ARKANSAS RIVER CORRIDOR

Appendix A: HEP Analysis

ARKANSAS RIVER CORRIDOR, TULSA COUNTY, OKLAHOMA

Introduction

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

Purpose

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

Study Authority

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

Section 3132. Arkansas River Corridor.

(a) IN GENERAL. – The Secretary is authorized to participate in the ecosystem restoration, recreation, and flood damage reduction components of the Arkansas River Corridor Master Plan dated October 2005. The Secretary shall coordinate with appropriate representatives in the vicinity of Tulsa, Oklahoma, including representatives of Tulsa County and surrounding communities and the Indian Nations Council of Governments.

(b) AUTHORIZATION OF APPROPRIATIONS. – There is authorized to be appropriated $50,000,000 to carry out this section.

Non-Federal Sponsor

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

Recommended Plan

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

Introduction

The United States Army Corps of Engineers (Corps) Tulsa District has initiated preparation of an Ecosystem Restoration Feasibility Study in response to the Section 3132 authorization of the 2007 WRDA. The purpose of this study is to evaluate the aquatic ecosystem restoration components of the October 2005 Arkansas River Corridor (ARC) Master Plan and determine if there is a Federal Interest that aligns with the Corps ecosystem restoration mission.

The feasibility study area is based on the study area and features identified in the ARC Master Plan. The area is comprised of the 42-mile long Arkansas River corridor in Tulsa County that begins just below Keystone Lake Dam, downstream east and south through Tulsa County to the Wagoner County line (Figure 1). Key tributary streams include but are not limited to Prattville Creek at Sand Springs, Crow Creek in Tulsa, and Vensel Creek at Jenks, Oklahoma.

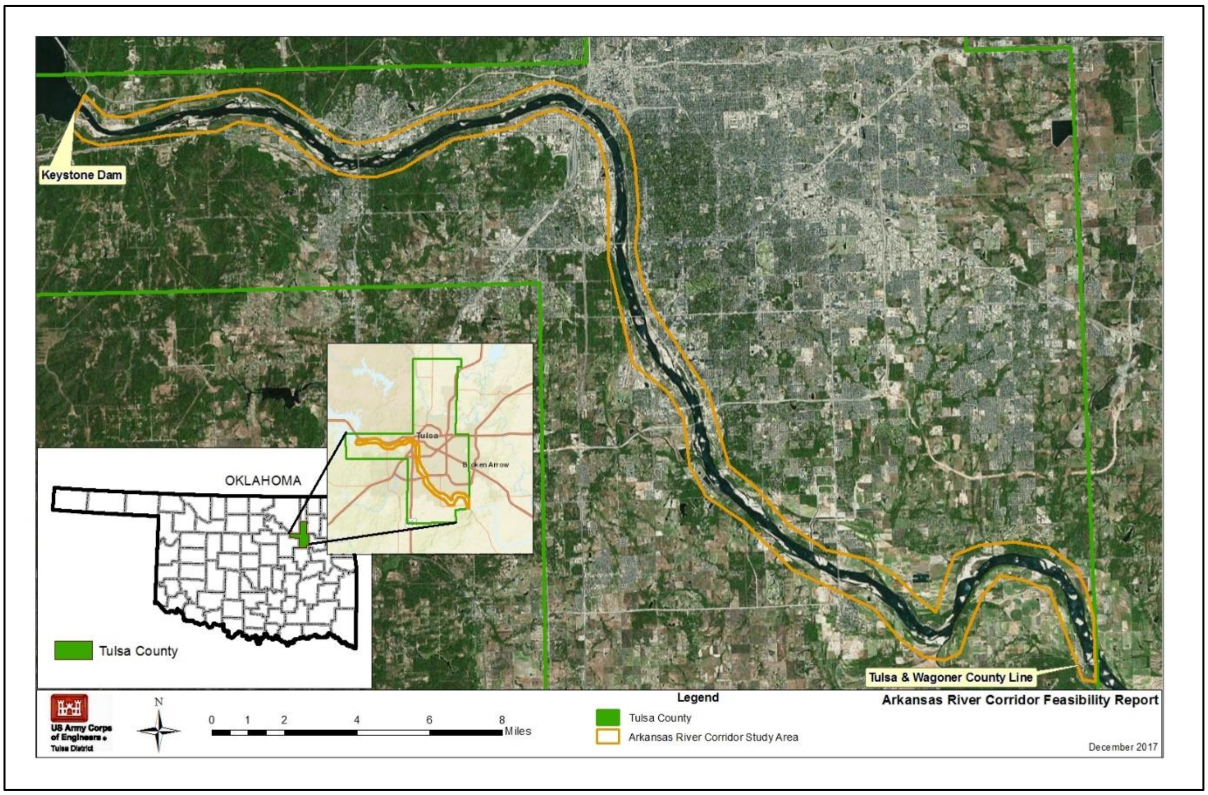

Figure 1. Arkansas River Corridor Study Area.

The construction of Keystone Dam was completed in 1964. The dam has successfully reduced the negative impacts of flooding along the ARC in Tulsa County; however, the dam has altered the natural flow regime of the river and the sediment dynamics downstream of the dam. These changes, combined with land use changes in the watershed, have altered the river corridor ecosystem.

Existing Conditions

While sandbar islands in the ARC persist from sediments transported during larger flood pool and hydropower releases, Keystone Lake acts as a sediment trap that significantly reduces the amount of sediment that maintains downstream island habitat for the federally endangered Interior Least Tern, referred to as Least Tern from here on. Also, frequent and extreme river flow fluctuations from hydropower operations at the dam have a drying effect on the aquatic habitat (USACE, 2009). The impacted geomorphology has resulted in streambank erosion problems at various locations, and the destruction of riverine wetlands and oxbow habitats that were once important fish nurseries and feeding/resting areas for migrant waterfowl. The loss of these habitats has decreased the species diversity and overall biological productivity of the remaining downstream habitat. The loss of slackwater nursery habitat for small fish and sandbar island habitat has impacted the federally endangered Interior Least Tern that primarily feed on fish and nest on sandbars. The riparian scrub-shrub habitat within the ARC also has been degraded as a result of land use changes. Other watershed concerns include pathogens, pesticides, and organics from urban, municipal, commercial, and agriculture runoff that affect the water quality.

With the construction of Keystone Dam and other river corridor developments, several ecological effects along with their drivers and stressors, were identified including altered flow regime, degrading floodplain conditions, and the loss of sandbar island habitat. They are displayed in the conceptual ecosystem model in Attachment 1.

Initial alternatives to be evaluated for implementation vary from no action to constructing an instream structure to restore and maintain minumum river flow, and wetland creation and supplemental vegetation plantings to increase wetland and riparian habitat value and diversity, as well as constructing sandbar island habitat to support nesting Least Terns.

The aquatic and terrestrial data collected were analyzed using the U.S. Fish and Wildlife Service’s Habitat Evaluation Procedures to describe the various existing habitats in the study area. The portion of the study area evaluated contains approximately 1,591 acres of river habitat (99.1%), 5.89 acres of wetland (0.4%), 3.82 acres of mixed riparian forest/scrub (0.2%), and 5 acres of potential sandbar habitat (0.3%). To varying degrees, all of the study area is subjected to past and/or ongoing human disturbance from nearby commercial and residential activities, agriculture operations, sand mining, automotive traffic, recreational activities, runoff of pollutants, etc. Wildlife habitat quality appears to vary throughout the area investigated. Areas subjected to less frequent impact appear to contain reasonably intact mixed riparian forest patches. These and other areas removed from permanent urbanized development are likely the most viable to benefit from preservation and restoration efforts to improve habitat diversity and quality, while promoting a variety of resident and migratory wildlife species.

This appendix describes existing/Future Without Project (FWOP) and Future With Project (FWP) fish and wildlife habitat conditions using field and desktop data collected from the Arkansas River Corridor study area between Keystone Dam and the Tulsa-Wagoner County line in Tulsa County, Oklahoma.

Resource Significance

One of Oklahoma's two large drainage basins, the Arkansas River above the Keystone Dam drains most of northern and central Oklahoma, with a total drainage area of approximately 74,500 square miles (U.S. ACE - Tulsa District, 2012). The Arkansas River, sixth longest river in the United States, originates in central Colorado on the east slope of the Rocky Mountains near Leadville, Colorado, and flows southeasterly through the states of Colorado and Kansas before entering Oklahoma in Kay County. In Oklahoma the Arkansas River runs southerly through Kaw Lake then southeast while forming border portions of Kay, Noble, Osage, and Pawnee counties until reaching Keystone Lake. After leaving Keystone Dam, it continues southeasterly through Tulsa and Wagoner counties before forming part of the border between Wagoner and Muskogee counties in its lower portion. The Cimarron River, a major tributary to the Arkansas River, originates in northeastern New Mexico and flows easterly for almost 700 miles before its confluence with the Arkansas River just upstream of the Keystone Dam.

In Oklahoma the Arkansas River is impounded by the Kaw Dam (Kaw Lake), the Keystone Dam (Keystone Lake), the Robert S. Kerr Lock and Dam (Robert S. Kerr Lake), the Webbers Falls Lock and Dam (Webbers Falls Reservoir), and the W.D.Mayo Lock and Dam near Sallisaw, OK. Major tributaries of the Arkansas River upstream of the Keystone Dam include the Cimarron River, the Little Arkansas River, the Ninnescah River, the Walnut River, and the Salt Fork of the Arkansas River.

The project area includes the 42-mile long Arkansas River Corridor (ARC) ecosystem, downstream of the Keystone Dam to the Tulsa/Wagoner County boundary. The Arkansas River, in the vicinity of Tulsa, Oklahoma, was once an uncontrolled prairie river but over the past century has been affected by anthropogenic activities. With completion of Keystone Dam in 1964, constructed for flood control and hydropower needs, river dynamics downstream from the dam have changed. Negative effects include disrupted river connectivity, altered flooding and low flow regimes, decreased sediment loads, decreased connection with riparian flood zones, and altered the food webs within the Arkansas River in Tulsa County. The dam has successfully reduced the negative impacts of flooding along the ARC in Tulsa County; however, it has altered the natural flow regime downstream of the dam. These alterations, combined with land use changes and construction of levees for residential, commercial and industrial flood protection, have significantly degraded the river corridor ecosystem.

Significance

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 P&G defines these significance criteria as:

- Institutional Recognition: The importance of the resource or attribute is acknowledged in the laws, adopted plans, and other policy statements of public agencies or private groups.
- Public Recognition: The resource or attribute is considered important by some segment of the general public.
- Technical Recognition**:** The importance of the resource or attribute is based on scientific or technical knowledge or judgment of critical resource characteristics.

In January 2011, the Corps and the Assistant Secretary of the Army (Civil Works) [ASA (CW)] initiated a study to improve the efficiency and effectiveness of the pre-authorization study process (U.S. ACE, 2011). One of the implementation measures identified by the study was the determination of Federal interest and level of Federal investment early in the study process. The paradigm requires alternative development and assessment beyond the National Economic Development (NED) and the National Ecosystem Restoration (NER) alternatives and the use of multi-criteria decision analysis in the selection of a "preferred" plan. Therefore, the identification of significant resources in the study area may provide additional criteria to include in a multi-criteria decision making analysis.

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, treaties, plans, and cooperative agreements established for the conservation and protection of these environmental resources.

Endangered Species Act

The Endangered Species Act of 1973 (ESA), as amended, "provides a means whereby the ecosystems upon which endangered and threatened species depend may be conserved, and to provide a program for the conservation of these species." The Department of the Interior, acting through the U.S. Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service is responsible for the protection of federally threatened and endangered species in the U.S. The ESA prohibits the take of listed animals and the interstate or international trade in listed plants and animals without a permit. The USFWS also maintains a list of candidate species, consisting of those where there is information that warrants proposal for listing under ESA, but listing them is precluded due to higher priority species.

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 (Table 1).

The smallest North American tern (21 to 24 centimeters in length), the Interior Least Tern (ILT, *Sterna antillarum*) was listed as federally endangered in 1985, and threats to survival include actual and functional losses of riverine sandbar habitat. The U.S. interior population breeds locally along the Colorado, Red, Arkansas, Missouri, Ohio, and Mississippi river systems (peaking May through June) and winters in Central and northern South America. The breeding adult is mainly gray above, with a black cap and nape, a white forehead, a black line running from the crown through the eye to the base of the bill, an orange-yellow bill often with a dark tip, white or grayish underparts, a short deeply forked tail, and yellow-orange legs and feet. A black wedge on the outer primaries is conspicuous in flight. Interior populations nest mainly on exposed riverine sandbars or salt flats. As a result of vegetational succession and/or erosion, preferred nesting habitat typically is ephemeral. Breeding in riverine situations depends on the presence of sandbars, favorable water levels during nesting season, and sufficient food. The ILT eats mainly small fishes (generally less than 9 cm long), sometimes crustaceans or insects, obtained by diving from air into shallow water usually less than 4 m deep. When breeding the tern usually forages within a few hundred meters of the colony, but occasionally up to 3 kilometers away (Carreker, 1985).

Decline of interior nesting populations has been coincident with human modification of river flow (e.g., reduction of spring floods by dams) and bank stabilization and channelization, resulting in reduced availability of bare island/sandbar nesting habitat. Consequent loss of aquatic habitat diversity and resulting changes in fish species composition and abundance also have contributed to the reduced tern population. Dams above colonies generally lower habitat quality by eliminating the spring floods that are necessary for alluvium deposition and the scouring of vegetation. Current major problems are human use and development of nesting habitat, and predation on adults, eggs, and young by birds and mammals (e.g. coyote, red fox, raccoon, skunk, opossum, domestic dogs/cats, rats, crows, gulls, herons, hawks, eagles).

Sandbars generally are not stable features of the natural river landscape, but are formed or enlarged, disappear or migrate depending on the dynamic forces of the river. Stabilization of major rivers to achieve objectives of navigation, hydropower, irrigation, and flood control have destroyed the dynamic nature of these processes, and current flow regimes differ greatly from historic regimes (Smith & Stucky, 1988). High flow periods may now extend into ILT nesting season. Extreme fluctuations can flood existing nesting sites, or alternatively expose nesting sites to land based predation, and dewater feeding areas. Many remaining sandbars are unsuitable for nesting because of vegetation encroachment, or are too low and subject to frequent inundation. Terns prefer sandy beaches or sandbars for nesting, and in urban areas such as the ARC, they encounter competition with humans and predators. Actions needed for recovery include monitoring of population trends and habitat requirements; protection, enhancement, and increase of ILT populations during breeding; managing reservoir and river water levels to the benefit of the species; and implementation of law enforcement actions at nesting areas in conflict with high public use (U. S. FWS, 1990). A memorandum of understanding has been developed between The Nature Conservancy, the Corps, ODWC, USFWS, the Tulsa Audubon Society, the River Parks Authority, and riverbed landowners for protection and management of essential habitat on the Arkansas River in Tulsa County. USACE annually monitors least terns in the Arkansas, Canadian, and Red Rivers in accordance with the USFWS 2005 Biological Opinion on the effects of USACE multipurpose projects including the Keystone Dam. ILT monitoring by the Corps and USFWS is accomplished by conducting onsite surveys during the summer nesting season (June through August). Creating, restoring, and maintaining least tern nesting habitat is identified as a critical component towards delisting of the species.

The federally threatened piping plover (*Charadrius melodus*) is known or believed to occur within Tulsa County, Oklahoma. The Great Plains population of the piping plover was listed as threatened in 1985. Piping plovers are migratory shorebirds that use isolated beaches and sandflats throughout central and eastern North America, breeding only in three geographic regions: beaches of the Atlantic Coast, shorelines of the Great Lakes, and along alkali wetlands and major rivers of the Northern Great Plains. The breeding population of the Northern Great Plains piping plover extends from Nebraska north along the Missouri River through South Dakota, North Dakota, and eastern Montana, and on alkaline (salty) lakes along the Missouri River Coteau (a large plateau extending north and east of the Missouri River) in North Dakota, Montana, and extending into Canada. The majority of piping plovers from Prairie Canada winter along the south Texas coast (U.S. Fish and Wildlife Service, 2015). Though declining, the Northern Great Plains breeding population remains the largest.

In the Great Plains, piping plover productivity may be affected by predation, habitat loss, human disturbance, and water management. Uncontrolled hunting in the early 1900s brought the species close to extinction. Breeding areas are primarily prairie lakes, rivers, and sloughs of Alberta, Saskatchewan, Manitoba, Montana, North Dakota, Minnesota, South Dakota, Nebraska, and Iowa. Winter census information indicates heavy concentrations occur in Texas between Corpus Christi and Brownsville. Piping plovers feed primarily on exposed beach substrates satisfying a diet consisting of invertebrates, including insects, marine worms, crustaceans, and mollusks.

This species migrates through Oklahoma each spring and fall. In Oklahoma, the piping plover is a biannual migrant, traveling between its nesting habitat to the north of Oklahoma (the Great Plains population nests from Kansas to southern Canada), and its wintering grounds on the gulf coast. There is a record of piping plovers nesting at Optima Lake in Texas County. Migration through Oklahoma is likely to occur from March through May, and July through September. Piping plovers usually migrate as individuals or small groups and may be seen along sandbars of major rivers, salt flats, and mudflats of reservoirs foraging on these shoreline habitats and eating small invertebrates. Conservation of this species has focused on breeding and wintering habitat and relatively little is known about the habitat used during migration. During migration, piping plovers have been documented in many areas of Oklahoma from the panhandle to the eastern border and probably migrate through or over all of Oklahoma (U.S. Fish & Wildlife Service, 2011). Open sandbar and shoreline habitat within the ARC may provide suitable resting and foraging habitat during migration through the state.

The federally threatened Red Knot (*Calidris canutus rufa*) was listed in 2015. It is known or believed to occur within Tulsa County in Oklahoma. Some red knots fly more than 9,000 miles from Tierra del Fuego in South America to the tundra of the Central Canadian Arctic twice each year. Populations of the red knot known as rufa, winter at the tip of South America in Tierra del Fuego, in northern Brazil, throughout the Caribbean, and along the U.S. coasts from Texas to North Carolina. The rufa red knot breeds in the tundra of the central Canadian Arctic from northern Hudson Bay to the southern Queen Elizabeth Islands.

Surveys indicate serious red knot population decline due to habitat change and loss, oil spills, toxins, red tides, disease, collisions with wind turbines, storms, and hunting. For much of the year red knots eat small clams, mussels, snails, and other invertebrates. Migrating knots can complete nonstop flights of 1,500 miles and more, converging on critical stopover areas to rest and refuel along the way. Migrating birds require stopover habitats rich in easily digested foods in order to gain enough weight to fuel the next portion of the migratory journey. Red knots arrive at stopover areas very thin, sometimes emaciated. They eat constantly to gain enough weight to continue their journeys, adding up to 10 percent of their body weight each day and nearly doubling their body weights during some stopovers. The red knot’s unique and impressive life history depends on suitable habitat, food, and weather conditions at far-flung sites across the

Western Hemisphere, from the extreme south of Tierra del Fuego to the far north of the central Canadian Arctic. Further, red knots need to encounter these favorable habitat, food, and weather conditions within narrow seasonal windows as the birds hopscotch along migration stopovers between wintering and breeding areas (U.S. Fish & Wildlife Service, 2013). Open sandbar and shoreline habitat within the ARC may provide suitable resting and foraging habitat during migration through the state.

The American burying beetle (*Nicrophorus americanus*), the largest species of the North American carrion beetles, was listed as federally endangered in 1989 (U.S. Fish and Wildlife Service, 1989). The historical range of the American burying beetle once included much of eastern temperate North America. Currently, the American Burying Beetle occurs across the eastern third of Oklahoma and has been documented in nearly 30 counties since 1995. The American Burying Beetle occupies a wide range of habitat types including tallgrass prairie, woodlands and forests. They reproduce in the spring and summer (early May through August). A pair of beetles will find a carcass that is approximately the size of a rat, bury it a few inches below the surface of the ground and lay a small clutch of 10 to 25 eggs on it. Their populations appear to be more limited by the availability of suitable carcasses for reproduction than by habitat loss (ODWC, 2016). Despite its apparently wide range, it is rare in most of the places where it occurs.

The reasons for the decline in American Burying Beetles are uncertain. Pesticide use has been speculated as a leading cause, and another potential factor may be a reduction in the abundance of carcasses that are of suitable size for successful reproduction. In addition to Oklahoma, populations exist in Arkansas, Missouri, Kansas, Nebraska, South Dakota, Rhode Island, and Massachusetts. The presence of the species has been documented in Tulsa County within the last 15 years (U.S. Fish and Wildlife Service, 2010). In 2007, a survey for American burying beetle was conducted over three nights, in representative habitats along the Arkansas River corridor, from Keystone Lake to downstream of the City of Bixby. Four individual American burying beetles were documented, with each occurring east of the river near the City of Bixby, Oklahoma (Cherokee CRC, LLC, 2009). The riparian streambanks occurring within the ARC study area are potentially suitable habitat for American burying beetle as the 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 the USFWS as unfavorable habitats (U.S. Fish and Wildlife Service, 2015).

