Three Rivers Southeast Arkansas Study

Appendix J: Coordination Act Report

THREE RIVERS SOUTHEAST ARKANSAS

Introduction

The Three Rivers Southeast Arkansas Feasibility Study (Three Rivers Study) is being conducted by the U. S. Army Corps of Engineers (USACE) to recommend modifications to the McClellan-Kerr Arkansas River Navigation System (MKARNS) that would provide long-term sustainable navigation and promote the continued safe and reliable economic use of the MKARNS.

Study Authority

Section 216, Flood Control Act of 1970 (Public Law 91-611) authorizes a feasibility study due to examine significantly changed physical and economic conditions in the Three Rivers study area. The study will evaluate and recommend modifications for long-term sustainable navigation on the MKARNS.

Study Purpose

There is a risk of a breach of the existing Soil Cement Structure near the entrance channel to the MKARNS on the White River. During high water events, Mississippi backwater can create significant head differentials between the Arkansas and White rivers. The existing Soil Cement Structure in the isthmus between the Arkansas and White rivers is subject to damaging overtopping, flanking and seepage flows that could result in a catastrophic breach and failure of the system. The uninhibited development of a breach, or cutoff, has the potential to create navigation hazards, increase the need for dredging, and adversely impact an estimated 200 acres of bottomland hardwood forest in the isthmus.

Based on the Section 216 authority, the study is investigating alternatives that would minimize the risk of cut off development, including reducing the cost of maintence associated with preventing cutoff development, while minimizing impacts to the surrounding ecosystem.

Non-Federal Sponsor

The Arkansas Waterways Commission is the non-federal sponsor for the Three Rivers Southeast Arkansas Study. An amended feasibility cost-sharing agreement was executed in June 2015.

Recommended Plan

The recommended plan consists of a newly constructed 2.5-mile long containment structure at an elevation of 157 feet above mean sea level (ft msl) that would begin on natural high ground just south and west of the existing Melinda Structure located on the south side of Owens Lake. It would continue east and cross the Melinda head cut south of the existing Melinda Structure. From there, it would head northeast and connect to the existing Soil Cement Structure north of Jim Smith Lake. It continues to follow the existing Soil Cement Structure alignment terminating at the existing Historic Closure Structure. The recommended plan also includes a relief opening at the Historic Cutoff to an elevation 145 ft msl regardless of the width. In addition, the existing Melinda Structure would be demolished in place and the debris would be pushed into the deep scour hole at the top of the head cut. Finally, adding an opening in the existing Owens Lake Structure between Owens Lake and the White River would prevent water from backing up into Owens Lake, which would impact the bottomland hardwood forest. The opening would be designed to allow fish passage into Owens Lake.

United States Department of the Interior

FISH AND WILDLIFE SERVICE

Arkansas Ecological Service Field Office
110 South Amity Road, Suite 300
Conway, Arkansas 72032

IN REPLY REFER TO:

November 14, 2017

Colonel Robert G. Dixon
Commander and District Engineer
Little Rock District U.S. Army Corps of Engineers
P.O. Box 867
Little Rock, Arkansas 72203-0867

Dear Colonel Dixon:

This is the U.S. Fish and Wildlife Service's (Service) final Fish and Wildlife Coordination Act Report (CAR) prepared in response to the Little Rock District's Three Rivers Feasibility Study. Our report assesses the impacts of the proposed project on fish and wildlife resources, identifies measures to adequately mitigate resource losses, and outlines conservation measures to address fish and wildlife resource concerns. This report has been prepared in accordance with the Fish and Wildlife Coordination Act (FWCA) (48 Stat. 401, as amended; 16 U.S.C. 661-667e.), the Endangered Species Act (87 Stat. 884, as amended: 16 U.S.C. 1531 et seq.), and the National Wildlife Refuge System Administration Act of 1966, as amended by the National Wildlife Refuge System Improvement Act of 1997 (16 U.S.C. 668dd-668ee). In keeping with the requirements of the FWCA, this report should be attached to and made an integral part of any report released for public review or forwarded to Congress for consideration.

Sincerely,

Melvin L. Tobin
Field Supervisor

Cc: Leopoldo Miranda, Assistant Regional Director of Ecological Services, USFWS
Mindy Gautreaux, Refuge Area One Supervisor, USFWS
Charles Sloan, Project Leader of Dale Bumpers White River NWR, USFWS
Kirbie McCallie, Ranger at Arkansas Post National Memorial, NPS
Jennifer Sheehan, Chief of Federal Regulatory Program, AGFC
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A Final Fish and Wildlife Coordination Act Report

on the

Three Rivers Feasibility Study

Prepared by:

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U.S. Fish and Wildlife Service
Southeast Region

November 14, 2017

EXECUTIVE SUMMARY

This summarizes the U.S. Fish and Wildlife Service's (Service) final Fish and Wildlife Coordination Act 2(b) Report (CAR) on the fish and wildlife resources likely to be impacted by the Three Rivers Feasibility Study Recommended Plan (RP). This report will accompany the U.S. Army Corps of Engineer's final Feasibility Study Report and Environmental Assessment on this project.

The Corps of Engineers Little Rock District (Corps) is charged with the operation and maintenance of the McClellan-Kerr Arkansas River Navigation System (MKARNS) for commercial navigation. The Three Rivers Feasibility Study (TRFS) was conducted to address problems associated with headcutting and erosion in the vicinity of the Historical Cutoff between the White and Arkansas Rivers subsequent to construction of the MKARNS. Several years after construction of the Historical Cutoff Closure Structure, the rivers began trying to reestablish a connection, which led the Corps to construct a series of new structures to prevent a cutoff between the two rivers from reforming.

