds, fish, and aquatic reptiles and amphibians would all benefit from the increased foraging, nursery, and refuge functions produced by the restored structure of rock riffles and aquatic vegetation. The construction of a rock riffle complex would maintain the necessary wetted area and wetland plantings to increase the aquatic vegetation diversity, taking the habitat from a scoured, non-productive state to a diverse, sustainable wetland. Although the pool structure would restore existing sandbar habitat, many of the existing sandbars are inundated, along with any Least Tern nests, during peak hydropower generation flows and late summer flood pool releases. The restored sandbar island would be constructed to maintain approximately 3 acres of suitable nesting habitat at 20,000 cfs. This additional measure adds to the resiliency of the Arkansas River corridor ecosystem and increases habitat diversity through the water depth, pool, and riffle complexes associated with sandbars. Most importantly, the restored sandbar provides reliable nesting habitat, above the reoccurring inundating flows, for the Federally-listed endangered Least Tern.

Alternative 2a is worth the Federal and local investment. The addition of a restored five acre sandbar island and wetland restoration efforts at the mouth of Prattville Creek not found in previous alternatives makes this the most comprehensive restoration alternative that incorporates the pool structure at the upstream location. It also increases the carrying capacity of the study area, adds to the resiliency of the ecosystem, increases the biodiversity and habitat value, and most importantly reconnects and restores distant river reaches and valuable habitats within the floodplain for native and federally and state listed species. This alternative would create 832 AAHUs over the No Action plan, and 8.1 over Alternative 2. It would provide 94.9 percent of the potential AAHUs and 96.6 percent of the maximum acres. The annual cost of Alternative 2a is approximately $4.1 million with a first cost of the alternative is approximately $93.3 million, an increase of $3.4 million over Alternative 2.

Is It Worth It? –Alternative 3

Alternative 3 is worth the Federal and local investment. Alternative 3 restores the maximum amount of riverine habitat spanning 42 river miles that would otherwise become predominantly dry river bed with stagnant isolated pools from just below Keystone Dam to the Tulsa-Wagoner County Line. Like Alternative 2, this alternative entails constructing a pool structure. It would be located one mile further downstream at RM 530 near Sand Springs, Oklahoma, and just upstream from the confluence of Prattville Creek and the Arkansas River. The function of this structure and qualitative ecological benefits are greater than Alternative 2 because the downstream location allows for an additional river mile of water storage above the structure. This additional river mile provides more habitat diversity including riverine pools, eddies, slackwater, and backwaters that support aquatic life throughout various life histories in the upstream habitat. This location also provides for additional storage capacity, allowing greater flow capabilities regarding both flow rate and duration by adding flexibility to adapt flow management to a wider range of environmental conditions. This is critical to addressing the fast changing habitat conditions when short-term droughts or basin wide precipitation is forecasted. Being able to lower the flow rate and prolonging minimum flow during short term droughts allows this measure to sustain considerably more riverine life downstream than the same structure located one mile upstream. When widespread precipitation is occurring and flood pool releases from Keystone Dam are anticipated during late season thunderstorms, additional flow can be released, connecting far more riverine and floodplain habitat. This provides more access to refuge areas for fish ahead of high flow events, buffers habitat from sudden flooding events, and limits erosive forces along the shoreline by building stronger riparian vegetation communities that naturally stabilize and protect shorelines.

Within one year, Alternative 3 further expands the restored area to an additional 121 acres of riverine habitat over Alternative 2 in the study area increasing the baseline riverine habitat from 1,422 acres to 3,735 acres, an approximate 163 percent increase in riverine habitat over the No Action plan. This alternative restores 99 percent (867.67 AAHUs) of the maximum possible AAHUs and 99 percent of the maximum possible acreage. The incremental cost per incremental output is approximately $14,000, an increase of $9,000 per incremental output over Alternative 2. The incremental increase in cost per output gained is relatively small compared to other alternatives.

Like Alternative 2, Alternative 3 restores existing sandbars, wetlands, and riparian components associated with wetlands downstream. Additionally, this alternative provides for the maximum amount of restored riverine acres upstream as well.

Alternative 3 is worth the Federal and local investment. The additional storage capacity adds to management capability of the downstream location for the pool structure and is worth the additional cost. The ability to adjust downstream flows based on current conditions allows for maximum restoration output on a seasonal basis. The 121 acres of additional restored riverine habitat over what is produced by Alternative 2 spans across 42 river miles, increases the carrying capacity of the study area, adds to the resiliency of the ecosystem, and most importantly reconnects and restores distant river reaches and valuable habitats within the floodplain for native and Federally and state listed species. However, several areas with sandbar, wetland and associated riparian habitat types have been degraded to the point that without more habitat specific restorative measures, no restored ecological function can be expected. The first cost is approximately $105 million, an annual cost of $4.5 million.

Is It Worth It? –Alternative 4

Alternative 4 is worth the Federal and local investment. Alternative 4 includes the pool structure measure and benefits described in Alternative 3 and addresses the loss of habitat diversity and associated functions through the restoration of 5.34 acres of wetlands at the mouth of Prattville Creek. Through the construction of a rock riffle complex to maintain the necessary wetted area and wetland plantings, the aquatic vegetation diversity increases, taking the habitat from a scoured, non-productive state to a diverse, sustainable wetland. The incremental cost per incremental output is $24,000, almost double that of Alternative 3. With this alternative, approximately 99.6 percent (872.69 AAHUs) of the total possible AAHUs are restored and 99.8 percent of the total acreage. The 5.34 acre wetland is the largest area available for wetland restoration throughout the study area due to floodplain constriction and land development along the river for multiple purposes. Aquatic insects, migratory waterfowl, shorebirds, fish, and aquatic reptiles and amphibians would all benefit from the increased foraging, nursery, and refuge functions produced by the restored structure of rock riffles and aquatic vegetation. Alternative 4 not only restores the maximum amount of riverine habitat, but also restores the lost benefits produced by a functioning wetland.

Alternative 4 is worth the Federal and local investment. The addition of 5.34 acres of restored wetlands not included in Alternative 3, increases the carrying capacity of the study area, adds to the resiliency of the ecosystem, increases the biodiversity and habitat value, and most importantly reconnects and restores distant river reaches and valuable habitats within the floodplain for native and federally and state listed species. This alternative targets riverine and wetland habitat for restoration, however it does not address the overall net loss of sandbar islands and riparian components associated with wetlands without additional restorative measures. The first cost for this alternative is approximately $107 million, an annual cost of $4.6 million.

Is It Worth It? –Alternative 5

Alternative 5 is worth the Federal and local investment. Alternative 5 includes the measures and benefits described in Alternative 4 and addresses the loss of sediment and sandbar nesting habitat for Least Terns in the study area through the restoration, via construction, of a five acre sandbar island near Broken Arrow, Oklahoma to facilitate continued Least Tern nesting. The total benefit of this alternative is approximately 875.7 AAHUs, an increase of approximately 3 AAHUs over Alternative 4, and an incremental cost per incremental output of approximately $30,000, an increase of $5,000 over Alternative 3. Although the pool structure would restore the function of existing sandbar habitat, many of the existing sandbars are inundated, along with any Least Tern nests, during peak hydropower generation flows and late summer flood pool releases. The sandbar island measure would be constructed to provide up to five acres of nesting habitat and maintain approximately three acres of sustainable nesting habitat at 20,000 cfs. This additional measure adds to the resiliency of the Arkansas River Corridor ecosystem and increases habitat diversity through the water depth, pool, and riffle complexes associated with sandbars. Most importantly, the restored sandbar provides reliable nesting habitat, above the reoccurring inundating flows, for the Federally-listed endangered Least Tern.

Alternative 5 is worth the Federal and local investment. The addition of a restored sandbar island, not found in Alternative 4, increases the carrying capacity of the study area, adds to the resiliency of the ecosystem, increases the biodiversity and habitat value, and most importantly

reconnects and restores distant river reaches and valuable habitats within the floodplain for native and federally and state listed species. It also provides greater benefits than Alternative 2a, because it provides additional storage for increased flexibility in managing river flow during weekends when hydropower typically does not occur and during more extreme drought and flooding conditions. This alternative targets riverine, wetland, and sandbar habitat for restoration, however it does not address the overall net loss of riparian components associated with wetlands. The first cost of this alternative is approximately $108 million, an annual cost of $4.7 million.

Is It Worth It? –Alternative 6

Alternative 6 may not be worth the Federal and local investment. Alternative 6 includes the measures and benefits described in Alternative 5 and further addresses the loss of habitat diversity and associated functions through the restoration of an additional 0.55 acres of wetlands along the left bank of the study corridor just upstream of the Riverside Drive and Interstate 44 intersection in Tulsa, Oklahoma. Construction of a rock riffle complex to maintain the necessary hydroperiod and wetland plantings increases the aquatic vegetation diversity, taking the habitat from a scoured, non-productive state to a diverse, sustainable wetland. The total AAHUs for this alternative are approximately 876.1 AAHUs, an increase of approximately 0.4 AAHUs and an incremental cost per incremental output of $390,000. Just over 99.9 percent of the total possible AAHUs are restored, along with 99.9 percent of total possible acres. Aquatic insects, migratory waterfowl, shorebirds, fish, and aquatic reptiles and amphibians would all benefit from the increased foraging, nursery, and refuge functions produced by the restored structure of rock riffles and aquatic vegetation.

Alternative 6 may not be worth the Federal and local investment. The addition of 0.55 acres of wetlands adds to the overall carrying capacity and habitat value of the study area. This alternative targets riverine, wetland, and sandbar habitat types for restoration, however the large increase in costs per incremental annual cost output prohibits justification for the associated small gains in environmental output. The first cost for this alternative is approximately $112 million, an annual cost of $4.9 million.

Is It Worth It? –Alternative 7

Alternative 7 may not be worth the Federal and local investment. Alternative 7 includes the measures and benefits described in Alternative 6 and addresses the loss of habitat diversity and associated functions through the restoration of 1.58 acres riparian plant communities associated with the wetland restoration efforts near the Riverside Drive and Interstate 44 intersection in Tulsa, Oklahoma. Riparian plant communities, specifically those adjacent to and buffer wetlands, have been largely degraded or lost in the Arkansas River Corridor by the frequent bouts of inundation and drying associated with the existing unnatural flow regime. Opportunities to restore this specific habitat type are extremely limited due to the loss of wetlands and associated riparian buffer habitat within the constricted floodplain. This additional measure, via Sandbar/Prairie Willow and Redosier Dogwood plantings, provides valuable riparian understory habitat components that support water and songbird nesting, disturbance buffers, and provide natural allochthonous material and bank stability to maintain wetland depth and function. Riparian plantings at this location increase riparian habitat and provide additional wetland buffer habitat and nesting areas. The alternative has a total benefit of 876.2 AAHUs, an increase of

approximately 0.1 AAHUs over Alternative 6, and an incremental cost per incremental output of $550,000, an increase of $157,000 over Alternative 6.

Alternative 7 may not be worth the Federal and local investment. The addition of 1.58 acres of restored riparian habitat, although not produced by any of the previously discussed alternatives, adds to the overall diversity and habitat value of the study area by targeting all habitat types for restoration, but does not produce enough environmental benefits to reasonably justify the incremental costs associated with this alternative. The first cost for this alternative is approximately $113 million, an annual cost of $5.0 million.

Is It Worth It? –Alternative 8

Alternative 8 may not be worth the Federal and local investment. Alternative 8 includes the measures and benefits described in Alternative 7 and further addresses the loss of habitat diversity and associated functions through the restoration of an additional 2.24 acres of riparian plant communities associated with the wetland restoration efforts at the confluence of Prattville Creek and the Arkansas River near Sand Springs, Oklahoma. As mentioned above, riparian plant communities, specifically those that are adjacent to and buffer wetlands, have been largely degraded or lost in the Arkansas River Corridor. Opportunities to restore this specific habitat type are extremely limited due to the loss of wetlands and associated riparian buffer habitat and the constricted floodplain. These Sandbar/Prairie Willow and Redosier Dogwood plantings provide additional riparian understory habitat. Riparian plantings at this location increase additional wetland buffer habitat and nesting areas, and contribute an additional 0.22 net AAHUs.

The addition of 2.24 acres of restored riparian habitat increases the carrying capacity and habitat diversity of the study area, and restores 100 percent of the identified acres suitable for restoration in this study. The alternative has a total benefit of 876.5 AAHUs, an increase of 0.3 AAHUs over Alternative 7, with an incremental cost per incremental output of $600,000. It represents a substantial increase in incremental cost per incremental output over Alternative 7.

Alternative 8 may not be worth the Federal and local investment. The addition of 2.24 acres of restored riparian habitat, although not produced by any of the previously discussed alternatives by restoring all targeted habitat types, adds to the overall diversity and habitat value of the study area, it does not produce enough environmental benefits to reasonably justify the incremental costs associated with this alternative. The large first costs of this alternative and increase in incremental annual cost per output do not represent the best use of Federal resources based on the small gains in environmental output. The alternative's first cost is approximately $113 million, an annual cost of $5.1 million.

3.10.3 Selection of the National Ecosystem Restoration Plan

The Least Tern is the primary resource of national significance identified within the study area. Creating, restoring, and maintaining Least Tern nesting habitat, particularly sandbar islands, was identified as a critical component towards delisting of the species in coordination conversations with USFWS.

Alternative 5 is the recommended/National Ecosystem Restoration plan. This alternative restores:

- 99.8% of total acreage identified for restoration within the study area

- 3 (riverine, wetland, sandbar) out of the 4 targeted habitat types
- Resilient nesting habitat for the Federally-listed endangered Least Tern
- River and floodplain connectivity throughout the 42 river mile study area
- Represents an incremental cost per incremental out of $29,900 over Alternative 4
- Approximate first cost of $108 million, with an annual cost of $4.6 million

The pool structure is critical to the restoration of the Arkansas River Corridor and all other measures depend on its restored river flow to be successful. Additionally, the need for wetland and sandbar island restoration is based on the limited existence of those habitats within the study area. Therefore, in order to meet study goals and objectives and increase the overall carrying capacity of the Arkansas River Corridor for the Least Tern, and all aquatic fauna, the implemented NER plan must restore river flow, wetland abundance and function, and sustainable sandbar habitat. Alternative 5 provides these key elements at a smaller incremental annual cost per output than any other alternative. Details for the design for both the pool structure and the constructed sandbar island can be found in Appendix G.

Alternatives 2 and 3 only restore river flow from the implementation of a pool structure. While river flow restoration is pivotal to overall ecosystem health, river flow alone does not address all of the problems identified in the study area, namely the loss of wetlands and sandbar habitat. Wetlands within the study area are largely degraded to the point that river flow alone would not revive their vegetative diversity or sustain the necessary hydroperiod needed for wetland development. Wetlands provide nursery, feeding, and refuge habitat for small forage fish, aquatic invertebrates, and migratory waterfowl. Least Terns, and numerous other fauna, depend on wetland productivity to produce food sources they need to survive. Without an increase in wetlands, the availability and abundance of forage fish may not meet the needs of a sustained and increasing Least Tern population in the study area.

Alternative 4 provides for restored river flow and wetlands, however it lacks the additional restorative components necessary to expand the carrying capacity of the Arkansas River Corridor to support additional nesting Least Terns. Sand abundance and sediment load transport have been severely impacted by the construction of Keystone Dam, hydropower and flood pool releases, and local sand mining operations. Restored river flow would restore the existing sandbars, however most are inundated or their above water surface areas are substantially reduced during daily hydropower releases. Without additional sandbar islands constructed to withstand at least the hydropower release of 12,000 cfs, which raises water depth approximately 1 to 5 feet within the river, nesting habitat abundance for Least Terns would not be restored.

3.10.3.1 Benefits B**eyond AAHUs**

In an ER study, it is critical to understand that all AAHUs are not the same from study to study or even within a single study. While the bulk of the restorative benefits in this study are generated from the pool structure, realizing that the benefits derived from the sandbar island and wetland restoring measures may be smaller, but provide entirely different functions from that of the riverine benefits is paramount. Therefore, the additional AAHUs found in Alternative 5 over Alternative 3 are not simply more of the same type of benefits. Rather the additional AAHUs found in Alternative 5 are derived from restored wetland function and sandbar island habitat that are entirely not produced with the implementation of Alternative 3.

The extensive urban, industrial, and agricultural development along the banks of the river exacerbate the problems associated with Keystone Dam. One of the biggest issues, is the limited area available for wetlands. The 5.34 acres of restored wetlands at the mouth of Prattville Creek represent a substantial increase in the abundance and quality of existing wetlands. Amphibians, fish, waterfowl, aquatic insects and plants would all benefit from the restoration of a functioning wetland. The rock riffle complex would largely protect and maintain the hydrologic profile to sustain the wetland communities while the wetland vegetative plantings would provide the basis for habitat diversity and for the return of native species. This measure would also provide a seed source for habitats downstream to naturally combat the encroachment of non-native species. While this measure produces fewer AAHUs than the pool structure, the type of benefits produced by a restored wetland differ greatly and would serve to compliment the riverine benefits to further strengthen and diversity the study area.

The same can be said of the few benefits produced by the sandbar island measure, it produces fewer benefits compared to its pool structure counterpart, however the type of benefits produced differ greatly from the riverine and wetland benefits. The construction of a sandbar island adds to the sustainability of nesting habitat in the area. This measure separates Alternatives 4 and 5 as Alternative 5, the NER, addresses this key conservation issue for Least Terns. As flows and related river depth increase, the amount of available nesting habitat decreases due to inundation. The constructed tern island would provide approximately 5 acres of nesting area at approximately 1,000 cfs. However, during hydropower generation flows can reach up to approximately 12,000 cfs. The constructed tern island would still provide approximately 3 acres of suitable nesting habitat at 20,000 cfs allowing continued nesting use of the sandbar island during late season flood pool releases from Keystone Dam. Aside from Least Terns, as the Arkansas River flows from mostly west to east in the study area spanning a large section of the Central Flyway, millions of migratory waterfowl, songbirds, and other marsh and wading birds move through the study area. The Federally threatened Red Knot and Piping Plover, may also use the sandbars for resting areas during their migration. Alternative 5 would promote additional carrying capacity and habitat diversity within the study area, relieving stress placed on wintering habitats further south, and breeding habitats to the north.

Alternatives 6, 7, and 8 consist of the same measures found in Alternative 5, plus additional wetland and riparian improvements, however due to their large annual incremental cost per output these alternatives were not recommended. Alternatives 2a, and 5 represent the two most complete and practicable restoration alternatives as they primarily restore river flow and downstream floodplain connectivity through the construction and operation of a pool structure. Both Alternatives 2a and 5 also entail constructing a sandbar island to support additional Least Tern nesting with suitable habitat remaining available at flows up to 20,000 cfs, as well as wetland restoration at the confluence of Prattville Creek and the Arkansas River to increase nursery habitat for the forage fish Least Terns depend on. These three measures generate a lift in carrying capacity within the Arkansas River Corridor as they address all needs (habitat, security, and food) of reproducing Least Terns.

The key difference between the Alternatives 2a and 5 is the location of the pool structure. The pool structure in Alternative 5 is one mile downstream from the pool structure in Alternative 2a. This gives Alternative 5 a distinct advantage over Alternative 2a while its completeness gives it further advantages over Alternative 3 **Error! Reference source not found.**5 shows a comparison of the No Action and Alternatives 2a, 3 and 5.

Table 15: Comparison of Existing Conditions, Alternative 2a, Alternative 3, and Alternative 5

Component	No Action	Alternative 2a	Alternative 3	Alternative 5
Constructability	Downstream HTRW	No further HTRW Risk	Potential further HTRW Risk	Potential further HTRW Risk
Operationally	Keystone Dam	4,860 ac-ft. storage	6,730 ac-ft. storage	6,730 ac-ft. storage
Adaptability	N/A	High & Low Flows	High & Low Flows	High & Low Flows
Climate Change	At-Risk	~2.5 days @1,000 cfs (at full capacity)	~3.5 days @1,000 cfs (at full capacity)	~3.5 days @1,000 cfs (at full capacity)
Ecologically	Deteriorating	+1,112 acre riverine pool	+1,321 acre riverine pool	+1,321 acre riverine pool
Completeness (riverine, sandbar, wetland, riparian)	0 out of 4 habitats	3 out of 4 habitat (on weekdays)	1 out of 4 habitats	3 out of 4 habitats
Sustainability	Net Sink	Weekend Sink	Stable	Net Source
Ecosystem Status	Degrading	Surviving	Limited	Thriving
Violates Planning Constraint	Does not address elements in the ARC Master Plan	No	No	No

The pool structure in Alternative 5 provides an additional 43 AAHUs over its counterpart in Alternative 2a, this equates to roughly 200 acres of additional shoreline, backwater, river habitat. Shorelines contain the needed aquatic and overstory vegetation used by fish and aquatic organisms for temperature and predator refuge as well as nursery and foraging grounds. The additional construction costs associated with Alternative 5's pool structure, due to the wide river channel, warranted further analysis comparing the two pool structures in regards to the benefits each possess that are not captured in the habitat analyses.

The habitat analyses captured benefits in the form of AAHUs reflecting the improvement in ecological metrics like expanding aquatic vegetation, sandbar substrate quality, and river flow regime. However, adaptability to climate change, operational capabilities, and the risk of not being able to provide downstream flows between hydropower releases among the two pool structure locations was not captured in the habitat analyses. These key comparisons allow for

further consideration of costs, benefits, and long-term restoration success. Those comparisons are elaborated below (and Figure 12 above).

An existing superfund site downstream of both pool structures exists along the left bank. The operation of either pool structure would not impact, expose, or otherwise disturb what remains of the superfund site. The superfund site is over a mile downstream from the pool structure location in Alternative 2a. The pool structure in Alternative 5 is approximately one quarter of a mile outside the boundary of the superfund site. Tulsa County, the study non-Federal sponsor, is aware of the proximity, fully understands their responsibility to provide a clean, non-contaminated project construction site, and is prepared to properly dispose of any HTRW components if they are encountered in the construction area of the pool structure at this site at 100 percent their expense.

Operationally, both locations would effectively store water released from Keystone Dam and release it downstream at the targeted 1,000 cfs. Neither structure would impact or require Keystone Dam operation changes. Instead, they would use the water released under current operations to improve the ecosystem, rather than continue to degrade it. The key difference between the two structures is that the downstream location in Alternative 5 allows for additional water storage. Alternative 2a's location would store approximately 4,860 acre feet of water at full capacity while the downstream location in Alternative 5 can store roughly 6,730 acre feet. This additional storage would provide additional habitat, and more importantly it would provide additional water for flow releases to support downstream habitat.