The USFWS lists the Northern long-eared bat (*Myotis septentrionalis*) threatened wherever it is found (U.S. Fish and Wildlife Service, 2016). It was federally listed in 2015 following studies that revealed a decline in populations from the spread of white nose syndrome. The Northern long-eared bat is found across much of the eastern and north central U.S., occurring in 37 states. The impact from the spread of white nose syndrome has been greatest in populations occurring in the northeastern U.S. where it is estimated that approximately 99 percent of the population has been affected. Currently, white nose syndrome is known to occur in 25 of the 37 states where Northern long-eared bats occur and is expected to spread to the remaining states (U.S. Fish and Wildlife Service, 2016). The USFWS lists Tulsa County as a location where Northern long-eared bats occur; however, no specific occurrence of the bats or hibernacula are provided. No occurrences of white nose syndrome have been observed within Tulsa County; however, Tulsa County is listed as a county within 150 miles of a county with a known infected hibernacula (Delaware County, Oklahoma) (U.S. Fish and Wildlife Service, 2016).

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. Mating takes place prior to hibernation, and delayed implantation of the embryo occurs in spring/summer. Each female gives birth to a single offspring during late May to late July. 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.

Table 1 Federally listed species potentially present in the ARC (U.S. Fish and Wildlife Service, 2016).

Name	Scientific Name	Federal Protection Status
Birds		
Least Tern	*Sterna antillarum*	Endangered
Piping Plover	*Charadrius melodus*	Threatened
Red Knot	*Calidris canutus rufa*	Threatened
Insects		
American Burying Beetle	*Nicrophorus americanus*	Endangered
Mammals		
Northern Long-eared Bat	*Myotis septentrionalis*	Threatened

Oklahoma Administrative Code Title 800 (Department of Wildlife Conservation) - Chapter 25 (Wildlife Rules) - Subchapter 19 (Oklahoma Endangered Species).

The ODWC is directed to facilitate the perpetuation of self-sustaining population levels of native wildlife species and thereby maintain the diversity of wildlife in Oklahoma. Wildlife species listed are those native species which have reproduced in or otherwise significantly used, as in migration or overwintering, areas within the state (of Oklahoma). Classifications of native wildlife species supports this effort and nominated species are reviewed by the ODWC, technical committees, and selected authorities. Species are then listed as 'State Endangered', 'State Threatened', or 'Species of Special Concern' (as either Category I, or Category II). A State Endangered Species is a native species whose prospects of survival or recruitment within the state is in imminent jeopardy. A State Threatened Species is a native species that, although not presently in danger of extirpation, is likely to become endangered in the foreseeable future in the absence of special protection and management efforts. Species of Special Concern may be classified as either Category I implying a native species with a presently stable or increasing population that current evidence indicates is especially vulnerable to extirpation because of limited range, low population or other factors; or as Category II, defined as species identified by technical experts as possibly threatened or vulnerable to extirpation but for which little, if any, evidence exists to document the population level, range or factors pertinent to its status (OAC, 2016). Current listed species in Oklahoma are identified in Table 2. Species of particular importance in the ARC are identified in bold print, and brief descriptions of those species follow.

Table 2 State (Oklahoma) Listed Endangered, Threatened, and Special Concern Species (Categories I and II) (OAC, 2016).

Common Name	***Scientific Name***
Endangered Species	
Cave Crayfish	*Cambarus tartants*
Neosho mucket	*Lampsilis rafinesqueana*
Longnose Darter	*Percina nasuta*
Threatened Species	
Arkansas River shiner	***Notropis girardi***
Blackside darter	*Percina maculata*
Category I Species	
Mountain plover	*Charadrius montanus*
Long-billed curlew	*Numenius americanus*
Ferruginous hawk	*Buteo regalis*
Golden eagle	*Aquila chrysaetos*
Prairie falcon	*Falco mexicanus*
Rich Mountain Slitmouth snail	*Stenotrema pilsbryi.*
Category II Mammal species	
Black-tailed prairie dog	*Cynomys ludovicianus*
Desert shrew	*Notiosorex crawfordi*
Eastern harvest mouse	*Reithrodontomys humulis.*
Golden mouse	*Ochrotomlvs nutalli*
Hog-nosed skunk	*Conepatus mesoleucus*
Keen's myotis	*Myotis keenii*
Long-tailed weasel	*Mustela frenata*
Meadow jumping mouse	***Zapus hudsonius***
Mexican free-tailed bat	*Tadarida brasiliensis*
Rafinesque’s big-eared bat	*Plecotus rafinesquii*
Rice rat	*Oryzomys palustris*
Ringtail	*Bassariscus astutus*
Seminole bat	*Lasiurus seminolus*
Small-footed myotis	*Myotis leibii*
Southern myoyis	*Myotis austroriparius*
Swift fox	*Vulpes velox*
Texas kangaroo rat	*Dipodomys elator*
Western big-eared bat	*Plecotus townsendii pallescens*
Woodchuck	*Marmota monax*
Category II Bird Species	
Bachman's sparrow	***Aimophila aestivalis***
Barn owl	*Tyto alba*
Bell's vireo	***Vireo bellii***
Burrowing owl	*Athene cunicularia*
Loggerhead shrike	***Lanius ludovicianus migrans***
Snowy plover	*Charadrius alewndrinus*
Swainson's hawk	***Buteo swainsoni***
Category II Reptile Species	
Alligator snapping turtle	***Macroclemys temminckii.***
Desert massasauga	*Sistrurus catenatus edwardsii*

Common Name	*Scientific Name*
Earless lizard	*Holbrookia maculata*
Gulf crayfish snake	*Regina rigida sinicola*
Louisiana milk snake	*Lampropeltis triangulum amaura*
Map turtle	*Graptemys geographica*
Northern scarlet snake	***Cemophora coccineacopei***
Round-tailed horned lizard	*Phrynosoma modestrum*
Texas garter snake	*Thamnophis sirtalisannectens*
Texas horned lizard	***Phrynosoma cornutum***
Texas longnosed snake	*Rhinocheilus leconteitessellatus*
Western mud snake	*Farancia abacurareinwardtii*
Category II Amphibian Species	
Four-toed salamander	*Hemidactylium scutatum*
Grotto salamander	*Typhlotriton spelaeus*
Mole salamander	*Ambystoma talpoideum*
Oklahoma salamander	*Eurycea tynerensis*
Ouachita dusky salamander	*Desmognathus brimleyorum*
Rich Mountain salamander	*Plethodon ouachitae*
Ringed salamander	*Ambystoma annulatum*
Squirrel treefrog	*Hyla squirella*
Three-toed amphiuma	*Amphiuma tridactylum*
Westem bird-voiced treefrog	*Hyla a. avivoca*
Western lesser siren	*Siren intermedia nettingi*
Category II Fish Species	
Alabama shad	*Alosa alabamae*
Alligator gar	*Atractosteus spathula*
Arkansas River speckled chub	*Platygobio [Hybopsis] aestivalis tetranemus*
Arkansas darter	*Etheostoma cragini*
Black buffalo	*Ictiobus niger*
Blue sucker	*Cycleptus elongatus*
Bluehead Shiner	*Notropis hubbsi*
Bluntface shiner	*Cyptinella camura*
Brown bullhead	*Ictalurus nebulosus*
Chain pickerel	*Esox niger*
Colorless shiner	*Notropis perpallidus*
Crystal darter	*Ammocrypta asprella*
Cypress minnow	*Hybognathus hayi*
Flathead chub	*Platygobio [Hybopsis] gracilis*
Goldstripe darter	*Etheostoma parvipinne*
Harlequin darter	*Etheosoma histrio*
Ironcolor shiner	*Notropis chalybaeus*
Kiamichi shiner	*Notropis ortenburgeri*
Mooneye	*Hiodon tergisus*
Mountain madtom	*Noturus eletherus*
Pallid shiner	*Notropis amnis*
Plains topminnow	*Fundulus sciadicus*
Redbreast sunfish	*Lepomis auritus*
Ribbon shiner	*Lythurus fumeus*

Common Name	Scientific Name
River darter	*Percina shumardi*
Shorthead redhorse	***Moxostoma macrolepidotum***
Shovelnose sturgeon	***Scaphirhynchus platorynchus***
Southern brook lamprey	*Ichthyomyzon gagei*
Spotfin shiner	*Cyprinella spiloptera*
Stonecat	*Noturus flavus*
Taillight shiner	*Notropis maculatus*
Wichita Mountain Spotted bass	*Micropterus punctulatus wichitae*
Category II Invertebrate Species	
Bowman cave amphipod	*Stygobromus bowmani*
Oklahoma cave amphipod	*Allocrangonyx pellucidus*
Prairie mole cricket	*Gryllotalpa major*
Regal fritillary butterfly	*Speyeria idalia*
Rich Mountain Slitmouth snail	*Stenotrema pilsbryi.*
Scaleshell mussel	*Leptodea leptodon*
Spectacle-case mussel	*Quadrula cylindrica*
Western fanshell mussel	*Cyprogenia aberti*

The Arkansas River Shiner (*Notropis girardi*) is a small, streamlined minnow with a small, dorsally flattened head, rounded snout, and sub-terminal mouth, listed as threatened by the State of Oklahoma. Historically, this shiner was widespread and abundant throughout the western portions of the Arkansas River basin in Kansas, New Mexico, Oklahoma, and Texas (there is an old record from western Arkansas). Schools of shiners often gather on the lee side of sandbars and ridges of sand in the river channel. They spawn after heavy summer rains and their eggs drift with the water current and develop as they are carried downstream. It is extirpated from the Arkansas River in Kansas and Oklahoma. The Arkansas River shiner was last found in the ARC project area in 1982 (Pigg, 1991). A small remnant population may persist in the Cimarron River (Oklahoma-Kansas), and nearly all of the remaining Arkansas River Shiners occur in the Canadian River in Oklahoma, western Texas, and eastern New Mexico. Reservoir construction is the most widespread cause of habitat loss. Reservoirs have inundated, dewatered, fragmented, or otherwise directly altered considerable sections of river habitat once inhabited by the species. Not only have reservoirs directly affected habitat immediately upstream of the dam, but altered downstream hydrologic regimes have also significantly reduced habitat (including encroachment of non-native salt cedar), and diminished the species ability to successfully reproduce. Water depletion and diversion continue to threaten the species, particularly in light of significant reductions to the High Plains Aquifer and projected effects of climate change. Water depletion has had a detrimental effect on water quality by exacerbating existing water quality threats such as nutrient loading and increased chlorides. Channelization of the Arkansas River has permanently altered and eliminated suitable habitat and is largely responsible for the extirpation of the species within the Arkansas River in Arkansas and Oklahoma (NatureServe, 2016a).

The Meadow Jumping Mouse (*Zapus hudsonius*) is listed as a Special Concern Species Category II Mammal by the State of Oklahoma. It is a mouse with yellowish brown upperparts; a broad dark dorsal stripe; a white venter and yellow sides; a long, round, sparsely haired, bicolored tail that is longer than the head and body; and very long hind feet. Preferred habitat is moist lowland areas with relatively thick vegetation, and open grassy and brushy areas of marshes, meadows, swamps, and streamsides. When inactive, it occupies an underground burrow, usually in a bank or hill (winter), or under logs or grass clumps. Diet includes invertebrates, seeds, leaves, buds, fruits, and subterranean fungi. The mouse is mainly nocturnal but commonly observed in daylight. It hibernates from about September-October to April-May. Overgrazing by cattle, removing required vegetative cover, and general habitat degradation are suspected reasons for population decline (NatureServe, 2016b).

Bachman's Sparrow (*Aimophila aestivalis*) is a Special Concern Species Category II Bird listed by the State of Oklahoma. It is a large (15 cm) sparrow with a large bill, buff or gray sides and breast, a whitish belly, a long dark rounded tail, gray upperparts heavily streaked with chestnut or dark brown, buffy-gray sides of head with a thin dark russet line extending back from the eye. This sparrow is more easily identifiable by its simple yet beautiful song than by plumage characteristics. Individuals of this species exhibit a lot of terrestrial locomotion such as walking, hopping, running; often they appear to be reluctant to fly. It is a habitat specialist historically found in mature to old growth southern pine woodlands subject to frequent growing-season fires. The sparrow requires a well-developed grass and herb layer with limited shrub and hardwood mid-story components. Ideal habitat was originally the extensive longleaf pine woodlands of the south. This species is considered to be one of the most rapidly declining bird species in North America. The primary management concern for is the provision of adequate habitat, which is ephemeral and often declines as a result of natural vegetation succession. In the absence of naturally occurring fires, active management (prescribed burning, clearcutting) generally is needed. Single areas generally cannot provide continuously favorable habitat, so successful management in a region generally will require the provision of a mosaic of sites in different stages of vegetation succession (NatureServe, 2016c).

Bell's Vireo (Vireo bellii) is a Special Concern Species Category II Bird listed by the State of Oklahoma. The Bell's Vireo is small songbird with drab gray coloring to greenish coloring above and white to yellow coloring below. The Bell's Vireo has one prominent wingbar with a fainter wingbar above it and a faint white eye ring. Juveniles are similar to adults, but whiter below and with more distinct wingbars. Declines may be related to loss of riparian habitat, particularly in western portions of its range. Urban development, water diversion, flood control projects, grazing, and the spread of agriculture have destroyed much western nesting habitat. Breeding populations in the U.S. are long-distance migrants. Most individuals migrate from breeding areas in late July to late September through northern Mexico, wintering primarily in central and southern Mexico along the Baja peninsula, and to Honduras. Spring migrants return early to mid-March, and reach northern limits of the breeding range in May. Preferred habitat is dense brush, willow thickets, mesquite, streamside thickets, and scrub oak, and in arid regions often near water. It nests in shrubs or low trees, usually averaging about one meter above ground, and usually in a horizontal or down sloping twig fork (NatureServe, 2016d). Bell's Vireo is found in open shrub land habitats that are dominated by willow, sand plum, rough leaf dogwood and hawthorn. They are found in shrubby rangeland and old-fields where sand plum and other deciduous thickets are common; and they are found in willow thickets along streams and the Arkansas River.

The Loggerhead Shrike (*Lanius ludovicianus*) is also a Special Concern Species Category II Bird listed by the State of Oklahoma. Loggerhead Shrikes are thick-bodied songbirds slightly smaller than the American robin. Their gray head contrasts with the wide, black mask, black bill, and white throat. Their tail is black with white corners; the wings are black with white at the base of the primaries, forming a small handkerchief spot when the wing is closed and larger white patches in flight. Juveniles have darker barring above and below. Preferred habitat is open country with scattered trees and shrubs, savanna, desert scrub, and, occasionally, open woodland. It often perches on poles, wires or fence posts, and suitable hunting perches are an important part of the habitat. Migration is generally a withdrawal southward from the northern half of the breeding range for winter. Populations have been declining throughout North America since the 1960s, and perhaps earlier. Part of the decline can be attributed to reforestation and loss of open habitat and thus represents a return to pre-settlement conditions when shrikes were probably absent from much of the heavily forested northern states. However, the decline has proceeded beyond what can be explained by habitat loss, as much suitable habitat remains unoccupied in most northern states. Decline has been recorded in all regions of the country, even those with much open habitat. Thus, the decline remains unexplained, with pesticides, loss of wintering habitat quality, suggested as possible causes (NatureServe, 2016e).

Swainson's Hawk (*Buteo swainsoni*), a Special Concern Species Category II Bird listed by the State of Oklahoma, is a broad-winged Buteo of between 48 and 56 cm in length with females slightly larger than males. Males and females have similar plumage. Swainson's Hawks are polymorphic with pale, light, and intermediate morph plumage ranging from dark to light or rufous in color. Most Swainson's Hawks have a sharp contrast between the wing linings and flight feathers. However, some of the darkest Swainson's Hawks do not have this distinction. Swainson's Hawks are distinguishable from other Buteos by their more narrow body and wings, but are still often confused with Broad-winged, White-tailed and Short-tailed Hawks. An ideal landscape for the Swainson's hawk provides large riparian nesting trees, agricultural fields, and open shrubland within relatively close proximity. Vertebrates (mainly mammals) dominate the diet during the breeding season, and invertebrates (especially crickets and grasshoppers) are common food at other times. Swainson’s hawk hunts for insects on the ground, may catch insects in air, or hunt while soaring or from a perch. They maintain a large breeding range in western and central North America, and winter mainly in southern South America. The hawk is relatively common in some areas, but pesticide use and habitat loss in breeding and nonbreeding range have resulted in population declines. Documentation of severe mortality associated with pesticide use (in Argentina in 1996) suggests up to 20,000 died as a result of pesticide spraying to control grasshoppers (NatureServe, 2016f).

The Alligator Snapping Turtle (*Macrochelys temminckii*) is a Special Concern Species Category II Reptile listed by the State of Oklahoma. This is a very large turtle with a huge head, strongly hooked jaws, an extra row of scutes along each side of the shell, three keels along the carapace, and a long tail. This species differs from the snapping turtle in its larger head, extra row of scutes along the sides of the shell, lack of a saw-toothed mid-dorsal tail ridge, more lateral position of the eyes, and presence of a wormlike lure on the upper surface of the tongue. Habitat consists of slow-moving, deep water of rivers, sloughs, oxbows, and canals or lakes associated with rivers. Diet includes various aquatic animals, vertebrate and invertebrate, carrion, and some plant material. Ongoing threats include habitat alteration and fragmentation, water pollution, deliberate harvest for human consumption, and incidental catch by commercial fishers. Overharvesting and habitat alteration are, or at least were, the major threats. Human disturbance may cause females to abandon nesting attempts, and renesting attempts increase exposure to predators. The Alligator snapping turtle is found in the vicinity of log/debris piles in the Arkansas River and tributary streams. Individual Alligator Snapping Turtles rarely leave the water (except females when they leave to lay their eggs) so they almost never colonize ponds or bodies of water not directly connected to perennial streams (NatureServe, 2016g).

The Northern Scarlet Snake (*Cemophora coccinea copei*), a Special Concern Species Category II Reptile listed by the State of Oklahoma, is a rare snake that is usually associated with oak woodlands and forests on sandy soils. It has only been documented a few times in Tulsa County. The northern scarlet snake is generally found under boards, rocks, and logs, in forests and open adjacent fields with well-drained soil. This species is nocturnal and is considered a burrower, spending most of its time underground (Cherokee CRC, LLC, 2009).

The Texas Horned Lizard (*Phrynosoma cornutum*) is also a Special Concern Species Category II Reptile listed by the State of Oklahoma. The Texas Horned Lizard is found in tallgrass prairie and shrubby prairie habitats. It is not restricted to sites with sandy soils, but it does appear to be the most common in sandy soils. Most of the recent records have been in the northern part of Tulsa County and along the Arkansas River. It is a flattened, wide-bodied lizard with long spines on the head, a short snout, and dark lines radiating from the eye on each side of the face. A mid-dorsal stripe is present with a row of enlarged scales on each side of throat, and two rows of pointed fringe scales on each side of the body. This lizard inhabits open arid and semiarid regions with sparse vegetation with grass, cactus, or scattered brush or scrubby trees. When inactive, individuals burrow into the soil, enter rodent burrows, or hide under rocks. The lizard eats mainly ants, and other small insects. Declines may be related to the spread of fire ants, use of insecticides to control fire ants, heavy agricultural use of land and/or other habitat alterations, and over-collecting for the pet and curio trade. This species is extremely vulnerable to changes in habitat, especially the loss of harvester ants. A 1992 Oklahoma survey found the species to be rapidly disappearing in eastern areas of Oklahoma where it was once known to be abundant (NatureServe, 2016h).

The Shorthead Redhorse (*Moxostoma macrolepidotum*) is a Special Concern Species Category II Fish listed by the State of Oklahoma. The shorthead redhorse is native to central and eastern North America. It inhabits small to large rivers and lakes, can tolerate clear to cloudy water, prefers loose substrate like gravel and sand, and feeds on benthic invertebrates and plant material. When it spawns, shorthead redhorse move into more shallow streams and spawn over gravel or rocky shoals. Dams that are built upstream disrupt spawning migration routes. Shorthead redhorse are intolerant to chemicals in the water, either from domestic sewage or from industrial waste (NatureServe, 2016i).

The Shovelnose Sturgeon (*Scaphirhynchus platorynchus*) is a Special Concern Species Category II Fish listed by the State of Oklahoma, presently being tracked and studied in the Arkansas River in Tulsa County, Oklahoma. It is the smallest species of freshwater sturgeon native to the U.S. The shovelnose sturgeon is impacted very little by turbidity and inhabits the open channel or main channel areas of the large rivers. This sturgeon spawns in spring or early summer migrating upstream. It prefers big river habitats feeding on bottom dwelling immature aquatic insects and other benthic invertebrates. In recent years fishing pressure for caviar has increased after the previously preferred beluga sturgeon of the Black and Caspian seas declined due to overfishing. Spawning and migration routes are impacted by dams (NatureServe, 2016j). In 2010 the USFWS published a final rule treating the shovelnose sturgeon as threatened due to similarity of appearance to the endangered pallid sturgeon (*Scaphirhynchus albus*) under the similarity of appearance provisions of the Endangered Species Act of 1973, as amended. The shovelnose sturgeon and the endangered pallid sturgeon are difficult to differentiate in the wild and inhabit overlapping portions of the Missouri and Mississippi River basins. Commercial harvest of shovelnose sturgeon has resulted in the documented take of pallid sturgeon where the two species coexist and is a threat to the pallid sturgeon (U.S. Fish and Wildlife Service, 2010). While the shovelnose sturgeon does occur in the Arkansas River in Oklahoma, the pallid sturgeon does not. Special Rule 17.44 specifically identifies those geographic areas covered by the Final Rule, not including the Arkansas River in Oklahoma.