The project area is at the lower end of the Arkansas River and White River basins near their confluences with the Mississippi River and encompasses 208 square miles. This "Three Rivers" area extends on the White River from its confluence with the Mississippi River upstream to near the confluence of La Grue Bayou and upstream about 35 miles on the Arkansas River from its confluence with the Mississippi. The first 10 miles of the White River serves as the entrance channel for the MKARNS via its connection to the Arkansas River through the Arkansas Post Canal. The White and Arkansas Rivers come to within approximately 1.5 miles of each other and flow nearly parallel to each other for a short distance along the study area. One of the most notable features of the Three Rivers area is the Historical Cutoff which connected the White and Arkansas Rivers. This channel had a top width ranging from 500 to 1,000 feet and ranged in length from 3.8 to 5.9 miles. It was closed during construction of the MKARNS.

The study area contains resources of national and international importance. It is an important component of one of the last remaining large blocks of contiguous bottomland hardwoods in the Mississippi Alluvial Valley. The lower White River basin provides habitat for over 235 species of birds, 58 species of mammals, and 58 species of reptiles and amphibians. It is the most important wintering area for mallards in North America. The White and Arkansas Rivers and associated floodplain aquatic habitats provide habitat for at least 24 families and 132 species of fish and 37 species of freshwater mussels. It provides habitat for several federally listed species.

The Three Rivers area holds several special designations. The lower White River basin carries designations as a Ramsar Wetland of International Importance and as an Audubon Society Important Bird Area. The lower Arkansas River is a state listed ecologically sensitive waterbody and is listed by the National Park Service on the Nationwide Rivers Inventory.

The Three Rivers area has been extensively modified by numerous water development projects associated mostly with development and maintenance of navigation on the Arkansas, White, and Mississippi Rivers. These projects have had immediate and continuing adverse impacts on the resources of the Three Rivers area. Construction includes neck cutoffs, dredging, river training structures, and revetments. MKARNS specific projects include construction of the Historical Cutoff Closure Structure, the Ark-White Containment Structure, Owens Lake Structure, Melinda Headcut Structure, Arkansas Post Canal, and several locks and dams, most recently Montgomery Point Lock and Dam at White River mile 0.5. Other projects that have had a major impact on the landscape, hydrology, and morphology of the area include levee construction, upstream dam construction, and installation of hydropower facilities.

The Corps' RP includes the construction of a new containment structure at an elevation of 157 feet NGVD (National Geodetic Vertical Datum) that will tie into existing high ground just downstream of the Melinda Headcut Structure. Approximately 1.2 miles of this will consist of raising the existing Ark-White Containment Structure while the remaining 1.3 miles will be along a new right-of-way. The Melinda Headcut Structure would be removed, thus reconnecting the bisected portions of Owen's Lake. An opening would be added to the Owen's Lake Structure in order to drain the area enclosed by it, natural high ground, the new containment structure, and the Ark-White Containment Structure. A passive weir would be constructed in the Historical Cutoff Closure Structure to allow flow between the White and Arkansas Rivers at an elevation of 145 feet NGVD and approximating the volume currently passing through the Owen's Lake and Jim Smith Lake channels. Less than 10 acres of direct impact would occur on the Dale Bumpers White River National Wildlife Refuge (Refuge). Very little change in flooding duration and timing is expected on nearby lands of conservation importance.

The RP contrasts with the Corps' previous plan as described in the Ark-White Containment Study (AWCS). That plan would have elevated the existing 2.6 mile long soil cement containment structure to 155 feet NGVD and extend it nearly seven additional miles to high ground near Lock 2. The plan did not incorporate an opening in the Historical Cutoff Closure Structure. It would have required acquisition of a 10-foot wide utility easement, a construction easement for 86.9 acres: 71.6 acres on Service property; 14.5 acres on Arkansas Game and Fish Commission (AGFC) property; 0.8 acres on Arkansas Department of Parks and Tourism (ADPT) property. In addition, it would have required the acquisition of a 1,216 acre flowage easement on the Refuge. This elevation would prevent overbank flow and overtopping for all high water events below the 8-year hydrologic event. The Corps withdrew this as the recommended alternative because of the likelihood that it would not meet compatibility requirements of the Refuge. They ultimately chose the "no action" alternative which incorporated repair of existing structures and possible construction of additional structures as needed. The Corps carried out the current study because this "no action" alternative was not fiscally or structurally sustainable.

SERVICE POSITION AND RECOMMENDATIONS

The Service supports the Corps' TRFS RP. This plan represents a significant improvement over the preferred alternative and selected alternative investigated during the AWCS. In the absence of detailed studies to describe the historical, current, and projected hydrological and morphological changes in the Three Rivers area, the current plan balances structural and environmental sustainability requirements. The design attempts to relieve the instability resulting from extreme head differentials between the White and Arkansas Rivers and the resulting threats to navigation while not significantly changing the hydrology of the surrounding bottomland hardwood habitats. The Service acknowledges the Corps' mission and objective to maintain navigation on the McClellan-Kerr Arkansas River Navigation System (MKARNS) and we believe that working together we can accomplish both of our agency's missions.

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INTRODUCTION

This is the U.S. Fish and Wildlife Service's final Fish and Wildlife Coordination Act Report (CAR) on the Three Rivers Feasibility Study (TRFS). This report discusses fish and wildlife resources, concerns, and planning objectives in the study area; evaluates alternative plans; discusses mitigation measures; and discusses potential fish and wildlife conservation measures. It has been prepared in coordination with the Arkansas Game and Fish Commission and is submitted in accordance with the Fish and Wildlife Coordination Act (FWCA) (16 U.S.C. 661-667e) and the Endangered Species Act (87 Stat. 884, as amended U.S.C. 1531 et seq.).

The TRFS is authorized under several laws. The navigation and flood control development provisions for the McClellan-Kerr Arkansas River Navigation System (MKARNS) in the Rivers and Harbors Act of July 24,1946, Public Law 525, 79th Congress, Chapter 595, as amended, authorized construction of the MKARNS; Public Law 91-649 named the project. Additional study was authorized by a March 11, 1982, resolution by the Committee on Public Works and Transportations of the United States House of Representatives. Additional authorities are contained in Section 216, 1970 FCA (P.L. 91-611, and sections 102, 103, 105 and 109, Water Resources Development Act of 1986 (P.L. 99-662). Section 136 of the Energy and Water Development Appropriations Act of 2004 authorized increasing the project depth to 12 feet.