Both structures would have the capability to release more or less water than the targeted 1,000 cfs to adjust to current conditions. With the extra storage, the downstream location has the added adaptability to work in concert with scheduled water releases from Keystone. When water is abundant and releases become frequent, Alternative 5 can provide approximately 1,000 cfs for a longer period than the upstream location in Alternative 2a. This would improve and expand riverine habitat, combat invasive species colonization, and promote naturally stabilized shorelines. When water is scarce, the extra storage can be used to either preserve aquatic life in the pool or sustain a lower minimal flow downstream to maintain aquatic life.

Either pool structure would also be subjected to the hydropower release schedule. At full capacity the pool structure in Alternative 2a can release 1,000 cfs for roughly two and a half days, Alternative 5's pool structure can release 1,000 cfs for roughly three and half days. Both structures possess adequate capacity to provide sufficient river flow during week days when normal hydropower releases are scheduled every 18-24 hours. However, when Keystone Lake is at conservation elevation (723.0 feet and below), hydropower releases typically do not occur on weekends as demands for electricity are much greater on weekdays. Therefore, either pool structure would need to regularly provide river flow for three days before being refilled by the next week's hydropower release. Both structures would have the ability to reduce their release flow rate to prolong river flow, however with the added storage in Alternative 5's downstream pool structure, it has the ability to provide the targeted 1,000 cfs over the weekend while the pool structure in Alternative 2a is likely to come up as half a day short every weekend. The loss of river flow for any period of time is lethal at some trophic level, prolonged loss of river flow amplifies that effect. Nesting Least Terns, their food source, and the overall ecosystem health would likely remain at risk on a regular basis with the implementation of Alternative 2a.

Alternative 5 is also more capable to combat the impacts that climate change may have on the ecosystem in the study area. When storms and flood pool releases are expected, both structures can release additional flows ahead of time, to more gently raise water levels and river flow. The pool structure in Alternative 5, through additional storage, can provide more river flow sooner, can provide target flows longer and can sustain minimum flows, buffering aquatic life trapped in isolated pools from high temperatures and low dissolved oxygen levels, longer than Alternative 2a. This allows fish, particularly forage fish for Least Terns, access to additional refuge areas as well as extra time to seek refuge.

Ecologically, both alternatives would provide a large riverine pool and sustain numerous backwater habitats. The riverine pool is roughly 210 acres larger in Alternative 5 than Alternative 2a. This area supports additional diverse aquatic and riparian habitat spanning a larger riparian corridor. The downstream location provides the added opportunity to manage river flow instead of to being at the mercy of it. The added flow capacity in Alternative 5 provides the framework for future environmental collaboration with our resource agency partners. Future threatened, endangered, and species of concern reintroductions, spawning efforts, and research would be possible with the implementation of Alternative 5. Alternative 5 has the ability to turn this stretch of the Arkansas River from a biological net sink, to a net source.

Ultimately, sustainability is the goal of any restoration project. The downstream structure allows for a synergistic effect of the key elements that capitalizes on the planning process, design opportunities, non-Federal sponsor and coordinating agency support. Sustainability is the gold standard for restoring, promoting, and conserving threatened and endangered species, and the larger ecosystem they, and us all, depend on.

The instream pool structure described in Alternative 5 would restore more natural flows in the study area by attenuating some of the high flows higher in the upper reaches of the study area that would otherwise sweep away lower laying tern nests, and maintain river flow necessary to isolate sandbars from terrestrial predators and recreational disturbances. Attenuating high flow events sooner also lessens the downstream erosion impacts on nesting sandbars and nursery side channel habitat for forage fishes, the primary food source for Least Terns, all of which promotes Least Tern nesting success. By restoring river flow and a more natural flow regime, the study area would also be more conducive to future sandbar creation and ongoing Least Tern conservation and monitoring efforts as well, relieving conservation pressure already placed on other nesting grounds.

Forage fishes utilize the slackwater and wetland habitats for growth, reproduction, and refuge from predators and high flow events. With Alternative 5, restored river flow would restore, sustain, and provide connectivity to those habitats. As Least Tern populations recover, the restoration of these habitats would provide the necessary increased carrying capacity to support a reliable, self-sustaining food base for Least Terns and other piscivorous species.

Once again the benefits provided by the pool structure to restore more natural flows to the study area is crucial to restoration success and sustaining aquatic life. Any period of time when a river goes dry is lethal at many trophic levels. Sudden flood conditions can be very harmful as well. This is where the additional storage of the downstream location for the pool structure is critical to maintaining a healthy resilient ecosystem. Forecasted climate change in this region of North America predicts droughts, heat waves, intense thunderstorms, and flash flooding. Coupled with irregular hydropower generation, this can create additional periods of shortages and surpluses

in the amount of water released from Keystone Dam, hence the need for flexibility of the pool structure to adapt to environmental conditions. When lowering flow rate releases, minimum flow can be maintained for much longer to sustain riverine life through short-term droughts with the pool structure located downstream as in Alternative 5. Likewise, when releases from Keystone Dam are more abundant, higher flows can be released, restoring and connecting additional floodplain habitat. Increasing downstream releases ahead of late season pool releases with the additional water stored provides depth which acts as a buffer against fast moving flow and promotes a wider, stronger floodplain ecosystem more capable of recovering from large flood events.

The more often this stretch of the river is subjected to extreme daily flow fluctuations, the more likely habitat types and food webs are to collapse or be severely altered due to certain species, typically non-native and invasive, being able to out compete native species for limited resources. Salt-cedar (*Tamarix ramosissima*) is the classic example of a plant species that can grow faster and establish itself in areas prone to more frequent, intense disturbances. Salt-cedar already exists in the study area in small pockets. Without restored flows, native species have little chance of outcompeting Salt-cedar. Furthermore, several sandbar islands have already been colonized by Salt-cedar, further hampering Least Tern nesting and sandbar regeneration. The restored flows naturally suppress early Salt-cedar growth, while allowing for native species expansion, and saving resources that would otherwise be expended in the mechanical and herbicide treatments of Salt-cedar.

Nearly all fish species native to the study area cannot survive more than a few minutes when stranded outside of water. When a river goes dry for hours or days with any type of regularity, as is does in the study area, the effects are seen floodplain wide in scale, and can be permanent in duration. When this reach of Arkansas River goes dry, it disconnects and disrupts sediment transport, fish migration routes, spawning habitats, pelagic dependent spawning behavior, and floodplain production.

Shovelnose Sturgeon and Paddlefish are largely absent from the study area other than in years of consistent river flow. This adds tremendous pressure on downstream reaches to maintain populations of these fish. In the event a disturbance forces those fish species, and others, to seek shelter in adjacent contiguous river reaches, this reach of the Arkansas River would be available to sustain those fish communities.

Providing a more consistent flow restores connectivity to tributary, slackwater, wetland, and riparian habitats. Alternative 5 reconnects these habitats in the study area, providing the opportunity to expand or reintroduce species of conservation concern including spawning populations of Paddlefish, Shovelnose Sturgeon, and the Federally-listed endangered Arkansas River Shiner (*Notropis girardi*).

With restored riverine, wetland, tributary, sandbar, and slackwater habitat structure, the increase in production of valuable foraging, resting, and breeding habitat would provide tremendous benefits to the avian, terrestrial, and aquatic communities year round.

In summary, Alternative 5 represents the most complete restorative option for Least Tern conservation. Collectively the restored flow regime and additional wetland and sandbar island habitat fulfill the life requisite needs of breeding and nesting Least Terns. Restoring the wetlands used by native riverine fishes for nursery habitat increases foraging opportunities needed to sustain nesting and rearing Least Terns and their offspring. Existing sandbar island

habitat, primarily used by Least Terns for nesting, would be restored through the implementation of the NER plan. However, due to decades of altered sedimentation transport limiting the amount of available sand within the study area and the inundation of lower elevation sandbars by hydropower and flood pool releases from Keystone Dam, reliable sandbar island habitat is limited. The construction of an additional sandbar island capable of providing three acres of reliable nesting habitat at flows up to 20,000 cfs expands the Arkansas River Corridor's ability to support a growing Least Tern population. By restoring habitat components that provide resources for Least Terns to complete all aspects of their life history when utilizing the study area, the Arkansas River Corridor can become a consistent source population for Least Terns. This lessens the burden of other nesting locations throughout their range to support the species as a whole and protects it from the long-term impacts that can occur when environmental disasters, such as hurricanes, flooding, drought, and contamination, reach other threatened and endangered species habitats.

Implementing the NER plan, Alternative 5, increases the Arkansas River Corridor's carrying capacity for the Least Tern, native river fishes, and all aquatic and riparian organisms within the study area. As the NER plan restores ecosystem function and sustainability, it allows other entities to pursue further conservation endeavors throughout the Arkansas River Corridor, providing further resources to promote a healthy, sustainable ecosystem. Based on three-day average releases, with the pool control structure in place, the minimum flow rate could be achieved 81.8 percent of days (298 days), a significant increase over the FWOP and historical average of 228 per year with an hourly release of 0 cfs. Finally, implementation of Alternative 5 would not increase the base flood elevation of the Arkansas River.

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4 RECOMMENDED PLAN

As discussed in Chapter 3, Alternative 5 is the NER plan. This Chapter explains why the NER plan is the Recommended Plan.[1] 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. During low flow conditions between flood pool and hydropower releases, the Arkansas River is reduced to a disconnected floodplain with few shallow pools remaining to shelter and provide for aquatic life and sandbar islands become exposed to terrestrial predators and disturbances. These conditions negatively impact Least Tern foraging, nesting, and rearing activities that ultimately hinder species recruitment and survival.

The NER plan would provide approximately 2,144 acres of additional riverine habitat, nearly doubling the amount of available habitat under low flow conditions. Also five acres of restored wetlands, and three acres of reliable sandbar island habitat 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 at a first cost of approximately $128.4 million (October 2018 prices).

4.1 Description of the Recommended Plan

Alternative 5 is the recommended/National Ecosystem Restoration plan. This alternative restores:

- 99.8% of total acreage identified for restoration within the study area;
- 3 (riverine, wetland, sandbar) out of the 4 targeted habitat types;
- Resilient nesting habitat for the Federally-listed endangered Interior Least Tern, and;
- River and floodplain connectivity throughout the 42 river mile study area.

Restoring river flow maintains a barrier, the river, between predators and urban disturbances along shoreline and nesting Least Terns on sandbar islands. The reconnected river reaches also restore migratory routes for native fish such as paddlefish to spawning and wintering habitats. Numerous other native fish would also benefit from the restored river flow such as Sauger and Paddlefish, which require sustained flows to support reproductive life history strategies. Side channel and shoreline habitats would also be restored and rejuvenated as the restored water regime would once again sustain aquatic life.

4.1.1 Restoration Features

4.1.1.1 Pool Structure below Hwy. 97 Bridge

For purposes of the feasibility study, the design of the proposed structure would capture and slowly release peaking hydropower and flood pool releases from the Keystone Dam, and, with design input and advice from resources agencies, provide sediment passage, and at least seasonal fish passage (upstream migration and spawn/fry movement downstream). At a maximum effective structure elevation height of 638 feet, the pool volume capacity is approximately 6,730 acre-feet with a pool surface area of 1,321 acres. The pool structure storage capacity was developed through modeling (Hydrologic Engineering Center's River

[1] In Chapter 5, the Recommended Plan is evaluated as the Recommended Alternative. In the FONSI, the Recommended Alternative becomes the Recommended Action.

Analysis System) and geographic information system analysis. Modeling analysis of proposed pool structure function and downstream flow was compared to historical post-Keystone Dam downstream discharge to estimate the potential to alleviate periods of no flow. The pool control structure storage would have a capacity that could provide a flow of 1,000 cfs approximately 80 percent of the time between periods of hydropower releases. The 1,000 cfs minimum flow estimate was derived from analysis of pre-Keystone Dam minimum flows in the Arkansas River through Tulsa, and from consultation with USFWS and ODWC identifying minimum flow that would restore the structure and function the riverine ecosystem. This full volume could provide downstream flows of 1,000 cfs for 3.4 days, 750 cfs for 4.5 days, or 500 cfs for 6.8 days.

Finally, public safety considerations would also be paramount during the design phase. The hydraulic roll-over effect that was a significant life safety risk in a previously existing re-regulation dam would be minimized through design of a sloped apron to reduce the hydraulic roll-over effect to less than significant. In addition, appropriate physical facility security measures would be utilized to limit public access near the pool structure.

4.1.1.2 Rock Riffle and Wetland Plantings at Prattville Creek

The fundamental measure at Prattville Creek is a rock riffle at the current confluence of Prattville Creek with the Arkansas River to restore a 5.34-acre wetland area. An engineered rocked riffle with weighted toe would be placed at the mouth of Prattville Creek at an elevation of approximately 640 feet. The structure would impound flows from Prattville Creek, and would be over-topped by high flows in the Arkansas River. An engineered rocked riffle placed at the mouth of Prattville Creek would create a wetland providing additional shallow water habitat to the Arkansas River Corridor system, and an area immediately upstream of the rock riffle conducive to velocity refuge, foraging, and nursery habitat for fish. The wetland increases the area of open water and provides an opportunity for the incorporation of additional management measures consisting of aquatic and riparian plant communities. The structure would divert some Prattville Creek flow into the original Prattville Creek channel that parallels the right bank of the Arkansas River to the original confluence, approximately 1 mile east (downstream) of the current mouth.

The north peninsula forming the current mouth of the Prattville Creek confluence has already received shoreline protection both on the Arkansas River side and on the Prattville Creek side. Considering the potential for erosive high flows moving down Prattville Creek directed into the south bank of the mouth area, longitudinal peaked stone toe protection for approximately 600 feet of the south bank of the proposed wetland area would maintain bank stability.

The rock riffle structure is a prerequisite for wetland plantings. Those plantings within the existing PSO electrical transmission corridor would generally be under 15 feet in height at maturity to limit the potential for vegetation to interfere with the operation of the line (PSO, 2016). Wetland Plantings around the perimeter of the created wetland (approximately 3,000 feet excluding the rock riffle) include Common Rush (*Juncus effusus*) and bulrushes (*Schoenoplectus spp.*) randomly planted and spaced approximately 1.5 feet on center. Wetland plantings would help stabilize banks of the wetland area, and provide forage and cover for insects, amphibians, mammals and waterfowl.

4.1.1.3 Constructed Sandbar Island

This management measure increases nesting habitat for the Least Tern. Ideal nesting habitat for Least Terns consists of sandbar islands isolated by river flows. While normal hydropower releases reach up to 12,000 cfs, typical mid-late summer rain events can increase river height and flow. Sandbar islands that remain unsubmerged during flows reaching 20,000 cfs promote more reliable, sustainable Least Tern nesting habitat. The constructed sandbar would be approximately five acres in size. Approximately three acres of which would continue to sustain nesting habitat during flows reaching 20,000 cfs. The sandbar island would be circular to oblong in shape, with maximum surface area and a surface height above water to exceed 18 inches at nest initiation (May or June). Based on an Oklahoma State University design (developed for the USACE-Tulsa District in May 2003), the placement of a rectangular riprap structure and a downstream chevron riprap structure would promote mid-stream sediment deposition resulting in habitable sandbar development. Sediment-transporting high and flood flow releases from Keystone Dam would promote sandbar development around the riprap structures, and provide scour to limit vegetative growth on sandbars when developed. Therefore, based on consultation with the USFWS and information from USACE Least Tern surveys, the most desirable reach in the study area is upstream of the Tulsa County line where the river more closely resembles a braided prairie stream. The proposed location is in the river just south of the Indian Springs Sports Complex in Broken Arrow, Oklahoma. The nesting substrate for the constructed island consist of native riverine sediments ranging in size from fine sand to small stones. In addition, the sandbars themselves provide water depth and flow diversity as well refuge for fish during higher flow events.

4.2 Benefits Gained for Nationally, Regionally, and Locally Significant Resources

Restoration of the Arkansas River Corridor would provide habitat benefits for a diverse community of aquatic organisms and wildlife; the most significant of which is the stop-over habitat benefits restoration would provide for nationally and internationally significant migratory birds of the Central Flyway. As evidenced by the numerous conservation and management cooperatives established to address adverse impacts to avian populations in North America, migratory birds are of great ecological value and contribute immensely to biological diversity. The backwater areas and vegetated shorelines included in the NER plan also provide food and cover for millions of waterfowl and migratory birds that utilize the Central Flyway. The study area lies along the eastern fringe of the Central Flyway and likely supports regular Mississippi Flyway migrants as well. The restored Arkansas River Corridor would provide tremendous additional habitat to support winter and summer migrants as the study area is positioned at a relative midpoint location for many species migration routes.

The restoration of connected river reaches also expands migratory routes for native fish in the Arkansas River Corridor and provides them access to side channel and backwater habitat they use for refuge, spawning, and nursery habitat.

Regionally, restoration of the Arkansas River Corridor would add to a larger habitat complex of the Arkansas River. Restoring river flow, wetlands, and sandbar habitat would greatly benefit the Federally-listed endangered Least Tern. The sustained river flows provided by the NER would maintain nesting habitat and forage fish species, restored wetlands increase forage fish abundance to support a growing Least Tern population, and the sandbar island constructed to withstand higher flow rates provides additional nesting habitat during elevated river stages.

The riparian corridor that brackets the study area would be further supported by continuous river flow provided by the NER. Currently, the shorelines are subjected to frequent bouts of drying followed by high flow events. This constant shift in water levels subjects the shorelines to increased erosion and fosters invasive species encroachment. The NER provides a more stable flow regime to support native riparian vegetation growth. Native vegetation naturally stabilizes shorelines providing habitat and reducing the need for expensive constructed shoreline stabilizing measures that offer little habitat.

4.2.1 Scarcity

The USFWS estimates 70 percent of the riparian habitats nationwide have been lost or altered. In the southwest, loss of native riparian vegetation exceeds 95 percent of historic habitats. These riparian habitats have been lost or altered due to river channelization, water impoundments, agricultural practices, and urbanization (Krueper, 1995). As riparian habitats across the country diminish, remaining riparian habitats become overcrowded and limited energy resources are not able to replenish fast enough for late arriving migrants or species that migrate later in the season.

In addition, species breeding in the riparian habitats must compete with a continuous onslaught of migratory birds utilizing their breeding habitat as stop-over habitats. Therefore, the restoration of riparian habitats across the country is essential for the continued existence of many migratory bird species.

Historically, this section of the Arkansas River was a large meandering river with extensive floodplain side channel and wetland habitat. The alteration of rivers, river flow, and riparian habitat, particularly though the construction of dams, and their impacts on native fauna is well known and documented. For example, numerous anadromous fish in the Pacific Northwest have been cut off from their spawning grounds due to dams and low water crossings. Significant efforts have been made over the last decade to remove these barriers. The construction and operation of Keystone Dam and associated hydropower has severely altered the study area. Paddlefish and shovelnose sturgeon populations have been largely reduced, isolated, or extirpated due to river modifications. The Arkansas River, especially moving downstream, is a highly modified system with several dams and locks in conjunction with the MKARNS.

Restoring this section of the Arkansas River to a more natural state promotes the proliferation of native species, both aquatic and terrestrial, and restores an ecosystem largely lost through river modifications.

4.2.2 Representativeness

The ability of the Arkansas River Corridor to exemplify a natural habitat or ecosystem in the northeastern Oklahoma area can be demonstrated by the species that continue to persevere in small numbers in the altered conditions and by the species that briefly reappear when abundant rainfall restores prolonged high flows in the area.

Least Terns, and other shore and wading birds, were likely common species in the area before the construction of Keystone Dam largely due to a higher presence of sandbar islands. Keystone Dam prevents sand from working through the study area replenishing sandbar islands. Sand mining operations further exacerbate the impacts of reduced sand quantities in the study area. Least Terns are currently surveyed each year in the study area to monitor nesting trends. When water is scarce, Least Tern nesting, and nesting success, is limited due to

predator access to nests as well as other disturbances. In years when rainfall, and subsequent flood releases are made during the nesting season, low laying nests are swept away and available nesting habitat is limited to only the highest sandbar islands.

Restoring river flow reconnects river reaches and returns the braided river conditions that promote sandbar islands. Constructing a sandbar island to maintain usable surface area during high flow events also allows those conditions to persist during daily hydropower operations. Maintaining river flow also directs Least Terns to the higher sandbars, reducing the number of nests swept away in rising river stages.

Paddlefish are present upstream of the study area above Keystone Dam and below the study area within the MKARNS. Additionally, Paddlefish return to the study area during periods of increased river flow.

In 2015 consistent river flow, from flood pool releases due to heavy rainfall, attracted hundreds of Paddlefish to the Arkansas River Corridor. However, when the flood pool releases ceased, they were trapped in isolated pools. Several perished in the remaining shallow pools, however with NER plan implementation, shallow stagnant water would not be as large of a threat to Paddlefish in the Arkansas River Corridor and could provide access to and provide additional spawning areas.

By restoring key habitat components, species historically present within the Arkansas River Corridor have the opportunity to thrive there once again.

4.2.3 Status and Trends

The loss of river habitat and river reach connectivity throughout the nation has recently come to the forefront of conservation efforts. Some efforts are underway to remove dams and low water crossings, notably in the Pacific Northwest, or construct additional features to allow fish passage through instream structures. However, river and stream reaches in the nation remain highly modified and disconnected, especially concerning movements of migratory fish and sediment within river systems. Without the implementation of the NER plan, the Arkansas River Corridor would continue to be a part of one of the many sections of river impacted by river development.

Based on a recent five year species review for the Least Tern, and in coordination discussions with USFWS, the Least Tern has the potential to be delisted. However, restoration and conservation of breeding habitat throughout the breeding range of the Least Tern remains the key hurdle for species recovery. While the NER plan, would not result in a delisting decision on its own, it would substantially contribute to the conservation and restoration of breeding habitat for Least Terns. Additionally, all other migratory birds that move through the area can utilize resources within the restored ecosystem.

The US Geological Survey (USGS) attributes the decline of Paddlefish in North America to altered river flow, overfishing, and pollution. They also note that Paddlefish are believed to be extirpated from Canada and several eastern states. Without restoration of large river reaches, Paddlefish populations remain at risk, particularly along the peripheries of their current range.

4.2.4 Connectivity

Downstream from the Arkansas River Corridor, the MKARNS provides a migration route upstream for numerous fish, including Paddlefish. Additionally the riparian corridor that brackets the Arkansas River provides, in some urban areas the only, natural habitat for species to use as

they move from one location to the other. The additional habitat conserved by the NER plan would connect this span of the Arkansas River to the MKARNS expanding the habitat available for several fish and amphibian species. The NER plan also increases the abundance and value of habitat available for migratory birds, including the Least Tern. By adding the number of available foraging, nesting, and resting sites, the NER plan helps migrating birds maintain energy reserves to reach their final destination.

4.2.5 Limiting Habitat

Limiting habitat is defined in the Planning Guidance Notebook as "habitat that is essential for the conservation, survival, or recovery of one or more species". Adequate migratory stop-over and breeding habitats are essential for the reproduction of migratory bird species, including numerous species of conservation concern. Sandbar islands are essential for Least Tern nesting success. Paddlefish also require sustained river flow, as all riverine fauna do, in order to survive and reproduce.