Fish and Wildlife Conservation Act Of 1956

The Fish and Wildlife Conservation Act (FWCA) of 1956 encourages all Federal agencies to utilize their statutory and administrative authority to conserve and promote the conservation of nongame fish and wildlife and their habitats.

Fish and Wildlife Coordination Act Of 1958

The Fish and Wildlife Coordination Act of 1934, as amended, recognizes the contribution of wildlife resources to the nation. The USFWS and ODWC have committed to dedicate time and resources to coordinate with USACE to develop, refine, and assess a set of measures that will ultimately yield identification of a preferred plan meeting the delivery team objectives for riverine habitat restoration that have significant environmental outputs for fish and wildlife resources. Riverine aquatic habitat that would be restored with implementation of the eventual recommended plan will meet intent and provisions of the Fish and Wildlife Coordination Act by recognizing the vital contribution of wildlife resources to the ARC, Oklahoma, and the Nation. Institutional significance is demonstrated by the extreme interest, commitment, and recognition given to this study by the USFWS and ODWC. The Act recognizes that incremental losses to flowing waters and their adjacent riparian habitats have become cumulatively important to nationally recognized resources and that mitigation of those losses is within the national interest. Similarly the restoration of these habitats could be shown to be incrementally nationally significant.

Migratory Bird Treaty Act

The United States has recognized the critical importance of this shared resource by ratifying international, bilateral conventions for the conservation of migratory birds. These migratory bird conventions impose substantive obligations on the U.S. for the conservation of migratory birds and their habitats, and through the Migratory Bird Treaty Act, the U.S. has implemented these migratory bird conventions with respect to the U.S. The Migratory Bird Treaty Act prohibits the taking, possessing, importing/exporting, selling, and transporting of any listed migratory bird, its parts, nest, or eggs. Included in the protection provided by this act are all North American diurnal birds of prey, except bald and golden eagles which are provided protection under the Bald and Golden Eagle Protection Act.

Oklahoma and the ARC are within the Central Flyway comprising more than half the landmass of the continental United States extending south into Central and South America. In the U.S. the Central Flyway spans the Rocky Mountains, the Great Plains, the arid Southwest, and the western Gulf Coast. The Central Flyway is a bird migration route that generally follows the Great Plains in the United States and Canada. Priority birds within the flyway include the Lesser Prairie Chicken, the Sanderling, the Redhead, and the Least Tern.

Birds of Conservation Concern identified as occurring or potentially occurring within the ARC are included in Table 3 below.

The Bald and Golden Eagle Protection

The Bald and Golden Eagle Protection Act (16 U.S.C. 668-668c), enacted in 1940 and amended, prohibits anyone, without a permit issued by the Secretary of the Interior, from "taking" bald eagles, including their parts, nests, or eggs. The Act provides criminal penalties for persons who "take, possess, sell, purchase, barter, offer to sell, purchase or barter, transport, export or import, at any time or any manner, any bald eagle ... [or any golden eagle], alive or dead, or any part, nest, or egg thereof." The Act defines "take" as "pursue, shoot, shoot at, poison, wound, kill, capture, trap, collect, molest, or disturb." "Disturb" means: “to agitate or bother a bald or golden eagle to a degree that causes, or is likely to cause, based on the best scientific information available, 1) injury to an eagle, 2) a decrease in its productivity, by substantially interfering with normal breeding, feeding, or sheltering behavior, or 3) nest abandonment, by substantially interfering with normal breeding, feeding, or sheltering behavior." In addition to immediate impacts, this definition also covers impacts that result from human-induced alterations initiated around a previously used nest site during a time when eagles are not present, if, upon the eagle's return, such alterations agitate or bother an eagle to a degree that interferes with or interrupts normal breeding, feeding, or sheltering habits, and causes injury, death or nest abandonment.

A violation of the Act can result in a fine of $100,000 ($200,000 for organizations), imprisonment for one year, or both, for a first offense. Penalties increase substantially for additional offenses, and a second violation of this Act is a felony. Numerous observations and nesting sites of the Bald Eagle within the ARC are documented (Cherokee CRC, LLC, 2009).

Table 3 Migratory Birds of Conservation Concern known to occur within the ARC (U.S. Fish and Wildlife Service, 2016).

Common Name	Scientific Name	Season
Acadian Flycatcher	*Empidonax virescens*	Breeding
Bachman's Sparrow	*Aimophila aestivalis*	Breeding
Bald Eagle	*Haliaeetus leucocephalus*	Year-round
Bell's Vireo	*Vireo bellii*	Breeding
Bewick's Wren	*Thryomanes bewickii ssp. bewickii*	Year-round
Black-crowned Night-heron	*Nycticorax nycticorax*	Breeding
Dickcissel	*Spiza americana*	Breeding
Field Sparrow	*Spizella pusilla*	Year-round
Fox Sparrow	*Passerella iliaca*	Wintering
Golden Eagle	*Aquila chrysaetos*	Wintering
Harris's Sparrow	*Zonotrichia querula*	Wintering
Henslow's Sparrow	*Ammodramus henslowii*	Breeding
Hudsonian Godwit	*Limosa haemastica*	Migrating
Kentucky Warbler	*Oporornis formosus*	Breeding
Le Conte's Sparrow	*Ammodramus leconteii*	Wintering
Least Bittern	*Ixobrychus exilis*	Breeding
Least Tern	*Sterna antillarum*	Breeding
Little Blue Heron	*Egretta caerulea*	Breeding
Loggerhead Shrike	*Lanius ludovicianus*	Year-round
Mississippi Kite	*Ictinia mississippiensis*	Breeding
Northern Flicker	*Colaptes auratus*	Year-round
Orchard Oriole	*Icterus spurius*	Breeding
Painted Bunting	*Passerina ciris*	Breeding
Prairie Warbler	*Dendroica discolor*	Breeding
Prothonotary Warbler	*Protonotaria citrea*	Breeding
Red-headed Woodpecker	*Melanerpes erythrocephalus*	Year-round
Rusty Blackbird	*Euphagus carolinus*	Wintering
Scissor-tailed Flycatcher	*Tyrannus forficatus*	Breeding
Short-eared Owl	*Asio flammeus*	Wintering

America's Watershed Initiative (AWI, 2016)
America's Watershed Initiative (AWI) is a collaboration working with hundreds of business, government, academic, and civic organizations to find solutions for the challenges of managing the Mississippi River and the more than 250 rivers that flow into it. The fourth largest watershed in the world, the Mississippi River Watershed carries the waters from the Rocky Mountains, the north woods of Minnesota and the Appalachian mountains, through delta wetlands and into the Gulf of Mexico. America's history, environment, prosperity, and future depend on the waters that flow though these heartland rivers.

AWI is a collaboration that seeks solutions for meeting the multiple demands placed on the vast and complex Mississippi watershed system by integrating issues, partners and ideas at the full watershed scale. It seeks to build and implement a vision based on collaboration and mutually beneficial outcomes in contrast to single purpose advocacy. It builds upon strong leadership present in many tributary watersheds. America's Watershed also seeks to link and augment these efforts, creating a broader partnership that can serve as a unified voice for the whole system, and support the effective resolution of issues that span multiple regions—issues such as energy, transportation, water quality, and floodplain management.

AWI develops a 'report card' for the full Mississippi River Basin and the five major subbasins (Missouri River, Arkansas/Red Rivers, Upper Mississippi River, Ohio/Tennessee Rivers, and Lower Mississippi) feeding into it measuring six broad goals – Ecosystems, Flood Control & Risk Reduction, Transportation, Water Supply, Economy, and Recreation. The Report Card, using real data and relevant information identified by experts in these fields, measures progress meeting each one of these goals. Overall, the Arkansas River and Red River Basin received an average score of C- on the report card for the six goals. The Arkansas River & Red River Basin received a grade of B for Ecosystems. The living resources indicator received a C. The streamside habitat indicator received a grade of C+ and the water quality indicator received a C-grade.

U.S. EPA's Healthy Watersheds Initiative (U.S. EPA, 2016)
EPA and other partners recognize the need to protect and maintain the full chemical, physical and biological quality of our Nation's waters. The Healthy Watersheds Initiative (HWI) explicitly addresses this need by expanding focus to include protection of intact aquatic ecosystems and integrated processes as they naturally occur within a watershed context: linked surface and subsurface waters and habitats comprised of continuous rivers with natural flowing water and sediment regimes; lakes and wetlands with natural water volumes and level variation; and springs and groundwater connected by hydrology. Many states, Federal agencies and other EPA partners have begun in recent years to implement broader, aquatic ecosystem based approaches that identify and protect their healthy watersheds. They recognize the benefits of protecting and maintaining high-quality waters, which include reducing the number of future impaired waters and resulting cost savings of not having to restore those waters; ensuring successful and holistic restoration and maintenance of restored waters; and the overall socioeconomic benefits of healthy watersheds. The ecological services that healthy watersheds provide—and the benefits they create—are often taken for granted when they exist in natural systems, and are difficult, expensive or impossible to achieve when they must be reproduced.

The HWI is intended to preserve and maintain natural ecosystems by protecting our remaining healthy watersheds, preventing them from becoming impaired, and accelerating our restoration successes. It is based on an integrated, systems-based approach to watershed protection, supported by the latest science that views watersheds as dynamic systems that include surface water (instream flow in rivers and lake levels) and sub-surface groundwater quantity variability, water quality, biological resources and their habitat, and other key processes (e.g., geomorphic) that support healthy aquatic resources. The HWI is based on a key, overarching concept: the integrity of aquatic ecosystems is tightly linked to the watersheds of which they are part. There is a direct relationship between land cover, hydrology, and key watershed processes and the condition of aquatic ecosystems.

A healthy watershed has, either in its entirety or as components, intact and functioning headwaters, wetlands, floodplains, riparian corridors, biotic refugia, instream and lake habitat, and biotic communities; green infrastructure; natural hydrology (e.g., range of instream flows, lake water levels); sediment transport and fluvial geomorphology; and natural disturbance regimes expected for its location. Healthy watersheds range from those undisturbed by humans to developed areas that still retain healthy components and habitat connectivity. Healthy watersheds are identified through integrated assessments of landscape condition, biotic communities, habitat, water chemistry and intact hydrologic (surface and subsurface) and geomorphic processes. Once identified, those habitats and processes can be protected as part of a comprehensive watershed plan that includes both protection and restoration. Moreover, healthy watersheds assessments are meant to be strategic in terms of focusing state and local protection resources toward remaining high-quality areas, and to help target restoration opportunities.

USACE-Nature Conservancy Sustainable Rivers Project (U.S. ACE - IWR, 2016)
The Sustainable Rivers Projects (SRP) is a U.S. Army Corps of Engineers and The Nature Conservancy partnership. It represents an ongoing effort to modify reservoir operations to achieve more ecologically sustainable flows, while maintaining or enhancing project benefits. SRP practitioners have advanced this mission through a combination of reservoir reoperation efforts at project sites as well as through training, staff exchanges, and the development of new technologies - all designed to advance the implementation of environmental flows at Corps reservoirs. Environmental flows are the flows of water in a river that sustain healthy ecosystems and the goods and services that humans derive from them. The project is being carried out under a Memorandum of Understanding between the Corps and the Conservancy. Corps and Conservancy staff recognize the potential for SRP activities to positively affect operations and surrounding ecosystems at the 600-plus reservoirs managed by the Corps nationwide.

The environmental effects of dams, reservoirs and other water control structures were poorly understood when many of these projects were built. By the 1960s and 1970s, government agencies, conservation groups and citizens nationwide began to evaluate the ecological impacts of development. The Corps has since worked to understand the effects of human influences on water resources and, when possible, mitigate impacts and improve the environment. SRP continues this work by exploring reservoir re-operations to benefit wildlife as well as humans. Using ‘state of the art’ technology and scientific expertise, the Corps and Conservancy are working to ensure that dams and reservoirs continue to provide the services people rely on while implementing environmental flows designed to improve conditions for the natural communities that also depend on our nation’s rivers.

The following laws and policies further add to the identification of Institutional Significance:

Water Resources Development Act Of 1986
The restored ecosystem functions that would be provided by the eventual recommended plan for the ARC study can be considered significant by the USACE because the restoration of these functions meet with the spirit of the Water Resources Development Act of 1986.

Water Resources Development Act Of 1990
Section 307(a) of the Water Resources Development Act of 1990 established an interim goal of no overall net loss of wetlands in the U.S. and set a long-term goal to increase the quality wetlands, as defined by acreage and function. The ARC ecosystem restoration study would not result in the loss of wetlands and waters of the U.S. as the proposed study would restore the ecological and hydraulic function to the ARC in addition to restoring wetlands.

Wrda 2007 Section 3132. Arkansas River Corridor, Oklahoma
Authorized participation in the ecosystem restoration component of the Arkansas River Corridor Master Plan dated October 2005. The Master Plan includes a comprehensive ecosystem restoration plan to improve riverine, riparian corridor, and open water habitats.

Executive Order 11990 (Protection Of Wetlands)
The intent Executive Order 11990 is to avoid to the extent possible the long and short term adverse impacts associated with the destruction or modification of wetlands, and to avoid direct or indirect support of new construction in wetlands wherever there is a practicable alternative. Agencies are directed to take action to minimize the destruction, loss or degradation of wetlands, and to preserve and enhance the natural and beneficial values of wetlands in carrying out the agency's responsibilities for (1) acquiring, managing, and disposing of Federal lands and facilities; and (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. Restoration of a more natural low flow regime within the ARC to support existing wetland areas, and restoration of wetland areas within the ARC, support the intent of Executive Order 11990.

Executive Order 13112 (Invasive Species)
Executive Order 13112 recognizes the significant contribution native species make to the wellbeing of the Nation's natural environment and directs Federal agencies to take preventive and responsive action to the threat of non-native species invasion and to provide restoration of native species and habitat conditions in ecosystems that have been invaded. As the ARC study would replace non-native vegetation with site-specific native vegetation, it would be in compliance with Executive Order 13112.

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 public, 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 developed to improve 42 miles of the ARC between Keystone Dam and the Tulsa County/Wagoner County line. The ARC Project was one component of Vision 2025, a long-term regional plan for the greater Tulsa area. As a result, the Indian Nations Council of Governments (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 ARC 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. In 2010 a reconnaissance study was completed which found a federal interest to continue into the feasibility study phase.

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. The institutional section of this document provides evidence supporting the technical significance of the resources, specifically the scarcity, status, and trends of the resources.

ILT populations in the ARC are technically significant based on a 2006 range-wide survey 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 (U.S. Fish and Wildlife Service, 2016). Habitat of the ILT found in the system, is negatively impacted within the ARC through diminished sediment transport affecting development and maintenance of existing nesting habitat. Periods of nominal flow associated with peaking hydropower operations at the Keystone Dam contribute to land bridging of in-stream nesting sites (increased predation and disturbance), diminished habitat of forage species through loss of slackwater fish nursery habitat, and desiccation of aquatic habitat. Foraging habitat quality and quantity have declined from historical levels. 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 ARC. Fish surveys conducted in 2006 and 2007 show an overall increase in abundance and diversity of intolerant species, and periods of no-flow limit the passage and habitat of some species (Cherokee CRC, LLC, 2009). Disruptions to the fisheries complicate the complex food web within and surrounding the river. The report concluded that having a constant flow of water, as opposed to drastic fluctuations, offers the opportunity for renewed organic matter inputs, limits thermal fluctuation, stabilizes dissolved oxygen concentrations, and provides stability during spawning periods.

The Oklahoma Comprehensive Wildlife Conservation Strategy (OCWCS) is a means to articulate the conservation strategies necessary to conserve the State's rare and declining wildlife species. The OCWCS is a guiding document for how the State uses funding apportioned by a federal conservation assistance program created by Congress in 2001 called State and Tribal Wildlife Grants. The program requires each state and territory to develop a strategic and comprehensive plan serving as guidance for use of program funding to address species of greatest conservation need before they reach a status where federal listing under the ESA is warranted. Oklahoma's initial OCWCS was completed in 2005 and a draft 2015 update has been prepared (ODWC, 2015). A strategy for identifying and ranking species of greatest conservation need has been developed with criteria including federal listing, state listing, global rankings, commercial harvest considerations, and regional endemic existence. Tier I represents highest conservation need. 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 ILT (Tier I), the Piping Plover (Tier II), and the Bald Eagle (Tier III) (ODWC, 2015).

The paddlefish (*Polyodon spathula*) is an ancient, planktivorous freshwater species that inhabits large rivers and lakes throughout much of the Mississippi River drainage and smaller rivers of the Gulf slope drainages in North America. Paddlefish migrate upstream, and based on environmental parameters, select areas for successful spawning and survival of early life stages. Spawning season is from March through June, when spring rains raise the water levels of rivers and water temperatures reach 50-60 degrees. Males and females gather in schools and release their eggs over gravel or sandbars. In 1989, the U.S. Fish and Wildlife Service was petitioned to include paddlefish on the list of Threatened and Endangered Species under provisions of the Endangered Species Act of 1973. The U.S. Fish and Wildlife Service, after collecting supplemental information from states, determined that the listing of paddlefish as 'threatened' was not warranted. They were once very abundant throughout their range, but have declined in numbers.

Habitat destruction and river modification are the most obvious changes affecting paddlefish abundance and distribution. Construction and operation of dams on mainstem streams have had severe impacts. Dams eliminated traditional spawning sites (paddlefish can live in reservoirs but need streams for spawning), interrupted natural spawning migrations, altered water flow regimes, dewatered streams, and eliminated backwater areas that were important as nursery and feeding areas. Dams have curtailed the long-range movements that may be required to maintain populations. It is likely that structural changes in big river systems have adversely affected most of the original habitat (NatureServe, 2016k). Additional threats to paddlefish include water quality issues associated with dam operations, and illegal harvest of adult paddlefish for caviar. Paddlefish are one of the most unique fish in Oklahoma. They can live up to 50 years and range throughout the U.S. from Montana to Louisiana. In Oklahoma, they are found mainly in the Grand Neosho, Arkansas and Red River systems. Paddlefish are well adapted to living in rivers and lakes. They inhabit many types of habitats and occur most frequently in deeper, low current areas such as side channels, backwater lakes, and tailwaters below dams. In 1992, Oklahoma fisheries biologists began an effort to re-introduce paddlefish to waters where they has become locally eradicated. Dams on several rivers have blocked the annual movements of paddlefish in several river systems. The fisheries division of the wildlife department have placed bands on thousands of paddlefish in lakes statewide. These bands are an important research tool allowing biologists to learn about population abundance, and individual growth (ODWC, 2016).

The proposed ARC ecosystem restoration project is designed to restore the degraded ecosystem structure, function, and dynamic processes to a less degraded, sustainable, more natural condition. Through restoration of a more natural low flow regime and restoring slackwater and wetland areas, improving and re-establishing structural components and functions of the riverine ecosystem can be realized. While elements contributing to the ARC ecosystem degradation will remain because they serve highly valuable purposes (e.g. flood risk management and hydropower), solutions proposed can reestablish ecosystem structure and functions, and improve environmental quality.

Restoration of a more natural low flow regime will maintain a connected riverine system diminishing the presence and frequency of isolated stagnant pools that interrupt riverine species life requisites and migratory pathways. A continuous low flow regime will allow greater connectivity to numerous backwater/slackwater areas and tributary mouths through the study area. Maintenance of a more natural low flow regime will contribute to a reduction of land-bridging of existing sandbar habitat (potential ILT nesting areas) reducing predation and disturbance. Restored river flow will restore, sustain, and provide connectivity to slackwater and wetland habitats allowing increased carrying capacity to support native species riverine and wetland trophic interrelationships. A more natural low flow regime will contribute to aquatic and riparian vegetation promotion and stability providing improved foraging and nursery habitat for aquatic insects, amphibians, fish, migratory waterfowl, and shorebirds.

The project is expected to contribute to the continued recovery of ILT populations by enhancing existing nesting habitat within the corridor by reducing land bridging of nesting sites, enhancing aquatic habitat of ILT forage species through smoothing highly variable peaking hydropower releases minimizing habitat desiccation, and developing new ILT nesting habitat within the ARC. Enhancement and development of a more natural low flow regime will coincidentally promote foraging habitat for the migratory Piping Plover, Red Knot, and other migratory waterfowl and shorebirds. Additionally, the proposed project will enhance and expand existing migratory fish habitat (Shovelnose Sturgeon, Paddlefish, and Shorthead Redhorse) through smoothing highly variable peaking hydropower releases minimizing habitat isolation and desiccation, and providing fish passage through a proposed pool structure. Enhancement of aquatic habitat for fish species will additionally promote foraging opportunities for resident Bald Eagles. Proposed measures including restoration of a more natural low flow regime, slackwater, wetland, and riparian development/enhancement will provide riverine connectivity, a more stable wetted riverine perimeter supporting aquatic and riparian vegetative growth, more resilient refugia and nursery habitat for native riverine fish species, and enhanced habitat for migrant and resident wildlife.