The MKARNS uses the first 10 miles of the White River as the entrance channel for the system that extends from the confluence of the White and Mississippi Rivers, Arkansas, to the Port of Catoosa on the Verdigris River, Muskogee, OK. The Corps initiated construction of the MKARNS in 1957 and opened the current 9-foot navigation channel to commercial navigation in 1971 at a total cost of $1.3 billion. The entrance to the MKARNS consists of a channel 9 feet deep by 300 feet wide, and associated structures in the project area, including the Historical Cutoff Closure Structure, Arkansas Post Canal, Lock and Dam 1 and Lock 2 in the Arkansas Post Canal, Wilbur Mills Dam (Dam 2) on the Arkansas River, revetments, the Ark-White Containment Structure (soil cement levee), the Melinda Headcut Structure, the Owens Lake Structure, the La Grues Lake Structure, the Jim Smith Lake geotube structures, and Montgomery Point Lock and Dam (Figure 1). The Montgomery Point Lock and Dam at the mouth of the White River was recently constructed to remedy low water conditions brought about by degradation of the Mississippi River channel. Other Corps work in the project area includes meander cutoffs on the Mississippi and Arkansas Rivers and flood control levees. The Corps has conducted numerous individual studies and produced several reports related to the Three Rivers area.

The TRFS was initiated due to continued damage to structures from erosion and headcutting in the area during flood events. Heavy flooding in 2011 resulted in the near loss of the Melinda Headcut Structure due to erosion along the western flank. Subsequent remedial actions have stabilized the structure, but erosion along flow paths in the area continue to present risks to navigation system infrastructure. New headcuts continue to develop in this area and show signs of initiating in Webfoot Lake to the east of the Historical Cutoff Closure Structure.

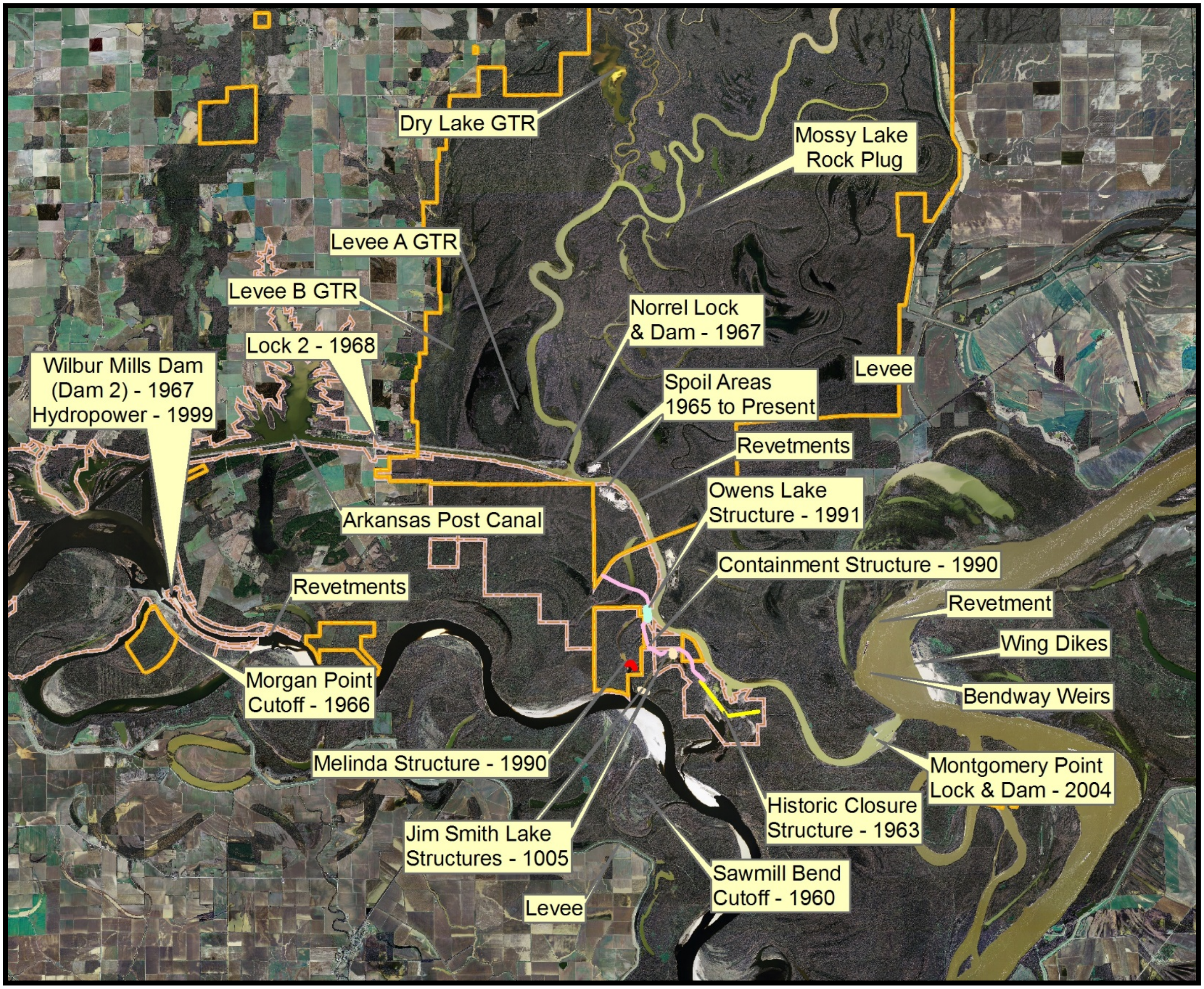

Figure 1. Man-made structures in the vicinity of the TRFS area, Arkansas and Desha Counties, Arkansas

INPUT, COORDINATION, AND CONCURRENCE OF STATE FISH AND WILDLIFE AGENCY

We have coordinated with the Arkansas Game and Fish Commission (AGFC) as a fellow cooperating agency with the Corps during the development of the TRFS. They reviewed this final CAR and indicated their concurrence. They will also submit a separate letter to be included in the final Feasibility Study Report and Environmental Assessment.