The sudden loss of river flow, occurring almost daily in the Arkansas River Corridor, has been shown to strand Paddlefish in life-threatening shallow pools. Undoubtedly, those same low flow periods expose Least Tern nests and fledglings to predators and other disturbances. While all disturbances do not result in a direct take of individual Least Terns, the cumulative effect of adult Least Terns constantly defending eggs and offspring likely have an indirect impact on survivorship of both parent and offspring.

4.2.6 Biodiversity

The central concept driving the entire Arkansas River Corridor study is the restoration of a diversity of habitats within the study area. The diversity of habitats provides resources for a diverse community of lower trophic level organisms which in turn supports a more diverse upper level trophic community. The primary restorative measure, the pool structure, not only addresses the resource of national significance, but provides the basis in which biodiversity improves throughout the Arkansas River Corridor ecosystem. In essence, the success of the Arkansas River Corridor study is defined by the degree and magnitude of river flow and floodplain habitat.

4.3 Benefits of the Recommended Plan to Other Federal Goals and Objectives

USACE formulates, designs, and constructs projects for specific missions and authorities including ecosystem restoration and recreation. USACE investment decisions are based on an established methodology to account for a project's benefit toward advancing a specific mission area. However, the lack of an accepted method to quantify the benefits a USACE project may have toward advancing other national priorities can leave much of the project's value to the nation unaccounted. Using the ecosystem restoration benefits as a foundation, a project such as the proposed Arkansas River Corridor restoration could provide other nationally significant benefits such as meeting water quality goals in a densely populated urban area by maintaining river flow and dilution of pollutants and promoting outdoor recreation by improving aesthetic value to existing outdoor recreation activities in the community. Projects that more holistically meet the goals of multiple Federal agencies reflect a more realistic and modern view of governmental spending.

4.3.1 National and Regional Economic Development, Environmental Quality, and Other Social Effects

In addition to the NER which captures the effects of the Recommended Plan on the Environmental Quality (EQ) account, three other accounts for consideration are identified in ER 1105-2-100, Planning Guidance Notebook: National Economic Development (NED), Regional Economic Development (RED), and Other Social Effects (OSE). The following provides a description of these accounts and the potential effects of the Recommended Plan.

NED considers changes in the economic value of the national output of goods and services. Often in an ER study, recreation benefits may be used to calculate NED. The ARC Master Plan describes many recreational opportunities, however, none appropriately complimented the ecosystem restoration features developed for this study and therefore no NED benefits could be captured for recreation.

RED considers the changes in the distribution of regional economic activity that could result from the plan. It is expected that by providing the stable river flows and fundamental ecosystem restoration, the Recommended Plan will allow Tulsa County and its partners to implement other aspects of the ARC Master Plan that include economic opportunities that take advantage of the restored river setting to attract businesses and people to the waterfront area.

OSE registers plan effects that are relevant to the planning process, but not reflected in the other three accounts. Again, the implementation of the recommended plan would be the foundation that allows Tulsa County and its partners to further implement the ARC Master Plan. The Master Plan has several recreation features within the corridor that would bring the residents of Tulsa to the waterfront. The recreation features implemented by others would not be directly co-located with restoration features of the recommended plan to allow the ecosystem to flourish, however, the benefits gained by a more natural river flow regime and wetland plantings would enhance the users outdoor recreation experience.

4.3.2 Other Federal Goals and Objectives

The proposed ecosystem restoration project could assist in advancing several other Federal goals, initiatives and missions including the Executive Office, EPA, Department of the Interior (DOI), the CEQ, and former First Lady Michelle Obama's campaign to improve the health of America's youth through the Let's Move Outside initiatives.

President Clinton signed EO 13186 regarding the Responsibilities of Federal Agencies to Protect Migratory Birds and EO 13112 regarding Invasive Species. EO 13186 states "…each agency shall, to the extent permitted by law and subject to the availability of appropriations and within Administration budgetary limits and harmony with agency missions restore and enhance the habitat of migratory birds as practicable; and design migratory bird habitat and population conservation principles, measures, and practices into agency plans and planning processes (…watershed planning) as practicable, and coordinate with other agencies and non-Federal partners in planning efforts." EO 13112 states "Each Federal agency whose actions may affect the status of invasive species shall, to the extent practicable and permitted by law, identify such actions; …to provide for restoration of native species and habitat conditions in ecosystems that have been invaded." The restoration of the Arkansas River Corridor would have permanent net positive impacts on the goals of both EOs.

EPA has taken the lead on the Urban Waters Federal Partnership that aims to stimulate regional and local economies, create local jobs, improve quality of life, and protect Americans' health by revitalizing urban waterways in under-served communities across the country. EPA notes that “urban patterns of development often make waterways inaccessible to adjacent neighborhoods. Lack of access limits a community's ability to reap the benefits of living so close to the water, whether through recreation, fishing or access to real estate.” Such is the case with this project where the Tulsa Levee System reduced flood risk but may have disconnected neighborhoods. The EPA notes that if “maintained properly, urban waters can also yield positive impacts for populations in both urban and upstream communities. The proposed ecosystem restoration project would restore the aquatic and riparian habitats of the adjoining creeks and tributaries as well as aesthetic value to existing and future hike and bike trails where appropriate thus addressing several of the Partnership goals. The DOI is spearheading the America’s Great Outdoors (AGO) Initiative that President Obama launched to develop a 21st Century conservation and recreation agenda. The goals of AGO as stated in President Obama’s April 16, 2010 memo are:

- Reconnect Americans, especially children, to America's rivers and waterways, landscapes of national significance, ranches, farms and forests, great parks, and coasts and beaches by exploring a variety of efforts, including:
- Promoting community-based recreation and conservation, including local parks, greenways, beaches, and waterways,
- Advancing job and volunteer opportunities related to conservation and outdoor recreation, and
- Supporting existing programs and projects that educate and engage Americans in our history, culture, and natural bounty.

The Recommended Plan supports these Administration goals by restoring more natural river flow and associated habitats so that corridors and connectivity projects can follow suit across outdoor spaces. This could further promote community-based recreation and provide an outdoor classroom for young and old alike to learn about watersheds, riparian zones, migratory birds, and native plants and animals.

The proposed restoration of the Arkansas River Corridor would support native riparian grasses, flowers, shrubs and trees in the area that would assist in addressing urban air quality issues and the restored river flow would minimize exposed river beds and fish kills which can produce unpleasant odors. All of these benefits address Center for Disease Control and Prevention’s healthy community design issues.

Housing and Urban Development (HUD) emphasizes sustainable communities that address health, bikeable cities, and community accessible parks while promoting ‘livability principles’ such as supporting existing communities, value communities, and neighborhoods, providing more transportation choices and coordinating policies and leveraging investments. The proposed NER plan restores ecosystem function and aesthetics, and while not the project’s main objective, it could promote further outdoor parks and recreation areas to meet these goals. Lastly, the former First Lady’s Let’s Move Outside initiatives are aimed at addressing childhood obesity in America. Quoting Mrs. Obama, “Let’s Move Outside, administered by the Department of Interior, was created to get kids and families to take advantage of America’s great outdoors-which abound in every city, town and community. Kids need at least 60 minutes of active and vigorous play each day to stay healthy, and one of the easiest and most enjoyable ways to meet

this goal is by playing outside. By linking parents to nearby parks, trails and waters – and providing tips and ideas – Let's Move Outside can help families develop a more active lifestyle." A restored Arkansas River Corridor provides the foundation to expand opportunities for outdoor recreation.

The Recommended Plan provides a healthy ecosystem near homes and schools to engage in recreational activities consistent with the goals of the Let's Move Outside program. As demonstrated in this section, the national benefits that can result from the proposed NER plan extend beyond the analysis used to assess the interest of USACE investment in this proposed project. The environmental benefits serve as the foundation for a greater national value. The proposed NER plan supports healthy living, sustainable communities, stewardship of natural resources, and urban outdoor recreation, to name only a few.

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5 ENVIRONMENTAL CONSEQUENCES

5.1 Environmental Consequences of "No Action" and "Recommended Plan" Alternatives

This section compares the potential environmental consequences for two alternatives in the project area: the "No Action" alternative and the Recommended Plan alternative. The "No Action" alternative serves as a baseline against which the Recommended Plan alternative can be evaluated. Alternative 2a, while identical in design and operation and footprint sizes of restoration measures found within the Recommended Action, differed in the location of the pool structures. As such, Alternative 2a had less storage capacity and limited ability to meet the reoccurring 1,000 cfs delivery needs between hydropower generations. The Recommended Plan, with the pool structure being located one river mile downstream, would have adequate storage to meet reoccurring 1,000 cfs flow needs between hydropower generations. Therefore, because the nature of impacts of Alternative 2a and the Recommended Plan were nearly identical, as described in the 404(b)(1) Analysis (Appendix L), except for Alternative 2a's ability to maintain the 1,000 cfs flow during weekends when hydropower generation typically does not occur, only the environmental consequences for the No Action and Recommended Action were analyzed.

The Recommended Plan consists of construction of the following three measures as described further elsewhere in this document:

- Pool Structure at RM 530 near the Highway 97 Bridge with gate operations allowing for sediment passage and at least seasonal fish passage.
- Ecosystem Restoration Measures with a rock riffle (grade control) to generate a semi-permanent wetland area near Prattville Creek at the current confluence of Prattville Creek with the Arkansas River, approximately 1,000 feet downstream of the pool control structure using longitudinal peaked stone toe protection and wetlands plantings.
- Constructed Sandbar Island for the creation of an Interior Least Tern nesting habitat near the Indian Springs Sports Complex in the City of Broken Arrow (approximately 5 miles downstream of the City of Bixby)

Refer to Chapter 3 for detailed descriptions and figures of the geographic extent of each of these measures. The "No Action" alternative is also referred to as the Future without Project Conditions and presumes no management measure would be taken to address the planning objectives. The discussion of each resource considers the direct and indirect effects of construction and operations related to the Recommended Plan and "No Action" alternative.

As in Chapter 2, this chapter describes the impacts of the two alternatives for each of the following resources:

- air quality;
- climate;
- water resources;
- hydrology and floodplains;
- riverine resources;

- biological resources;
- threatened and endangered species;
- cultural resources;
- land use, recreation and transportation;
- socioeconomics and visual aesthetics;
- utilities;
- health and safety;
- hazardous toxic and radioactive waste, and;
- geology and soils.

The identification of potential impacts includes consideration of both the context and the degree of the impact. When feasible, distinctions are made between short- and long-term impacts; negligible and significant impacts; and negative and positive impacts. A negligible impact may have an inconsequential effect or be unlikely to occur; whereas a significant impact would have more pronounced or severe consequences, generally adverse. If the current condition of a resource would be improved or an undesirable impact would be lessened, the impact is considered beneficial. Finally, a "no impact" determination is made when the action does not noticeably affect a given resource. Cumulative impacts are those that are likely to occur over a long period of time or as a result of combining the expected impacts of two or more unrelated actions.

The Recommended Plan would have no significant impact on any of the resource areas. During construction, a minimal, and temporary impact would result in the following resource areas: soils, noise, air, vegetation, wildlife, and surface water. However, each of these impacts would be controlled through the use of best management practices (BMPs) described below.

5.2 Characterization of Potential Impacts

5.2.1 Direct versus Indirect Effects

The terms "effect" and "impact" are synonymous as used in this analysis. Both short- and long-term effects are relevant in considering the significance of an impact. Effects are also expressed in terms of duration. The duration of short-term impacts is considered to be 1 year or less. Long-term impacts are described as lasting beyond 1 year. They can potentially continue in perpetuity, in which case they would also be described as permanent. Effects may be beneficial or adverse and may apply to the full range of natural, esthetic, historic, cultural, and economic resources of the project area and the surrounding area. Definitions and examples of direct and indirect impacts as used in this document are as follows:

- **Direct Impact.** A direct impact is one that would be caused directly by implementing one of the two alternatives and that would occur at the same time and place.
- **Indirect Impact.** An indirect impact is one that would be caused by implementing one of the two alternatives and that would occur later in time or farther removed in distance but would still be a reasonably foreseeable outcome of the action. Indirect impacts may include induced changes in the pattern of land use, population density, or growth rate, and indirect effects to air, water, and other natural resources and social systems.
- **Relationship of Direct versus Indirect Impacts.** For direct impacts to occur, a resource must be present. For example, if highly erodible soils were disturbed as a direct result of the use of heavy equipment during construction of a home, there

could be a direct effect on soils due to erosion. This could further indirectly affect water quality if stormwater runoff containing sediment from the construction site were to enter the river.

5.2.2 Significance Criteria and Impact Characterization Scale

In accordance with CEQ regulations and implementing guidance, impacts are evaluated in terms of their significance. The term "significant," as defined in 40 CFR 1508.27, part of the CEQ regulations for implementing NEPA, requires consideration of both context and intensity. Context means that the significance of an action must be analyzed in several settings, such as society as a whole (human, national); the affected region; the affected interests; and the locality. Significance varies with the setting of the Proposed Action. For instance, in the case of a site-specific action, significance would usually depend on the effects on the locale rather than on the world as a whole.

Intensity refers to the severity of impact with regard to the above ratings (minor through significant). Factors contributing to the evaluation of the intensity of an impact include, but are not limited to, the following:

- The balance of beneficial and adverse impacts, in a situation where an action has both;
- The degree to which the action affects public health or safety;
- The unique characteristics of the geographic area where the action is proposed, such as proximity to parklands, historic or cultural resources, wetlands, prime farmlands, wild and scenic rivers, and ecologically critical areas;
- The degree to which the effects on the quality of the human environment are likely to be controversial;
- The degree to which the effects of the action on the quality of the human environment are likely to be highly uncertain or involve unique or unknown risks;
- The degree to which the action might establish a precedent for future actions with significant effects or represents a decision in principle about a future consideration;
- Whether the action is related to other actions with individually insignificant but cumulatively significant impacts. Significance exists if it is reasonable to anticipate a cumulatively significant impact on the environment. Significance cannot be avoided by terming an action "temporary" or by breaking it down into small component parts;
- The degree to which the action might adversely affect districts, sites, highways, structures, or objects listed in or eligible for listing in the NRHP or might cause loss or destruction of significant scientific, cultural, or historic resources;
- The degree to which the action might adversely affect an endangered or threatened species or habitat that has been determined to be critical under the Endangered Species Act of 1973;, and;
- Whether the action threatens a violation of Federal, state, or local law or requirements imposed for the protection of the environment.

Impacts are characterized by their relative magnitude. Adverse or beneficial impacts that are significant are the highest levels of impacts. Conversely, minor negative or minor positive effects are the lowest level of impacts. In this document, five descriptions are used to characterize the level of impacts. In order of degree of increasing impact they are:

- Significant Negative Effect
- Moderate Negative Effect

- Minor Negative Effect
- No Impact or Negligible Effect
- Minor Positive Effect
- Moderate Positive Effect
- Significant Positive Effect

The terms “effect” and “impact” are synonymous as used in this analysis.

5.3 Air Quality

5.3.1 No Action Alternative

Under the “No Action” Alternative, there would be no change and therefore no impacts to existing air quality as a result of the Recommended Plan.

5.3.2 Recommended Plan

Short-term, minor adverse effects to air quality are possible during construction of the three measures included in the Recommended Plan. Construction would generate fugitive dust from ground disturbing activities (e.g., excavation, grading, soil piles, etc.) in addition to the emissions of all criteria pollutants from the combustion of fuels in construction equipment. Fugitive dust emissions would be greatest during the initial site preparation activities and would vary from day-to-day depending on the construction phase, level of activity, and prevailing weather conditions. However, the quantity of uncontrolled fugitive dust emissions from construction is expected to be minimal since the majority of the work would be performed instream. The use of BMPs during construction (e.g. application of water for dust control if necessary, use of cleaner-burning fuels, energy efficient equipment) would limit these minor, short term impacts. No long-term effects to air quality are anticipated as a result of the Recommended Plan. Further discussion is provided in section 4.2 below.

5.4 Climate, Climate Change, and Greenhouse Gases

5.4.1 No Action Alternative

The “No Action” alternative would not result in a change in greenhouse gas (GHG) emissions or related influences on the local, regional, or global climatic conditions as described in the section above.

Appendix N describes the projected impacts of climate change on regional temperatures, rainfall, and associated river flow. The USACE Watershed Climate Vulnerability Assessment Tool was used to assess the Lower Arkansas watershed, which contains the entire study area, for vulnerability to ecosystem functions based projected climate change impacts relative to other watersheds.

Based on the results of the USACE Watershed Climate Vulnerability Assessment presented in Figure 7 (Appendix N), relative to the other 202 HUC04 watersheds in the continental U.S., the Lower Arkansas watershed (HUC 1111) is more vulnerable to the impacts of climate change on ecosystem functions. For the Lower Arkansas watershed, the major drivers of the computed vulnerability score are, “At Risk Freshwater Plants”, “Runoff Elasticity”, and “the Macroinvertebrate Index”.

These results were driven by upward trends in temperature (Figure 1, Appendix N), which can accelerate the drying and desiccation of aquatic habitat and associated communities. Without

the project, conditions in the Arkansas River corridor downstream of Keystone Dam, which is already subjected to drying cycles between hydropower releases, would see the available refuge pools dry up more quickly as a result of the increasing temperatures. These refuge pools are where small fish and macroinvertebrates seek shelter and play a major role in the ecosystem.

The mean projected annual maximum streamflow is also projected to increase (Figure 5, Appendix N) as precipitation increases.

5.4.2 Recommended Plan

As discussed in the Chapter 2 Section 3.0 and appendix N, the climate change analysis for this project identified that average temperatures are trending upward. As a result of peak cooling demand, hydropower releases are not anticipated to decrease as household energy requirements increase to cool homes in the warming climate. Regional rainfall, also projected to increase 6 to 20 percent. In terms of intensity, trends in the project area show that the rainfall events have slightly increased in intensity. Along with rainfall, observed average streamflow has shown an upward trend within the project area. Accumulated rainfall will continue to be routed through Keystone Dam, providing source water for the minimum flow releases.

The project also includes construction of rock riffle structure that will be used to develop a wetland area downstream of the pool control structure. The project will provide some resiliency to the ecosystem that will allow it to thrive even with the impacts of the projected changing climate. During construction, the project could temporarily contribute to GHG emission. However, the impact is expected to be minimal and temporary. Therefore, the Recommended Plan would be expected to have temporary and minimal direct impacts on the local air quality resulting from GHG emissions.

Air quality impacts from the Recommended Plan would include emissions from earth moving equipment, dump trucks, pickup trucks, and other construction equipment. These potential emissions are not expected to exceed primary or secondary standards for the six criteria pollutants due to: phased construction activities occurring over less than three and one half years, small footprint of Recommended Plan's features (< 3 acres), location of the construction activities being on the outskirts of the Tulsa metropolitan area, which is 80 miles from the nearest metropolitan area of equal or greater size (Oklahoma City). Furthermore, two of the three construction areas are separated by approximately 30 miles. Therefore, emissions from the activities associated with the Recommended Plan are not considered regionally significant for purposes of General Conformity. Because of this, it is expected that emissions from the Recommended Plan construction would not cause or contribute to new violation of any NAAQS in the area.

The Recommended Plan would be expected to generate additional commercial development and recreational activity in the immediate area that would likely result in some additional traffic and construction-related emissions. These additional emissions are not expected to be significant in the context of the Tulsa metro area. Therefore, no significant adverse, indirect impacts to the local climate, climate change, or greenhouse gases would result from the Recommended Plan. Therefore, the proposed project is expected to be in compliance with the Clean Air Act.

5.5 Water Resources

5.5.1 No Action Alternative - Surface Water

Currently, during the no/low flow conditions, there are 1,824 acres of surface waters, including both riverine and lake waters, in the study area. Under the "No Action" alternative, there would be an expected conversion of riverine to lake habitat regarding total surface water resources in the study area. Zink Dam, at full volume, currently impounds 233 acres within the river channel. Zink Dam upgrades in the near future are expected to facilitate increased seasonal fish passage and impound an additional 170 acres of river channel. Another low water dam, in the South Tulsa/Jenks area, is proposed downstream of Zink Dam. This low water dam is still in the USACE regulatory permitting phase. It was accounted for in HEP modeling by converting the existing river acreage in its expected inundation pool into lake habitat acreage (Table 10, Appendix A). When considering the two low water dam actions in the study area under the "No Action" alternative, total surface water in the ARC is expected to increase by 473 acres. However this conversion of river to lake reduces riverine habitat from 1,591 to 1,422 acres.

At Prattville Creek, the 5.34 acres of backwater area continually experiences the ebb and flow of water releases from Keystone Dam, limiting the extent of surface to only brief periods. As such, the HEP analysis indicated virtually no wetland function without consistent wetted areas to support aquatic vegetation (Appendix A, Table 13).

Morphological characteristics such as channel width, depth, and bed aggradation and degradation would continue to evolve in response to changes in the watershed hydrology, which is significantly impacted by the regulated flows from Keystone Dam as well as the urbanization of the local watershed; and, the reduced sediment supply downstream of Keystone Dam as a result of sediment deposition in Keystone Lake. Although there was little change in the position of most of the banks of the Arkansas River channel through the study area from 1950 to 2010, there was an apparent decrease in sediment storage in the form of mid-channel and meander bars. Under the "No Action" alternative, flows in the river would not change from existing conditions and the recent morphological trends are likely to continue; and, the negative ecological consequences associated with the existing conditions would continue to persist.

5.5.2 Recommended Plan - Surface Water

The Pool Structure at RM 530 would operate to primarily maintain 1,000 cfs river flow downstream in the absence of flood pool or hydropower releases. At full capacity, extends upstream from the structure nearly 9 miles to just below Keystone Dam. This river reach encompasses at least 13 perennial or intermittent tributaries. As such, the water depth at the confluence with these tributaries would be more stable allowing increased fish access for temperature and flow refuge during larger releases. The magnitude of the water depth change imparted by the construction of the pool structure measure is within the historical range of water depths that have occurred within the Arkansas River; so, this change is not likely to impart any negative morphological impacts on the mainstem channel or tributaries upstream or downstream of the structure. In addition, water stored upstream of the pool structure would only be temporarily stored, and refilled with the next release from Keystone Dam, as it would be released to maintain river flow downstream.