Habitat Assessments

Habitat Evaluation Procedures (HEP) were developed by US Fish and Wildlife Service (USFWS) in 1980 to quantify impacts of resource developments on fish and wildlife habitats (USFWS 1980 a,b,c). HEP is used to model existing habitat conditions and project changes in habitat quantity and quality over time using Habitat Suitability Indices (HSIs) to mathematically express habitat quality under alternative future scenarios. HSIs are calculated using environmental variables such as vegetation cover, hydrologic regime, and water quality for species and/or community. Algorithms are used to define habitat quality on a scale from 0-1, with 1 being the highest quality habitat. Habitat Units (HUs) are then calculated by multiplying the HSI value by the number of habitat acres affected.

Habitat units can then be annualized in the form of Average Annual Habitat Units (AAHUs) over specific time periods, also known as Target Years (TYs), based on the project. Target Years are defined based on expected time periods for an ecological response for a given habitat type. The relationship between the differences in AAHUs across the defined TYs is used to project and quantify change in habitat value among the with-project and with-out project scenarios.

Since their inception, results of these assessments have often been applied by natural resource managers and decision-makers (Williams 1988; VanHorne and Wiens 1991; Brooks 1997; Brown et al. 2000; Store and Jokimaki 2003; Shifley et al. 2006; Van der Lee et al. 2006; and others).

Virtually all attempts to use HSI models have been heavily criticized, and many criticisms are well deserved. In most instances, these criticisms have focused on the lack of: (a) identification of the appropriate context (spatial and temporal) for the model parameters, (b) a conceptual framework for what the model is indicating, (c) integration of science and values, and (d) validation of the models (Kapustka 2005; Barry et al. 2006; Hirzel et al. 2006; Inglis et al. 2006; Ray and Burgman 2006; Van der Lee et al. 2006; and others). A fundamental problem with these approaches continues to be the inability to link species presence or relative abundance with relevant aspects of habitat quality (VanHorne and Wiens 1991), such as productivity.

Despite such criticisms, HSI models have played an important role in the characterization of a site's ecological condition. They represent a logical and relatively straightforward process for assessing risks to fish and wild-life habitat (Williams 1988; VanHorne and Wiens 1991; Brooks 1997; Brown et al. 2000; Kapustka 2005). The controlled and economical means of accounting for habitat conditions makes HEP a decision-support process that is superior to techniques that rely heavily upon professional judgment and superficial surveys (Williams 1988; Kapustka 2005). They have proven to be invaluable tools in the development and evaluation of restoration alternatives (Williams 1988; Brown et al. 2000; Store and Kangas 2001; Kapustka 2003; Store and Jokimaki 2003; Gillenwater et al. 2006; Schluter et al. 2006; Shifley et al. 2006), managing refuges and nature preserves (Brown et al. 2000; Ortigosa et al. 2000; Store and Kangas 2001; Felix et al. 2004; Ray and Burgman 2006; Van der Lee et al. 2006; and others), and mitigating the effects of human activities on wildlife species (Burgman et al. 2001; National Research Council 2001; Van Lonkhuyzen et al. 2004). These modeling approaches emphasize usability. Efforts are made during model development to ensure that they are biologically valid and operationally robust. Most HSI models are constructed largely as working versions rather than as final, definitive models (VanHorne and Wiens 1991). Simplicity is implicitly valued over comprehensiveness, perhaps because the models need to be useful to field managers with little training or experience in this area. The model structure is therefore simple, and the functions that go into the models are relatively easy to understand. The functions that are included in each model are based on both published and unpublished information that indicates the variables that can influence the potential density of a species through direct or indirect effects on its life requisites. The general approach of the Suitability Index graphs is valid, in that the suitability of habitat to a species is likely to exhibit strong thresholds below which the habitat is usually unsuitable and above which further changes in habitat features make little difference. And as such, most HSI models should be seen as quantitative expressions of the best understanding of the relations between easily measured environmental variables and habitat quality available. Habitat suitability models are a compromise between ecological realism and limited available input data (Radeloff et al. 1999; Vospernik et al. 2007).

While empirical HSI models are being continuously produced for new species, it is unlikely that there will ever be production models for all the species of interest. Recent analyses suggest that the restoration and management focus must be broadened beyond species, and the numbers of sites created, restored, and managed must be increased to preserve the full range of the nation's biodiversity (Noss and Cooperrider 1994; Higgins et al. 1999; Groves et al. 2000, 2002; Poiani et al. 2000; Groves 2003; White and Fennessy 2005; and others). For the past several years, the study team at USACE's Engineering Research and Development Center-Envrionmental Laboratory (ERDC-EL) has been called upon by USACE field offices (i.e., Districts) to assist in the development and application of HSI models. Under the auspices of the USACE's System-Wide Water Resources Program (SWWRP), ERDC has reviewed these activities, identified "lessons learned" from these experiences, and proposed a new approach to HSI modeling based on characterizing communities as a whole – the intent being to capture the watershed aspects of ecosystem restoration and management activities on a larger scale, which accommodates a federal planning process time scale (1–2 years) yet still quantifies non-monetary benefits in a manner supportive of the U.S. Army Corps' Strategic Plan for Water Resources and the USACE's Environmental Operating Principles. This new model-building paradigm lifts HSI models out of the site-specific approach of yesteryear, allowing for landscape-level accountability regardless of the community assessed.

The basic premise has been to focus community-based index model development on four interrelated components: Diversity, Vegetative Structure, Hydrography (including water quality, hydrology, and biogeochemical/soil characteristics), and Spatial Context (ranging from juxtaposition to disturbance).

This approach to model development synthesizes the diffuse literature, identifies knowledge and data gaps to guide future research, and provides a framework for assimilating new information acquired in the future to facilitate adaptive management. Current efforts aim to improve ecosystem assessments by providing a framework that couples conceptual modeling, community-based HSI modeling, and Geographic Information Systems (GIS)-based data processing/spatial analysis under a unified planning environment. Key to this approach is the ability of the model to utilize expert knowledge in a transparent fashion, and the ability to characterize communities across the system in a reasonable manner using GIS as a support tool.

Several advantages of this approach are evident. First the technique provides a logically consistent ordering of relations among environmental factors, as defined by the nature of their influences on organisms and their habitat. Second, these relations can be supported by formal logical expressions (mathematical equations) couched in terms of ecosystem integrity. Third, the approach provides a standard framework that can be applied to all manner of ecosystems, facilitating model consolidation across large studies with multiple species or communities of concern. And finally, in the process of constructing alternative designs and assessing these with landscape-level community models, attention may be drawn to variables that might otherwise be overlooked.

Model Selection

A meeting was held on 23 May 2016 including Josh Johnston (ODWC) Northeast Region Fisheries Supervisor, Kevin Stubbs, (USFWS) fish and wildlife biologist based out of the Oklahoma Ecological Services Field Office, and USACE Regional Planning and Environmental Center (RPEC) biologists Daniel Allen, David Gade, Brandon Wadlington, and RPEC section chief Kelly Burks-Copes. The purpose of the meeting was to select Corps certified species HSI models that would best represent the Arkansas River Corridor study area habitats (riverine/sandbar, wetlands, riparian) to evaluate existing habitat, future without project conditions, and habitat response to proposed restorative measures. These species models would also aid in selection of the most practicable habitat restoration alternative(s). Species models selected included the Least Tern (Carreker, 1985), Paddlefish (Hubert, Anderson, Southall, & Crance, 1984), Walleye (McMahon, Terrell, & Nelson, 1984), Bigmouth Buffalo (Edwards, 1983), Slider Turtle (Morreale & Gibbons, 1986), and the Red-winged Blackbird (Short, 1985). All models selected are certified by USACE Headquarters for use and were also evaluated and endorsed by the USACE Ecosystem Restoration Planning Center of Expertise for use based on regional and cover type applicability.

The Least Tern, Paddlefish, Walleye, and Bigmouth Buffalo models were selected to evaluate riverine habitat throughout the study area within the ARC.

The Least Tern is a federally listed endangered species currently present and monitored in the system. Least terns annually nest on the exposed sandbar islands within the study area. Proposed project measures, including flow regime enhancement and nesting island construction, offer opportunities to restore and maintain Least Tern habitat.

Least Tern habitat value is primarily based on cover, forage, and reproductive quality (Table 4). The Least Tern model has two options available for calculating Least Tern cover suitability index based on existing vegetation cover. With the majority of the shorelines consisting of either bare or mostly vegetation covered ground, the suitability index for cover is assumed to be determined solely by the percentage of herbaceous and shrub cover (V3), consequently the average height of herbaceous and shrub canopy (V4) was not needed for habitat analysis. The percent of aquatic area (V1) is frequently limited by the low flow conditions in the ARC.

Table 4. Least Tern HEP formulas and Variables.

Species	Life Requisite Suitability Indices (LRSI)	HSI Formula
Least Tern	Cover, Forage, Reproduction	Minimum LRSI value between Forage and Reproduction
	Life Requisite Suitability Index Formulas & Variables	
	Cover	Equal to V3
	Forage	((2*V1)+V2)/3
	Reproduction	Minimum value between V3 and V5
	V1	Percent aquatic area
	V2	# of disparate aquatic wetlands
	V3	% herbaceous and shrub cover
	V4	Average height of herbaceous and shrub canopy
	V5	Quality of nesting substrate

Paddlefish, native to the Arkansas River system, are highly impacted by habitat fragmentation and the existing flow regime. V2, V3, V7, V8, and V9 metrics are all limited by no/low flow conditions. Additionally, Paddlefish are highly migratory fish preferring deep water habitat to winter in, and will migrate upstream to spawn over gravel and cobble substrates. Habitat assessments for Paddlefish focuses on reproductive and habitat variables (Table 5).

Table 5. Paddlefish HEP formulas and Variables.

Species	Life Requisite Suitability Indices (LRSI)	HSI Formulas
Paddlefish	Reproduction, Habitat	Individual HSI values are derived for each LRSI component Reproduction = $(V1*V2*V3*V4*V5*V6)^{1/6}$ Habitat = $(V7*V8*V9^2*V10)^{1/5}$
	Life Requisite Suitability Index Formulas & Variables	
	Reproduction $(V1*V2*V3*V4*V5*V6)^{1/6}$	
	Habitat $(V7*V8*V9^2*V10)^{1/5}$	
	V1 Yearly frequency of at least a 21 day period of rising water between 10-17C	
	V2 Yearly frequency of spring access to upstream spawning river	
	V3 Accessible area of gravel and cobble substrate	
	V4 Average magnitude of spring water rise/average midwinter flow for a period exceeding 10 days with water temps 10-17C	
	V5 Average current velocity	
	V6 Min DO in potential spawning areas while water temps are 10-17C	
	V7 Area of possible summer and winter habitat	
	V8 Average width of river channel or reservoir inhabited during summer and winter	
	V9 % of water area continuous with summer and winter habitat w/ current velocity of <0.05 m/sec in the river system (backwaters, reservoirs)	
	V10 # of eddies in summer and winter channel habitats	

Walleye were selected as a surrogate species for Sauger, a pelagic spawning species highly dependent on a constantly flowing Arkansas River to support reproductive activities. Sauger eggs and larval spawn must remain suspended in the flowing river for several days to avoid desiccation or being stranded and buried by sediment along the river bed. All variables were used to calculate habitat value except for trophic status of lake (V14) as no lacustrine habitat was identified for restoration efforts (Table 6). Due to the no/low flow conditions, the percent of instream cover and aquatic vegetation would be limited.

Table 6. Walleye HEP formulas and Variables.

Species	Life Requisite Suitability Indices (LRSI)	HSI Formula
Walleye	Cover, Food, Reproduction, Water Quality	Minimum LRSI value between Cover, Food, Reproduction, and Water Quality
	Life Requisite Suitability Index Formulas & Variables	
	Cover	((3*V1)+V3)/4
	Food	(V1+V2)/2
	Reproduction	Minimum value between V7,V10,V11,V12, & V13
	Water Quality	Minimum value between V4,V5,V6,V8 & V9
	V1	Average transparency depth in summer
	V2	Relative abundance of small (<12cm) forage fish in spring & summer
	V3	% water body w/cover (boulders, logs, brush, veg) & DO > 3mg/L in summer
	V4	Least suitable pH during year
	V5	Min DO in pools and run (R) or above thermocline (L) in summer
	V6	Min DO during summer-fall along shallow shoreline
	V7	Min DO in spawning areas in spring
	V8	Mean weekly water temp in pools R, or above thermocline in summer (L)
	V9	Mean weekly water temp in shallow shoreline in late spring-early summer
	V10	Mean weekly water temp during spawning in spring
	V11	Degree days between 4-10C from Oct 30-April 15
	V12	Spawning habitat index
	V13	Water level during spawning and embryo development
	V14	Trophic status of lake

An attempt was made by the team to select a certified HSI model representing forage fish habitat for Least Tern and other larger fish species. The team identified the Bigmouth Buffalo as the best available model to represent the feeder fish community habitat (Table 7). Similar to the Walleye model, percent vegetation cover would be a limiting factor as current no/low flow conditions minimize aquatic vegetation growth and abundance.

Table 7. Bigmouth Buffalo HEP formulas and Variables.

Species	Life Requisite Suitability Indices (LRSI)	HSI Formula
Bigmouth Buffalo	Food/Cover, Water Quality, Reproduction, Other	Minimum LRSI value between Food/Cover*Water, Quality*Reproduction^{2}*Other$^{1/5}$, and Reproduction
	Life Requisite Suitability Index Formulas & Variables	
	Food/Cover	$(V1*V13)^{1/2}$
	Water Quality	$(V2*V3*V4^{2}*V6*V8)^{1/6}$
	Reproduction	Minimum value between $(V5^{2}*V6*V9^{2})*V11$ and V5*V9
	Other	Equal to V7
		V1 % of Pools/marsh waters during spring & summer
		V2 Average max monthly turbidity in average summer
		V3 pH during the year
		V4 Max water temp in summer (adult)
		V5 Average max water temps in nursery habitats in spring & summer
		V6 Min DO during spring and summer
		V7 Average current velocity
		V8 Max salinity in spring & summer
		V9 Dominant Substrate Type in spawning areas
		V10 % littoral area & protected embayments during summer
		V11 Water level fluctuation before and after spawning
		V12 Min TDS during growing season
		V13 % veg cover in pools, backwater, marshes/embayments, shorelines

Included in ecosystem restoration measures proposed for the ARC is development of wetland areas and buffering riparian habitat along the periphery of said wetlands. The slider turtle model was selected to assess functional wetland habitat (Table 8). Water regime (V4) is directly tied to the flow fluctuations currently in the ARC.

Table 8. Slider Turtle HEP formulas and Variables.

Species	Life Requisite Suitability Indices (LRSI)	HSI Formula
Slider Turtle	Food/Cover, Water, Temperature	Minimum LRSI value between Food/Cover, Water, and Temperature
	Life Requisite Suitability Index Formulas & Variables	
	Food/Cover	Equal to V1
	Water	Minimum value between V2,V3, and V4
	Temperature	Equal to V5
		V1 % cover of emergent and submerged vegetation V2 Velocity V3 Water Depth V4 Water regime V5 mean water temp during critical period

Also included in restoration measures are riparian plantings to buffer and stabilize the banks along the wetland habitat. The Red-winged Blackbird model was selected to assess potential enhancements to riparian area habitats (Table 9). V1 and V5 are correlated to water regime of adjacent wetlands, whose production is currently limited by flow fluctuations in the ARC.

Table 9. Red-winged Blackbird HEP formulas and Variables.

Species	HSI Formula & Variables
Red-winged Blackbird	Type of emergent vegetation (V1)*Water Regime (V2)*Carp Presence (V3)*Odonata presence (V4)*Water-Vegetation Ratio (V5)
	V1 If emergent herb. Veg. is mostly broad cattails (1.0), if not 0.1 V2 If water usually present throughout year (1.0), if not 0.1 V3 If carp are absent (1.0), if not 0.1 V4 If Odonata larvae are present (1.0), if not 0.1 V5 If wetland contains equal mix of water and emer. Herb. Veg. (1.0), dense veg (0.3), little veg (0.1) V6 If suitable foraging area in cond. A wetland (0.9), mid-overstory (0.4), understory (.1) V7 If upland provides dense, tall, herb. Veg (1.0), if not (0.1) V8 If moving, grazing, or burning, etc do not occur in most years (0.1), if not (0)

Data collection

Field Data

Field data collection was initially scheduled for the week of May 30th-June 3rd 2016. The week leading up to the effort brought additional widespread precipitation to the Upper and Lower Arkansas River Basins. Keystone Lake elevations continued to climb in the flood control pool as did subsequent water releases. On May 30th, according to a stream gage located approximately 15 river miles downstream of Keystone Dam at the Interstate 244 bridge, the Arkansas River exhibited flows in excess of 31,000 cfs. With personnel safety in mind, in additional to river habitat being outside the target condition, the survey was postponed.

After discussing the existing and anticipated future flow rates within the study area with USACE H&H staff, low flow conditions were not expected to return until at least early July, assuming no additional precipitation occurred in the basin. This was concluded based on the amount of water present in the flood control pool at Keystone Lake and the estimated time it would take to return the lake back to conservation pool level.

Initial concerns regarding the collection of substrate composition, aquatic vegetation, and other habitat feature data outside of target conditions were discussed SWD on June. Specifically, increased flows and water levels may limit the survey team's ability to access or assess riverine habitat.

After further discussions with H&H staff on June 6th and 7th, 2016, the flow rates for the study area were expected to be back within the upper hydropower release rates (~11,500 cfs) by June 8th, 2016. Based on the following, field data collection was conducted on June 9th and 10th, 2016:

- Target conditions were at least a month away, but not guaranteed to occur then either
- Hydropower releases would continue to impact survey efforts regardless of base flow rates
- Local resource agency staff, the non-federal sponsor representative, and USACE biologists were all available to participate in data collection efforts within this time frame
- The local professional knowledge and experience within the interagency field survey team would limit assumptions using previous data collection efforts, on-site discussion, and consensus building
- Similar assumptions would likely be made regardless of the sampling period due to the influences of FRM, hydropower, and urban development on the study area.
- Additional data could be collected to describing the high flow conditions to aid in forecasting future with and future without project conditions.

The interagency field survey team consisted of three USACE Regional Planning and Environmental Center (RPEC) biologists Melinda Fisher, Zia Flossman and Brandon Wadlington, two ODWC Fisheries Division biologists, Eric Brennan and Chris Whisenhunt, based out of the Northeast Region Jenks, Oklahoma Office, and Gaylon Pinc, the owner/senior environmental program manager of the Program Management Group, LLC and non-federal sponsor representative based out of Tulsa, Oklahoma. Josh Johnston, ODWC Northeast Region Fisheries Supervisor, and Kevin Stubbs, fish and wildlife biologist based out of the USFWS' Oklahoma Ecological Services Field Office were unable to attend but were contacted following survey efforts to relay field conditions, assumptions being made and to provide input on model projections.

As mentioned above, sampling locations were limited to sites with safe access to target habitat types. Riverine habitat was sampled at eight separate locations while wetland and riparian conditions were surveyed at 5 locations throughout the study area (Figure 2). Attachment 2 contains approximate survey locations and general area pictures taken while surveying habitat conditions.