PRIOR REPORTS

Several reports have been written by the Service on the McClellan-Kerr Arkansas River Navigation System (MKARNS) which includes the Three Rivers area and associated work in the project area. The findings of the most pertinent reports are summarized below.

<u>November 1986 – Draft CAR</u>
The Service defined fish and wildlife problems and needs for the AWCS, discussed the projected amount of bottomland hardwood habitat that would be lost from the project, and recommended the amount of land that would be needed to mitigate for project impacts.

<u>April 1987 – Planning Aid Report</u>
The Service provided the Corps with an inventory of natural resources for the proposed White River Entrance Channel Arkansas and Desha Counties, Arkansas, within a one mile corridor on either side of the White River from River Miles 1 to 10. It included a discussion of the significance of those resources, and a projection of presence or absence of those resources into the future.

<u>August 1990 – Draft CAR</u>
The Service defined fish and wildlife problems and needs for the Montgomery Point Lock and Dam Study, discussed the projected amount of bottomland hardwood habitat that would be lost from the project, and recommended the amount of land that would be needed to mitigate for project impacts.

<u>October 2003 –Planning Aid Report</u>
The Service identified fish and wildlife resources, problems and needs for the AWCS area.

<u>June 2005 – Draft CAR</u>
The Service identified fish and wildlife resources, problems and needs for the MKARNS deepening project that proposes to deepen the navigation channel from nine to twelve feet.

<u>July 22, 2009 – Draft CAR</u>
The Service provided background information regarding fish and wildlife resources and habitat in the project area and assessed the potential impacts associated with various AWCS alternatives. We recommended that the Corps proceed with the "No Action" alternative until a comprehensive "Three Rivers Study" could be completed to help identify historic and current hydrologic and geomorphic conditions in an effort to construct a solution that is sustainable and compatible with the purposes of the Refuge.

March 2, 2017 – Draft CAR
The Service provided background information regarding fish and wildlife resources and habitat in the project area and assessed potential impacts associated with the Tentatively Selected Plan (TSP). We indicated support for the TSP.

DESCRIPTION OF STUDY AREA

The TRFS area is at the lower end of the Arkansas River and White River basins near their confluences with the Mississippi River and encompasses about 208 square miles. This area extends north to near the confluence of Bayou LaGrue and the White River. It extends south along the Arkansas River to near the confluence with the Mississippi River. The eastern boundary is formed largely by the Mississippi River. The area extends west along the Arkansas River to Dam 2 and along the Arkansas Post Canal to Lock 2 (Figure 2). The first 10 miles of the White River serves as the entrance channel for the MKARNS via its connection to the Arkansas River through the Arkansas Post Canal. The White and Arkansas Rivers come to within approximately 1.5 miles of each other and flow nearly parallel to each other for a short distance along the study area.

The White and Arkansas Rivers are both major tributaries of the Mississippi River. The 27,765 square mile White River basin is in north and east Arkansas and southern Missouri. The White River traverses 720 miles through two physiographic regions, the Ozark Highlands and the Mississippi Alluvial Plain, before flowing into the Mississippi River. Average rainfall in the basin is approximately 50 inches per year. By contrast, the Arkansas River flows approximately 1,450 miles through four states in a generally southeastern direction from its headwaters near Leadville, Colorado to its confluence with the Mississippi River. Its drainage basin encompasses approximately 160,500 square miles in seven states and several distinct ecoregions. The Mississippi River, the major controlling force in the Three Rivers area, has a drainage area encompassing approximately 41 percent of the lower 48 United States (~1,250,000 square miles). Mean annual flow at Helena, AR, is 480,000 cubic feet per second (cfs) (McCabe 1990). Discharge can exceed 1.5 million cfs. The lower Mississippi Alluvial Valley begins below the confluence of the Ohio River and Mississippi Rivers, near Cairo, IL, and comprises approximately 25 million acres, with all but about 2 million acres cut off by levees. High stages on the Mississippi River can cause water to back up the White and Arkansas Rivers considerable distances; conversely, low flows in the Mississippi increase the hydraulic gradient of these rivers. Even though the Mississippi River is the major controlling force, flood flows in the White and Arkansas Rivers can and often do occur independently of each other and of the Mississippi River. Flooding in the study area is most common during late fall to spring; however, flooding periodically extends into early summer.

One of the most notable features of the Three Rivers area is the Historical Cutoff. This channel provided a frequent connection between the two rivers that was used extensively by steamboats during the 1800's and early 1900's to move between the two rivers. The Historical Cutoff had a sinuous channel that ranged in length from about 3.8 miles in 1917 to approximately 5.4 miles in 1940 and 5.9 miles in 1949 (Pinkard *et al.* 2003) (Figure 3). Channel width (top bank to top