The pool upstream of the flow regime measure would sustain a higher and semi-permanent water table elevation during low-flow periods, thereby helping to sustain riverbank vegetation that might otherwise suffer from desiccation. Flow releases, the primary function of the pool

structure, would maintain a more consistent minimum flow and should also help elevate or sustain the water table base elevation during low-flow periods along the mainstem channel through the project area. This would benefit riparian vegetation as well, thereby enhancing the stability of the channel banks. Riverine habitats within the mainstem channel would become more persistent and increase in acreage, from 1,422 acres to 3,735 acres throughout the study area from increases in daily minimum flow. Upstream of the pool structure, riverine habitat would increase from the existing 457 acres maintained by no to low flow conditions to 1,321 acres of riverine habitat. Figures 5 and 6 display the differences between the current riverine habitat maintained by the low flows (100 cfs) and the increase in riverine surface waters provided by the 1,000 cfs releases. These would all be long-term, positive impacts to the surface water resources in the project area. Riparian shorelines along the nearly nine river miles upstream of the pool structure may also experience negligible to minor benefits as the increase in aquatic connectivity may enhance or further sustain existing vegetation communities. Shoreline vegetation naturally stabilizes soils while providing cover, shade, and refuge for fauna across all taxa.

Hydraulic modeling would be required to predict the shear-stresses and velocities in the vicinity of the flow regime measure under the range of flows to be encountered. Higher shear-stresses and velocities in the downstream proximity of the structure would likely require the design of hydraulic controls and bank protection measures to prevent undesirable river bed and or bank scour resulting from the presence or operation of the flow regime measure. Continued coordination with agencies will ensure the final design and operation meets the restoration goals while not impacting Keystone Dam operations.

The measures at Prattville Creek would consist of an engineered rocked riffle to impound a small area of surface water at the mouth of Prattville Creek to maintain 5.34 acres of wetland habitat. This also restores some backwater wetlands into the original Prattville Creek channel that parallels the right bank of the Arkansas River. The HEP analyses (Appendix A, Table 29) indicated that the wetland restoration measures would elevate wetland output of the 5.34 acres from nearly non-existent wetland function to optimum conditions. These would be long-term, localized benefits to the surface water resources at this location.

To ensure the backwater remnant of Prattville Creek can receive water from the active channel, a topographic survey of the project site would be necessary. The survey would be used to measure the existing active channel invert elevation as well as the remnant channel invert elevation. The final elevation of the engineered rocked riffle would need to be capable of maintaining the water surface elevation under desired flow conditions sufficiently enough to maintain native aquatic vegetation communities.

The Constructed Sandbar Island, with further analysis, would be placed to avoid significant changes to the local flow velocity and water surface elevation in the Arkansas River that would result in erosion along the adjacent shorelines. The Arkansas River channel is nearly 2,000 feet wide in the area of interest for the constructed sandbar island. The feasibility level design (Appendix G) shows the two part chevron shaped riprap structure having dimensions of 43’ x 10’ x 3’ (front) and 56’ x 10’ x 3’ (back). An existing sandbar island using the same methodology was constructed in the ARC downstream of Zink Dam. Lessons learned from the design, placement, and performance of that sandbar island, along with additional hydraulic computations, would ensure the placement of the sandbar island does not result in erosive

near-bank shear stresses or velocities along the existing Arkansas River banks, or a significant rise in the base flood flow event.

Additional discussion on surface water impacts are provided below in section 7.0 below.

5.5.3 No Action Alternative - Groundwater Resources

Under the “No Action” alternative, there would be no changes in the existing groundwater conditions in the study area and, therefore, no impacts would be anticipated.

5.5.4 Recommended Plan - Groundwater Resources

The Pool Structure at RM 530 would create a more permanent riverine habitat along the Arkansas River reach between Keystone Dam and the structure, so the elevation of the adjacent water table along this reach is anticipated to be elevated accordingly. The exact lateral and longitudinal extent to which the groundwater gradient would be impacted is difficult to quantify in the absence of monitoring wells. However, any change to the groundwater elevation is expected to be within the range of historical groundwater elevations associated with low-flow to high-flow river conditions. Therefore, any potential negative impacts are anticipated to be short-term and minor.

The long-term positive effects resulting from an elevated and more accessible groundwater table for the riparian vegetation during periods of low-flow conditions should be substantial. Downstream of the flow regime measure, the impacts to groundwater are anticipated to be minor, but positive for the same reason mentioned above as it relates to riparian vegetation.

The measures at Prattville Creek would impound a small volume of surface water at the mouth of the creek, and divert some water into the old channel parallel to the Arkansas River. Therefore, the local groundwater table would likely become slightly elevated as well, which would be a relatively minor impact from a spatial context, but temporally substantial in that the project would restore and sustain a wetland environment at this location.

No impacts to the existing groundwater conditions are anticipated as a result of the Constructed Sandbar Island.

5.5.5 No Action Alternative - Water Quality

Under the “No Action” alternative, the existing fluctuations in river flows would continue. Water quality concerns associated with periods of low or no flows would continue including potential short duration low DO conditions and seasonal temperatures swings associated with shallow pools of water. Localized sedimentation and erosion would continue in the Arkansas River due to continued flood risk operations within the project area. Without improved flow management, water quality parameters such as temperature and DO would continue to have seasonal swings. Therefore, direct impacts to water quality with the “No Action” alternative would be long-term, moderate, and negative. Indirect effects could include impaired aquatic habitat.

5.5.6 Recommended Plan - Water Quality

Potential impacts on water quality, such as increased turbidity, may occur during construction and post-construction operation of the Pool Structure at RM 530 and ecosystem restoration measures. During the construction phase, stormwater runoff would have the potential to transport sediment and other pollutants to receiving waters. However, implementation of standard construction BMPs (e.g., silt fences, and temporary coffer dams) during construction

and revegetation following construction would minimize the risk. The ODEQ stormwater permit (National Pollutant Discharge Elimination System construction permit) would establish practices to be implemented to protect water quality. As result, the potential for adverse impacts on water quality during construction would be short-term and minor.

Longer term, the operation of the pool structure would facilitate more stable downstream flow conditions reducing periods of low flows and support improved DO conditions in the existing 1,591 acres of riverine habitats and expand those conditions to an additional 2,414 acres that would otherwise go dry in the Arkansas River. Although the current ODEQ 303(d) listings indicate that the river is meeting the DO standards, the Recommended Plan would support the maintenance and improvement of DO conditions in the river. Installation of the proposed bank restoration and 5.34 acres of wetland habitat on Prattville Creek would reduce the rate of erosion in this reach of the river, thus reducing turbidity/sediment loading. In addition, the wetland vegetation would provide an additional level of treatment of stormwater runoff in the Prattville Creek watershed before entering the Arkansas River. Therefore, the Recommended Plan could result in moderate positive impacts to water quality***.***

ODEQ reviewed the Recommended Plan and concluded that the project would not violate Oklahoma's water quality standards (Appendix L).

5.6 Hydrology and Floodplains

5.6.1 No Action Alternative – Arkansas River Flows

Under the "No Action" alternative, no changes to the existing river flow regime are expected. As a result, the Arkansas River throughout the study area would continue to be subject to the highly unnatural flow regime that results primarily from Keystone Dam operations. The unnatural flow regime is particularly evident during low-flow conditions when the only releases from Keystone Dam are from the conservation pool for hydropower generation, which occurs on an on-demand basis. Under such conditions, the project area experiences daily bouts of brief (roughly 4 to 6 hour) periods of 6,000 cfs to 12,000 cfs flows, followed by extended periods (18- to 20-hours) of no flow releases from Keystone Dam. This creates a disruptive, unnatural flow regime impacting all aquatic and riparian habitat types as well as the flora and fauna throughout the study area. Therefore, under the "No Action" Alternative the river would continue to experience significant, long-term, negative impacts to the ecological functions reliant upon a more natural hydrologic flow regime.

5.6.2 Recommended Plan - Arkansas River Flows

The Pool Structure at RM 530 would help restore a more natural flow regime in the Arkansas River through the study area by providing timed releases of water of approximately 1,000 cfs to supplement flows between hydropower generation and flood pool releases. Appendix J, Figure 3 shows increase in minimum flow that would be provided by the pool structure. The structure would have a full pool volume capacity of approximately 6,730 acre-feet, surface area of 1,321 acres, and stretch nearly 9 miles upstream to Keystone Dam. The full pool volume could provide downstream flows of 1,000 cfs for 3.4 days, 750 cfs for 4.5 days, or 500 cfs for 6.8 days. The flow regime measure would help attenuate flow peaks, which would also contribute to restoring a more natural flow regime therefore providing long-term, moderate positive effects. The flow attenuating effect would be expected to decrease as the flows reached the higher magnitude flows, but attenuation of the more frequent flow peaks would be expected. Because the pool structure be would located a relatively short distance downstream from Keystone Dam; and,

because there would be a means to control flow through the structure; the potential for significant sediment accumulation within the pool is anticipated to be low. There is likely to be an increased potential of local bed and bank scour in the downstream proximity of the structure; therefore, the engineering design would need to minimize the potential and or include protective measures in the design. In September 2017, a 1,000 cfs flow test was conducted from Keystone Dam. General observations, noting the restorative benefits of the increased minimum flow the proposed project would provide, and photographs are available in Appendix M.

Impacts to hydrology resulting from the measures at Prattville Creek are considered to be minor, but long-term, given the relatively small surface area and volume of the target backwater effect needed to create the wetland habitat. The final design and construction would need to account for the local hydraulic changes induced by the riffle to ensure any increased scour or erosion potential under high-flow conditions within Prattville Creek were accounted for in the design. Protective measures such as bank toe rock and bioengineering would be implemented as necessary.

To ensure the downstream segment of the remnant Prattville Creek can receive water from the active channel, a topographic survey of the project site would be necessary. The survey would be used to measure the existing active channel invert elevation as well as the remnant channel invert elevation. The final elevation of the engineered rocked riffle would need to be capable of elevating the water surface elevation under desired flow conditions sufficiently enough to allow water to flow into the remnant channel.

There would be no changes to hydrology associated with the Constructed Sandbar Island, therefore no impacts to hydrology are anticipated.

5.6.3 No Action Alternative - Floodplains

Under the “No Action” alternative, there would be no change in existing conditions, as no construction within floodplains would occur. Therefore, no impacts to floodplains would be anticipated as a result of the “No Action” alternative.

5.6.4 Recommended Plan – Floodplains

Construction associated with all three elements of the Recommended Plan would occur in a mapped flood hazard area associated with the Arkansas River floodplain. As proposed, the flow regime measure, Least Tern nesting island, and the engineered rocked riffle for Prattville Creek would all be constructed within the FEMA floodway. A FEMA floodway is the channel of the river or stream, plus any adjacent floodplain areas that must be kept free of encroachment so that the 1-percent annual chance flood can be carried without substantial increases in flood heights (FEMA, 2016a). Minimum Federal standards limit such increases to 1 foot, provided that hazardous velocities are not produced.

Project design and construction would ensure that the flood-carrying capacity of the river is maintained and preserved, and that the structures built for the project meet all requirements for flood-proofing and achieve regulatory compliance. Construction at the project site would comply with 28 CFR, Part 63 and FEMA review procedures by minimizing the amount of fill that would be placed in the flood hazard areas. The proposed fill would be hydraulically modeled to provide data to ensure regulatory compliance.

A floodplain would be impacted by any activity that would change the available flood storage within the designated area. Short-term impacts may result from construction, underground installation, and open cutting within the floodplain. The Recommended Plan is, therefore, expected to have moderate, short-term, direct impacts during construction and negligible long-term, direct impacts to designated floodplains after construction.

Under the Recommended Plan, all impacts would be confined to the immediate project area. The flood conveyance capacity of the Arkansas River would remain unchanged as a consequence of the proposed action. No impacts to floodplains would be expected, as the proposed action would be designed to avoid any increase in base flood elevation. Therefore, the Recommended Plan would result in no indirect impacts to floodplains.

5.6.5 No Action Alternative - Levees

Several areas within the project area are protected from flooding threats by levees, and are noted as such in the FEMA FIRMs. Under the “No Action” alternative, there would be no change in existing conditions, as no construction would occur within the levees. Therefore, no impacts to levees would be anticipated as a result of the “No Action” alternative.

5.6.6 Recommended Plan - Levees

Several areas within the project area are protected from flooding threats by levees, and are noted as such in the FEMA FIRMs. USACE designed the levees to contain a river flow rate of 350,000 cfs, with 3 feet of freeboard. Design and construction of the Recommended Plan would ensure that the flood-carrying capacity of the river is maintained and preserved so that impacts to local levees are avoided. Therefore, no impacts to levees would be anticipated as a result of the Recommended Plan.

5.7 Riverine Resources

5.7.1 No Action Alternative - Wetlands

Under the “No Action” alternative, flows in the river would not change from existing conditions. Continued daily changes in the flow regime would promote desiccation and inundation of wetland habitats and continue to reduce their stability in study area. The lack of vegetation strata stability and shifting river sediments from the extreme daily flow fluctuations would continue to allow wetland habitat smothering. These disruptions to stability would continue to allow non-native, invasive species such as Johnson grass and salt cedar to out compete native species. Wetland habitats within the study area would remain subject to annual seasonal flood events during which these destabilized wetlands are inundated and scoured by higher river flows. Therefore, moderate, long-term, negative impacts to wetlands would occur as a result of the “No Action” alternative.

5.7.2 Recommended Plan - Wetlands

The potential impacts from the proposed plan would result in the permanent loss of approximately 2.89 acres of riverine habitat occurring in the footprints of the constructed restoration measures as identified in the 404(b)(1) analysis found in Appendix L. The restoration and expansion of wetland and riverine habitat more than compensates for the wetland loss.

The pool structure at RM 530 impact on wetlands could include the expansion of riverine habitats from the construction of the pool structure and improved floodplain connectivity to shoreline wetlands within the outer footprint of the associated riverine pool. Surface water

quality in wetlands within the vicinity of the flow regime measure could be temporarily disturbed during construction as a result of scour or sedimentation from stormwater runoff from construction areas with disturbed soils. All practicable measures, including the use of appropriate BMPs and coffer dams, would be implemented to minimize impacts.

The attenuation of flows downstream of the pool structure would provide consistent daily hydrology for shoreline and backwater wetland habitats which would promote increased stability for further habitat development. The increase in hydrologic stability would promote a moderate, long-term increase in wetland acreage within the study area downstream of the flow regime measure, which would in turn increase available habitats for fish, macroinvertebrates, amphibians, reptiles, birds, and stabilize food webs. Increases in wetland acreages in the short-term would primarily be from the development of additional early successional emergent wetland habitats at lower elevations. The connectivity of wetland habitat types to other habitats such as riverine and riparian corridors would increase as wetland acreages increase. Overall the pool structure would provide moderate, long-term positive impacts to wetland habitats within the study area.

The potential impacts from the implementation of rock riffles and creation of wetland habitat at Prattville Creek would include a minor, long-term positive increase in available wetland and open water habitats and stabilized banks at this location. The stable wetland habitat would create permanent habitat for wildlife such as fish, macroinvertebrates, amphibians, reptiles, and birds and in turn serve to stabilize the local aquatic food web. Increased long-term water quality benefits from reduced sedimentation and pollutant transport downstream would be localized and therefore relatively minor. The wetland would also serve as a source for the downstream transport of organic detritus benefiting downstream food webs. The armoring of banks and directing of surface water towards the original mouth of Prattville Creek downstream, would provide additional surface water for aquatic communities in that location.

No impacts (negligible) on wetlands habitats are anticipated from the creation of the Constructed Sandbar Island. Short-term localized reductions in water quality in wetlands immediately downstream may result from construction activities. All practicable measures, including the use of appropriate BMPs, would be implemented to minimize impacts. The location selected for the construction of the Least Tern nesting island would be within existing riverine sandbar habitat and areas of wetland habitat would be avoided.

5.7.3 No Action Alternative – Riverine Sandbars

Under the “No Action” alternative, flows in the river would not change from existing conditions. Daily changes in the flow regime would continue to expose and inundate sandbars, and promote non-native, invasive species such as Johnson grass to out compete native species. Therefore, moderate, long-term negative impacts to riverine sandbars would continue.

5.7.4 Recommended Plan – Riverine Sandbars

The potential impacts from the pool structure on riverine sandbars would include the permanent loss of riverine habitat from the construction of the low water dam and conversion of periodically inundated sandbar habitat to riverine habitats within the footprint of the associated riverine pool. With the Recommended Plan, riverine sandbar habitat would continue to be a common habitat type within the study area, furthermore the occurrence of land-bridged sandbars would be reduced. Downstream of the pool structure, the attenuation of high flows would negligible,

allowing normal beneficial sandbar scouring to continue. Stable non-vegetated sandbars would provide increased nesting habitat for Interior Least Terns. Therefore, the construction of the flow regime measure would provide moderate, long-term positive impacts to riverine sandbar habitats.

Some minor, temporary impacts may occur to riverine sandbars in the vicinity of the Prattville Creek restoration efforts from access by heavy vehicle equipment during construction. These impacts are considered negligible within the study area and would be considered to have no impact.

Potential impacts from the construction of the Least Tern nesting island would include temporary impacts to riverine sand bar habitats in the vicinity of the construction area from the access of heavy equipment during construction. No other impacts to riverine sandbars in the study area would be anticipated. The creation of the Least Tern nesting island would expand existing nesting habitat in conjunction with the construction of the flow regime measure and the riverine pool. The overall impacts are considered negligible within the study area and would be considered to have no impact.

5.7.5 No Action Alternative – Open Water Habitat

Under the “No Action” alternative, flows in the river would not change from existing conditions. Open water habitats size, location, and connectivity to other habitats is primarily a function of river flows. Under the “No Action” Alternative these habitats would continue to be reduced and would continue to vary based on changes in the flow regime. Open water habitats would continue to experience significant, long-term negative impacts under the “No Action” Alternative.

5.7.6 Recommended Plan – Open Water Habitat

The potential impacts from the construction of the pool control structure would include substantial, long-term positive impacts from the increase in riverine habitat throughout the study area. The 1,321-acre riverine pool would be create riverine habitat upstream of the flow regime measure with a maximum depth of 10 feet. Downstream of the flow regime measure, the existing 1,591 acres of riverine habitats would become more persistent and increase to 2,414 acres throughout the study area from the increases in minimum flow. The operation of full and partial height gates would manage river flow based on releases from Keystone Dam. When water is abundant, the higher river flows would be allowed to pass free of reregulation. During reoccurring hydropower generation, the river flow would be managed to maintain more consistent minimum river flow at a target flow rate of 1,000 cfs.

The increase in acreage and higher average daily flows would provide increased connection of riverine habitats to other surface waters, wetlands, and riverine sandbars. The increase in permanent open water acreage would promote increases in fish abundance and biomass in the study area. The more persistent flows would help to stabilize aquatic food webs that become established in these habitats. Migratory water fowl, shorebirds, and wading birds would have increased resting and foraging habitats.

The creation of a rock riffle and wetland habitat feature at the mouth of Prattville Creek would create a small permanent pool behind the rock riffle. The pool would provide a small increase in local open water habitats along with increases in fish and macroinvertebrate abundance and biomass. There would also be localized minor habitat increases for migratory, wading, and shore birds. Water from Prattville Creek would be directed downstream towards the historic

mouth of Prattville Creek provided increased localized surface water availability. The creation of the permanent pool at the mouth of Prattville Creek would provide minor, long-term, positive impacts to riverine habitats in the study area.

No impacts (negligible) are anticipated from the creation of a Least Tern nesting island near Broken Arrow on riverine habitats. The island would be constructed as close to the center of the river channel and away from taller shoreline vegetation as practicable. Some temporary water quality impacts from construction activities may occur in open water habitats immediately downstream of the construction area. All practicable measures, including the use of appropriate BMPs, would be implemented to minimize impacts.

5.8 Biological Resources (Fish and Wildlife)

5.8.1 No Action Alternative

Under the "No Action" alternative, flows in the river would not change from existing conditions. Available habitats for fish, insects and reptiles, such as wetlands and open water, would continue to be degraded as described in previous sections keeping the abundance of these organisms low. The connectivity of these habitats would continue to be reduced during low flow conditions restricting passage for migratory fish upstream and the downstream transport of fish eggs and larvae. Foraging, resting, and nesting opportunities for migratory waterfowl, shorebirds, and wading birds would also be reduced from the continued degradation of these habitats. Therefore, under the "No Action" Alternative the river would continue to experience significant, long-term, negative impacts towards biological resources.

5.8.2 Recommended Plan

The potential impacts from the construction of the pool control structure on wildlife within the study area are expected to provide significant, long-term positive effects from the increase in daily minimum flows and stabilization and increase of available aquatic habitats. Loss of riverine and sandbar habitat, totaling 2.89 acres would occur from the construction of the Recommended Plan, fish and wildlife displaced during construction would have access to habitats in the vicinity of the structure. The construction and operation of the pool structure would significantly increase riverine habitat up and downstream of the structure, which would promote an increase in abundance and biomass of fish, including forage species of the Least Tern. Recreational fishing opportunities would increase in the area of the riverine pool as well as downstream, but a net benefit to fisheries would be realized.

CH2M (2009) compiled fish passage flow constraints for many species in the study area in a technical memorandum *Arkansas River Corridor Projects: Fish Passage Data Review and Analysis.* Paddlefish, considered one of the less capable species in the study area in regards to swimming performance, would require flow fields to be in the range of 2-4 feet per second (fps). Other more agile fish in the ARC, such as sauger and striped bass, are much more capable of navigating higher flow fields, and boast burst speeds between 4.9-11.5 and 5.2-8.5 fps, respectively.

The pool structure design and operation would maintain passage for migratory fish such as Shovelnose Sturgeon and Paddlefish to upstream habitats and would allow for the passage of fish eggs and larvae to downstream habitats during flood pool releases from Keystone Dam. As such, access to the 10 river miles of spawning areas upstream of the pool structure would continue with the pool structure in place. Preliminary flow field analyses show that, when the full

height gates are down, flow fields between 2-4 fps are maintained through the pool structure allowing fish passage for migrating and spawning fish. Boulder fields and sloped approaches would also be placed in select areas to provide diverse fish passage routes. Boulder fields provide flow refuge for smaller fish species, as well as interstitial habitat for minnow sized fish. Larger migratory fish would use more direct passage routes through sloped areas without boulder fields. These areas allow fish passage for larger species while limiting obstructions that could cause fish physical damage if swam into with excessive speed. As in the case of the paddlefish whose elongated rostrum can be damaged if the fish encounters large objects while swimming. As such, access to the 10 river miles of spawning areas upstream of the pool structure would continue with the pool structure in place. These areas contained larger shoreline and side channel rock and cobble substrates encountered during field surveys, potentially originating from nearby or upstream rip-rap areas. Regardless of origin, the rock and cobble substrates provide egg deposition areas and cover for several fish species.

Preliminary flow field analyses also show that during the 1,000 cfs flow releases, flow fields would be approximately 8 fps and initially limit fish passage opportunities to the more agile fish species. During reregulation periods, as pool height falls, flow fields would become lower providing additional periods of fish passage for species needing slower moving water. These additional fish passage periods would be provided to the maximum extent practicable through gate operation and detailed design, provided those operations and features do not impact the ability to deliver the 1,000 cfs flow, as the primary function of the pool structure is to provide river flow in the absence of water releases from Keystone Dam.