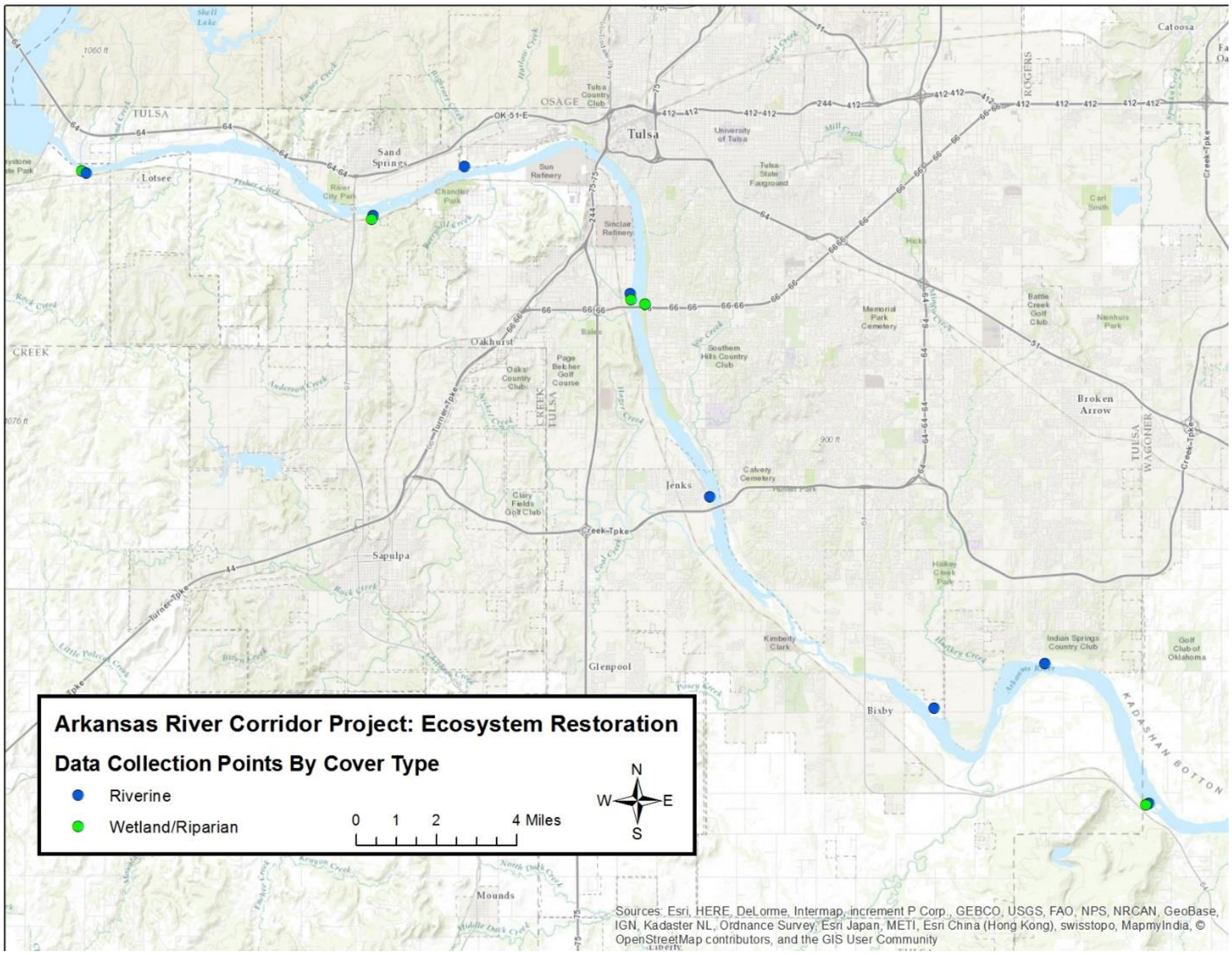

Figure 2. Arkansas River Corridor Project. Data Collection Points by Cover Type.

The collective knowledge of HEP, field sampling techniques, previous and on-going biological studies knowledge, and most importantly intimate knowledge of local riverine habitat conditions during low flow periods allowed for reliable data collection outside of target habitat conditions. In addition, past, present, and planned projects impacting the study area were also discussed during data collection efforts and are accounted for within the projected habitat conditions, particularly the acreage of riverine habitat. Expected future projects included the increase in pool size above the Zink Low Water Dam and the construction of a low water dam within city limits of Jenks, Oklahoma. The surface water acreage maintained upstream of those pools were not included as part of the restored riverine acre totals as those areas were assumed to be lake habitat.

Water Quality

Varieties of HSI model variables are required for the five models selected to evaluate environmental benefits within the ARC. It was not possible to collect data for estimation of all variables during the data collection effort performed June 9 – 10, 2016. Water quality variables (turbidity, pH, salinity, total dissolved solids, dissolved oxygen, water temperature, and degree-days), required in fish species HSI models, were collected from current data archives collected from several locations within the ARC project area. The Oklahoma Water Resources Board (OWRB), in ongoing assessment of designated beneficial uses of streams and lakes to maintain state water quality standards, has conducted survey monitoring since 1998 associated with the Beneficial Use Monitoring Program (BUMP). Two fixed stream sites occur within the ARC project area (the Arkansas River at Sand Springs [120420010130-001AT] and the Arkansas River at Bixby [120420010010-001AT]). Site data were obtained for each of these sites (OWRB, 2015), and relevant data was extracted for water quality variable estimation. Additional water temperature (2007 to present) and dissolved oxygen (2011 to present) data was obtained via the USGS National Water Information System (NWIS) from USGS 07164500, ~15 miles downstream of the Keystone Dam (USGS, 2016).

HEC-RAS

The unsteady-state HEC-RAS models developed to represent the ARC system were driven primarily by measured historic daily release data from the Keystone Dam for the period 1994 through 2015 (U.S. ACE - Tulsa District, 2015). The HEC-RAS models developed for this application were derived from models originally constructed to evaluate flood flows and dam breach scenarios (extremely high flows) on the Arkansas River. Measured release data from Keystone Dam ranged from ~117,000 cfs to zero (0) cfs through the 1994 to 2015 period of record. Tulsa District H&H personnel invested significant effort adjusting the unsteady-state model (driven by Keystone Dam measured release data) to run successfully for the full period of record at a minimum flow of 100 cfs. This was determined to be a discharge level low enough to distinguish this nominal flow (100 cfs), in terms of water surface area, water surface elevation, stream depth, and stream velocity, from the 1,000 cfs enhanced flow regime proposed as the fundamental ecosystem restoration feature.

Various iterations of the HEC-RAS models were prepared to represent existing conditions, multiple with-project conditions (proposed flow regime from Keystone Dam, or pool structures at the original reregulation dam site or the alternate site), and future with and without project conditions (Zink Lake Dam modification and Jenks Pool structure). Steady state model runs at various specific discharge levels (including 100 and 1,000 cfs), using the same HEC-RAS ARC model iterations, provided raster output data of water surface area, depth, and stream velocity. Terrain data, used within the HEC-RAS Mapper feature, allowed production of output raster images of water surface elevation, depth, and velocity associated with high-resolution digital elevation. Digital elevation for the ARC, derived from digital terrain data originally developed in 2001-2002, and updated in 2010 with digital orthophotography, provided 2-foot contour intervals (Aerial Data Service, Inc., 2015).

Areal estimates of project area riverine, pool (created by pool structures), and backwater acreages were estimated using raster outputs from HEC-RAS steady state models of the ARC. Raster images, using terrain derived from the 2010 2-foot contour data, depicting water surface area at discharge levels of 100 and 1,000 cfs were exported from HEC-RAS Mapper into GRASS GIS (GRASS Development Team, 2015) for analysis. Total water surface area (acres) in the ARC in Tulsa County was calculated from exported HEC-RAS raster maps at discharge levels of 100 and 1,000 cfs under existing conditions. Areal extents of instream pools created by the proposed project pool structure (two potential locations) and other pool structures in the system (existing and future conditions) were calculated within GIS using existing and proposed structure elevations and the terrain data (at 3-meter resolution).

Hydropower generation is typically between three and ten hours in duration during weekdays when peak power demands occur. Hydropower releases range from 6,000 to 12,000 cfs depending on the number of turbines in production. During hydropower generation, adequate river flow exists in the ARC. However, outside of the brief generation periods, several hours, and up to two to three days over weekends, of no water releases regularly limit sustained aquatic ecosystem function in the ARC. Figure 2 in Appendix J (H and H) shows the general hydrograph resulting from hydropower production that regularly occurs in the ARC. The reoccurring no to low flow conditions that occur in the absence of flood pool releases from Keystone Dam limits river reach connectivity, sediment transport through and below Keystone Dam, and backwater wetland inundation regimes. The reduction in flow, and subsequent riverine habitat further limits aquatic plant growth and distribution, nursery and refuge habitat availability and access for fish, seasonal water quality, landbridge sandbar islands to shoreline disturbances, and limit overall ecosystem structure and function.

When the water levels rise behind Keystone Dam, releases are not always limited to the capacity of the power generation system. Figure 3 in Appendix J (H and H) shows the resulting hydrograph from hydropower production followed by flood pool releases that can occur in the ARC, particularly during the Spring monsoon season. As shown in Figure 3, releases are limited to the power generation capacity for much of May 2015, for example, but when the pool behind Keystone Dam rises, flood pool releases are made through the tainter gate. These extended, higher flow releases can trigger fish migration and spawning with require days or weeks of continued flow to transport eggs and fish fry downstream, maintain deposited fish eggs free of accumulated sediments, scrape vegetation from sandbar islands and minimize landbridging to sandbar islands necessary for migratory bird nesting success.

As soon as water levels are below the flood pool, hydropower generation releases would once again resume based on peak energy demands. This interruption of river flow returns the aquatic ecosystem back to limiting conditions of no or low flow. As such, single flow rate (100 and 1,000 cfs) surface water acreages were then applied to environmental modeling outputs with respects to flow management measures. They represent the minimum flows that would limit ecosystem outputs regardless of periodic higher flows.

Additional flow rate analyses were considered for use in additional habitat modeling, however, the differences in output between the two structures would have been parametric for any flow rates modeled as the function and operation of the flow management measures are identical.

The additional time and funding to model outputs of variable flows would not have added planning decision benefits or changed plan selection. Storage capacity data was readily available and taken into consideration in the Is it Worth It? analysis to determine the NER.

Target Years

Target Year (TY) 0 habitat conditions are represented by the existing, or baseline, habitat conditions. The field and desktop collected data were used to describe the habitat and quantify habitat units. Target Year 0 conditions serve as a basis of comparison for both future without and future with project scenarios.

Additional TYs were identified based on when implemented measures would be expected to elicit community responses represented by changes in the projected habitat variables.

Target Year 1 is used as a standard comparison year to identify and capture changes in habitat conditions that occur within one year after measures have been constructed. Amount of wetted area, reduction in invasive species, improved water regimes are likely variables that may improve within this time period.

In general wetland diversity in restored areas can match nearby reference condition wetlands within 2-5 years. Therefore, TY 4 was selected to allow enough time for wetland plantings establishment and invasive species management to restore and stabilize the selected areas. Aquatic vegetative abundance and diversity are key variables to assess community response at this target year.

Similarly, TY 10 was selected capture the riparian habitat associated with the restored wetlands. These areas would entail targeted riparian scrub species plantings. Ten years post-planting is adequate to capture a mature riparian scrub habitat that buffers the restored wetlands. Riparian plant abundance and diversity are also key response variables for this target year.

Target Year 50 is the planning life span of the project and is used as the last projected target year for the study. Restorative measures should be produce mature habitat by this target year and represent the restored habitat types within the study area.

Habitat Analysis

The sheer number of calculations necessary to conduct a Habitat Evaluation Procedure evaluation in a study necessitates the use of automated systems to complete the assessments in a timely manner. ERDC-EL (has developed Habitat Evaluation and Assessment Tools (HEAT) to address this need (USACE, 2012). HEAT is USACE Headquarters certified and was endorsed for use on this project by the USACE Eco-PCX.

Habitat Evaluation Assessment Tools is a fully automated interface to facilitate simultaneous HEP assessments.

HEAT's HEP is a Microsoft Access® 2003-2007 software module developed by ERDC-EL to automate standard HEP calculations in an attempt to facilitate large-scale ecological assessments efficiently and effectively. The HEP module uses Microsoft Windows-compatible programming to: (1) solve complex mathematical calculations quickly, and (2) provide a highly intuitive, visual interface to facilitate communication between the system and the user. As with any sophisticated mathematical evaluation, a well-tested, efficiently written, standard software package is a critical tool that saves time, and improves the reliability and repeatability of the results. However, these modules cannot replace a sound understanding of the conceptual basis of HEP, or their application to the decision-making process. HEP should not be viewed as the end-all means to providing the only predictive environmental response to project development. Rather, the HEP module should be viewed as a tool that can provide rational, supportable, focused, and traceable evaluations of environmental effects.

The HEP module was designed to process large quantities of data quickly and efficiently, handling a large number of index models simultaneously. Each model can incorporate any number of cover types. Each model can include any number of variables, and the user can incorporate as many components or functions into each model as demanded. These capabilities support the examination of complex studies with large numbers of permutations. In some studies, it is not unusual to evaluate 10 to 15 index models (with more than 25 cover types) in an attempt to describe complex interdependencies (i.e., interrelation-ships) within the ecosystem. The large number of tedious mathematical calculations necessary to compute HEP at this level requires a powerful tool to evaluate environmental output. HEAT's HEP module, enhanced by its abilities to communicate these activities in an organized fashion, can quickly accomplish this task. The number of permutations, processing speed, and program performances are limited only by the capacity of the user's hardware, where data storage becomes the limiting factor.

The HEP module allows users to evaluate a large number of projected changes (future conditions) across numerous years for each alternative design. The HEP module allow users to assign projected values to the variables with the index models for each year considered across the life of the project (i.e., each TY). This capability allows users to manage forecasts across the long-term planning horizon. Again, the number of permutations is limited only by computer storage capacity. HEAT's HEP module evaluates any species or community HSI model. In most instances, a species or community can be described based upon its single cover type dependence. A standard HEP software package must complete these computations, regardless of whether the model utilizes a single cover type or multiple cover types. The HEP module can be used to calculate suitability for any single or multiple cover type models whether they are single- or multi-formula models.

The HEAT modules are capable of reevaluating index models as the user adapts previously created alternative designs to fit new situations. It is not necessary to reinvent indices, cover type interdependencies, or life requisite interrelationships once a standard evaluation configuration has been created. The modules allow access to previously created configurations and introduce change (e.g., adding field data, projected values, TYs, indices, cover types, acreages, etc.). This capability supports the software's utilization in a wide range of agency activities over the long term. For example, an alternative design developed to evaluate project impacts for a stream restoration study in the past can be adapted to evaluate stream restoration projects throughout the region in the future. By simply altering the cover type composition of a previously developed HEP datafile, the software can characterize and assess for regional variations, and quickly quantify impacts and/or benefits resulting from these changes. Thus, as projects are funded or evolve, these assessments can be easily implemented with little effort devoted to modeling "setup" in the HEAT system.

HEAT has a series of automated utilities designed to make the HEP process more user-friendly allowing this project to proceed on schedule while evaluating multiple restorative measures across several cover types and target years. HEAT was used to conduct species model based habitat analysis for the ARC project.

Existing/Future Without Project Conditions

Table 10 is a summary of estimated total and riverine water surface area, in acres, in the ARC comparing the existing conditions/FWOP, and the FWP. A graphic overview of the ARC project area are shown in Figures 3 and 4.

Including the existing Zink Lake pool, total water surface area in the ARC from Keystone Dam to the Tulsa County boundary at a discharge level of 100 cfs is 1,824 acres. Subtracting the 233 acres of Zink Lake pool area (elevation at 617 feet) from that total, riverine water surface area in the ARC at a flow rate of 100 cfs is 1,591 acres in Year 0. Riverine acreages diminish in the future as Zink Dam modifications and Jenks Dam construction occurs, and pools generated by these activities inundate riverine areas.

Acreage within the Zink and proposed Jenks pools were not counted as riverine habitat, as the operation and design of those structures are not part of this project.

The Zink Dam modification (from elevation 617 to 620 feet) is assumed to occur in the near future (Year 4), while the Jenks Low Water Dam completion (elevation 597 feet) is pushed further into the future (Year 10).

Acreage upstream of the potential pool structures in this study were counted as riverine habitat as the design and operation of the pool structure will maintain riverine habitat. The pool structure will facilitate sediment transport, up and downstream fish and egg passage, and maintain river flow.

Two potential locations for a pool structure, designed to capture and release Keystone Lake hydropower discharges at a rate of approximately 1,000 cfs, are near Sand Springs, OK. One location is upstream of the Hwy. 97 Bridge over the Arkansas River where a former reregulation structure existed. At an elevation of 638 feet, the pool area created by this structure is 1,112 acres. Total water surface area in the ARC in this scenario is 4,229 acres. Subtracting the existing Zink Lake pool area (233 acres) a total estimated 4,117 acres riverine water surface area at Year 1. Riverine acreages diminish in Year 4 with Zink Dam modifications to 4,023 acres. In Year 10 and beyond total riverine acreage in the ARC diminishes further with Jenks Dam construction resulting in 3,735 acres assessed for environmental benefits analysis. As in previously described scenarios, riverine acreages diminish in future years because of Zink Dam modifications and Jenks Dam construction.

Either pool structure would be able to deliver the target 1,000 cfs while providing for fish, egg, and sediment passage, however, the difference in location of the structure yields differences in key river flow performance metrics as noted in Table 11. Most notably, the RM 530 location would be able to provide river flow throughout the weekend when normal hydropower operations do not occur, whereas, the RM 531 location could not. This key parameter should be taken into consideration during *Is It Worth It?* analysis in the main report.

Table 10. Summary of estimated acreages of total and riverine water surface areas in the ARC.

Scenario	Discharge	Description	Year 0 (ac)	Year 1 (ac)	Year 4 (ac)	Year 10 (ac)	Year 50 (ac)
Existing Conditions (Without Project)	100 cfs	Total ARC Water Surface Area	4,610	4,610	4,610	4,610	4,610
		Zink Lake Pool Area	233	233	403	403	403
		Jenks Pool Area	0	0	0	472	472
		Dry River Bed	2,786	2,786	2,649	2,313	2,313
		Riverine Water Surface Area	**1,591**	**1,591**	**1,558**	**1,422**	**1,422**
Pool Structure (River Mile 531)	1,000 cfs	Total ARC Water Surface Area	4,610	4,610	4,610	4,610	4,610
		Pool Area (@ 638 structure elevation)	0	1,112	1,112	1,112	1,112
		Zink Lake Pool Area	233	233	403	403	403
		Jenks Pool Area	0	0	0	472	472
		Dry River Bed	2,786	381	306	121	121
		Riverine Water Surface Area	**1,591***	**3,996**	**3,901**	**3,614**	**3,614***
Pool Structure (River Mile 530)	1,000 cfs	Total ARC Water Surface Area	4,610	4,610	4,610	4,610	4,610
		Pool Area (@ 638 structure elevation)	0	1,321	1,321	1,321	1,321
		Zink Lake Pool Area	233	233	403	403	403
		Jenks Pool Area	0	0	0	472	472
		Dry River Bed	2,786	493	587	875	875
		Riverine Water Surface Area	**1,591***	**4,117**	**4,023**	**3,735**	**3,735***

Table 11. River Flow Comparison of the No Action, and Pool Structure at RMs 531 and 530.

Component	No Action	RM 531 Location	RM 530 Location
Storage	No Change	4,860 acre-foot storage	6,730 acre-foot storage
Adaptability	No Change	High & Low Flows due to Full & Partial Height Gates	High & Low Flows due to Full & Partial Height Gates
Flow Duration	No Change	~2.5 days @1,000 cfs (at full capacity)	~3.4 days @1,000 cfs (at full capacity)
Fish, Egg, and Sediment Passage	No Change	At least seasonal	At least seasonal

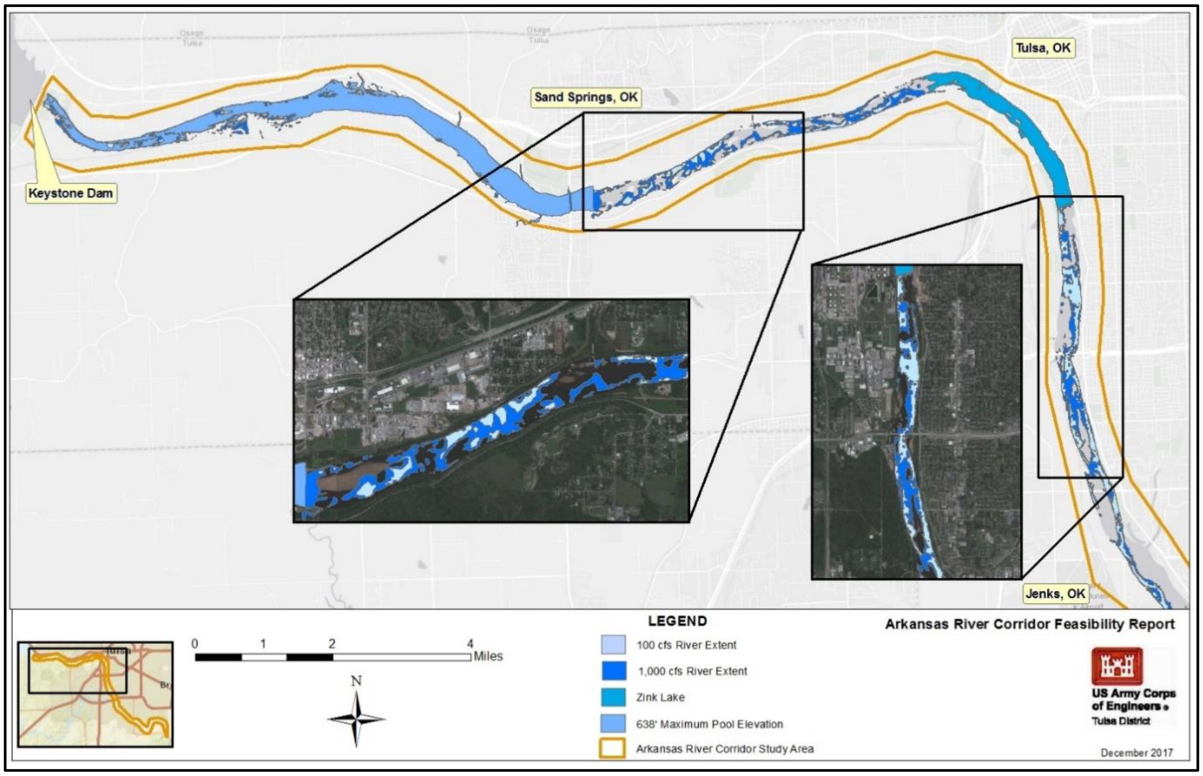

Figure 3. A comparison of FWOP and FWP water surface area in the ARC (upper region).