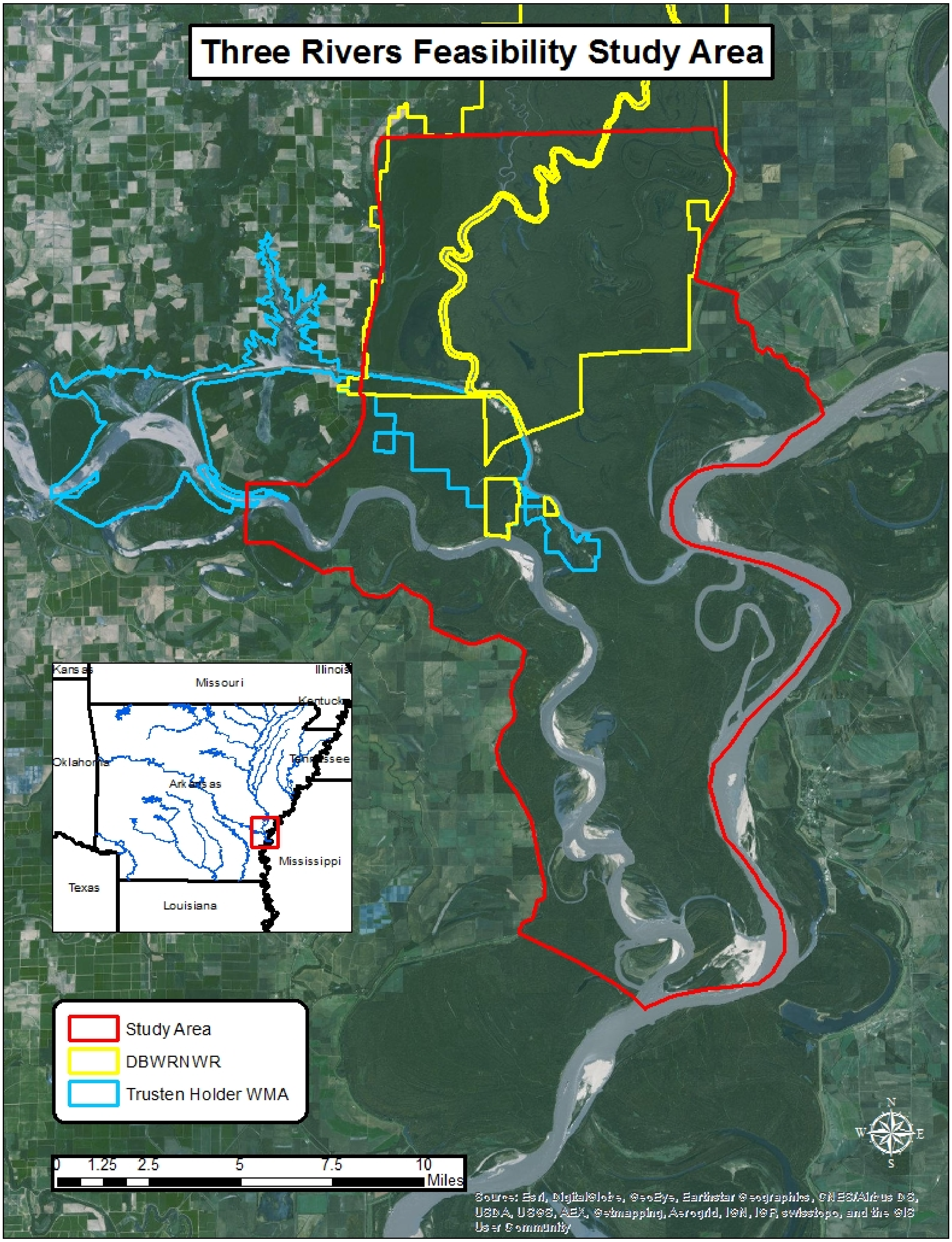

Figure 2. Arkansas – TRFS Area, Arkansas and Desha Counties, Arkansas.

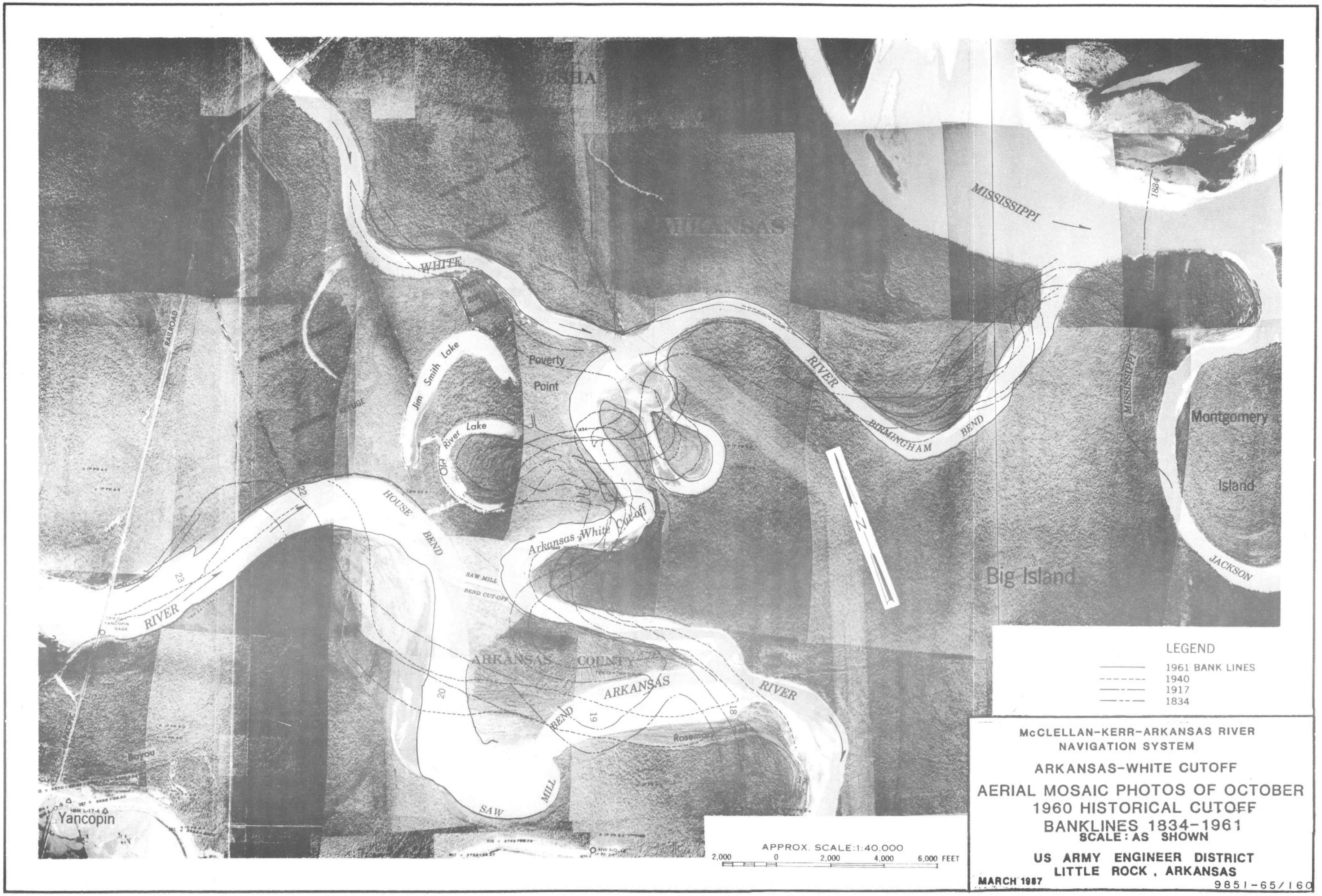

Figure 3. Historical Cutoff Between the Arkansas and White Rivers, Arkansas and Desha Counties, Arkansas.