The pool structure does not present a significant barrier in regards to fish movement in the study area. The flow fields through the pool structure's full height gate sections during flood pool releases, which trigger and promote fish migration and spawning, would maintain the upstream river reach connectivity during the most critical periods.

In the current condition, no/low river flow regularly limits fish movements throughout the study area. While fish passage through the pool structure would be limited to more agile species during the 1,000 cfs release, nearly 30 river miles of connected, flowing riverine habitat would be maintained downstream that would otherwise be limited to fragmented reaches with minimal to no flow. The increase of minimum flow in the ARC from 100 cfs to 1,000 cfs would expand riverine habitat from 1,422 acres to 3,735 acres. 2,414 of the 3,735 acres would occur downstream of the pool structure in areas less impacted by urban development and Keystone Dam operations.

Sandbar islands and shoreline vegetation are more persistent in the downstream areas, likely due to the increased distance from Keystone Dam and larger metropolitan areas that allows some dissipation of water release energy and less fragmented shoreline habitats. During the 1,000 cfs test release from Keystone Dam (see Appendix M), aerial photography displayed the increased connectivity to backwater wetland and tributary habitat throughout the study area as indicated in the HEC-RAS modeling. Connectivity to these habitats increases refuge habitat for small fish from warmer temperatures, predators, and larger water releases. Subsequently, minor, long-term benefits would occur throughout the food web as these areas promote forage fish. Other fish, numerous migratory wading birds, raptors, and small mammals would realize minor, long-term benefits from the increase feeding opportunities.

Upstream of the structure, up to 1,321 acres of riverine habitat spanning nearly ten river miles would be available for fish and other wildlife that would otherwise be the first area of riverine habitat to be reduced to low/no river flow conditions.

Cherokee CRC (2009) reported that during a seasonal fisheries survey in the ARC from October 2006 through September 2007, 11 species including four native minnows and other larger species were only collected downstream of Zink Dam. Habitat differences, water quality conditions, and/or Zink Dam (as currently operated) were identified as potential limiting factors of species absence upstream of Zink Dam. With the increase of minimum river flow and more persistent river connectivity within the floodway to backwater areas and shoreline cover, minor, long-term benefits for fish species diversity and distribution are expected. Increased availability of persistent habitat for fish species not detected upstream of Zink Dam, and other species already present upstream of Zink Dam, would allow them to proliferate and balance species distribution throughout the ARC.

River flow during broadcast spawning and fish egg incubation periods is critical for fish reproductive success in the ARC. Sauger, paddlefish, striped bass, and shovelnose sturgeon for example, all need continued river flow to complete reproductive life histories. Striped bass broadcast eggs in river currents which need to drift downstream for 36-75 hours before hatching. Sauger, paddlefish, and shovelnose sturgeon deposit eggs on coarser substrates where they need to remain submerged in river flow, but unburied for several days up to 2 weeks. Under current conditions, the loss of river flow can strand striped bass eggs on river beds, shorelines, and or in isolated pools. Deposit spawners' eggs can become exposed and desiccate during no/low flow conditions. Lower flow can also bury eggs with sediment deposition. With the release of 1,000 cfs to fill in river flow gaps, fish eggs along with sauger fry, and other aquatic species that depend on river flow in early life stages, will have more consistent river flow and habitat availability throughout the 30 river miles of downstream river habitat below the pool structure. As such, the 1,000 cfs water release would be conducive to and improve long-term reproductive success of several fish species in the ARC. The release of 1,000 cfs would maintain the minimum 1 fps river flow needed to keep eggs suspended in the water column through the pool structure and continue floating downstream.

Downstream of the pool control structure, the increase in the acreage, stability, and connectivity of available riverine habitats would benefit fish, invertebrates, reptiles, amphibians, and birds. The increase of 2,414 acres stable wetland and open water habitats would provide additional nurseries for juvenile fish which provide a food source for foraging birds such as the Least Tern. The connectivity of these habitats would promote an increase of wildlife abundance throughout the study area.

By maintaining more consistent river flow, riverine habitat output in the ARC nearly doubles from 482 AAHUs to 867 AAHUs.

Some minor, long-term negative impacts may include the increase in abundance and occurrence of invasive species already present in the study area such as grass carp, common carp, white perch, flathead catfish, and zebra mussel.

The potential impacts on wildlife from the creation of the ecosystem restoration measures at Prattville Creek would include localized benefits to wildlife from the creation of 5.34 acres of wetland and open water habitats. Initial assessments of this area found virtually all wetland functions had been lost due to the frequent drying regime. Through the rock riffle feature, and

native aquatic plantings, a wetland footprint would be maintained to promote nursery habitat for juvenile fishes and habitat for invertebrates. The planted wetland vegetation would increase foraging and nesting opportunities for wading birds and shorebirds. The Recommended Plan elevates this areas output from essentially zero AAHUs, to 5 AAHUs through restored aquatic vegetation communities. Amphibians and wildlife would also benefit from the shoreline habitat structures which would provide refuge and nesting opportunities. Erosion and fill of the wetland area would also be minimized by the rock riffle as it would stabilize eroding banks and serve a breakwater function during larger releases. During initial field survey efforts, the only areas with submergent and emergent aquatic vegetation was behind a similar rock riffle feature that maintained a wetland area during no/low flow conditions. Numerous slider turtles were also observed within that wetland footprint. Due to limited wetland habitat within the ARC, there would be a minor, long-term positive impact on wildlife within the study area from the ecosystem restoration measures at Prattville Creek.

No impacts (negligible) are anticipated for biological resources within the study area from the construction of the Constructed Sandbar Island. The potential for some temporary sedimentation and water quality degradation of downstream habitats during construction would occur but would be reduced to the extent possible through implementation of best management practices, including constructing during no/low flow periods. The potential impacts of this ecosystem restoration measure would focus on Least Tern habitat and are described in the subsequent section.

Resource agencies stated their support (Appendix I) of the pool structure as long as the construction and operation promotes riverine habitat in areas both up and downstream of the structure by facilitating fish passage, sediment transport, and river flow.

5.9 Threatened and Endangered Species

5.9.1 No Action Alternative

Under the “No Action” alternative, flows in the river would not change from existing conditions. Moderate long-term, negative indirect impacts to listed species would continue primarily from the degradation of available habitats such as wetlands, riverine sand bars, and open water that are utilized for nesting and foraging. Nesting opportunities for the Least Tern would continue to be reduced from the loss and instability of riverine sand bar habitat, establishment of invasive plant species such as Johnson grass, increased land-bridging allowing predation on eggs and chicks, and decreased foraging opportunities. The extreme fluctuations in flows would continue to flood and wash out nests and chicks established at low elevations.

The impacts to migratory visiting species such as Piping Plover and Red Knot would also continue under the “No Action” Alternative as these species also depend on riverine and sandbar habitats. Within the study area they would continue to utilize marginal shoreline habitat for foraging and resting. The Northern Long-eared Bat which utilizes the study area for foraging, would continue to do so if existing conditions were maintained.

The American Burying Beetle has been documented to occur within the study area however the available habitats such as wetlands and areas with saturated soils are not favorable habitats for the American Burying Beetle and this would continue under the “No Action” Alternative.

The “No Action” Alternative would have no impact on Critical Habitat for these listed species since there is no designation of Critical Habitat within the study area.

5.9.2 Recommended Plan

Least Terns utilize the study area, particularly sandbar and riverine habitat, for foraging, nesting and rearing activities. Sandbar habitat at the location of the proposed pool structure and upstream to Keystone Dam is subject to highly variable sub-daily flow fluctuations from hydropower generation. No documented Least Tern nesting activity has been recorded during annual nesting surveys in this area since 2005. Least Tern foraging opportunities would increase up and downstream of the pool structure with the increase in riverine and open water habitat as described above in section 7.0. The restoration of riverine habitat would also benefit their main source food, small fish. . Riverine sandbars downstream of the flow regime measure would become more stable from the improved flow regime providing an increase in overall habitat acreage and quality for Least Tern nesting and foraging while not increasing flows to depths of flood pool or hydropower generation releases, thus avoiding any increases in inundation of lower laying Least Tern nests. Predation on eggs and chicks would decrease as increases in open water areas and flow channels (braids) would reduce land bridging to riverine sandbar habitats. Increased flows would also reduce the encroachment of vegetation on sandbars. A net benefit to listed species, particularly the Least Tern, is expected primarily from the increase in river flow that provides nesting sandbar habitat isolated from terrestrial predators and human disturbances. The potential impacts include moderate, long-term positive effects from the increase in daily flows and stabilization of available habitats. Marginal riverine sandbar and shoreline habitats may be reduced from the construction of the pool structure.

Based on the evaluation of impacts discussed above, USACE has determined the Recommended Plan may affect, but is not likely to adversely affect the Least Tern and was concurred with by USFWS (Appendix I). However, it would likely provide permanent, long-term benefits to the Least Tern. Minor, temporary impacts to the Least Tern may occur during construction, but can be minimized or avoided by conducting constructing activities outside of the Least Tern nesting season when they are not present within the study area.

Migratory visiting species such as the Piping Plover and Red Knot, while rare, would receive negligible to minor, long-term positive benefits from increased flows within the study area. The restored riverine sandbar and shoreline habitats would be used for resting and foraging during their migration. The quantity and quality of these habitats would increase in the study area under the Recommended Plan. No impacts to the Northern Long-eared Bat would be anticipated as the majority of foraging habitats such as forested hillsides and ridges would not be affected.

Unfavorable habitats to the American Burying Beetle such as wetlands, open water, and areas with saturated soils would become more persistent with the riverine pool upstream of the flow regime measure. The unfavorable habitats would occur along the fringes of the riverine pool in areas that already experience inundation during typical flood pool releases. Negligible, long-term negative impacts to the American Burying Beetle may occur, however it's occurrence within the study area, particularly in the river channel, is already limited by the presence of unfavorable habitats under existing conditions.

No impact to listed species from the ecosystem restoration measures at Prattville Creek are anticipated. The footprint of the area of construction is small and there are no known occurrences of listed species utilizing the location. The expected utilization of the created wetland area by listed species would be negligible. The increase in foraging area for Least

Terns, Piping Plovers, and Red Knots is negligible compared to the availability of foraging areas within the rest of the study area.

The potential impacts to listed species from the creation of a permanent Least Tern nesting island would include minor, long-term positive benefits to the Least Tern. The island would be maintained free of vegetation in perpetuity and regularly monitored for erosion providing assurances that the quality of the created habitat would be insured.

There are no potential impacts to other listed species such as Piping Plover, Red Knot, American Burying Beetle, and Northern Long-eared Bat, as these species would not be expected to be found in the location proposed for the sandbar island's construction and would likely not utilize the island to any benefit above other available habitats within the vicinity or study area.

5.10 Cultural Resources

A large portion of the area affected by the Recommended Plan has not been formally surveyed for cultural resources. There is potential for unidentified cultural resources, including historic standing structures and both historic and pre-contact archeological sites to exist within the project area. These resources are nonrenewable and could be directly and indirectly affected by the construction of structures or features associated with the project, as well as by subsequent public use. Impacts that can adversely affect cultural resources include anything that might significantly destroy or alter the important features of those resources. Direct and indirect effects to cultural resources can result from human activities or natural events. There is a moderate probability that unidentified cultural resources that may be eligible for listing in the NRHP are located within the proposed recommended measure footprints. These sites could see direct adverse effects as a result of construction activity for the pool structure including construction laydown/stockpile areas or temporary construction facilities. The areas with the highest potential for adverse impacts to cultural resources are primarily along the shoreline where excavation associated with construction of the low water pool structure would occur. Indirect impacts may include changes to the visual character surrounding any historic properties within the viewshed of the proposed pool structure.

5.10.1 No Action Alternative

Under the "No Action" alternative, none of the proposed construction activities occur and there would be no impacts to cultural resources beyond natural formation processes such as erosion or allusion.

5.10.2 Recommended Plan

There are three known cultural resources at or near the proposed low water pool structure (Sand Springs Levee, 34TU197 and 34TU200). The Sand Springs Levee/Tulsa County Levee District 12 has not been evaluated for NRHP eligibility, but was constructed in 1945 and can be described as a significant piece of Tulsa's infrastructure. The proposed restoration measures will have no direct impacts on the levee. Potential indirect impacts include a change to the historic viewshed of the levee. However, the historic viewshed of the area has already been significantly altered by urban development and construction of the Highway 97 Bridge. Site 34TU197 is located on a sandbar near the south bank of the Arkansas River and could be disturbed or completely destroyed by construction of the proposed low water pool structure. The site currently has an undetermined NRHP eligibility status; further testing is required to

determine whether intact subsurface deposits are present. Site 34TU-200 is a historic debris scatter, believed to have been associated with early 20th century commercial and industrial operations at Sand Springs. The site is located in the floodplain along the north bank of the Arkansas River. It has been disturbed by river flow and subsequent dumping events, and has been determined not eligible for listing in the NRHP due to a lack of integrity.

There are currently no known resources within the area proposed for the rock riffle placement near Prattville Creek, nor the location proposed for the constructed sandbar island. No cultural resources survey has been conducted at these locations, therefore a Programmatic Agreement has been developed in consultation with the Oklahoma State Historic Preservation Office, Oklahoma Archaeological Survey, and Tulsa County to ensure that cultural resource investigations are conducted and impacts to historic properties are resolved prior to construction activities. If cultural resources are identified during a future survey, NRHP eligibility and potential adverse impacts will be analyzed at that time. Any necessary mitigation of adverse effects will be coordinated in accordance with the Programmatic Agreement (See Appendix C) and Section 106 of the National Historic Preservation Act.

5.11 Land Use, Recreation and Transportation

5.11.1 No Action Alternative

Under the "No Action" Alternative, there would be no impacts to land use, recreation or transportation resources from implementation of the Recommended Plan. Land use changes in downtown areas occur over time and would be expected to continue within the Arkansas River Corridor into the future. The area currently has various industrial land uses. Over time, some of the areas near the proposed pool structure could transition to other land uses however, without the creation of the resulting riverine pool aesthetics as part of the proposed action, such infill redevelopment would likely be limited. Similarly, under the "No Action" alternative, there would be no change in existing recreation or transportation resources within the study area. Recreational benefits to local and nonlocal users and the potential for economic redevelopment of adjacent areas that could result would not be realized.

5.11.2 Recommended Plan

Construction of the Pool Structure at RM 530 would directly affect land use within a 1,500-foot corridor transecting the Arkansas River with tie-ins near South Main Street on the north side and approximately 1,000 feet upstream of Prattville Creek on the south side. Lands impacted include shoreline and riparian areas adjacent to the Arkansas River. These lands are currently zoned for agricultural or industrial purposes and are undeveloped on the north side of the river while the south side of the river is used to corral, feed, groom, and train the Sand Springs Public Schools 4-H and Future Farmers of America students' show animals. The Recommended Plan would result in this limited area being developed for the pool control structure such that it would be considered an industrial or institutional/utilities use in the future and therefore would have a minor, negative effect on land use. While the ecosystem restoration measures would improve the function and aesthetics of these areas, no actual changes in land uses are anticipated and therefore no impacts.

Operation of the pool structure would directly impact a narrow corridor adjacent to the Arkansas River at an elevation of approximately 635 feet, due to inundation. These lands are generally a mix of forests and woodlands, introduced and semi-natural vegetation, or agricultural uses with limited development. Notable land uses directly adjacent to this potentially inundated corridor

include recreation lands associated with Sand Springs River City Park and Case Community Center, a mobile home community and three sand mining operations. Additionally, a segment of Burlington Northern Railroad/State Highway 51 are directly adjacent to southern bank of the Arkansas River just upstream of Highway 97 while an electrical transmission line and West 11th Street directly parallel approximately 4,000 feet of the north bank. While the majority of these lands fall outside the potential inundation elevation, there is the potential for a minor, negative effect on lands used by sand mining operations as well as the transportation routes directly adjacent to the River. Due to the construction of the ecosystem restoration measures, associated lands would function better and therefore provide minor benefit. Indirect land use changes associated with the proposed action could include increased residential, commercial and mixed use development in Sand Springs and other adjacent areas due to the creation of an aesthetic and recreational amenity.

The proposed pool structure inundation area remains within the existing river channel. At the maximum pool elevation, the existing boat ramp is not fully inundated, rather the distance from the top of the ramp to the water would be shorter. No adverse change in its operation is expected. Within the ARC Master Plan, numerous outdoor recreation features are described. While not part of this study, those features can be pursued by cities, counties, and other entities. Although this study's focus is ecosystem restoration, various outdoor activities are compatible and supported by the proposed plan that fit within the existing infrastructure in the Tulsa area including wildlife viewing, fishing, hiking, and biking. To provide for personal safety and operational security first, there are no public access features to or on the pool structure as part of the federal project. Those features may be developed later by local entities.

5.12 Socioeconomics and Visual Aesthetics

5.12.1 No Action Alternative

Under the “No Action” Alternative, there would be no change and therefore no impacts to existing socioeconomic conditions would result. Similarly, the “No Action” Alternative would not result in potential disproportionate adverse impacts to minority or low-income populations.

5.12.2 Recommended Plan

Construction and operation of the Recommended Plan would directly affect the proximate socioeconomic resources of the City of Sand Springs and the northwestern corner of Tulsa County. A lesser indirect effect could occur downstream of the pool control structure due to its operation as well as the concurrent implementation of the other ecosystem restoration measures within the Arkansas River Corridor. As described in the ARC Master Plan, there is tremendous economic development potential associated with the Sand Springs riverfront area located adjacent to the pool control structure. Additionally, the pool control structure would provide impressive views of downtown Tulsa to the east while views to the west from River City Park would be of the more natural, wooded areas along both the north and south banks of the river. The provision of additional access, connectivity and recreational amenities could have a significant positive effect on the population and economy of these proximate communities, a minor positive effect on the downstream corridor and would not result in potential disproportionate adverse impacts to minority or low-income populations. While visual and aesthetic preferences are unique to each individual, implementation of the Recommended Plan could have a significant positive effect on the visual aesthetics of these proximate communities and a minor positive effect on the downstream corridor.

5.13 Utilities

5.13.1 No Action Alternative

Under the "No Action" Alternative, there would be no change and therefore no impacts to existing utilities.

5.13.2 Recommended Plan

Construction of the Recommended Plan would temporarily impact utilities while the three outfalls located below the proposed pool elevation are relocated or retrofitted. The balance of the construction and operation would not affect the existing wastewater treatment plants, gas pipelines nor the existing PSO electrical transmission corridor crossing the river just east of the bridge near the confluence of Prattville Creek. The wetland plantings associated with the measures at Prattville Creek would generally be under 15 feet in height at maturity to limit the potential for vegetation to interfere with the operation of the overhead line (PSO, 2016). As a result, while there would be a short-term minor negative effect on utilities, long-term impacts would be negligible.

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.

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 (Appendix J) shows the water surface profiles for tailwater conditions for operating one or both hydropower generating units.

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

5.14 Health and Safety

5.14.1 No Action Alternative

Under the "No Action" Alternative, there would be no change and therefore no impacts to health and safety.

5.14.2 Recommended Plan

Due to historical incidents with the former reregulation dam as well as below Zink Dam during high river flows, public safety is a major design consideration for any new structure in the Arkansas River. While subsurface currents created below a dam are often responsible for accidents, the design of pool control structures in general have improved greatly, allowing for a greater degree of public safety (Guernsey, et. al, 2005). The operation of full and partial height gates, along with sloped spillways would minimize the roll-over effect that would otherwise be created by water moving over vertical structures. In addition, physical security measures to prohibit public access to the structure would be in place to further limit the risk of people falling in the river near the pool structure. Since the potential health and safety risk cannot completely be removed, the Recommended Plan is projected to have a minor negative effect on health and safety.

5.15 Hazardous, Toxic and Radioactive Waste

5.15.1 No Action Alternative

Under "No Action" alternative, no impacts from hazardous or toxic substances would occur.

5.15.2 Recommended Plan

The construction and operation of the pool control structure at RM 530 could directly affect the Sand Springs Petrochemical Complex, or vice versa. The chemical complex, located approximately 0.25 miles downstream of the proposed pool structure location, was designated a Superfund site in 1986. It was removed from the National Priority List in 2000. While multiple cleanup efforts have been carried out at the site, there is a low potential to encounter previously undiscovered hazardous waste through construction excavation. As a precaution, the non-Federal Sponsor (Tulsa County) would conduct an environmental site investigation as part of the proposed action to confirm that no undiscovered hazardous waste sources exist in proximity to the construction area. Additionally, BMPs would be implemented to prevent movement of substances if they should be unexpectedly encountered. As part of the BMPs, the Complex would be avoided and not be disturbed, excavated, or used for laydown, parking or stockpiling during construction.

Potential for negligible short-term impact from spill of fuel or oil associated with construction equipment exists.

5.16 Geology and Soils

5.16.1 No Action Alternative

Under the "No Action" alternative, existing geologic conditions in the future would remain unchanged from historic and current conditions. There would be no impact on geology, topography, and local seismicity. It is likely that soils along the banks of the Arkansas River would continue to erode as wetland habitats and vegetated banks continue to be destabilized by extreme changes in the daily flow regime. Sediments trapped by Keystone and Zink dams would continue to reduce sediments loads within the study area promoting channel incision and further bank erosion. Soils would continue to experience minor, long-term negative impacts.

5.16.2 Recommended Plan

The construction of a pool control structure, rock riffles, and rock chevrons for the sandbar island would need to extend to underlying bedrock to anchor features in place, altering local topography within the 2.89 acre footprint of the features in the study area. Therefore, impacts to geology would occur from the construction of the Recommended Plan. The keying in and anchoring of the structures throughout the 2.89 acre footprint of physical restoration structures would result from the Recommended Plan.

No faults exist within the study area. The study area is located in a region classified with low seismic risk. There would be no impacts to local seismicity or geologic faults as a result of the Recommended Plan.

The impacts to soils within the study area overall would be negligible. Minimal impacts to Prime Farmland, outside of the Sand Springs city limits, would occur along the shoreline with the construction of the pool structure and rock riffles. Those areas however were not expected to be farmed due to their proximity to the bank slopes river and other infrastructure and

developments. The NRCS was coordinated with under the Farmland Protection Policy Act, the submitted AD-1006 form disclosing the impacts is located in Appendix I. The attenuation of the river's flow would increase the acreage and stability of wetland habitats and vegetation along the banks of the river. The rooted vegetation in these habitats serves to stabilize soil from erosion. However, sediment load depletion would increase as sediments are trapped behind the proposed pool control structure, and existing Keystone and Zink dams and therefore channel incision and bank erosion would continue. During construction, heavy equipment would be used to move and compact soils in construction areas. Disturbed areas would be kept to the minimum required to complete the work. Sedimentation and erosion controls would be implemented during construction to minimize erosion of surrounding soils due to soil and or ground disturbance.