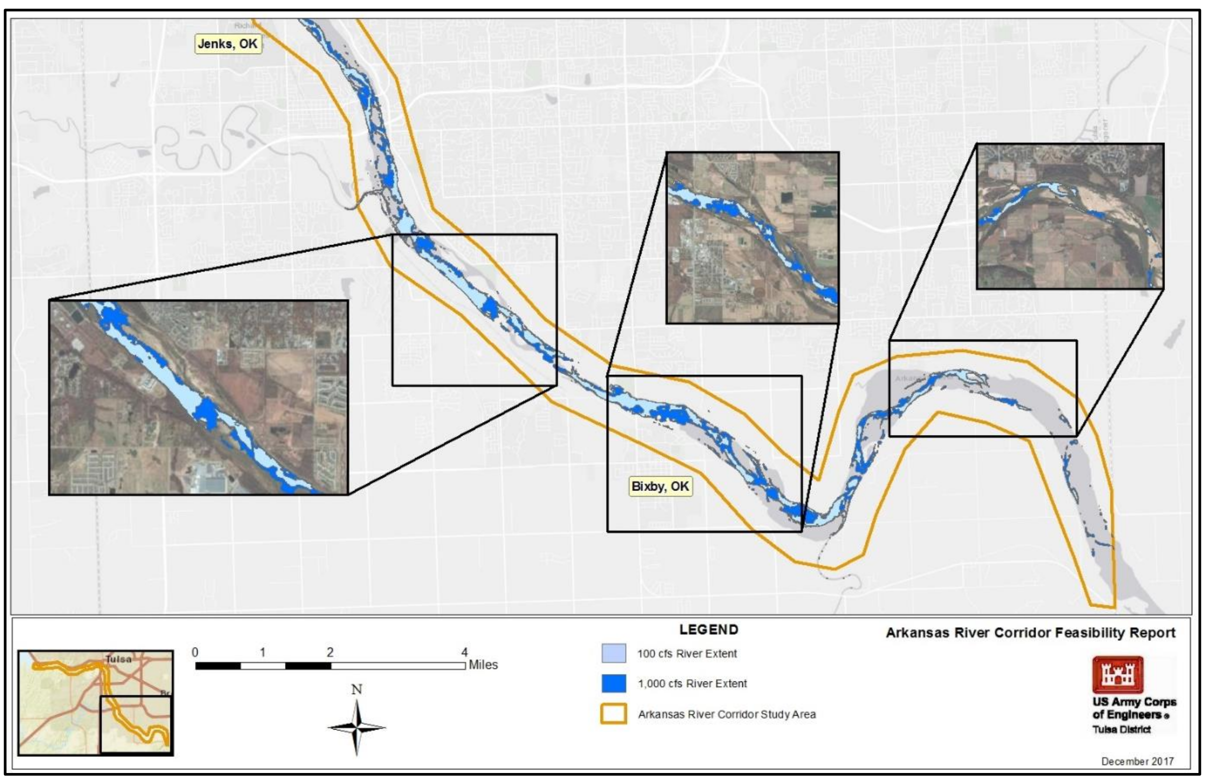

Figure 4. A comparison of FWOP and FWP water surface area in the ARC (lower region).

The alternate location for the project proposed pool structure is approximately one mile downstream from the original structure location downstream of the Hwy. 97 Bridge. A pool created by this structure at an elevation of 638 feet is 1,321 acres. Total water surface area in the ARC in this scenario is 4,350 acres. Subtracting the existing Zink Lake pool area (233 acres) from the total results in an estimated 3,996 acres riverine water surface area at Year 1. As described in the existing conditions scenarios, riverine acreages diminish in future years because of Zink Dam modifications and Jenks Dam construction. Thus, total riverine acres in Year 4, corresponding with Zink Dam modification, decrease to 3,901. In Year 10 and beyond, the construction of the Jenks Low Water Dam diminishes the total riverine acreage to 3,614 acres. Riverine acreages diminish in future years because of Zink Dam modifications and Jenks Dam construction.

Baseline Riverine Habitat Conditions Throughout the Study Area

HEAT was used to apply the habitat conditions, or HSIs from the species models, from the field and desktop data collection efforts to the HEC-RAS generated riverine habitat acreage. Habitat Units and AAHUs were then derived to serve as a basis for comparison between the Without- and With-Project scenarios. Four species were used to characterize the same riverine cover type. Each species model contained metrics that, as a whole, represented the structure and function of the ecosystem as a whole rather than just for these four species. In order to avoid under, or over, estimating habitat conditions based on any one of those species they were all weighted equally. Thus, the average Without-Project AAHUs for Least Tern, Paddlefish, Bigmouth Buffalo, and Walleye was carried forward for CE/ICA analysis for the baseline riverine habitat conditions (Table 12).

Least Tern habitat value scored higher than anticipated. The relationship between the percentage of surface and the large river system allowed Least Tern HSI value for forage to score high. The limiting HSI for the Least Tern was the nesting substrate quality. Due to altered sediment transport and extreme flow fluctuations, few areas in the study area contain the ideal mix of sand, silt, and gravel for nesting.

Paddlefish HSI scores were largely influenced by the quantity of available spawning and summer habitat. These areas consist of deeper aquatic habitats found within river systems including slackwater areas or impoundments. With the increase of Zink Dam and the anticipated South Tulsa/Jenks low water dam, a slight improvement in habitat quality was identified.

Walleye and Bigmouth Buffalo scores were low due to minimal aquatic vegetation within the ARC. The drastic changes in the river stage and flow promote little aquatic vegetation growth, especially the frequent periods of dry shoreline and riverbeds being exposed to high summer temperatures.

Table 12. Without Project Conditions for Riverine Habitat.

Without-Project Conditions- Riverine Habitat						
Least Tern						
TY 1	TY 2	HSI 1	HSI 2	Acres 1	Acres 2	HUs
0	1	0.650	0.650	1591	1591	1,034.150
1	4	0.650	0.650	1591	1558	3,070.275
4	10	0.650	0.650	1558	1422	5,811.000
10	50	0.650	0.650	1422	1422	36,972.000
					Without-Project AAHUs:	937.749
Paddlefish						
TY 1	TY 2	HSI 1	HSI 2	Acres 1	Acres 2	HUs
0	1	0.445	0.445	1591	1591	708.372
1	4	0.445	0.473	1591	1558	2,168.929
4	10	0.473	0.510	1558	1422	4,394.198
10	50	0.510	0.510	1422	1422	29,030.970
					Without-Project AAHUs:	726.049
Walleye						
TY 1	TY 2	HSI 1	HSI 2	Acres 1	Acres 2	HUs
0	1	0.183	0.183	1591	1591	290.358
1	4	0.183	0.183	1591	1558	862.039
4	10	0.183	0.183	1558	1422	1,631.551
10	50	0.183	0.183	1422	1422	10,380.600
					Without-Project AAHUs:	263.291
Bigmouth Buffalo						
TY 1	TY 2	HSI 1	HSI 2	Acres 1	Acres 2	HUs
0	1	0.000	0.000	1591	1591	0.035
1	4	0.000	0.000	1591	1558	0.104
4	10	0.000	0.000	1558	1422	0.197
10	50	0.000	0.000	1422	1422	1.252
					Without-Project AAHUs:	0.032
					Average Without-Project AAHUs:	**481.780**

Baseline Wetland and Riparian Habitat Conditions at Prattville Creek

The largely degraded tributary mouth has lost virtually all of its wetland properties. Very little function remains (Table 13). The primary driver in the function loss is the frequent ebb and flow of the area. As high flow water releases are made erosion and instant inundation coupled with extended periods of exposed dry soil limit aquatic vegetation growth.

Table 13. Without Project Conditions for Prattville Creek Wetland Habitat.

Without-Project Conditions at Prattville Creek: Wetland Habitat						
Slider Turtle						
TY 1	TY 2	HSI 1	HSI 2	Acres 1	Acres 2	HUs
0	1	0	0	5.34	5.34	0
1	4	0	0	5.34	5.34	0
4	10	0	0	5.34	5.34	0
10	50	0	0	5.34	5.34	0
					Without-Project AAHUs:	0

The riparian habitat that immediately buffers Prattville Creek is largely altered due to powerline right of way maintenance and invasive species encroachment. Namely Salt Cedar and Johnson grass. Additionally, riparian habitat quality for the Red-winged Blackbird is also tied to the adjacent wetland's aquatic plant diversity, which was shown to be poor.

Table 14. Without Project Conditions for Prattville Creek Riparian Habitat.

Without-Project Conditions at Prattville Creek: Riparian Habitat						
Red-winged Blackbird						
TY 1	TY 2	HSI 1	HSI 2	Acres 1	Acres 2	HUs
0	1	0.000	0.001	2.24	2.24	0.001
1	4	0.001	0.001	2.24	2.24	0.007
4	10	0.001	0.001	2.24	2.24	0.013
10	50	0.001	0.001	2.24	2.24	0.090
					Without-Project AAHUs:	0.002

Similar wetland conditions existing at the I-44/Riverside location. The only difference in this area was a small area impounded by riprap that maintained a small wetted area. This area exhibited small patches of aquatic vegetation, thus the small increase in habitat value. Numerous slider turtles were also seen in the survey area.

Table 15. Without Project Conditions for I-44/Riverside Wetland Habitat.

Without-Project Conditions at I-44/Riverside: Wetland Habitat						
Slider Turtle						
TY 1	TY 2	HSI 1	HSI 2	Acres 1	Acres 2	HUs
0	1	0.120	0.120	0.55	0.55	0.066
1	4	0.120	0.120	0.55	0.55	0.198
4	10	0.120	0.120	0.55	0.55	0.396
10	50	0.120	0.120	0.55	0.55	2.640
					Without-Project AAHUs:	0.066

Once again riparian habitat was largely missing except for small patches of Salt Cedar. Habitat value remained virtually non-existent.

Table 16. Without Project Conditions for I-44/Riverside Riparian Habitat.

Without-Project Conditions at I-44/Riverside: Riparian Habitat						
Red-winged Blackbird						
TY 1	TY 2	HSI 1	HSI 2	Acres 1	Acres 2	HUs
0	1	0.000	0.000	1.58	1.58	0.000
1	4	0.000	0.000	1.58	1.58	0.000
4	10	0.000	0.000	1.58	1.58	0.001
10	50	0.000	0.000	1.58	1.58	0.006
Without-Project AAHUs:						0.000

Baseline Sandbar Habitat Conditions near the Indians Springs Sports Complex

In order to assess an area for sandbar island restoration, the Least Tern's riverine cover type model was applied as the sandbar islands reside within the river channel. The area surveyed is noted to have increased Least Tern nesting presence. The relationship between the percentage of shoreline vegetated to open water habitat dictated the area's habitat quality. The shorelines in this area are heavily vegetated giving Least Tern's little option for shoreline nesting. However, foraging opportunities and nesting substrate scored higher as this area is located within the lower extent of the study area farther away from Keystone Dam which attenuates some of the high energy from water releases. This allows for more diverse substrates to remain in the river channel as well as increased fish abundance.

Table 17. Without Project Conditions for Indian Springs Sandbar Habitat.

Without-Project Conditions at Indian Springs: Sandbar (Riverine) Habitat						
Least Tern						
TY 1	TY 2	HSI 1	HSI 2	Acres 1	Acres 2	HUs
0	1	0.4	0.4	5	5	2.0
1	4	0.4	0.4	5	5	6.0
4	10	0.4	0.4	5	5	12.0
10	50	0.4	0.4	5	5	80.0
Without-Project AAHUs:						2.00

Measure Sites, Development, and Conceptual Design

USACE assessed an array of alternatives during the plan formulation stage of the Feasibility Investigation to meet the Project's Purpose and Need. Plan formulation is the process of building alternative plans that meet planning objectives and avoid planning constraints. Alternative plans are a set of one or more management measures functioning together to address one or more planning objectives. A management measure is a feature or activity that can be implemented at a specific geographic site to address one or more planning objectives.

The range of alternatives to meet the purpose and need are bound by those ecosystem restoration items addressed in the ARC Master Plan which served as the basis for the list of potential management measures. General locations within the study area are depicted on Figure 5.

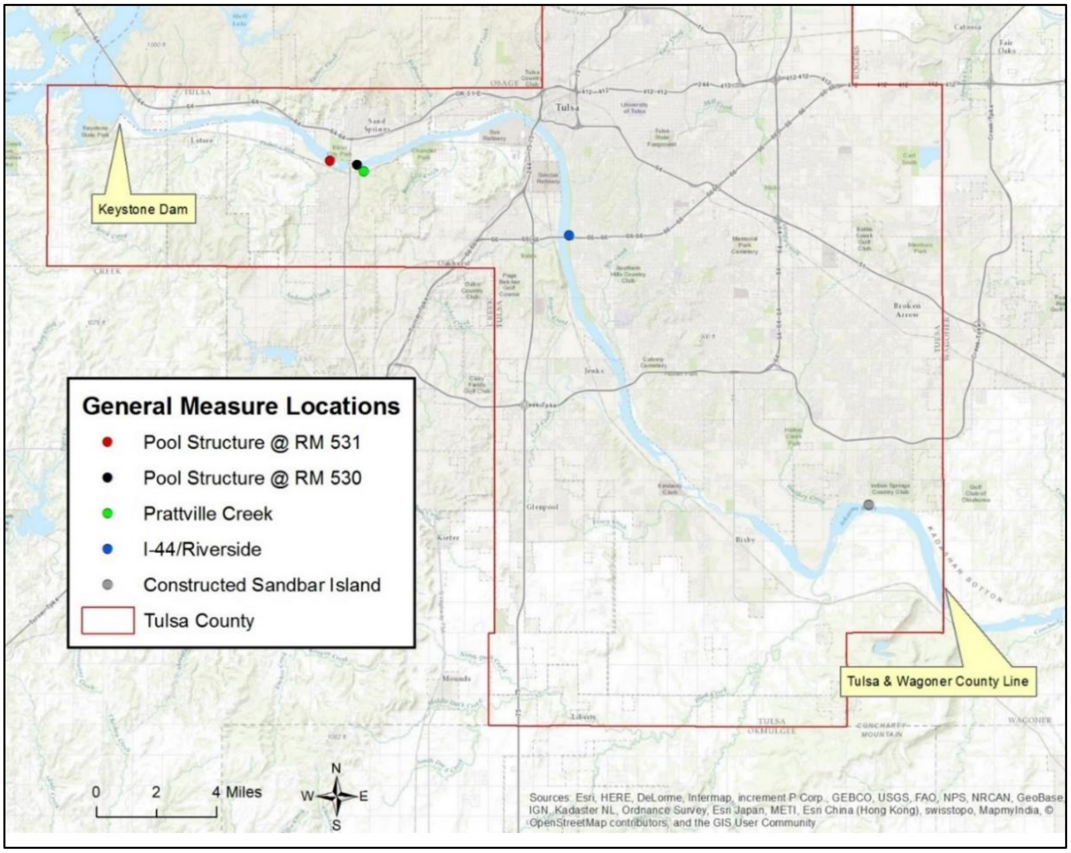

Figure 5. General Measure Locations within the Arkansas River Corridor

A flow regime management measure is to construct a pool control structure using state-of-the art technology. The pool control structure will be designed to alleviate periods of no instream flow between hydropower generation pulses and during extended periods of no hydropower generation. The pool structure will function similarly to a reregulation dam removed in 1985 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 will capture and slowly release hydropower discharge pulses and include additional design features addressing safety concerns, and sediment and fish passage. Proposed pool structure storage capacity was developed (at each location) through modeling (Hydrologic Engineering Centers River 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% 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. There are 2 candidate sites for pool control structures. River mile 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. An instream pool control structure is a prerequisite for all other management measures. Sites further downstream from the RM 530 location were screened out due to potential Hazardous Toxic Radiologic Waste (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.

The design of the proposed structure will capture and slowly release peaking hydropower 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 height of 638 feet, the pool volume capacity is approximately 4,860 acre-feet with a pool surface area of 1,112 acres (Figure 6). 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 design of the proposed structure will capture and slowly release peaking hydropower 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 height of 638 feet, the pool volume capacity is approximately 6,730 acre-feet with a pool surface area of 1,321 acres (Figure 6). 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.

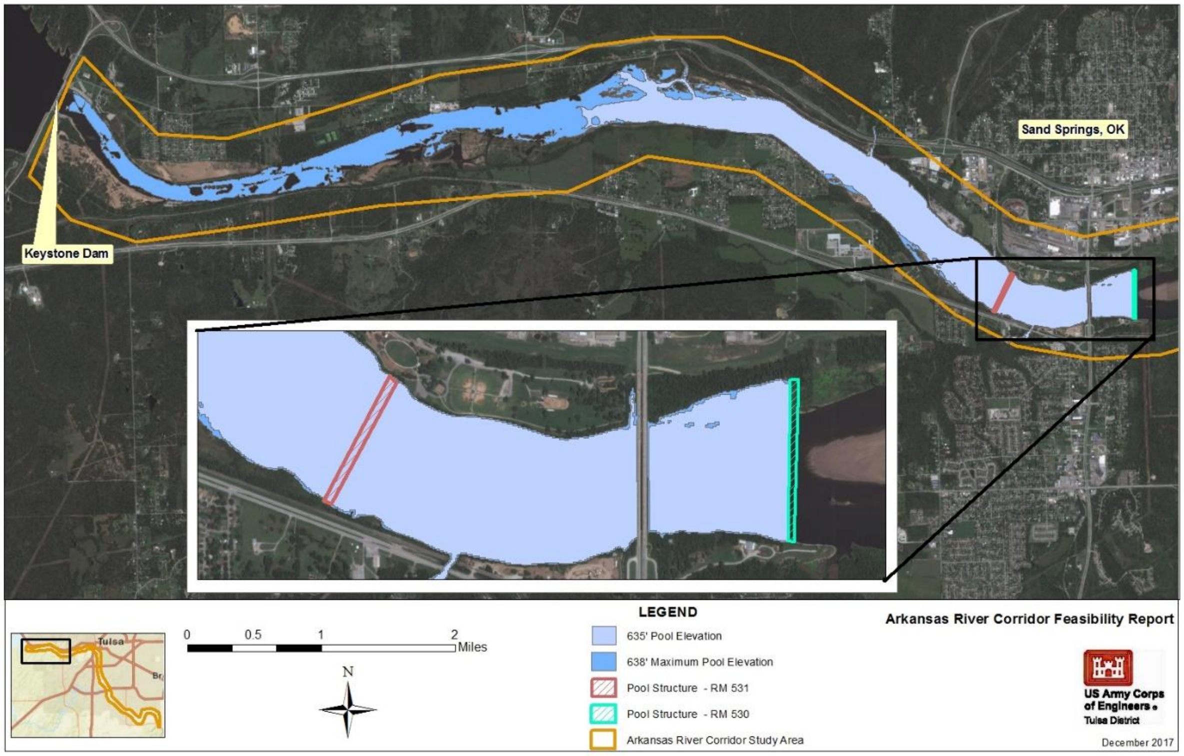

Figure 6. Potential locations for a pool structure: RM 531 (Old reregulation dam [removed in 1985] site) or RM 530 near Sand Springs, OK.

Prattville Creek is a right-bank tributary to the Arkansas River downstream of the Highway 97 Bridge at Sand Springs, Oklahoma (Figure 6). 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. An engineered rocked riffle with weighted toe placed at the mouth of Prattville Creek at a maximum elevation of approximately 640 feet. The structure will impound flows from Prattville Creek, and will 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 ARC 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 will 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 restored wetland will primarily provide additional shallow water aquatic habitat to the ARC system, and an area immediately upstream of the rock riffle conducive to velocity refuge, and nursery habitat for fish.

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 will maintain bank stability.

The rock riffle structure is a prerequisite for riparian and wetland plantings. Those plantings within the existing Public Service Company of Oklahoma (PSO) electrical transmission corridor will 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 will 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, and Redosier Dogwood (*Cornus sericea*) (approximately 5 feet on center). Riparian planting will provide additional bank/slope stabilization, shading for wetland area edge zones, allochthonous organic input into the wetland system, and provide forage and cover for insects, amphibians, mammals, and birds.