bank) ranged from 500 ft. to 1,000 ft. and is comparable to the White River Channel width making it capable of carrying flows at least equal to the White River. The highest elevations recorded in the channel were between 120 and 130 feet. The 1940 and 1949 profiles show a definite downward slope from the Arkansas to the White River, but the 1917 profile did not show a discernable slope through the cutoff channel. The direction of flow on the 1917 and 1940 surveys was from the Arkansas to the White River. The 1949 survey showed the direction of flow from the White River to the Arkansas River, but Pinkard *et al.* (2003) felt that observed gage records indicated the flow was more likely to be from the Arkansas River to the White River. During high flow or flood events, however, water moved through the cutoff between the two rivers in both directions as well as across the floodplain, through sloughs, depressions, and lakes. Stage fluctuations in the White and Arkansas Rivers of 56 feet have been recorded, and stage in either the White or Arkansas can be 16 to 25 feet higher than the other (Barkley 1987).The Historical Cutoff was closed during construction of the MKARNS, which highly altered the hydrodynamics in the area; any flow between the two rivers that comes through this pathway now gets there through a more circuitous route. The history of development in the study area and its significance is addressed in more detail in another section of this report.

Topography of the Three Rivers area is typically characterized as having low relief and a flat to gently rolling surface. However, this description provides only a superficial glimpse of the topographic complexity of the landscape and the significant influence small topographic changes can have on the timing, extent, and duration of flooding, and the plant communities that develop in response to these varied conditions. The diverse topography of the study area is characteristic of alluvial river systems as evidenced by the various floodplain features found there, including backswamps, natural levees (i.e., ridges), sloughs, bayous, and oxbow lakes. This complex topography combines with seasonal, annual, and long term high and low water cycles and flooding to create a diversity of hydrologic conditions vital to the productivity of the system, and a spatial and temporal range of habitat conditions. Both fish and wildlife are dependent on flooded forest for breeding, nesting, spawning, and nursery habitat in the inundated floodplain. They also depend on higher, drier sites for food, cover, and as refuge from floodwaters. The vast forested wetlands in the Three Rivers area also perform numerous other beneficial functions, including floodwater detention, nutrient cycling, and water quality improvement.

Land use/land cover in the study area is predominately bottomland hardwood forest (BLH). The lower White River and lower Arkansas River basins inside the levees are also dominated by BLH. By contrast, land use outside the levees in the MAV portion of river basins is primarily agriculture. The forest associations found within the study area vary depending on the frequency and duration of flooding. Cypress-tupelo (*Taxodium distichum/Nyssa aquatica*) and scrub-shrub swamps are located in low lying areas permanently or semi-permanently flooded. Water hickory/overcup oak (*Carya aquatica/Quercus lyrata*) associations are located in frequently flooded low lying areas. Somewhat more elevated areas, which are still influenced by overbank flooding, support American elm (*Ulmus americana*), ash (*Fraxinus* spp.), sugarberry (*Celtis laevigata*), American sycamore (*Platanus occidentalis*), Nuttall oak (*Q. texana*), willow oak (*Q. phellos*), and sweetgum (*Liquidambar styraciflua*). Infrequently flooded, poorly drained areas are vegetated with willow oak, water oak (*Q. nigra*), swamp chestnut oak (*Q. michauxii*), cherrybark oak (*Q. pagodifolia*), and shagbark hickory (*Carya ovata*). Black willow (*Salix nigra*) is common on elevated point bars and cottonwood (*Populus deltoides*), river birch (*Betula* *nigra*), and boxelder (*Acer negundo*) are found on natural levees. Timber harvested from these forests contributes to the local economy.

The distribution of plant communities in river floodplain forests is directly and indirectly influenced by hydrology (Kellison *et al.* 1998, Wharton *et al.* 1982, Dale 1984, Reinecke *et al.* 1989, Hodges 1997). Plant survival and reproduction are tied to the timing, depth, duration, and frequency of flooding (Fredrickson 1978). Sediment distribution and soil formation are influenced by flooding, which indirectly influences water relationships in plant communities (Reinecke *et al*. 1989). Patrick *et al.* (1981) described the difference between vegetative zones in the bottoms as being only scarcely visible. The lower White River basin fits this description well, with vegetative community changes occurring at a matter of several inches to a foot difference in elevation. Consequently, changes in flood frequency, duration, or height could result in impacts to extensive areas, thus affecting habitat availability and overall wetland and ecosystem function.

Notable exceptions to the major land cover type found in the study area are the dredge disposal areas on both private land and on the Refuge. Annual deposition of dredge material on the site maintains mostly unvegetated open sand with small areas of young willow. The sites are elevated approximately 30 to 50 feet above the White River floodplain and contain millions of cubic yards of dredge material.

The amount of jurisdictional wetland in the study area has not been determined. Service biologists conducted field inspections in 1986 along 14 transects located within a one mile wide corridor on both sides of the White River from the approximately RM 8 to the mouth. At each sample site along the transects, biologists collected vegetation and soils data and used it to classify forest type and determine the amount of wetland in the project area. Based on vegetative and soil wetland indicators, approximately 88 percent of the sites were classified as wetland (Barkley 1986). This only constitutes a portion of the current study area, which is more topographically diverse and extends a greater distance from the rivers.