5.17 Cumulative Impacts

Potentially, the most severe environmental degradation does not result from the direct effects of any particular action, but from the combination of effects of multiple, independent actions over time. As defined in the CFR, 40 CFR 1508.7 (CEQ Regulations), a cumulative effect is the "impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions." Some authorities contend that most environmental effects can be seen as cumulative because almost all systems have already been modified. Principles of cumulative effects analysis, as described in the CEQ guide Considering Cumulative Effects under NEPA, are:

- Cumulative effects are caused by the aggregate of past, present, and reasonably foreseeable future actions.
- Cumulative effects are the total effects, including both direct and indirect effects, on a given resource, ecosystem, and human community of all actions taken, no matter who (Federal, non-Federal, or private) has taken the actions.
- Cumulative effects need to be analyzed in terms of the specific resource, ecosystem, and human community being affected.
- It is not practical to analyze the cumulative effects of an action on the universe; the list of environmental effects must focus on those that are truly meaningful.
- Cumulative effects on a given resource, ecosystem, and human community are rarely aligned with political or administrative boundaries.
- Cumulative effects may result from the accumulation of similar effects or the synergistic interaction of different effects.
- Cumulative effects may last for many years beyond the life of the action that caused the effects.
- Each affected resource, ecosystem, and human community must be analyzed in terms of the capacity to accommodate additional effects, based on its own time and space parameters.

According to the CEQ regulations a cumulative effect is defined as:

> "The impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes such other actions." (40 CFR §1508.7)

Principles of cumulative effects analysis are described in the CEQ guide "Considering Cumulative Effects under the National Environmental Policy Act." For this analysis, cumulative effects are examined in terms of how the Recommended Action could affect downstream resources through interaction with other past, present, and reasonably foreseeable future actions. CEQ guidance on cumulative effects analysis states:

> "For cumulative effects analysis to help the decision-maker and inform interested parties, it must be limited through scoping to effects that can be evaluated meaningfully. The boundaries for evaluating cumulative effects should be expanded to the point at which the resource is no longer affected significantly or the effects are no longer of interest to affected parties." (40 CFR 1508.7)

The Recommended Plan has the potential for cumulative effects (with past, present, and reasonably foreseeable future projects) on land use, water resources, the socioeconomic environment, biological resources including protected species, and recreation. The cumulative effects assessment is limited to projects reasonably foreseeable through 2025 within the study areas for various resources described in Chapter 5. The geographical boundaries for cumulative effects analysis are limited to the Arkansas River Corridor.

5.17.1 Past, Present, and Reasonably Foreseeable Projects within the Arkansas River Corridor

Recent past and ongoing projects or federal actions within the Arkansas River Corridor were considered as part of the baseline or existing conditions within the study area. These projects were considered in terms of their relevance to the Recommended Action. Each project and published environmental document was reviewed to consider the implication of that project and its synergy with the Recommended Action. Of particular concern were potential overlap in affected area, project timing, and the relevance of impacts to the resources, ecosystems, and human communities of concern.

As depicted in Table 166, five known projects were identified and considered to have potential cumulative effects, mostly due to the overlapping region of influence (ROI) of the proposed project area. The past, present and reasonably foreseeable projects and actions within the proposed project location are summarized in Table 16. Additional development, as identified in the 2005 ARC Master Plan, could further impact the terrestrial and aquatic habitats in the ARC. However, should further development arise, those efforts would also have to adhere to the applicable local, state, and Federal ordnances, policies, and regulations to account for, and offset where applicable, impacts the environment.

The George Kaiser Family Foundation sponsored a proposed land-based park, the Gathering Place. This riverfront development includes approximately a total of 100 acres of land along the east bank of the Arkansas River. In January 2018, the Chapman Adventure Playground opened to the public. Other features currently under construction include restaurants, a lodge, and water recreation. . Some of the other proposed project components include a land bridge over the Riverside Drive, trails, gardens, parking, cafes, playgrounds, urban wetlands, and a pond. The primary area includes the Blair Mansion property at 26th Place.

Table 17 includes a comparison of cumulative effects for each of the pertinent resource areas that maybe impacted by the Recommended Action or other projects in the Arkansas River Corridor. In some cases, there is potential interaction among some projects as identified in Table 177. These interactions have the potential to either increase or offset possible

environmental consequences. The Recommended Plan is not expected to add to any significant cumulative effects to natural, physical or human environments resulting from other projects, either recently completed, ongoing, or proposed on within the project area or within the Arkansas River Corridor.

Table 16: Past, Present and Reasonably Foreseeable Projects and Actions within Project Area ROI

Location Within Project Area ROI	Project or Action				
	Past Actions	**Present Actions**	**Reasonably Foreseeable Future Actions**	**Environmental Documentation**	**Implementation Timeframe**
Area Immediately Above and below Zink Dam	Zink Lake Area Maintenance Dredging: Authorization to dredge 15-20,000 cubic yards of sands within activity and conducted on an as-needed basis			CWA-404 permit application with USACE.	Permit valid until April 30, 2018.
A Gathering Place for Tulsa public park	N/A	Upland development for public park, recreational facilities, and river access: Phase I (66.5) acres): construction from 24th to 31 streets on the east side of the Riverside Drive and from 24th St to 33rd Pl along the west side.	Phase 2: south of 31st Street (25 acres)	CWA-404 permit application with USACE.	Playground area opened January 2018. Total timeline 6-7 years (approximately 2020).
Tulsa levee system improvements			Levee system rehabilitation and repair	Feasibility Study by Tulsa County. Risk Assessment by the Risk Management Center of the USACE.	2017-2023.
Zink Lake Area at 29th and Riverside Drive	Construction of Zink Dam	Periodic gate maintenance	Reconstruction of the existing low water dam and recreational improvements in Zink Lake and east bank below the dam	CWA-404 permit application with USACE.	2017-2018.
South Tulsa/Jenks Low Water Dam located downstream of the Creek Turnpike bridge	N/A	N/A	Construction of new low water dam and recreational features on east and west banks of project vicinity.	Future CWA-404 permit application with USACE.	By 2022

Table 17: Comparison of Cumulative Effects

Resource	Historic Conditions	Existing Conditions	Future Without Project (No Action Alternative)	Cumulative Effects (Comparison of Future with Action Alternative Impacts)
Arkansas River (O&M)	Since the 1960s the river corridors flows have been impacted by Keystone Dam and hydropower production. USACE operates and manages the Keystone Lake and Dam.	USACE operates and manages the Keystone Lake and Dam for the purpose of flood control, water supply, hydroelectric power generation, navigation and fish and wildlife.	No change from existing conditions.	No change from existing conditions
Air Quality	General deterioration of air quality due to increases in human populations and industry. Improvements as a result of implementation of legislation.	Improved air quality due to regulations, public outreach, education and improved available and affordable control technology.	There would be temporary, short term, minor impacts due to emissions during construction of the other projects.	Implementing the proposed project would include minor short-term adverse effects on air emissions due to construction activities. Minor additive effects may occur if the projects are constructed simultaneously
Climate	Global warming trend beginning in the 1800's. Increase in GHG emissions increasing during the industrial revolution.	Warming trend and GHG emissions are continuing.	There would be temporary, short term, minor impacts due to GHG emissions during construction of the other projects.	Implementing the proposed project would have temporary, short term, minor impacts due to GHG emissions during construction that could affect climate change and would be additive with other projects in the corridor.

Resource	Historic Conditions	Existing Conditions	Future Without Project (No Action Alternative)	Cumulative Effects (Comparison of Future with Action Alternative Impacts)
Water Resources				
Open Water Groundwater Water Quality	Fluctuating water levels due to Keystone Dam operations and seasonal flows. The impoundment of Arkansas River and the influence of Keystone Dam have altered the natural conditions once uncontrolled prairie river. Sands in the river wash down to the Zink Lake area. Construction of flood control levees along west and east bank of Arkansas River corridor in Tulsa. Degraded water quality due to human and industrial activity and reduced volume of water within the study area. Reduced riverine habitats	Continued degradation of riverine habitats within the study area from reduced flows and flow extremes. Reduced availability of riverine habitats. Continued degradation of water quality from increased human activity and disturbances within the watershed. Reduction in the downstream sediment supply below Keystone Dam. Released sands continue to accumulate above Zink Dam. Bank erosion and the disappearance of mid-channel bars as water released from Keystone Dam scours the channel bed and banks to re-establish equilibrium between flow and sediment transport Maintenance of existing flood control infrastructure. Water quality standards meet beneficial uses requirements.	The seasonal and operational fluctuations of the Arkansas River below the Keystone Dam continue degrading the riverine habitats and ecosystems.	Implementing the other low water dam projects within ARC, the long-term benefits would be additive with other projects to water resources if the operations of the other low water dams are coordinated through an adaptive management. This would improve the daily flows and attenuate the extreme flow variability which is a primary driver for overall impacts within the study area. The direct affects would be realized at lower elevations within the study area where inundation would increase and become more regular. Flow attenuation would promote stability for riverine and wetland habitats which would provide long-term benefits to wildlife and water quality. Bank erosion would reduce as vegetation stabilizes and scouring flows are reduced. Acreages of open water would increase. Impacts to groundwater would be considered localized and negligible as ground water gradients changes would be minimal.

Resource	Historic Conditions	Existing Conditions	Future Without Project (No Action Alternative)	Cumulative Effects (Comparison of Future with Action Alternative Impacts)
Hydrology and Floodplains	The impoundment of Arkansas River and the influence of Keystone Dam have altered the natural flow conditions within the study area. Daily flows are greatly reduced and experience extreme fluctuations. The changes in the flow regime have led to deteriorated water quality, bank erosion, and loss of habitats for wildlife. Sediment starvation has occurred from sediment loads being trapped behind Keystone and Zink dams reducing riverine sandbar creation. Floodplains have been impacted from erosive scour during extreme flows and colonization of non-native, invasive plant species such as Johnson grass and salt cedar. No changes to floodplain storage.	The seasonal and operational fluctuations of the Arkansas River below the Keystone Dam continue to degrade ecosystems within the study area. Sediment starvation downstream of Keystone and Zink dams continues. Continued bank erosion and the disappearance of mid-channel bars as water released from Keystone Dam scours the channel bed and banks to re-establish equilibrium between flow and sediment transport. Continued colonization of floodplain habitats by invasive plant species. No changes to floodplain storage.	The seasonal and operational fluctuations of the Arkansas River below the Keystone Dam continue degrading the riverine habitats and ecosystems.	Releases from pool structure would augment river flow over weekends when there are no hydropower releases. Implementing the other low water dam projects within ARC, the operational procedures and benefits would be via adaptive management of the low water dams. The ecosystem within the study area would realize long-term positive impacts from the increase and attenuation of the flow regime. Water quality would improve from increases in water volumes and stabilization of wetland communities. Stabilization of flows would promote greater habitat availability to wildlife. Some reduction in establishment of invasive plant species within low elevation floodplain habitats where inundation would increase. No impacts to floodplains are expected as each low water dam would be designed to avoid any increase in base flood elevation. Rehabilitation and restoration of levee system would reduce flooding risk within the ARC.

Resource	Historic Conditions	Existing Conditions	Future Without Project (No Action Alternative)	Cumulative Effects (Comparison of Future with Action Alternative Impacts)
Vegetation and Habitat				
Wetlands	Wetland habitat acreages within study area reduced and disconnected to other habitats due to reductions in flow regime. Wetlands destabilized due to flow fluctuations which has selected for early successional, emergent marsh habitat types.	Reduced wetland habitat acreage and connectivity to other habitats. Available wetland habitats dominated by early successional emergent marsh types due to decreased stability in study area.	No change from existing conditions.	Increased wetland habitat acreages and connection to other habitats from increased flow regime. Development of wetland vegetation strata (shrubs, trees) from improved hydrologic stability. Improved water quality. Increases in habitat for aquatic, semi-aquatic, and terrestrial wildlife species within study area.
Riverine Sand Bars	Sand bar habitat formation reduced from sediment starvation in reach downstream of Keystone Dam. Sand bar habitats destabilized from extreme fluctuations in flow regime. Vegetated sand bars being colonized by invasive plant species.	Ongoing reduction in stabile riverine sand bar habitat in the reach downstream of Keystone Dam from sediment starvation and extreme fluctuations in the flow regime. Continued establishment of invasive plant species.	No change from existing conditions.	Continued reduction in riverine sand bar habitat in reach of study area downstream of Keystone Dam. Significant reduction in habitat acreage from the conversion of riverine sand bar habitats to open water within the riverine pool footprint behind the flow regime measure. Improved stability of remaining habitats from increased flow regime. Reduced establishment of invasive plant species at lower elevations due to increased inundation.
Open Water	Reduction in riverine habitat acreages and connection to other habitats from reduced flow regime	Reduced riverine habitat acreage and connectivity to other habitats.	No change from existing conditions.	Significant increase in riverine habitats from the expansion and restoration of 3,735 acres of riverine habitat by flow regime measure. Increase in riverine habitats and connectivity throughout the study from the increased flow regime.

Resource	Historic Conditions	Existing Conditions	Future Without Project (No Action Alternative)	Cumulative Effects (Comparison of Future with Action Alternative Impacts)
Biological Resources (Fish and Wildlife)	Reduced abundance of native wildlife species within the study area from the reduction in nursery (wetlands, open water) and foraging habitats (wetlands, riverine sand bars, and open water). Impediments to migratory fish passage and larval/egg transport from Keystone and Zink dams. Poor development of aquatic food webs which provide food sources for larger wildlife and listed species.	Continued reduced abundance of wildlife within study area due to reduced habitat availability and connectivity.	The seasonal and operational fluctuations of the Arkansas River below the Keystone Dam continue degrading the riverine habitats and ecosystems.	Maintaining any flow in the river would improve water quality and fish habitat. Releases from pool structure would augment river flow over weekends when there are no hydropower releases. Implementing the other low water dam projects within ARC, the operational procedures and benefits would be via adaptive management of the low water dams. Significant benefit to wildlife from stabilized flow regime promoting increase in habitat acreages and connectivity. Increase in nursery and foraging habitats. The pool structure in the Recommended Plan would be designed to facilitate at least seasonal passage for migratory fish and larvae/eggs. Resource agencies strongly support other low water dams include passage for migratory fish and larval/egg transport.

Resource	Historic Conditions	Existing Conditions	Future Without Project (No Action Alternative)	Cumulative Effects (Comparison of Future with Action Alternative Impacts)
Threatened and Endangered Species	Un-vegetated riverine sand bar habitat within the study area has supported a viable interior Least Tern population and suitable nesting habitat. Loss of riverine sand bar habitat from sediment starvation has reduced available nesting habitat downstream of Keystone and Zink Dams. Extreme fluctuations in flow regime wash away low elevation nests, eggs, and chicks. Increased predation on eggs and chicks from land bridging of nesting habitats with upland habitats. Prey species such as small fishes reduced in abundance with in study area due to reduced flow regime. Other listed species either present in low abundance due to preferred habitats not being present (American Burying Beetle), or are migratory incidental species (Piping Plover, Red Knot), or are minimally dependent on habitats found within the study area (Northern long-eared Bat).	Least Tern populations stable within the study area but likely reduced from historic populations due to reduced nesting habitats and continued impacts to nests from flow fluctuations and predation.	Existing habitat conditions are projected to continue or worsen in the future without project condition with no restoration of riverine habitat, connectivity for migratory fish, nesting habitat for Least Terns, or habitat diversity. Without stabilizing flow conditions, “land bridge” effect may take place and affect Federally-listed endangered Least Terns who annually nest on the sandbar islands in the ARC. This allows terrestrial predators’ easy access to nesting colonies as well as disturbances from human recreation that further limit nesting success. The low flow conditions also induce Least Terns to nest in unsuitable low-lying areas. Hours or days later when Both inundation and low flow conditions contribute to nesting failure in the ARC.	Moderate long-term benefit to Least Tern populations from increase in abundance of habitats, stabilized flow regime reducing impacts to nests, eggs, and chicks, increased surface water habitats promoting reduced land bridging and predation, and an increase in abundance of prey species from increased habitat availability. Minor long-term benefits to migratory listed species such as the Red Knot and Piping Plover as increase in habitats such as wetlands and open water would increase refugia for resting and foraging within the study area. No benefits anticipated for the American burying beetle or Northern long-eared bat since these species depend on habitats not readily available within the study area or impacted from the proposed alternative.
Cultural and Archeological	Federal undertakings are subject to the NHPA Section 106 process and other laws pertaining to cultural resources.	Human activities as well as natural processes can potentially degrade or destroy cultural resources.	No change from existing conditions.	The proposed action could impact known as well as unknown cultural resources

Resource	Historic Conditions	Existing Conditions	Future Without Project (No Action Alternative)	Cumulative Effects (Comparison of Future with Action Alternative Impacts)
Land Use, Recreation and Transportation	Conversion of a prairie and sandstone hill landscape over time for agricultural, transportation and commercial / industrial uses. Introduction of recreation activities within corridor with the addition of trails, amenities, parks, look outs, recreational clubs, and entertainment facilities. An increase in non-water based transportation infrastructure in the form of roads, railroads, and bridges.	Ongoing re-development and enhancement of downstream recreation opportunities and transportation improvements within the river corridor.	Land use development in the corridor would likely continue but would not be clustered along the riverfront in Sand Springs. Continued development of recreation opportunities in leased and private lands in a more piecemeal fashion. Other infrastructure projects in the corridor would include downstream transportation improvements and the addition of other low water dams.	The proposed action could provide cumulative benefits to the land use and recreation resources of Sand Springs and proximate areas by facilitating better public access to the River. Implementing the proposed project would not affect transportation resources.
Socioeconomics	Increasing populations and commercial development in the communities along the Arkansas River corridor.	Population centers and economic development continue along the river corridor.	No change from existing conditions.	
Visual Aesthetics	Human population growth, development, and other human activities have the potential to destroy, enhance, or preserve visual resources. Historical transportation and industrial development activities adjacent to the river have negatively affected the visual and aesthetics of the river corridor.	Development activities continue to detract from the visual and esthetic resources of the corridor though efforts are ongoing to improve downstream conditions.	No change from existing conditions.	

Resource	Historic Conditions	Existing Conditions	Future Without Project (No Action Alternative)	Cumulative Effects (Comparison of Future with Action Alternative Impacts)
Utilities	Development of extensive utility infrastructure throughout the corridor. Increased investment in water supply, wastewater, energy, communication and stormwater control facilities and structures in populated areas along the Arkansas River corridor.	Ongoing operation and maintenance of existing utilities and infrastructure within Arkansas River Corridor.	No change from existing conditions.	
Health and Safety	Degradation and destabilization of the river banks due to natural processes and human development without appropriate best management practices. Historical low water dam designs could cause dangerous roller effects that are a recreational safety concern.	Increased human activity along unstable river banks pose recreational health and safety issues to the public.	No change from existing conditions.	Health and safety of the Flow Regime Measure would be addressed through its design. Improved safety for those proximate to the ecosystem restoration measures.
Hazardous Materials or Toxic Substances	Degradation of some areas untreated and uncontrolled discharges, especially in urbanized and/or industrialized areas with improvements as a result of implementation of legislation. Former EPA Superfund Site located near the proposed pool structure location at RM 530.	Hazardous materials use and transportation are a regulated activity, thus monitored and permitted only when impacts are minimized and BMPs implemented. Site has been removed from the NPL in 2000.	No change from existing conditions.	No change from existing conditions. Risk of encountering HTRW is unknown – may range from nothing, to materials that require special handling/disposal to large scale clean up prior to construction.

Resource	Historic Conditions	Existing Conditions	Future Without Project (No Action Alternative)	Cumulative Effects (Comparison of Future with Action Alternative Impacts)
Geology, Seismicity, and Soils	Sediment continuity from the upstream reach has been interrupted by Keystone Dam and the flow regime has been modified. The channel downstream of Keystone Dam has experienced incision and bank erosion as it has been scoured of sediment to regain the sediment load of the river that is trapped upstream in Keystone Lake. The river banks have continued to erode due to sandy soils. The channel downstream of Keystone Dam has experienced incision and bank erosion as it has been scoured of sediment to regain the sediment load of the river that is trapped upstream in Keystone Lake.	Widespread bank erosion has continued throughout the river corridor and along the project area.	Erosion would likely continue until the banks of the channel are armored along the entire reach below Keystone Dam.	Improved river banks and reduced erosion due to armoring. Minor short-term adverse effect on soils if any of the future projects overlap during construction period. Some of the projects may overlap in the period of construction and minor cumulative effects may occur. River bank armoring and aquatic ecosystem restoration would have a beneficial additive impact on soils.

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6 PROJECT IMPLEMENTATION AND PUBLIC INVOLVEMENT

This chapter discusses aspects of implementation of the Recommended Plan such as Preconstruction Engineering and Design, monitoring and adaptive management and operation, maintenance, repair, replacement, rehabilitation, as well as consultation and coordination that has or will occur throughout the study process including contacts made during development of the proposed action, other alternatives considered, and writing of the Feasibility Study report and integrated Environmental Assessment.

6.1 Project Implementation

Project implementation for ecosystem restoration projects is comprised of three phases – Pre-Construction Engineering and Design (PED), construction, and monitoring and adaptive management. Implementation of the Recommended Paln is within the existing authorization for construction, and would not require further Congressional approval, except for appropriation of funds.

6.1.1 Pre-Construction Engineering and Design

The PED Phase is cost shared 65 percent Federal, 35 percent non-Federal for ecosystem restoration projects in accordance with WRDA 1986. However, a cap has been set on the Federal investment in this project at $50M by the study authority. Prior to initiating the PED phase, the design team must develop a Project Management Plan (PMP) which defines the scope, work breakdown structure, schedule, and budget to complete PED. Additional items in the PMP are related to value management and engineering, quality control, communication, change management, and acquisition strategy. The draft PMP must be developed, negotiated, and agreed upon by all parties of the PED phase prior to initiation of the PED phase.

A number of activities are expected to take place during PED. These include the completion of a Design Documentation Report (DDR), plans and specifications (P&S), execution of the Project Partnership Agreement (PPA), and contract award activities. Continued coordination with USFWS, ODWC and SWPA would ensure the final design and restorative measures achieve restoration goals while avoiding adverse impacts.

The development of the DDR includes completing the final design of project features. As part of the DDR, the team would complete any ground surveys, utility surveys, and drilling and testing for subsurface (geotechnical) conditions as necessary to complete the final design. Also, resource agencies would help inform pool structure design to ensure flow, sediment transport, and fish passage requirements are addressed. The measure locations would be further defined based on surveys. Design parameters for all project features would be defined for development of the plans and specifications. Continued coordination with SHPO would ensure requirements for cultural resource investigations and mitigation continue to be met during construction.