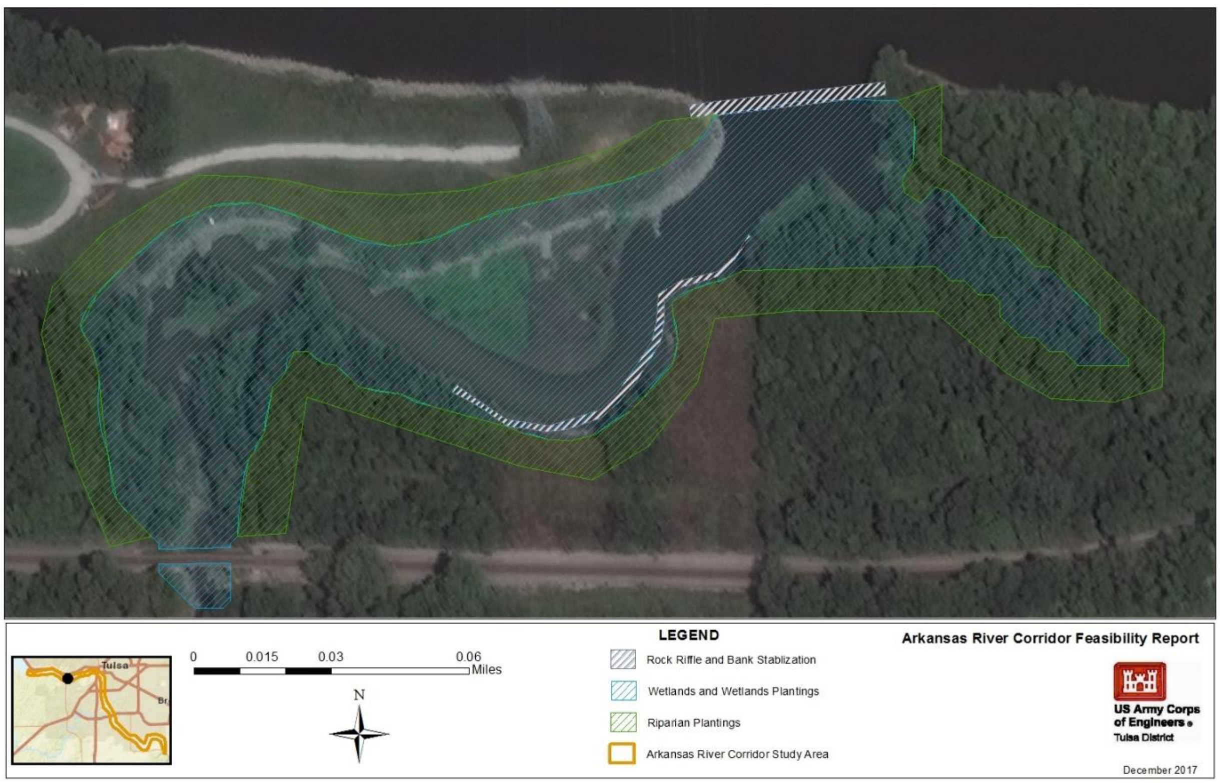

Figure 7. Prattville Creek Wetland Restoration Measures

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 Arkansas River just upstream of I-44 Bridge (Figure 8). Rock riffle features will 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, will be composed of sized rock able to withstand anticipated maximum velocities in the Arkansas River. Each wing deflector will 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 [approx. 10-20 degrees]. Instream elevations of the wing deflectors (approximately 607.1 feet) will 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 will generate instream slackwater areas. The measure will provide additional resilient wetland areas totaling 0.55 acres, and velocity refuge zones for fish and wildlife within the ARC.

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), will 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, Common Rush, 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 will 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.

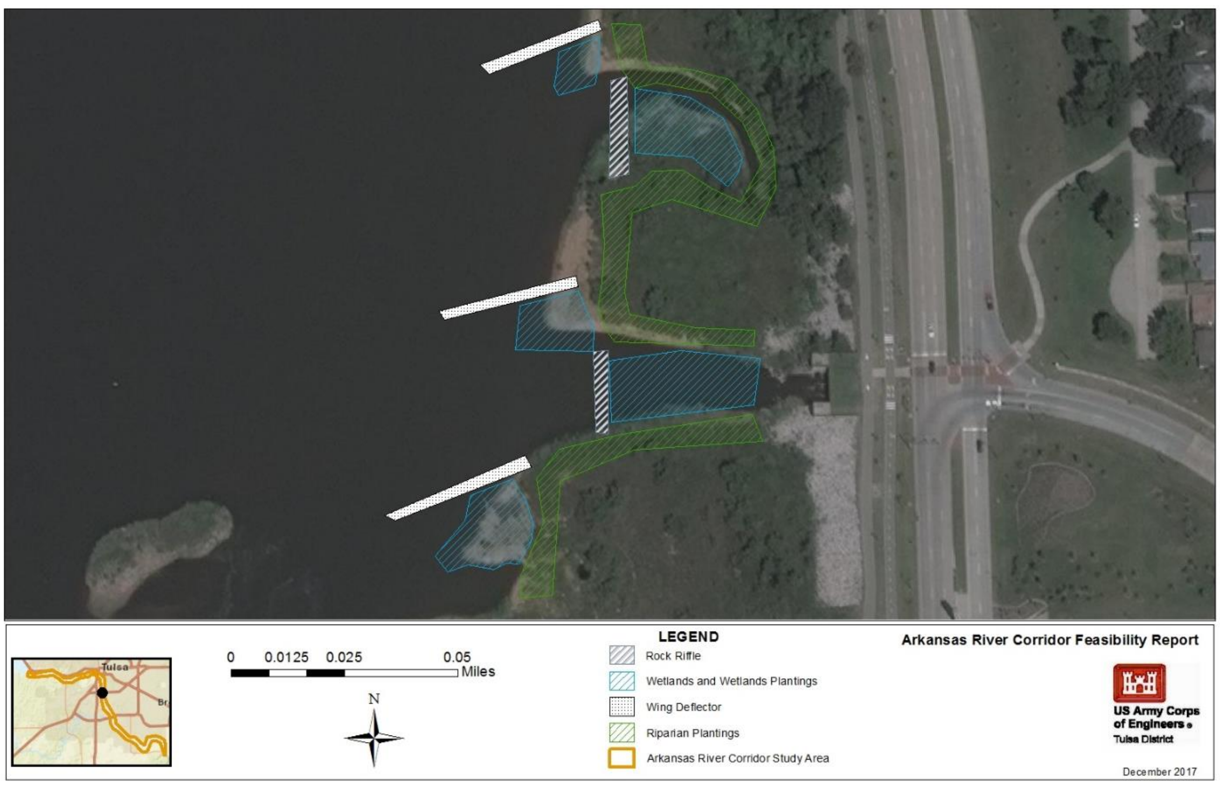

Figure 8. I-44/Riverside Wetlands and Slackwater

In order to restore Least Tern nesting habitat capable of withstanding reoccurring hydropower releases, a constructed sandbar island would needed to maintain adequate elevation. This management measure increases nesting habitat for the Interior Least Tern. While Keystone Dam has limited sediments available within the study area, other sandbar islands still exist.

Therefore, it is believed that enough sediments are passed through Keystone Dam or orginate from tributaries below the dam to create and maintain the proposed sandbar island.

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. Sandbar islands that remain unsubmerged during flows reaching 20,000 promote more reliable, sustainable Least Tern nesting habitat. The constructed sandbar would be approximately 5 acres in size. Approximately 3 acres of which would sustain nesting habitat during flows reaching 20,000 cfs. The sandbar island will be circular to oblong in shape, with maximum surface area and a surface height above water to exceed 18 inches at nest initiation that is usually in May or June. Based on an Oklahoma State University design (developed for the USACE-Tulsa District in May 2003), the proposed tern island will develop approximately 5 acres of surface area at 1,000 cfs flow in the Arkansas River. 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 will promote sandbar development about the riprap structures, and provide scour to limit vegetative growth on sandbars when developed. The proposed location is in the Arkansas River just south of the Indian Springs Sports Complex in Broken Arrow, Oklahoma (Figure 9). Based on consultation with the U.S. Fish and Wildlife Service 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 nesting substrate for the constructed island consist of native riverine sediments ranging in size from fine sand to small stones. Sediment movement during high (flood control) releases from Keystone Dam (flows > 20,000 cfs) will accumulate adjacent to placed rock chevrons ensuring development of additional, exposed, and resilient least tern island nesting habitat area of approximately 3 acres at flows up to 20,000 cfs

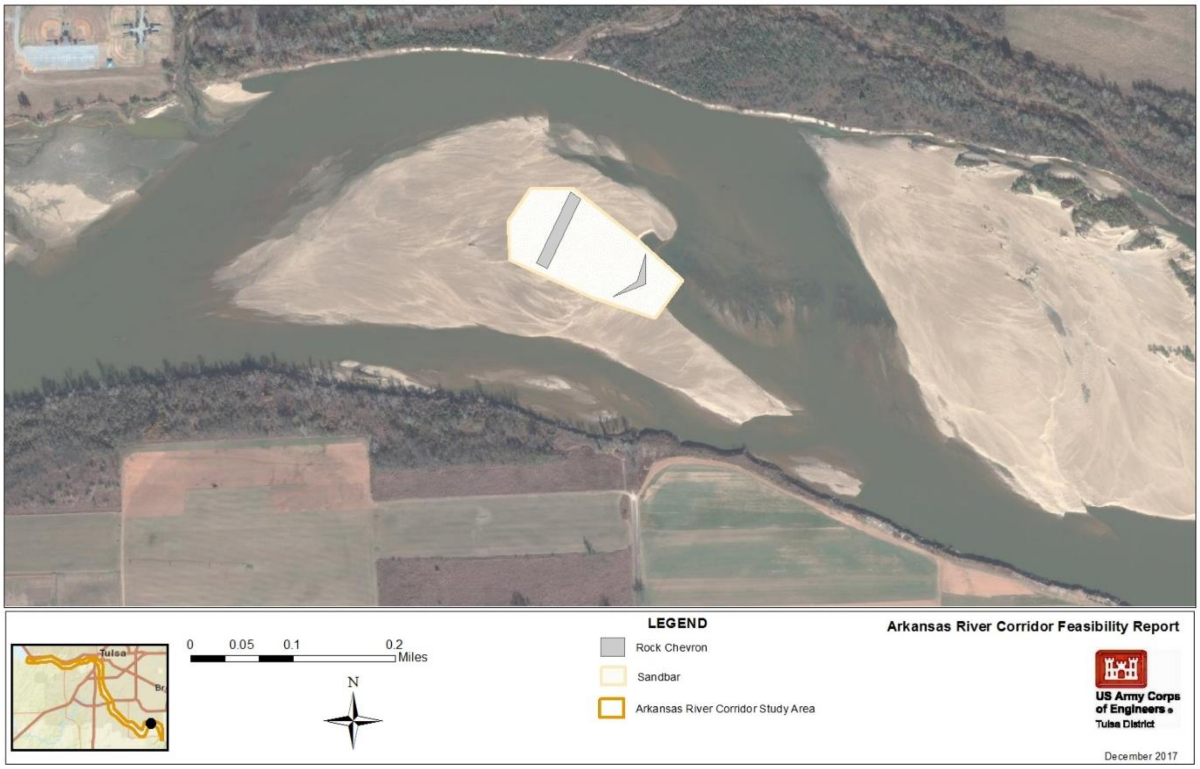

Figure 9. Constructed Least Tern Island

Future With Project Conditions- Pool Structure @ 531

With the implementation of a pool structure at river mile 531, the quantity of riverine habitat increases by 2,023 acres. The additional acres of riverine habitat occur within the banks of the of Arkansas River on what is dry river bed and sandy substrates during the low flow conditions. These dry areas have zero value in regards to riverine habitat. This is the major driver of the gain in net habitat benefits (Table 18). The expansion of available habitat on a large scale offers all aquatic species in the study area increased resources to fulfill their cover, forage, and reproductive needs.

While vast improvements were made in the amount of available surface area water, again the Least Tern habitat quality was limited by the existing substrate composition. Not captured in the model was the restoration of existing sandbar island habitat. Restored river flow maintains the river barrier between disturbances and the nesting areas.

Modest habitat quality improvements were once again made for the Paddlefish, however the pool structure affords the Paddlefish access to more breeding and summer habitat. Perhaps the greatest improvement, although not captured in the model, was the restoration of river reach connectivity. This will allow expanded migratory routes and access to additional spawning grounds within the ARC.

Walleye habitat quality remaining stagnant, although aquatic vegetation was projected to increase in small increments. Still, not enough to capture an increase in the Walleye model.

However, the Bigmouth Buffalo was able to register habitat quality improvements. These were primarily driven by the projected increases in shorelines and backwater aquatic vegetation. Although not projected to be large swaths of vegetated areas. Smaller, narrows areas along the shoreline in protected areas will have a marked impact on the amount of nursery and refuge area for forage fish and aquatic invertebrates.

Future With Project Conditions- Pool Structure @ 530

With the implementation of a pool structure at river mile 530, the quantity of riverine habitat increases by 2,144 acres. The additional acres of riverine habitat occur within the banks of the of Arkansas River on what is dry river bed and sandy substrates during the low flow conditions. These dry areas have zero value in regards to riverine habitat. Once again this is the major driver of the gain in net habitat benefits. The two locations offer the same riverine benefits downstream of the structures (Table 19). The only difference is the area between the two pool structures. The pool structure at river mile 530 offers and additional 121 acres of riverine habitat containing depth and flow diversity as well as shoreline and backwater microhabitats.

Again small to modest increases in surface area water, shoreline and backwater aquatic vegetation, and areas of deeper water were projected. Largely the same limitations that applied to the same measure at river mile 531 applied to this location as well.

Table 18. With Project Conditions for Riverine Habitat.

With-Project Conditions: Pool Structure @ River Mile 531: Riverine Habitat						
Least Tern						
TY 1	TY 2	HSI 1	HSI 2	Acres 1	Acres 2	HUs
0	1	0.650	0.650	1591	3996	1,815.775
1	4	0.650	0.650	3996	3901	7,699.575
4	10	0.650	0.650	3901	3614	14,654.250
10	50	0.650	0.650	3614	3614	93,964.000
					With-Project AAHUs:	2,362.672
					Net AAHUs:	1,424.920
Paddlefish						
TY 1	TY 2	HSI 1	HSI 2	Acres 1	Acres 2	HUs
0	1	0.445	0.541	1591	3996	1,397.125
1	4	0.541	0.543	3996	3901	6,421.785
4	10	0.543	0.580	3901	3614	12,657.760
10	50	0.580	0.590	3614	3614	84,628.230
					With-Project AAHUs:	2,102.098
					Net AAHUs:	1,376.050
Walleye						
TY 1	TY 2	HSI 1	HSI 2	Acres 1	Acres 2	HUs
0	1	0.183	0.183	1591	3996	509.814
1	4	0.183	0.183	3996	3901	2,161.805
4	10	0.183	0.183	3901	3614	4,114.464
10	50	0.183	0.183	3614	3614	26,382.210
					With-Project AAHUs:	663.366
					Net AAHUs:	400.070
Bigmouth Buffalo						
TY 1	TY 2	HSI 1	HSI 2	Acres 1	Acres 2	HUs
0	1	0.000	0.005	1591	3996	8.368
1	4	0.005	0.011	3996	3901	93.151
4	10	0.011	0.028	3901	3614	427.620
10	50	0.028	0.031	3614	3614	4229.321
					With-Project AAHUs:	95.169
					Net AAHUs:	95.137
					Average Net With-Project AAHUs:	824.05

Future With Project Conditions: Pool Structure @ RM 530

Table 19. With Project Conditions for Riverine Habitat.

With-Project Conditions: Pool Structure @ River Mile 530: Riverine Habitat						
Least Tern						
TY 1	TY 2	HSI 1	HSI 2	Acres 1	Acres 2	HUs
0	1	0.650	0.650	1591	4117	1,855.100
1	4	0.650	0.650	4117	4023	7,936.500
4	10	0.650	0.650	4023	3735	15,128.100
10	50	0.650	0.650	3735	3735	97,100.000
					With-Project AAHUs:	2,440.594
					Net AAHUs:	1,502.850
Paddlefish						
TY 1	TY 2	HSI 1	HSI 2	Acres 1	Acres 2	HUs
0	1	0.445	0.541	1591	4117	1,427.934
1	4	0.541	0.543	4117	4023	6,619.393
4	10	0.543	0.580	4023	3735	13,067.210
10	50	0.580	0.590	3735	3735	87,461.660
					With-Project AAHUs:	2,171.524
					Net AAHUs:	1,445.475
Walleye						
TY 1	TY 2	HSI 1	HSI 2	Acres 1	Acres 2	HUs
0	1	0.183	0.183	1591	4117	520.855
1	4	0.183	0.183	4117	4023	2,228.326
4	10	0.183	0.183	4023	3735	4,247.507
10	50	0.183	0.183	3735	3735	27,265.510
					With-Project AAHUs:	685.244
					Net AAHUs:	421.950
Bigmouth Buffalo						
TY 1	TY 2	HSI 1	HSI 2	Acres 1	Acres 2	HUs
0	1	0.000	0.005	1591	4117	8.730
1	4	0.005	0.011	4117	4023	97.722
4	10	0.011	0.028	4023	3735	449.235
10	50	0.028	0.031	3735	3735	4,446.944
					With-Project AAHUs:	100.053
					Net AAHUs:	100.021
					Average Net With-Project AAHUs:	867.57

Future With Project Conditions: Prattville Creek – Wetland Habitat

Immediate habitat improvements were projected with the implementation of a rock riffle complex to provide the hydroperiod necessary to support moist soil and aquatic vegetation (Table 20). This promotes a diverse wetland habitat.

Table 20. With Project Conditions for Wetland Habitat.

With-Project Conditions: Prattville Creek - Rock Riffle Complex						
Slider Turtle						
TY 1	TY 2	HSI 1	HSI 2	Acres 1	Acres 2	HUs
0	1	0	0.289	5.34	5.34	0.771
1	4	0.289	0.378	5.34	5.34	5.340
4	10	0.378	0.467	5.34	5.34	13.528
10	50	0.467	0.556	5.34	5.34	109.173
					With-Project AAHUs:	2.576
					Net AAHUs:	2.58

Further increasing diversity while shortening the time to wetland maturity, additional wetland plantings are projected to restore a functioning wetland system at this locations (Table 21).

Table 21. With Project Conditions for Wetland Habitat.

With-Project Conditions: Prattville Creek – Rock Riffle Complex + Wetland Plantings						
Slider Turtle						
TY 1	TY 2	HSI 1	HSI 2	Acres 1	Acres 2	HUs
0	1	0	0.556	5.34	5.34	0.989
1	4	0.556	0.822	5.34	5.34	11.036
4	10	0.822	1.000	5.34	5.34	29.192
10	50	1.000	1.000	5.34	5.34	213.600
					With-Project AAHUs:	5.096
					Net AAHUs:	5.10

Although buffering riparian habitat would further benefit nesting and resting migratory birds and reduce erosion and sedimentation of the wetland, no added benefits were captured when projected both rock riffles and riparian plantings at the Prattville Creek site (Table 22).

Table 22. With Project Conditions for Wetland Habitat.

With-Project Conditions: Prattville Creek – Rock Riffle Complex + Riparian Plantings						
Slider Turtle						
TY 1	TY 2	HSI 1	HSI 2	Acres 1	Acres 2	HUs
0	1	0	0.289	5.34	5.34	0.771
1	4	0.289	0.378	5.34	5.34	5.340
4	10	0.378	0.467	5.34	5.34	13.528
10	50	0.467	0.556	5.34	5.34	109.173
With-Project AAHUs:						2.576
Net AAHUs:						2.58

As described above, the measure combination of rock riffles and wetland plantings restores wetland structure and function. The additional of riparian plantings to the projection did not add to the habitat quality (Table 23).

Table 23. With Project Conditions for Wetland Habitat.

With-Project Conditions: Prattville Creek – Rock Riffle Complex + Riparian Plantings + Wetlands Plantings						
Slider Turtle						
TY 1	TY 2	HSI 1	HSI 2	Acres 1	Acres 2	HUs
0	1	0	0.556	5.34	5.34	0.989
1	4	0.556	0.822	5.34	5.34	11.036
4	10	0.822	1.000	5.34	5.34	29.192
10	50	1.000	1.000	5.34	5.34	213.600
With-Project AAHUs:						5.096
Net AAHUs:						5.10

Future With Project Conditions: Prattville Creek – Riparian Habitat

The construction of a rock riffle complex to maintain hydroperiod for moist soil and aquatic habitat increases habitat quality in the Red-winged Blackbird model marginally (Table 24). However, wetland and riparian plant diversity would still remain low and limiting to habitat quality.

Table 24. With Project Conditions for Riparian Habitat.

With-Project Conditions: Prattville Creek - Rock Riffle Complex						
Red-winged Blackbird						
TY 1	TY 2	HSI 1	HSI 2	Acres 1	Acres 2	HUs
0	1	0.000	0.001	2.24	2.24	0.001
1	4	0.001	0.001	2.24	2.24	0.007
4	10	0.001	0.001	2.24	2.24	0.013
10	50	0.001	0.001	2.24	2.24	0.090
					With-Project AAHUs:	0.002
					Net AAHUs:	0

Adding riparian plantings to the rock riffle measure increases habitat quality, only slightly though due to carp likely present in the area.

Table 25. With Project Conditions for Riparian Habitat.

With-Project Conditions: Prattville Creek – Rock Riffle Complex + Riparian Plantings						
Red-winged Blackbird						
TY 1	TY 2	HSI 1	HSI 2	Acres 1	Acres 2	HUs
0	1	0.000	0.010	2.24	2.24	0.011
1	4	0.010	0.010	2.24	2.24	0.067
4	10	0.010	0.010	2.24	2.24	0.134
10	50	0.010	0.010	2.24	2.24	0.896
					With-Project AAHUs:	0.022
					Net AAHUs:	0.02

Replacing riparian plantings with wetland plantings yields similar results (Table 26). The need for a diverse plant community to produce both forage and cover is evident in the Red-winged Blackbird model.