The lower White and Arkansas Rivers ecosystem is characterized by the complex interaction of hydrologic, geomorphic, and biotic processes. These processes regularly experience wide fluctuations around a set of average conditions. Normal low river stages with periodic extreme low water during dry climatic conditions act in concert with seasonal high water and wet climatic cycles to create and maintain a diverse and incredibly rich environment. Fish and wildlife that permanently reside here or stop over during annual migrations have adapted to endure or even exploit these extreme conditions.

The natural seasonal and periodic flood cycles have direct and/or indirect impacts upon all other components of the ecosystem. These flooding cycles are instrumental in creating suitable aquatic and terrestrial habitat and in structuring the bird, mammal, and fish communities in the lower White and Arkansas Rivers. Though floods have historically been viewed as disturbances, in reality, any departure from the normal hydrological regime, such as flow alteration and/or flood prevention, should be considered a disturbance (Bayley 1995, Benke *et al*. 2000). Anthropogenic alterations to rivers that result in the disruption of the intensity, frequency, or timing of natural disturbances (i.e. winter/spring floods) may upset the ecological integrity of these disturbance dependent systems (Ward and Stanford 1995).

The importance of these ecological relationships between fish and wildlife and the river hydrology cannot be overstated. Yaich (1994) said, "A basic appreciation of the hydrology of the Cache/Lower White Rivers ecosystem, and recognition of its importance as the driving force behind all other ecosystem processes and functions is fundamental to addressing long-term conservation." Habitats, and the species that use them, are controlled by the frequency, duration, timing, and depth of flooding, which in turn are tied to topographic variation; terraces, backswamps, abandoned channels, and natural levees and their interaction with annual and long term hydrologic cycles. The result is a habitat complex that ranges from deeply flooded to isolated unflooded areas and a moving "edge" throughout the floodplain as floodwaters rise and recede. Bayley (1995) described the "dynamic interaction between water and land" as being the principal process for production and maintenance of river-floodplains.

The overall health of the lower Arkansas and White Rivers ecosystem, as well as that of the individual species that form its biotic component, are dependent upon the heterogeneity created by both the winter/spring flood cycle and the geomorphic and topographic characteristics of the main channels and floodplain. The floodplain habitat types present in the study area (i.e., main channel, side channel, tributaries, inundated floodplain, sloughs, and oxbow lakes) all contribute to the diversity of organisms found there. An even larger assortment of microhabitats (woody debris, substrate types, depth, and velocity) are present within each of the broader habitat types. The result of this habitat heterogeneity is an aquatic ecosystem containing at least 132 species of fish, 37 species of freshwater mussels, and many hundreds of species of other invertebrates. The interconnection of these organisms with their physical environment and one another is such that the alteration of one component (i.e. altered physical habitat or natural cycles, loss of a species, introduction of a species) may have undesirable affects upon one or many other elements.

The character of the study area including plant community composition and vigor is controlled by the hydrology. Geomorphology and soils also play an important role in determining the plant communities present. The hydrology of the Arkansas and White Rivers area has been dramatically altered by human land use practices. The Mississippi River is the major controlling factor in the Three Rivers area, but the four Corps constructed reservoirs on the main stem of the upper White River and three on tributaries also exert a major influence on stage and duration of flows. Storage and release of flood flows and peaking hydropower generation through these dams have reduced the high and low flow peaks on the White River upstream of the study area while increasing mid-range flows (Figure 4). The series of locks and dams on the Arkansas River, operated for navigation and flood control, have had a major impact on the lower river. Hydropower generation capability added to the operation of Dam 2 in 1999 significantly altered the already altered flow conditions. Its operation during peak demand and the restrictions above the station for maintaining a reliable navigation channel have resulted in daily stage fluctuations of up to 6 - 8 feet (Haase 2003 pers. comm.).

Fish spawning and nursery habitat are among the best recognized values of floodplain habitats. Fishes that exploit these habitats may benefit from years of high river discharge because they readily take advantage of the temporarily abundant food resources available on the floodplain. This increase in available energy can lead to more successful reproduction (Ross and Baker 1983). Between 75 and 100 species of fish inhabit bottomland hardwood wetlands during one or more of their stages (Robison and Buchanan 1988, Killgore and Miller 1995, Killgore and Baker 1996). Rising water in late winter/early spring allows some species, such as smallmouth buffalo (*Ictiobus bubalus*), to move into flooded timber, agricultural land, or seasonally connected backwaters to spawn. Spawning normally commences in April and continues until June in Arkansas. Fishes, such as bowfin (*Amia calva*), spotted gar (*Lepisosteus oculatus*), and topminnows (*Fundulus spp.*) spawn in shallow water over vegetation in areas similar to that preferred by smallmouth buffalo (Robison and Buchanan 1988). Unlike smallmouth buffalo, however, these and other fishes often remain on the floodplain after spring floods recede. They are adapted to occupy the warm, often hypoxic or anoxic waters of oxbow lakes and sluggish sloughs. Some species (i.e., topminnows and livebearers) take advantage of the thin layer of dissolved oxygen present at the water/atmosphere interface, while others such as bowfin and gar have adaptations allowing them to “gulp” air at the surface to obtain atmospheric oxygen (Hoover and Killgore 1998).

Past river engineering projects on the Mississippi, White, and Arkansas Rivers have induced many changes to these rivers and their associated floodplain resources. The degradation of the Mississippi River channel has evoked reactions up both the White and Arkansas Rivers. Channel degradation, lateral scour, and headcutting in the White River has been documented (King *et al.* 2016). Pinkard *et al*. (2003) documented significant geomorphic changes in the lower Arkansas River over the last 75 to 100 years. Notable among those changes is the channel degradation in the range of 10 to 15 feet that has been observed. In addition, the river has undergone adjustments in its planform as it attempts to adjust its slope and sinuosity relationships.