P&S includes the development of project construction drawings and specifications, estimation of final quantities, and completion of the government cost estimate. Drawings and specifications are made available to contractors interested in bidding on the construction of the proposed project. It is estimated that several sets of plans and specifications would be developed for the pool structure, wetland features, and sandbar island. Arrangements for onsite archeological monitoring during construction should be finalized prior to the conclusion of P&S so they may be documented in the PPA.

A PMP for the construction phase must be developed, negotiated, and agreed upon by all parties of the construction phase prior to initiation of the construction phase.

The PPA is a binding agreement between the Federal government and the non-Federal sponsor which must be approved and executed prior to the start of construction. The PPA sets forth the obligations of each party. The non-Federal sponsor must agree to meet the requirements for non-Federal responsibilities which would be identified in future legal documents. Some of the likely responsibilities are:

1. Provide the non-Federal share as further specified below:
   a. Provide 35 percent of design costs in accordance with the terms of a design agreement entered into prior to the Federal Government's commencement of design work for the project;
   b. Provide all lands, easements, and rights-of-way, including those required for relocations, the borrowing of material, and the disposal of dredged or excavated material; perform or ensure the performance of all relocations; and construct all improvements required on lands, easements, and rights-of-way to enable the disposal of dredged or excavated material all as determined by the Federal Government to be required or to be necessary for the construction, operation, and maintenance of the project;
   c. Provide, during construction, any additional funds necessary to make its total contribution equal to 35 percent of shared design and construction costs;
   d. Provide, during construction, 100 percent of design and construction costs in excess of shared design and construction costs.
2. Shall not use Federal Program funds (those funds provided by a Federal agency, plus any non-Federal contribution required as a matching share therefor) to meet any of the non-Federal obligations for the project unless the Federal agency providing the funds verifies in writing that the funds are authorized to be used for the project;
3. Prevent obstructions or encroachments on the project (including prescribing and enforcing regulations to prevent such obstructions or encroachments) that might reduce the outputs produced, hinder operation and maintenance of the project, or interfere with the proper function of the project;
4. Shall not use the project, or real property interests required for construction, operation, and maintenance of the project, as a wetlands bank or mitigation credit for any other project;
5. Comply with all applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended (42 U.S.C. 4601-4655), and the Uniform Regulations contained in 49 Code of Federal Regulations Part 24, in acquiring lands, easements, and rights-of-way required for construction, operation, and maintenance of the project, including those necessary for relocations, the borrowing of materials, or the disposal of dredged or excavated material; and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act;
6. For so long as the project remains authorized, operate, maintain, repair, rehabilitate, and replace the project, or functional portions of the project, including any mitigation features, at no cost to the Federal Government, in a manner compatible with the project's authorized purposes and in accordance

with applicable Federal and State laws and regulations and any specific directions prescribed by the Federal Government;

7. Give the Federal Government a right to enter, at reasonable times and in a reasonable manner, upon real property interests that the non-Federal sponsor now or hereafter owns or controls to inspect the project, and, if necessary, to undertake any work necessary to the functioning of the project, including operation, maintenance, repair, rehabilitation, or replacement of the project;
8. Hold and save the United States free from all damages arising from the construction, operation, maintenance, repair, rehabilitation, and replacement of the project and any betterments, except for damages due to the fault or negligence of the United States or its contractors;
9. Keep and maintain books, records, documents, or other evidence pertaining to costs and expenses incurred pursuant to the project, for a minimum of three years after final accounting;
10. Comply with all applicable Federal and state laws and regulations, including, but not limited to: Section 601 of the Civil Rights Act of 1964 (42 U.S.C. 2000d) and Department of Defense Directive 5500.11 issued pursuant thereto; the Age Discrimination Act of 1975 (42 U.S.C. 6102); the Rehabilitation Act of 1973, as amended (29 U.S.C. 794) and Army Regulation 600 7 issued pursuant thereto; and 40 U.S.C. 3141-3148 and 40 U.S.C. 3701-3708 (labor standards originally enacted as the Davis-Bacon Act, the Contract Work Hours and Safety Standards Act, and the Copeland Anti-Kickback Act);
11. Perform, or ensure performance of, any investigations for hazardous substances that are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Public Law 96-510, as amended (42 U.S.C. 9601-9675), that may exist in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be required for construction, operation, and maintenance of the project. However, for lands that the Federal Government determines to be subject to the navigation servitude, only the Federal Government shall perform such investigations unless the Federal Government provides the non-Federal sponsor with prior specific written direction, in which case the non-Federal sponsor shall perform such investigations in accordance with such written direction;
12. Assume, as between the Federal Government and the non-Federal sponsor, complete financial responsibility for all necessary remediation and response costs of any hazardous substances regulated under CERCLA that are located in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be required for construction, operation, and maintenance of the project;
13. Agree, as between the Federal Government and the non-Federal sponsor, that the non-Federal sponsor shall be considered the operator of the project for the purpose of CERCLA liability, and to the maximum extent practicable, operate, maintain, repair, rehabilitate, and replace the project in a manner that will not cause liability to arise under CERCLA; and

14. Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended (42 U.S.C. 1962d-5b), and Section 103(j) of the Water Resource Development Act of 1986, Public Law 99-662, as amended (33 U.S.C. 2213(j)), which provide that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until each non-Federal interest has entered into a written agreement to furnish its required cooperation for the project or separable element.

6.1.2 Real Estate Acquisition

The non-Federal sponsor is responsible for the lands, easements, rights-of-way, relocations, and disposal areas required for project construction, and operation and maintenance of the project. Anticipated real estate requirements for the project are described in Appendix H, Real Estate Plan. Following the Execution of the PPA, the non-Federal sponsor would be provided a right of way map delineating the real estate necessary for construction, operation, and maintenance of the proposed project. Real estate activities would be coordinated between Tulsa County's Real Estate Office and the Real Estate Office of the Tulsa District. Also, prior to any solicitation of construction contracts, the District Chief of Real Estate is required to certify in writing that sufficient real property interest is available to support construction of the contract.

6.1.3 Contract Advertisement and Award

Once the PPA is executed, the plans and specifications completed, and the rights of entry provided to USACE-Tulsa District, a construction contract would be solicited and advertised. Prior to awarding the contract, the non-Federal sponsor must provide any applicable cash contribution. The contract would be awarded to the lowest responsive bidder and notice to proceed can be expected within 30-45 days from bid opening.

6.1.4 Project Construction

After award of the construction contract, the Government would manage project construction. Inherent with such contracts, a warranty period for actual construction items and plantings would be specified. Construction of the pool structure, rock riffle structures, and sandbar island is expected to take 2 years to complete. Wetland plantings would begin when the rock riffle work is complete and seasonably appropriate. Planting would occur over at least two seasons within the same planting area. There would be a 2 year contract period beyond each specific planting period to ensure the wetland habitat is alive and thriving. This activity includes removing any non-native or invasive species, watering (if needed), and replacement vegetation to ensure a minimum survival rate. Performance standards for the establishment of vegetation and control of non-native and invasive species would be refined during PED. During construction, an archeologist would monitor excavation. Should any significant cultural resources be identified, mitigation procedures would take place prior to further excavation. Total implementation time is expected to be two years.

6.1.5 Monitoring and Adaptive Management

Monitoring and if necessary, adaptive management, would occur until the ecological restoration success criteria in the Monitoring and Adaptive Management Plan are determined by the Division Engineer to have been met. Monitoring and adaptive management costs cannot increase the total Federal costs beyond the authorized project cost limit for this project.

Monitoring efforts would be conducted with Tulsa County and USACE personnel. See Appendix A for the Monitoring and Adaptive Management Plan.

6.1.6 Operation, Maintenance, Repair, Replacement, Rehabilitation (OMRRR)

The non-Federal sponsor is responsible for the OMRRR of the completed project. USACE-Tulsa District would update the existing Arkansas River Corridor OMRRR plan which also includes management strategies for sustainable riverine ecosystem management. USACE-Tulsa District would provide the updated plan upon successful completion of the project construction (or a representative portion thereof), prior to turning over the project to the non-Federal sponsor. OMRRR of the proposed restoration project is comprised of the structural integrity of the pool structure, rock riffle structures, and sandbar island structures. Based on a survey of other ecosystem restoration studies, OMRRR costs are estimated at $349,000.

Section 1161 of WRDA 2016 specifies that 10 years after ecological success has been determined, the responsibility of a non-federal sponsor to conduct O&M activities on non-mechanical and non-structural elements of an ecosystem restoration project will cease. The sections below describe the non-mechanical and non-structural elements of each proposed restoration measure and analyzes the long-term risks to restoration success should O&M activities for those elements not occur.

6.1.6.1 Pool Structure

Routine maintenance would include periodic inspection, repair of localized erosion, removal of excess sediment and debris, and replacement of dislodged or broken riprap or rock. Water releases from the pool structure would help minimize the need for sediment and debris removal. All elements of this measure are considered structural and/or mechanical. The pool structure is vital to the long-term restoration success as the pool structure's primary purpose is to increase the minimum river flow in the study area. As such, should any O&M activities cease and compromise the operation of gates or limit the capacity stored water for release, immediate deficits in environmental benefits would likely occur and conditions would return to the future without project condition.

6.1.6.2 Prattville Creek Measures

Some vegetation loss would likely occur during years 3-5 of the project, particularly if the area experiences a significant flood event or if an extended drought occurs as wetland plants rely on ponded water at appropriate elevations. This potential loss of habitat is mitigated by the use of seedling wetland plantings. Seedlings are more likely to withstand flood forces while root systems become firmly established and can access additional moisture deeper in the soil. An increase in debris is expected during and after flood events. The removal of this debris is accounted for in the OMRRR estimate.

All elements of the Prattville Creek measures are considered structural in nature regarding O&M activities except for invasive species management. Following the following the establishment of native aquatic plant communities and restoration success, the onsite sources for native vegetation reestablishment should be able to sustain ecological output. While extreme durations of drought or flooding can dramatically reduce native community extent, native seed soil loads would be available to revegetate the wetland area upon the return of more normal conditions and allow for continued restoration success.

6.1.6.3 Least Tern Island

Annual inspections would be needed to monitor for and prevent significant vegetative growth. Also the riprap chevrons would need inspection after high flow events to identify any damaged areas in need of repair. The integrity of the chevron is key to creating the necessary flow fields that would promote and maintain sandbar habitat.

All elements of the Least Tern Island measure are considered structural in nature regarding O&M activities except for vegetation management. Following establishment of the sandbar island and restoration success, the existing monsoon driven spring floods are expected to scour and maintain nesting habitat. While extreme durations of drought can allow for vegetation communities colonize and mature, the return of seasonal high flows will scour and remove vegetation. The sandbar island is expected to self-sustaining due to the loose nature of sandbar substrates combined with the erosive forces of monsoon induced river flows that will regularly scour and deposit sand.

6.2 Project First Cost and Cost Sharing

Plan formulation was done using FY2016 (October 2015) price levels and a federal discount rate of 3.125%. Table 18 below presents the project first cost, interest during construction, and annual cost based on FY2018 (October 2017) price levels and the federal discount rate of 2.75%, per Economic Guidance Memorandum 18-01. The average annual OMRRR cost stated at current price level is not affected by the date that PED or OMRRR commences. The OMRRR cost is the responsibility of the Non-Federal Sponsor. Table 19 shows the cost summary of project costs.

Table 18: Project first cost, interest during construction and annual cost (FY18 prices, October 2017)

Item	Ecosystem Project First Costs	Benefits
Investment Cost		
First Cost	$128,375,000	
Interest During Construction	$1,905,000	
Total Investment Cost	$130,280,000	
Annual Cost		
Interest and Amortization	$4,826,000	
OMRRR	$349,000	
Total Annual Cost	$5,175,000	
Annual Benefits		
Average Annual Habitat Units		875.7

Table 19: Cost Summary (FY18 prices, 2.75% federal discount rate)

Construction Item	Cost
Lands & Damages	
Lands	$14,870,000
Relocations	$217,000
Elements	
Dams	$68,963,000
Fish and Wildlife Facilities	$2,722,000
Roads, Railroads, & Bridges	$6,947,000
Monitoring & Adaptive Management*	$2,371,000
Buildings Grounds, & Utilities	$188,000
Subtotal	**$96,278,000**
Preconstruction Engineering & Design (PED)	$21,735,000
Construction Management	$10,362,000
Total First Cost	**$128,375,000**

*Monitoring and Adaptive management cost includes redesigning and construction of any physical structure (the rock riffle, the rock chevrons, or portions/gates of pool structure) determined necessary through the monitoring process that it is not producing the environmental benefits as intended (see Appendix A for more details on the Monitoring and Adaptive Management Plan)

6.2.1 Cost Apportionment

In accordance with WRDA 1986, implementation of the recommended plan would be cost shared 65 percent Federal – 35 percent sponsor costs. However, Section 3132 of WRDA 2007 caps the Federal investment at $50M. The Non-Federal Sponsor will be responsible for all costs exceeding that amount regardless of the cost share percentages. Table 20 below provides a breakdown of the cost apportionment for the recommended plan.

Table 20: Cost Apportionment for Implementation of the Recommended Plan (FY18 prices, 2.75% federal discount rate)

Feature	Federal	Non-Federal	Total
Feasibility Study	$1,500,000	$1,500,000	$3,000,000
Implementation Costs			
Restoration Features (Excluding LERRD)	$80,086,000		
LERRD		$13,821,000	
PED	$21,735,000		
Construction Management	$10,362,000		
Monitoring & Adaptive Management*	$2,371,000		
Total Implementation Costs	**$114,554,000**	**$13,821,000**	**$128,375,000**
Standard Cash Contribution	($29,844,250)	$29,844,250	
Standard Cost Apportionment (Implementation 65%-35%)	$86,209,750	$43,665,250	$128,375,000
Total Costs (Feasibility and Implementation)	**$84,943,750**	**$45,165,250**	
Additional Cash Adjustment to Maximum Authorized Federal Investment	($34,943,750)	34,943,750	
Maximum Authorized Federal Investment (Feasibility and Implementation)	**50,000,000**		
Less Feasibility Cost	($1,500,000)	($1,500,000)	
Total Cost Apportionment for Implementation	**$48,500,000**	**$79,875,000**	**$128,375,000**
Cost Share Percentage	38%	62%	100%

*Monitoring and Adaptive management cost includes redesigning and construction of any physical structure (the rock riffle, the rock chevrons, or portions/gates of pool structure) determined necessary through the monitoring process that it is not producing the environmental benefits as intended (see Appendix A for more details on the Monitoring and Adaptive Management Plan).

6.3 Project Implementation Schedule

Table 21 is a proposed project implementation schedule for the Recommended Plan. The schedule will be refined after the cost risk analysis is completed. The final schedule would be coordinated and approved by the non-Federal sponsor and included in the PED PMP.

Table 21: Proposed Project Implementation Schedule

Activity	Start	End
Director's Report Signed		June 2018
Planning, Engineering and Design	June 2018	August 2020
Real Estate Acquisitions	June 2018	April 2019
Procurement Process	June 2020	January 2021
Construction	January 2021	October 2023
Financial Closeout	October 2023	September 2024

6.3.1 View of the Local Sponsor

Tulsa County is identified as the non-Federal sponsor. Tulsa County supports the recommended plan and intends to participate in its implementation. A letter of support stating this intent is included in Appendix I.

6.3.2 Views of Resource Agencies

The USFWS and ODWC are supportive of the recommended plan. The recommended plan fulfills a number of their missions and objectives. ODWC has been involved in the data collection and both agencies helped select species models, informed metric projections, developed pool structure operation constraints, and provided input throughout the study.

6.3.3 Environmental Operating Principles

The Arkansas River Corridor Ecosystem Restoration Feasibility Study incorporates environmental sustainability by restoring more natural river flow creating a naturally functioning riverine system capable of sustaining aquatic habitats and balanced sediment flows. The project balances ecosystem restoration within an existing flood risk management project by restoring habitat without increasing the existing flood risk. The plan was consistent with all applicable laws and policies, and the Corps and its non-Federal sponsor continued to meet our corporate responsibility and accountability for the project in accordance with those laws and policies. The study team used appropriate ways and means to assess cumulative impacts to the environment through the National Environmental Policy Act and the use of engineering models, environmental surveys and coordination with natural resource agencies. As a result of employing a risk management and systems approach throughout the life cycle of the project, the project design evolved to address as many concerns as possible with no mitigation required to address adverse impacts.

6.4 Environmental Compliance

This section demonstrates how the proposed Recommended Plan would comply with applicable environmental laws and regulations.

6.4.1 Advisory Circular 150/5200-33A - Hazardous Wildlife Attractants on Near Airports

The advisory circular provides guidance on locating certain land uses having the potential to attract hazardous wildlife to or in the vicinity of public-use airports. The circular provides

guidance on wetlands in and around airports and establishes notification procedures if reasonably foreseeable projects either attract or may attract wildlife.

In response to the Advisory Circular, the United States Army as well as other Federal agencies, signed a Memorandum of Agreement (MOA) with the Federal Aviation Administration (FAA) to address aircraft-wildlife strikes. The MOA establishes procedures necessary to coordinate the proposed actions more effectively to address existing and future environmental conditions contributing to aircraft-wildlife strikes throughout the United States. Three airports within the National Plan of Integrated Municipal Systems are located in the Tulsa Metropolitan Area. They are William R. Pogue Municipal Airport in Sand Springs, Tulsa International Airport, and Richard Lloyd Jones Jr. Airport also known as Riverside Airport.

The FAA determined that none of the restorative measure considered would increase aviation wildlife strikes at any of the airports mentioned above.

In accordance with the Advisory Circular, USACE will continue to coordinate with the FAA and the Animal and Plant Health Inspection Service (APHIS) of the U.S. Department of Agriculture to address potential hazardous wildlife attractants near airports within the Tulsa Metropolitan Area with respect to the Recommended Plan. Copies of all coordination letters are included in Appendix I.

6.4.2 Section 404 of the Clean Water Act

USACE, under direction from Congress, regulates the discharge of dredged and fill material into all waters of the United States, including wetlands. Although USACE does not issue itself permits for construction activities that would affect waters of the United States, USACE must meet the legal requirements of the Act. A 404(b)(1) analysis was conducted for the Arkansas River Corridor project (Appendix L – Clean Water Act Compliance). Some 2.89 acres of riverine habitat loss would occur within the footprint of the proposed measures. These losses are more than offset by the large increase in riverine habitat alone.

No net loss of waters of the United States would occur under the proposed alternatives.

6.4.3 Section 401/402 of the Clean Water Act

The construction activities that disturb upland areas (land above Section 404 jurisdictional waters) are subject to the National Pollutant Discharge Elimination System (NPDES) requirements of Section 402(p) of the Clean Water Act.

ODEQ was provided a copy of the 404(b)(1) analysis for review and issued the State Water Quality Certification under Section 401 of the Federal Clean Water Act on 14 February 2018 as the proposed project supports water quality standards through the expansion of riverine and wetland habitat (see Appendix L Clean Water Act Compliance).

Within Oklahoma, ODEQ is the permitting authority and administers the NPDES. Operators of construction activities that disturb 5 or greater acres must prepare a Storm Water Pollution Prevention Plan (SWPPP), submit a Notice of Intent to ODEQ, conduct onsite posting and periodic self-inspection, and follow and maintain the requirements of the SWPPP. During construction, the operator shall assure that measures are taken to control erosion, reduce litter and sediment carried offsite (silt fences, hay bales, sediment retention ponds, litter pick-up, etc.), promptly clean-up accidental spills, utilize BMPs onsite, and stabilize site against erosion before completion.

6.4.4 Section 176(c) of the Clean Air Act

Federal agencies are required by this Act to review all air emissions resulting from federally funded projects or permits to insure conformity with the State Implementation Plans in non-attainment areas. The Tulsa Metropolitan Area is currently in attainment for all air emissions; therefore, the Recommended Plan would be in compliance with the Clean Air Act.

6.4.5 Section 106 of the National Historic Preservation Act

Under the National Historic Preservation Act, federal agencies must "take into account the effects of their undertakings on historic properties" [(36 CFR 800.1(a)]. In order to identify historic properties which may be impacted by the proposed undertaking, USACE has conducted background research, consulted with the Oklahoma State Historic Preservation Officer (SHPO), Oklahoma Archaeological Survey (OAS), and requested input from nine Federally-recognized Native American Tribes. Two of the nine Tribes contacted have elected to consult with USACE on the proposed undertaking. Consultation and coordination with these groups is ongoing and will continue throughout project design, and construction. Because USACE cannot fully determine the effects of the undertaking on historic properties at this time, USACE, Oklahoma SHPO, OAS, and the non-federal sponsor are developing a programmatic agreement to resolve adverse effects to historic properties. USACE has invited the Advisory Council on Historic Preservation and the two consulting Tribes to participate in the agreement; none have elected to join the agreement at this time. A copy of the Programmatic Agreement is included in Appendix C; copies of consultation correspondence are included in Appendix I.

6.4.6 Executive Order 13112, Invasive Species

EO 13112 recognizes the significant contribution native species make to the well-being of the Nation's natural environment and directs Federal agencies to take preventive and responsive action to the threat of the invasion of non-native plants and wildlife species in the United States. This EO establishes processes to deal with invasive species and among other items, establishes that Federal agencies "will not authorize, fund, or carry out actions that it believes are likely to cause or promote the introduction or spread of invasive species in the United States or elsewhere unless, pursuant to guidelines that it has prescribed, the agency has determined and made public its determination that the benefits of such actions clearly outweigh the potential harm caused by invasive species; and that all feasible and prudent measures to minimize risk of harm will be taken in conjunction with the actions."

The construction and operation of Keystone Dam along with urban and rural development within the Arkansas River Corridor has caused degradation of natural river flow resulting in the loss of an aquatic environment supporting native aquatic species. Linked to the aquatic degradation is the loss of native riparian and wetland vegetation species, and sandbar island habitat, which is vital to the aquatic environment and supports native residential and migratory, game and nongame wildlife species.

The degradation of appropriate river flow has resulted in the loss of the necessary components for the life cycle of the numerous migratory bird and fish species and the food sources they depend on. The existing unnatural flow regime and imbalance in the predator/prey relationship has assisted in the expansion of non-native invasive species into the aquatic and riparian habitats. The measures included in the Arkansas River Corridor ecosystem restoration study would help reduce invasive plant species expansion and promote native flora and fauna. Required operation and maintenance of the Arkansas River Corridor study area by the non-

Federal sponsor during long-term management of that area would keep the negative influence of non-native invasive plants at a minimum. The proposed project would be in compliance with EO 13112 by promoting and restoring native aquatic and riparian vegetation species to the degraded habit.