Table 26. With Project Conditions for Riparian Habitat.

With-Project Conditions: Prattville Creek – Rock Riffle Complex + Wetland Plantings						
Red-winged Blackbird						
TY 1	TY 2	HSI 1	HSI 2	Acres 1	Acres 2	HUs
0	1	0	0.010	2.24	2.24	0.011
1	4	0.010	0.010	2.24	2.24	0.067
4	10	0.010	0.010	2.24	2.24	0.134
10	50	0.010	0.010	2.24	2.24	0.896
					With-Project AAHUs:	0.022
					Net AAHUs:	0.02

The combination of all three measures at the Prattville Creek location allows for the greatest increase in the habitat quality (Table 27). Yet again, only slight gains are produced due to the limiting factor being carp access to the restoration site.

Table 27. With Project Conditions for Riparian Habitat.

With-Project Conditions: Prattville Creek – Rock Riffle Complex + Riparian Plantings + Wetland Plantings						
Red-winged Blackbird						
TY 1	TY 2	HSI 1	HSI 2	Acres 1	Acres 2	HUs
0	1	0	0.100	2.24	2.24	0.112
1	4	0.100	0.100	2.24	2.24	0.672
4	10	0.100	0.100	2.24	2.24	1.344
10	50	0.100	0.100	2.24	2.24	8.960
					With-Project AAHUs:	0.222
					Net AAHUs:	0.22

Future With Project Conditions: I-44/Riverside – Wetland Habitat

Similar to the projected wetland conditions at the Prattville Creek area, habitat improvements were projected with the implementation of a rock riffle complex to provide the hydroperiod necessary to support moist soil and aquatic vegetation (Table 28). This promotes a diverse wetland habitat and increased habitat value.

Table 28. With Project Conditions for Wetland Habitat.

With-Project Conditions: Riverside - Rock Riffle Complex						
Slider Turtle						
TY 1	TY 2	HSI 1	HSI 2	Acres 1	Acres 2	HUs
0	1	0.120	0.289	0.55	0.55	0.112
1	4	0.289	0.378	0.55	0.55	0.550
4	10	0.378	0.467	0.55	0.55	1.393
10	50	0.467	0.556	0.55	0.55	11.244
					With-Project AAHUs:	0.266
					Net AAHUs:	0.200

Likewise, when wetland plantings are paired with the rock riffle complex, the wetland area is projected to be fully restored (Table 29).

Table 29. With Project Conditions for Wetland Habitat.

With-Project Conditions: Riverside – Rock Riffle Complex + Wetland Plantings						
Slider Turtle						
TY 1	TY 2	HSI 1	HSI 2	Acres 1	Acres 2	HUs
0	1	0.120	0.566	0.55	0.55	0.186
1	4	0.556	0.822	0.55	0.55	1.137
4	10	0.822	1.00	0.55	0.55	3.007
10	50	1.00	1.00	0.55	0.55	22.000
					With-Project AAHUs:	0.527
					Net AAHUs:	0.460

Again, while there are obvious buffering qualities, riparian plantings do not increase habitat value when compared to implementing the rock riffle complex alone (Table 30).

Table 30. With Project Conditions for Wetland Habitat.

With-Project Conditions: Riverside – Rock Riffle Complex + Riparian Plantings						
Slider Turtle						
TY 1	TY 2	HSI 1	HSI 2	Acres 1	Acres 2	HUs
0	1	0.120	0.289	0.55	0.55	0.112
1	4	0.289	0.378	0.55	0.55	0.550
4	10	0.378	0.467	0.55	0.55	1.393
10	50	0.467	0.556	0.55	0.55	11.244
					With-Project AAHUs:	0.266
					Net AAHUs:	0.200

Wetland habitat quality is projected to be maximized with the combination of rock riffles and wetland plantings to supplement any native vegetation that may exist to fully diversify the area (Table 31). Adding riparian plantings to this scenario did not increase the habitat quality in the models.

Table 31. With Project Conditions for Wetland Habitat.

With-Project Conditions: Riverside – Rock Riffle Complex + Riparian Plantings + Wetlands Plantings						
Slider Turtle						
TY 1	TY 2	HSI 1	HSI 2	Acres 1	Acres 2	HUs
0	1	0.120	0.566	0.55	0.55	0.186
1	4	0.556	0.822	0.55	0.55	1.137
4	10	0.822	1.00	0.55	0.55	3.007
10	50	1.00	1.00	0.55	0.55	22.000
					With-Project AAHUs:	0.527
					Net AAHUs:	0.460

Future With Project Conditions: I-44/Riverside Riparian Habitat

The addition of a rock riffle complex to maintain hydroperiod for moist soil and aquatic habitat increased habitat quality in the Red-winged Blackbird marginally (Table 32). However, wetland and riparian plant diversity would still remain low and limiting to habitat quality.

Table 32. With Project Conditions for Riparian Habitat.

With-Project: Riverside - Rock Riffle Complex						
Red-winged Blackbird						
TY 1	TY 2	HSI 1	HSI 2	Acres 1	Acres 2	HUs
0	1	0.000	0.001	1.58	1.58	0.001
1	4	0.001	0.001	1.58	1.58	0.005
4	10	0.001	0.001	1.58	1.58	0.009
10	50	0.001	0.001	1.58	1.58	0.063
					With-Project AAHUs:	0.002
					Net AAHUs:	0.002

Riparian plantings, in addition to the rock riffle increases the habitat quality, however the possible presence of carp, an invasive fish species known to impact aquatic plant communities minimizes the output of the habitat in the Red-winged Blackbird model (Table 33).

Table 33. With Project Conditions for Riparian Habitat.

With-Project: Riverside – Rock Riffle Complex + Riparian Plantings						
Red-winged Blackbird						
TY 1	TY 2	HSI 1	HSI 2	Acres 1	Acres 2	HUs
0	1	0.000	0.010	1.58	1.58	0.008
1	4	0.010	0.010	1.58	1.58	0.047
4	10	0.010	0.010	1.58	1.58	0.095
10	50	0.010	0.010	1.58	1.58	0.632
					With-Project AAHUs:	0.016
					Net AAHUs:	0.02

With the combination of the rock riffle and wetland plantings, the Red-winged Blackbird models shows similar improvements in habitat quality to the combination of the rock riffle and riparian plantings due to the increases in plant diversity (Table 34).

Table 34. With Project Conditions for Riparian Habitat.

With-Project: Riverside – Rock Riffle Complex + Wetland Plantings						
Red-winged Blackbird						
TY 1	TY 2	HSI 1	HSI 2	Acres 1	Acres 2	HUs
0	1	0.000	0.010	1.58	1.58	0.008
1	4	0.010	0.010	1.58	1.58	0.047
4	10	0.010	0.010	1.58	1.58	0.095
10	50	0.010	0.010	1.58	1.58	0.632
					With-Project AAHUs:	0.016
					Net AAHUs:	0.02

The combination of all measures possible at the I-44/Riverside site yields the highest increase in habitat quality (Table 35). However, the likelihood of carp in the area prevents and significant increases in habitat quality.

Table 35. With Project Conditions for Riparian Habitat.

With-Project: Riverside – Rock Riffle Complex + Riparian Plantings + Wetland Plantings						
Red-winged Blackbird						
TY 1	TY 2	HSI 1	HSI 2	Acres 1	Acres 2	HUs
0	1	0.000	0.100	1.58	1.58	0.079
1	4	0.100	0.100	1.58	1.58	0.474
4	10	0.100	0.100	1.58	1.58	0.948
10	50	0.100	0.100	1.58	1.58	6.320
					With-Project AAHUs:	0.156
					Net AAHUs:	0.16

Future With Project Conditions: Indian Springs – Sandbar Island Habitat

With restored river flow, the Indian Springs area provides foraging areas for the Least Tern. Nesting habitat would be limited due to shoreline vegetation. However, with the construction of a sandbar island, the combination of abundant forage fish, isolated nesting grounds, and the chevrons structures maintaining substrate diversity, the conditions are set for ideal Least Tern habitat (Table 36).

Table 36. With Project Conditions for Sandbar Habitat.

Least Tern						
With-Project: Constructed Sandbar Island						
TY 1	TY 2	HSI 1	HSI 2	Acres 1	Acres 2	HUs
0	1	0.4	1.0	5	5	3.5
1	4	1.0	1.0	5	5	15.0
4	10	1.0	1.0	5	5	30.0
10	50	1.0	1.0	5	5	200.0
					With-Project AAHUs:	4.97
					Net AAHUs:	2.97

To conduct the CE/ICA analysis, these environmental restoration benefits (increase in with-project Average Annual Habitat Units) and annual costs (expressed in thousands of dollars) were entered into the IWR Planning Suite, resulting in an array of Best Buy Plans for the study that provide ecological benefits to resident and migratory birds, as well as native fish and other biotic components utilizing the ARC. The feasibility level Monitoring and Adaptive Management Plan can be found in Attachment 3.

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Attachment 1: Arkansas River Corridor Conceptual Ecosystem Model

	Arkansas River Corridor					Keystone Dam		
DRIVERS	Partial levee	Sand mining	Urbanization / Industrialization	Channelization	Constructed Bank Stabilization	Hydropower	Flood Control	Existing Impoundment
STRESSORS	loss of riparian corridor	modification of natural sand structure and function develoment / migration	poor water quality	allochthonous material input	loss of vegetative cover	Unnatural riverine flows	Unnatural riverine flows	unbalanced / altered sediment transport
			Disturbance			highly variable daily flows	extreme high flows	aquatic species migration barrier
ECOLOGICAL EFFECTS	decreased water quality/temperature - loss of shade	loss of sandbar habitat	invasive/non-native species	decreased productivity	loss/interuption of trophic interationships	drying-out of aquatic habitat	loss of natural braided aquatic system (including slackwater/backwater habitat loss)	loss of riverine biodiversity
	loss flood plain interaction	loss of refuge pools	shift of fish community to more tolerant species			increased disturbance/predation on nesting colonies	loss of sustainable sandbar habitat and vegetated island habitat	loss of aquatic structure / heterogeniety
	loss of invertebrate production / diversity		loss of bank seepage due to lack recharge					
	loss of terrestrial heterogeniety							
PERFORMANCE MEASURES	diversity and duration of flow	functional & sustainable area (acres, square feet...); quantity based on flow variability	water chemistry	biomass; abundance	linear feet, percent cover, vertical stratification,	number of sandbar / bank connection based on flow variability	sustainable flow and depth diversity	richness, abundance, etc
	breeding bird survey	water depth diversity	fish sampling		vegetative species diversity	predator monitoring	stage, quantity, area	breeding survey
	canopy cover	velocity diversity			diversity and duration of flow	diversity of flow		flow and substrate diveristy

Attachment 2: Survey Location Coordinates and Pictures

Site	Cover_Type	UTM_X	UTM_Y
County Line	Riverine	792504	3979029
County Line	Wetland/Riparian	792384	3978973
Indian Springs	Riverine	788092	3984450
Sand Plant	Riverine	783677	3982534
ODWC	Riverine	774314	3990660
Riverside	Wetland/Riparian	771461	3998243
Cherry Creek	Riverine	770843	3998656
Zink	Riverine	763966	4003504
Prattville	Riverine	760321	4001423
Prattville	Wetland/Riparian	760270	4001278
Swift Park	Wetland/Riparian	748459	4002848
Swift Park	Riverine	748651	4002750
Cherry Creek	Wetland/Riparian	770872	3998400

Swift Park Looking Upstream

Prattville Creek Looking North

Prattville Creek Looking South

Zink Looking South

Cherry Creek Looking Southeast

I-44/Riverside Looking South

ODWC Looking East

Attachment 3: Monitoring and Adaptive Management Plan

This section outlines the feasibility level monitoring and adaptive management plan for the Arkansas River Corridor Ecosystem Restoration Study. This plan identifies and describes the monitoring and adaptive management activities proposed for the project and estimates their cost and duration. This plan will be further developed in the preconstruction, engineering, and design (PED) phase as specific design details are made available.

The ARC adaptive management plan will describe and justify whether adaptive management is needed in relation to the alternatives identified in the Feasibility Study. The plan will outline how the results of the project-specific monitoring program would be used to adaptively manage the project, including specification of conditions that will define project success.

The primary intent of this Monitoring and Adaptive Management Plan is to develop monitoring and adaptive management actions appropriate for the project's restoration goals and objectives. The presently identified management actions permit estimation of the adaptive management program costs and duration for the ARC Ecosystem Restoration Project. This plan is based on currently available data and information developed during plan formulation as part of the feasibility study.

Uncertainties remain regarding the exact project features, monitoring elements, and adaptive management opportunities. Components of the monitoring and adaptive management plan, including costs, were estimated using currently available information. Uncertainties will be addressed in PED, and a detailed monitoring and adaptive management plan, including cost breakdown, will be drafted by the project delivery team (PDT) as a component of the design document.

Authority and Purpose

Ecosystem restoration feasibilities are required to include a plan for monitoring the success of the restoration (Section 2039, WRDA 2007). "Monitoring includes the systematic collection and analysis of data that provides information useful for assessing project performance, determining whether ecological success has been achieved, or whether adaptive management may be needed to attain project benefits." Section 2039 also directs that a Contingency Plan (Adaptive Management Plan) be developed for all ecosystem restoration projects.

Project Goals and Objectives

During the initial stages of project development, the PDT developed restoration goals and objectives to be achieved by the restoration measures. The goal of the ARC Ecosystem Restoration Project is to restore structure and function of the aquatic habitat within the ARC corridor. The resulting objective focuses on the importance of riverine habitat in the study area for breeding Least Terns and native riverine fishes. Specifically, the ecosystem restoration objective for the ARC is to "restore the overall aquatic habitat and significant aquatically 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".

Management and Restoration Actions

The PDT performed a thorough plan formulation process to identify potential management measures and restoration actions that address the project objective. Numerous alternatives were considered, evaluated, and screened in producing a final array of alternatives. The PDT subsequently identified a tentatively selected plan (TSP). The TSP included the following ecosystem restoration components:

- Constructing a pool structure at river mile 530 to capture hydropower releases, and re-release them at approximately 1,000 cfs to maintain more natural river flow, restoring 3,375 acres of riverine habitat.
- Restore 5.34 acres of wetland habitat at the confluence of Prattville Creek and the Arkansas River using rock riffles to maintain necessary hydroperiod to support wetland habitat in additional to wetland plantings and
- Restore 3 acres of sandbar island habitat that can remain above water during river flows up to 20,000 cfs for Least Tern nesting.

Implementation

Pre-construction, during construction, and post construction monitoring shall be conducted by utilizing a Monitoring and Adaptive Management Team (MAMT) consist of representatives of the U.S. Army Corps of Engineers (USACE), Tulsa County, USFWS, ODWC, and contracted personnel (if needed).

Monitoring will focus on evaluating project success and guiding adaptive management actions by determining if the project has met Performance Standards. Validation monitoring will involve various degrees of quantitative monitoring aimed at verifying that restoration objectives have been achieved for both biological and physical resources. Effectiveness monitoring will be implemented to confirm that project construction elements perform as designed. Monitoring will be carried out until the project has been determined to be successful (performance standards have been met), as required by Section 2039 of WRDA 2007. Monitoring objectives have been tied to original baseline measurements and HEC-RAS modeling that were performed during the Habitat Evaluations Procedures modeling effort and are summarized in Table 1 and discussed below. Adaptive management measures will be considered upon the first instance of failure to meet a performance standard. Metrics and specific adaptive measure triggers will be refined during PED.

River Flow

The modeled benefits were based upon the pool structure providing at least 1,000 cfs between hydropower generation cycles. USGS stream gages already monitor river flow within the study area and can be readily used to monitor pool structure performance. Maintaining the 1,000 cfs near the constructed sandbar island measure will be key to its success as the river barrier provides nesting Least Terns with some protections against terrestrial disturbances. If the 1,000 cfs target is not being met, or the 1,000 cfs is not being achieved over weekends between releases from Keystone Dam, initial remedies should include adjustments to gate operations. If operational changes still do not achieve the 1,000 cfs target changes in gate design would be needed.

Table 1: Monitoring Criteria, Performance Standards, and Adaptive Management Strategies for the ARC Ecosystem Restoration Project Measurement.

Measurement	Performance Standard	Adaptive Management
River Flow	1,000 cfs	Alter pool structure operations/design to achieve 1,000 cfs river flow
Sediment Transport	Maintain ≥ 80% of storage pool free of sediment	Excavate/flush accumulated sand, silt and debris to the downstream side of structure.
Fish & Egg Passage	Minimum depth and flow fields maintained	Repair of passage routes; redesign of flow fields; alter release regime during key migration/spawning periods
Rock riffle complex	>80-percent of complexes functioning with minimal maintenance	Repair of complexes; redesign of complexes.
Wetland Plantings	>50% of planted area consisting of native plant community within 2 years	modification of plant species composition;increased irrigation
Chevron stability	1 acre of sandbar development per normal year	Redesign of chevron.

Fish and Egg Passage
Pool structure design will include at least seasonal fish and egg passage to support migratory and spawning life histories. Adequate depth and flow during this period with be maintained by both flood pool and hydropower releases as well as the pool structure releases. Annual measurements to ensure passage fields have not been damaged and altered will ensure the structure does not impede fish, or their eggs from moving through the structure. If the full height gates are unable to lay flat close enough to the river bed, or unpassable flow fields prevented fish passage, additional sloped approaches or taller gates would be designed and implemented.

Sediment Transport
The study area is already facing sediment starvation due to Keystone Dam. The pool structure should not contribute to this issue and further limit sandbar habitat development downstream. The storage capacity behind the pool structure is paramount to river flow restoration success, if sediment build up doesn't allow for the necessary storage to support downstream flows, restoration success will be diminished dramatically. If sediment build up occurs such that 20% of the pool capacity is lost, gate operation changes should be made to facilitate downstream passage. Dredging or sand mining may be needed if river flow is unable to transport sediments. If the design and operation of the structure promotes constant sediment buildup, gate design changes will be needed to facilitate increased sediment transport.

Rock Riffle Complex
The purpose of the rock riffles is to maintain a hydroperiod conducive to wetland plant growth. Excessive leaking or in adequate elevation of the rock riffle that does not promote river ebb and flow between the Arkansas River and wetland area will need to be addressed to maintain

wetland health. If river ebb and flow is blocked during reoccurring hydropower generation, the height of the rock riffle should be lowered to increase connectivity.

Wetland Plantings

Native wetland plantings should become established within 50% of the planting area within two years. If the native wetland plantings exhibit higher than expected mortality under normal conditions a change in the species being planted should be made to establish native wetland plant communities. The new species should be selected based on local conditions so that survivorship increases.

Chevron Stability

The chevron shaped riprap structures are critical to sandbar development and stability. At least one acre of sandbar development should occur per year during normal flow years. If flow conditions conducive to sandbar development did not produce at least one acre of sandbar habitat, the chevrons should be inspected and evaluated for redesign.

Reporting

Evaluation of the success of the ARC Ecosystem Restoration Project will be assessed annually at a maximum until all performance standards are met. Site assessments will be conducted annually by the MAMT and an annual report will be submitted to the USFWS, ODWC, Tulsa County, and other interested parties by January 30 following each monitoring year.

Permanent locations for photographic documentation will be established to provide a visual record of habitat development over time. The locations of photo points will be identified in the pre-construction monitoring report. Photographs taken at each photo point will be included in monitoring reports.

Monitoring and Adaptive Management Plan Costs

Costs to be incurred during PED and construction phases include drafting of the detailed monitoring and adaptive management plan. Cost calculations for post-construction monitoring are displayed for a three year monitoring period. It is intended that monitoring conducted under the ARC Ecosystem Restoration Project will utilize a centralized data management, data analysis, and reporting functions associated with the USACE data management structure. All data collection activities will follow consistent and standardized processes established in the detailed monitoring and adaptive management plan. Cost estimates include monitoring equipment, photo point establishment, data collection, quality assurance/quality control, data analysis, assessment, and reporting for the proposed monitoring elements (Table 2). Unless otherwise noted, costs will begin at the onset of the PED phase and will be budgeted as construction costs.

Table 2: Cost Estimates for Implementation of the Monitoring and Adaptive Management Plan for the ARC Ecosystem Restoration Project.

Category	Activities	PED Set-Up & Data Acquisition	Construction	3-year Post Construction	Total
Monitoring: Planning and Management	Monitoring workgroup, drafting detailed monitoring plan, working with PDT on performance measures	$25,000			$25,000
Monitoring: Data Collection	Vegetation Flow fields		$15,000 $15,000	$60,000 $60,000	$75,000 $75,000
Data Analysis	Assessment of Monitoring Data and Performance Standards		$15,000	$30,000	$45,000
Adaptive Management Program	Detailed Adaptive Management Plan And Program Establishment Management of Adaptive Management Program Contingency	$25,000		 $2,000,000 581,000	$25,000 $2,000,000 581,000
Database Management	Database development, management and maintenance		$15,000	$25,000	$40,000
Total		$50,000	$60,000	$2,175,000	$2,285,000