6.4.7 Executive Order 11988, Floodplain Management

EO 11988 was enacted May 24, 1977, in furtherance of the National Environment Policy Act of 1969, as amended (42 U.S.C. 4321 et seq.), the National Flood Insurance Act of 1968, as amended (42 U.S.C. 4001 et seq.), and the Flood Disaster Protection Act of 1973 (Public Law 93-234, 87 Star. 975). The purpose of the EO was to avoid, to the extent possible, the long and short-term adverse impacts associated with the occupancy and modification of floodplains and to avoid direct or indirect support of floodplain development wherever there is a practicable alternative.

The order states that each agency shall provide and shall take action to reduce the risk of flood loss, to minimize the impact of floods on human safety, health and welfare, and to restore and preserve the natural and beneficial values served by floodplains in carrying out its responsibilities for (1) acquiring, managing, and disposing of Federal lands and facilities; (2) providing Federally undertaken, financed, or assisted construction and improvements; and (3) conducting Federal activities and programs affecting land use, including but not limited to water and related land resources planning, regulating, and licensing activities. All alternatives would be designed to ensure that the combination of all ecosystem restoration measures proposed would not result in a decrease in the floodplain capacity and or increase in flood risk to the study area. The Recommended Plan would be in compliance with EO 11988.

ER 1165-2-26 sets forth general poly and guidance for USACE implementation of EO 11988, as is pertains to the planning, design, and construction of Civil Works projects. The objective of this EO is to avoid, to the extent possible, long and short-term adverse impacts associated with the occupancy and modification of the base flood plain.

Due to the nature and authorization of this aquatic ecosystem restoration project and the proposed measures' functions, there were no other practical alternatives to locating the proposed project in the base flood plain. The design and operation of each measure will minimize hazard and risk associated with flood and human safety while restoring and maintaining beneficial values of the base flood plain. A public meeting in Sand Springs, Oklahoma in February 2017 relayed this information to the public and provided an opportunity comment.

As the proposed project restores and enhances fish and wildlife value within the ARC aquatic environment, other developments within the base flood plain may occur due to the increased aesthetic value of riverine habitat and opportunities for recreation. However, some of those developments already exist (boats ramps and trails), while new developments would require the necessary planning and permits to avoid impacts to the environment and the base flood plain.

6.4.8 Executive Order 13186, Migratory Birds

The importance of migratory non-game birds to the nation is embodied in numerous laws, executive orders, and partnerships. The Fish and Wildlife Conservation Act of 1980 demonstrates the Federal commitment to conservation of non-game species. Amendments to the Act adopted in 1988 and 1989 direct the USFWS to undertake activities to research and

conserve migratory non-game birds. EO 13186 directs Federal agencies to promote the conservation of migratory bird populations, including restoring and enhancing habitat. Migratory Non-game Birds of Management Concern is a list maintained by the USFWS. The list helps fulfill a primary goal of the USFWS to conserve avian diversity in North America. Additionally, the USFWS Migratory Bird Plan is a draft strategic plan to strengthen and guide the agency's Migratory Bird Program.

The proposed ecosystem restoration would contribute directly to the U.S. Fish and Wildlife Service Migratory Bird Program goals to protect, conserve, and restore migratory bird habitats to ensure long-term sustainability of all migratory bird populations.

6.4.9 Executive Order 12898, Environmental Justice

EO 12898 “Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations” dated February 11, 1994, requires all Federal agencies to identify and address disproportionately high and adverse effects of its programs, policies, and activities on minority and low-income populations. Environmental justice is the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation and enforcement of environmental laws, regulations and policies. Data was compiled to assess the potential impacts to minority and low-income populations within the study area. Even though minorities account for a large portion of the local population and the low-income population in the study area is above the national and local averages, construction of the proposed alternatives would not have a disproportionately high or adverse effect on these populations. No environmental justice concerns are anticipated and the Recommended Plan would be consistent with EO 12898.

6.4.10 Executive Order 13045, Protection of Children

EO 13045 “Protection of Children from Environmental Health Risks” dated April 21, 1997 requires Federal agencies to identify and address the potential to generate disproportionately high environmental health and safety risks to children. This EO was prompted by the recognition that children, still undergoing physiological growth and development, are more sensitive to adverse environmental health and safety risks than adults.

Short-term impacts on the protection of children would be expected during construction. Numerous types of construction equipment such as backhoes, bulldozers, graders, and dump trucks, and other large construction equipment would be used throughout the duration of construction of the Recommended Plan. Because construction sites and equipment can be enticing to children, construction activity could create an increased safety risk. The risk to children would be greatest in construction areas near densely populated residential neighborhoods. During construction, safety measures would be followed to protect the health and safety of residents as well as construction workers. Barriers and “No Trespassing” signs would be placed around construction sites to deter children from playing in these areas, and construction vehicles and equipment would be secured when not in use. Since the construction area would be flagged or otherwise fenced, issues regarding Protection of Children are not anticipated.

6.4.11 Fish and Wildlife Coordination Act

The Fish and Wildlife Coordination Act (FWCA) requires Federal agencies that are impounding, diverting, channelizing, controlling, or modifying the waters of any stream or other body of water

to consult with the USFWS and appropriate State fish and game agency to ensure that wildlife conservation receives equal consideration in the development of such projects. From the initial stages of the Arkansas River Corridor study, the USFWS and ODWC have been involved in the planning process.

Both agencies provided comments throughout the planning process. ODWC biologists participated in the Arkansas River Corridor field surveys and both agencies provided input on the models used to assess existing and future Arkansas River Corridor habitat conditions.

The USFWS provided a Planning Aid Letter and Coordination Act Report (Appendix I) describing existing conditions in the study area in addition to restoration measure recommendations regarding design, operation, and physical placement (Appendix I).

Both USFWS and ODWC prefer changes to Keystone Dam operations to improve minimum river flow in the ARC. However, because the study authorization constraints limit measure consideration to only those found in the ARC Master Plan, this recommendation was not adopted. In order to first meet the primary restoration goal of maintaining more consistent minimum river flow, also identified by resource agencies as primary limiting factor within the study area, the pool structure concept was developed and supported by resource agencies assuming the final design and operation of the pool structure will meet their primary recommendations including; the location of the pool structure be located as far upstream as possible while still being able to deliver the targeted flow, the water stored upstream of the pool structure would be primarily used to maintain river flow downstream for at least 72 hours, fish, egg/larvae, and sediment passage must be achieved to the maximum extent practicable, at a minimum, during flood pool releases that support fish migration and spawning, and the release of 1,000 cfs from the pool structure should be coordinated with existing and proposed low water dams downstream to ensure the 1,000 cfs flow is maintained throughout the study area. All of these recommendations were adopted into the design and operation of the pool structure as they are considered essential to meeting restoration objectives while minimizing adverse impacts that traditional low water dams have been associated with.

Two locations for the pool structure were evaluated, both in the upper reaches of the study area. The river mile 531 location, site of the former reregulation dam, could provide downstream flows of 1,000 cfs for 2.5 days, 750 cfs for 3.3 days, or 500 cfs for 4.9 days. While able to increase minimum river flow up to 1,000 cfs most of the time, weekends without hydropower or flood pool releases may have required a reduction in flow rate release as the storage capacity of this location would not support 1,000 cfs for more than 2.5 days.

The river mile 530 location, included in the Recommended Plan, would provide downstream flows of 1,000 cfs for 3.4 days, 750 cfs for 4.5 days, or 500 cfs for 6.8 days. This meets minimum storage needs to provide river flow over weekends when hydropower production typically does not occur, and provides added flexibility to extend river flow at lower release rates during more extended droughts.

In order to achieve fish, egg/larvae, and sediment passage, a combination of design and operation constraints were adopted. Independent sections of full and partial height gates would be opened during flood pool releases that stimulate fish migration and spawning. Preliminary analysis shows that 2-4 fps flow rates would exist moving over and through the pool structure during this time. This is within swimming capabilities of paddlefish and shovelnose sturgeon, considered two of the less capable fish in the study area in regards to swimming performance.

Areas of sloped approaches and boulder fields would create diverse passage areas. Smaller minnow sized fish would utilize boulder fields to rest between movements, open sloped areas would to facilitate passage for larger fish that do not need velocity refuge and avoiding obstructions that can cause harm to fish swimming at higher speeds.

Fish passage during 1,000 deliver periods is expected to be limited. Preliminary analyses show flow fields at 8 fps through the structure. While this is passable for more agile species in the ARC, such as striped bass and sauger, more detailed design and analyses will be conducted during PED to further explore design and operation options in support of fish passage during 1,000 cfs release periods. Fish passage during 1,000 cfs release periods is a secondary goal. In current conditions, fish passage throughout the study is limited as no/low flow conditions limit river reach connectivity. The 1,000 cfs river flow would expand connectivity throughout the study area that would otherwise not exist.

Regarding recommendations for backwater wetland restoration efforts, the Prattville Creek and I-44/Riverside measures were developed and evaluated. Rock riffle and wetland plantings at Prattville Creek were included in the Recommended Plan. As such, the recommendations for planting native aquatic vegetation and only treating (mechanical/herbicide) vegetation to remove invasive/exotic/noxious species were adopted to promote restoration success at Prattville Creek.

Additionally, USFWS recommended the constructed sandbar island be located as close to the center of the river channel as practicable and in areas with shorter shoreline vegetation in order to increase nesting success. Annual removal of excessive vegetation may also be needed to maintain optimum nesting habitat, however annual spring monsoons and associated flood pool releases are expected to scour and remove the majority accumulated vegetation. Sand mining, when and where appropriate, may be used to maintain river channels and flow around the sandbar island to isolate it from terrestrial predators. These recommendations were adopted. The final design and placement of the constructed sandbar island will be place as far into the center of the channel as practicable.

The Monitoring and Adaptive Management Plan for the Recommended Plan also entails monitoring and correcting for adequate flow fields, invasive species removal, and vegetation removal prior to Least Tern nesting activity to ensure restoration success is achieved.

USFWS and ODWC will continue to be involved in the next phase of the Arkansas River Corridor Ecosystem Restoration project as their expertise in local natural resources will be vital to ensuring the final design and operation of the Recommended Plan would produce the expected environmental benefits.

6.5 Monitoring and Adaptive Management Plans

In an effort to ensure the success of the Recommended Plan, the restoration measures implemented will be periodically surveyed to provide feedback on the response of the ecosystem and its resources to the management measures taken. By connecting the ecosystem response to the restoration as well as the management measures, potential beneficial adaptations and adjustments to the project or management plan can be identified to ensure continued success of the project. This is especially true of the plantings that will have to be frequently monitored from their initial planting until reasonable stabilization is achieved. To accomplish this goal, periodic monitoring of the restoration measures will be conducted after the

completion of the construction of project features and the initial plantings. A Monitoring and Adaptive Management Plan is included in Appendix A.

6.6 Mitigation

No Clean Water Act mitigation is required for the Recommended Plan. However, during construction and maintenance of the restorative measures, best management practices would be followed to further minimize impacts to the environment. In addition, mitigation would be required during cultural resource activities.

All practicable means to avoid or minimize environmental impacts due to construction of the Recommended Plan will be considered. The Recommended Plan will be designed with the smallest practicable footprint to still meet the requirements of the proposed project.

6.7 Public Involvement

6.7.1 Agency Coordination

Copies of agency coordination letters are presented in Appendix I. Formal and informal coordination has been and will continue to be conducted with the following agencies:

- U.S. Army Corps of Engineers
- U.S. Fish and Wildlife Service
- Oklahoma Historical Society
- State Historic Preservation Office
- Environmental Protection Agency, Region 6 Office
- Oklahoma Department of Wildlife Conservation
- Oklahoma Department of Environmental Quality
- Federal Aviation Administration
- Natural Resources Conservation Service of the U.S. Department of Agriculture
- Oklahoma Water Resources Board
- Oklahoma Conservation Commission
- Oklahoma Biological Survey
- University of Oklahoma-Oklahoma Archaeological Survey
- Oklahoma Department of Transportation Environmental Programs Division
- Oklahoma Department of Tourism and Recreation Department
- Caddo Nation of Oklahoma
- Cherokee Nation
- Kialegee Tribal Town
- Muscogee (Creek) Nation, Oklahoma
- Osage Nation, Oklahoma
- Seminole Nation of Oklahoma
- Thlopthlocco Tribal Town, Oklahoma
- Wichita and Affiliated Tribes of Oklahoma
- United Keetoowah Bank of Cherokees
- Southwestern Power Administration
- U.S. Geological Survey

ODWC and USFWS were involved throughout the study process. They participated in initial brainstorming and problem identification and provided comments throughout the Arkansas River Corridor study process. ODWC also participated in the data collection and field surveys.

6.7.2 Public Information and Review

Public information meetings and opportunities for public input have been abundant and began in 2003 when studies were initiated for the Arkansas River Corridor Master Plan. This plan became the basis for the feasibility study. Public meetings were held several times prior to completion of the Plan in 2006. To initiate the feasibility phase of the study through the SMART planning process a charette was conducted in Oct 2014. It was broadly attended by the Corps vertical team, Tulsa County, engineering and leadership from the cities of Jenks, Bixby, Tulsa, and Sand Springs, River Parks Authority, local planning groups, and congressional staff.

A public meeting was held on February 27, 2017. Some 25 members of the public attended the meeting and six comments were received both at the meeting and in the following weeks. All public comments and responses can be found at the end of Appendix I.

In accordance with NEPA, a 30-day review period of the Feasibility Study Report, integrated EA was provided via a Notice of Availability. The document was posted on the Tulsa District Website (www.swt.usace.army.mil) during that period.

SWPA submitted several comments during the public review period. One concern they expressed is the fear that the proposed project would require changes to power generation and SWPA operations. The proposed alternative is designed to work under current SWPA operations. It is further designed to accommodate increased hydropower releases should power demand increase over time. No changes to SWPA operations are necessary for the success of the proposed alternative and the proposed alternative should not impact SWPA operations. SWPA was pleased to be reassured that the pool structure concept was developed with no expectation or need for changes in their operations or in the operation of Keystone Dam that may impact power generation. All of SWPA's comments and USACE's responses can be found at the end of Appendix I.

6.8 Conclusions

The Recommended Plan and the No Action alternative have been evaluated in this Feasibility Study and integrated EA. No significant impacts to the human environment are identified from the implementation of the Recommended Plan. The Recommended Plan consists of a pool structure at RM 530 located just downstream of the Highway 97 Bridge that will release stored water at 1,000 cfs during low flow periods that typically occur between hydropower generation cycles. Additionally, a rock riffle structure will create a 5.34 acre wetland, supplemented by native wetland plantings, at the confluence of Prattville Creek and the Arkansas River. Lastly, the Recommended Plan includes a constructed sandbar island near Broken Arrow, Oklahoma to provide additional nesting habitat for the Least Tern at river flows up to 20,000 cfs.

The Recommended Plan will cause no long-term adverse environmental impacts within the study area. There are no impacts to habitat for threatened or endangered species; all impacts to wetlands and waters of the U.S. have been evaluated in the 404(b)(1) analysis. Adverse

impacts to cultural resources, either buried or in the cultural landscape will be identified and appropriate mitigation will be completed prior to project construction.

As an ecosystem restoration project, the Recommended Plan is intended to have long-term beneficial impacts to the Arkansas River Corridor and surrounding areas. The Recommended Plan is supported by Tulsa County, U.S. Fish and Wildlife Service, and the Oklahoma Department Wildlife Conservation.

Based on the findings of this section, USACE determined that an Environmental Impact Statement (EIS) was not required. USACE has prepared a Finding of No Significant Impact (FONSI) under NEPA.

The Tulsa District recommends the approval and implementation of the NER plan/Recommended Plan as described in this document. The following conclusions are based on the study findings in connection with the Feasibility Report and Integrated Environmental Assessment.

- The Recommended Plan is a multi-measure project consisting of ecosystem restoration features which do not adversely affect the performance of the existing flood risk management project.
- A significant need is identified to warrant implementation of ecosystem restoration measures for these project purposes.
- The recommended plan consists of 3,735 acres of riverine habitat restoration, and 5.34 acre wetland restoration with aquatic plantings and three acres of sandbar island habitat. The average annual habitat gain for the combined restoration area is 875.66 Average Annual Habitat Units.
- The project first cost is estimated at $128.4 million in October 2017 prices. The annual cost for the last habitat unit gained is $29,000.
- Total project first cost is $128.4 million in October 2017 prices, with annual costs of $5.2 million at a 2.75% discount rate over 50 years.
- Monitoring and Adaptive Management costs (Appendix A) are estimated at $2.4 million.
- Tulsa County is identified as the non-Federal sponsor for the implementation of the recommended plan. Federal and non-Federal cost apportionments for the recommended restoration plan are $50.0 million and an estimated $61.0 million, respectively.
- The potential to impact cultural resources under this alternative are minimal due to previous activities conducted at the site and the shallow depth of most proposed ground disturbing activities. To minimize the impacts to resources that may be encountered during construction, an archeological monitor would be on site to identify cultural resources should they be discovered. The monitor would assess the significance of the resource and mitigate for impacts before ground disturbing activities would be allowed to continue in the vicinity. In this way, no significant impacts for the implementation of the action alternatives would be expected.
- The recommended plan would cause no long term adverse environmental impacts within the study area. A draft FONSI has been prepared and is included in the documentation for the Feasibility Report and Integrated Environmental Assessment. Distribution of the

report, including the draft FONSI, was made available for public review and comment in February 2017.

- The recommended plan is supported by the Tulsa County, Cities of Tulsa and Sand Springs, U.S. Fish and Wildlife Service, and the Oklahoma Department of Wildlife Conservation.

The Arkansas River Corridor Ecosystem Restoration Project Recommended Plan:

- fulfills the USACE restoration mission,
- is in accordance with the USACE Civil Works Strategic Plan,
- is in accordance with the USACE Environmental Operating Principles,
- is in compliance with USACE restoration and recreation policies,
- is technically sound,
- is sustainable though the application of geomorphologic principles for sediment transport, hydraulic modeling, native vegetation species survivability, and synergistic effects,
- restores biological and environmental resources that were present prior to the construction of the Keystone Dam,
- restores limiting habitat for the Interior Least Tern and other migratory bird and fish species,
- complements other Federal, state, and local restoration programs and projects,
- demonstrates ecosystem restoration and flood risk management can co-exists effectively with the existing Keystone Dam and Tulsa Levee System,
- provides connection to adjacent habitats within the Arkansas River Watershed,
- restores the Arkansas River to a more natural structure and function resulting in the greatest practicable sinuosity, slope gradient, velocity, and sediment transport while maintaining the current effectiveness of the flood risk management function of Keystone Dam, and
- is supported by U.S. Fish and Wildlife Service, and Oklahoma Department of Wildlife Conservation, as well as having widespread local support.

RECOMMENDATION

I propose the ecosystem restoration features identified as the Recommended Plan in the Arkansas River Corridor Feasibility Report and Integrated Environmental Assessment, Tulsa County, Oklahoma proceed with implementation in accordance with the cost sharing provisions set forth in this report.

This recommendation is made with the provision that, prior to project implementation, the non-Federal sponsor shall enter into a binding agreement with the Secretary of the Army to perform the items of local cooperation, as specified in this document.

The recommendations contained herein reflect the information available at this time, and current Department of the Army, and U.S. Army Corps of Engineer policies governing formulation of individual projects. The recommendations do not reflect the program and budget priorities inherent to the formulation of a national Civil Works construction program, nor the perspective of higher review levels within the Executive Branch of the U.S. Government. Consequently, the recommendations may be modified before they are transmitted to Congress as proposals for implementation funding. However, prior to transmittal to Congress, the sponsor, the State, interested Federal agencies, and other interested parties will be advised of any modifications, and be afforded the opportunity to comment further.

Christopher A. Hussin

Christopher A. Hussin

Colonel, U.S. Army

Commanding

Date 26 MARCH 2018

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ACRONYMS

AAHU – Average Annual Habitat Unit

AGO – Americans' Great Outdoor

APE – Area of Potential Effect

APHIS – Animal and Plant Health Inspection Service

ARC – Arkansas River Corridor

BMP – Best Management Practice

BNSF – Burlington Northern Santa Fe

CAR – Coordination Act Report

CE/ICA – Cost Effectiveness and Incremental Cost Analysis

CEQ – Council on Environmental Quality

CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act

CFR – Code of Federal Regulations

CFS – Cubic Feet per Second

CWA – Clean Water Act

DDR – Design Documentation Report

DO – Dissolved Oxygen

DOI – Department of the Interior

DSAC – Dam Safety Action Classification

EJSCREEN – Environmental Justice Screen

EO – Executive Order

ER – Engineering Regulation

FAA – Federal Aviation Administration

FEMA – Federal Emergency Management Agency

FIRM – Flood Insurance Rate Map

FONSI – Finding of No Significant Impacts

FWCA – Fish and Wildlife Coordination Act

GHG – Green House Gases

GKFF – George Kaiser Family Foundation

GMAP – Groundwater Monitoring and Assessment Program

HEC-RAS – Hydrologic Engineering Center's River Analysis System

HTRW – Hazardous, Toxic, and Radioactive Waste

HUD – Housing and Urban Development

INCOG – Indian Nations Council of Governments

IWR – Institute for Water Resources

MOA – Memorandum of Agreement

MKARNS – McClellan-Kerr Arkansas River Navigation System

MSA – Metropolitan Statistical Area

NAS – Nonindigenous Aquatic Species

NEPA – National Environmental Policy Act

NER – National Ecosystem Restoration

NFS – Non-Federal Sponsor

NHPA – National Historic Preservation Act

NPDES – National Pollutant Discharge Elimination System

NPL – National Priorities List

NRCS – National Resources Conservation Service

NRHP – National Register of Historical Places

NWS – National Weather Service

ODEQ – Oklahoma Department of Environmental Quality

OMRRR – Operation, Maintenance, Repair, Replacement, & Rehabilitation

ORV – Off-Road Vehicle

OWRB – Oklahoma Water Resources Board

PDT – Project Delivery Team

PED – Preconstruction Engineering and Design

PPD – Project Partnership Agreement

PSO – Public Service Company of Oklahoma

RCRA – Resource Conservation and Recovery Act

ROI – Region of Influence

RPA – River Parks Authority

SWPA – Southwestern Power Administrations

SWPPP – Storm Water Pollution Prevention Plan

RM – River Mile

SHPO – State Historical Preservation Office

SMART – Specific, Measureable, Attainable, Risk Informed, Timely

TRI – Toxics Release Inventory

TSP – Tentatively Selected Plan

TVA – Tennessee Valley Authority

UPRR – Union Pacific Rail Road

USACE – United States Army Corps of Engineers

USDA – United States Department of Agriculture

USEPA – United States Environmental Protection Agency

USFWS – United States Fish and Wildlife Service

USGS – United States Geological Survey

WGS – Water Quality Standards

WRDA – Water Resources Development Act

WWTP – Waste Water Treatment Plant

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