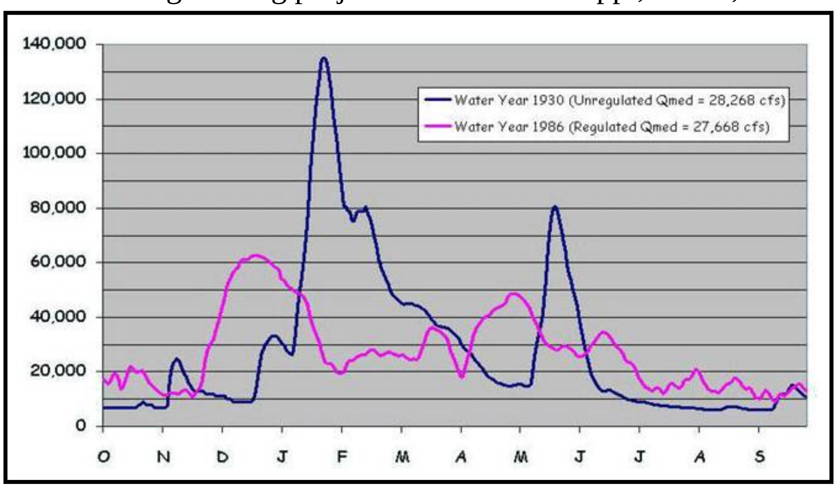

Figure 4. Hydrograph of the White River at Clarendon, Arkansas, Showing Flow Alteration Following Construction and Operation of Dams on the Upper White River and Tributaries

The numerous projects for the MKARNS constructed over the past 40 years in the study area near the White River have invoked unforeseen, though not unpredictable, fluvial geomorphic responses. As levees and other structures were constructed to try to stop the Arkansas and White Rivers from reestablishing the proper hydrologic and hydraulic conditions needed to achieve stability, new pathways have been exploited and existing pathways have been further eroded. Construction of new or repairs of existing structures are the consequence. Other land use developments, such as agricultural production, and municipal and residential expansion have also contributed to the large number of changes to the natural hydrologic and fluvial processes of this already dynamic system; changes the consequences of which have been both immediate and long term. The rivers are still experiencing geomorphic adjustments as a result of these.

Cultural Resources

The TRFS area includes some of the most important archaeological sites in eastern Arkansas, including the original Arkansas Post. The project area spans large portions of the Refuge and the National Park Service's (NPS) Osotouy Unit, which is recognized as being "the spiritual center of the Quapaw tribal homeland and…culture." It also includes a historical plantation (AR0016) within the project's footprint (Dunn and Riggs 1987), as well as several other archaeological sites, including the Menard-Hodges Mounds, Wallace Bottom (3AR179) and Lake Dumond sites (3AR110) (Ford 1961; House, Starr, and Stewart-Abernathy 1999; House 2001 & 2002; House and Lockhart 2005; and House and Akridge 2005). The Menard-Hodges Mounds (3AR3), located on NPS's Osotouy Unit, became a National Historic Landmark in 1989 (McKithan and Barnes 1988). In addition, House has recorded at least one mound complex on Owens Lake. The Service, in partnership with the Quapaw Tribe and the Arkansas Archeological Survey, nominated the Wallace Bottom Site for listing on the National Register of Historic Places in 2007. This site, based upon the archaeological evidence, is the Quapaw village of Osotouy and the 17^{th}-early 18^{th} century French Arkansas Post. Due to the site's proximity to the National Historic Landmark (NHL)-listed Menard-Hodges Mounds, the Service, the Quapaw Tribe, the AAS, and the NPS are revising the NHL nomination. The NHL nomination will be a multiple-property district that includes the Wallace Bottom Site, the Lake Dumond Site, and the Menard-Hodges Mounds.

There have been 10 boat wrecks along the White River's 245-mile long navigation corridor and 20 archaeological sites and/or structures. Those sites include the Roland Mound (3AR30), Jacks Bay Landing (3AR31), the Jacks Bay Mound A (3AR186), and Baytown Mounds (3MO1). The majority of the sites are eligible, but not listed, on the National Register of Historic Places (Buchner and Krivor 2001).

Major landowners

Major landowners in the study area include the Service, Corps, Arkansas Game and Fish Commission (AGFC), and Anderson-Tully Company (ATCO). Other private ownerships are interspersed among these larger ownerships. Service and AGFC lands are managed to benefit fish and wildlife resources. ATCO land is managed primarily for timber production with collateral management for fish and wildlife. Corps lands not used for navigation are managed, in part, by the AGFC for fish and wildlife.

Arkansas Game and Fish Commission **-** The AGFC administers the 10,268 acre Trusten Holder Wildlife Management Area (WMA). The area contains about 2,444 acres of White River National Wildlife Refuge and about 4,372 acres of Army Corps of Engineers land. Habitats on the WMA are primarily bottomland hardwoods adjacent to the White River in Desha and

Arkansas Counties, Arkansas. Typical tree species include overcup and Nuttall's oak, sugarberry, green ash, and persimmon. Management practices include selective timber harvest and planting food plots. Popular game species include whitetail deer, squirrel, cottontail and swamp rabbit, bobwhite quail, mourning dove, and waterfowl.

Dale Bumpers White River National Wildlife Refuge - The Refuge comprises approximately 160,000 acres in Desha, Monroe, Arkansas, and Phillips Counties in eastern Arkansas, primarily within the floodplain of the lower White River. The refuge encompasses 90 of the lower 100 miles of the White River in Arkansas, as well as three miles of the Arkansas Post Canal. Established in 1935, the refuge includes about 154,000 acres of bottomland hardwood forests, 1,000 acres of grassland, 900 acres of cropland, and 4,000 acres of natural and man-made lakes. The bottomland hardwood forest within the refuge represents nearly 20 percent of the state's remaining bottomland hardwood forest acreage and is a major component of the largest remaining contiguous bottomland hardwood forests on any tributary of the Mississippi River.

As the host of the largest concentration of wintering mallard ducks in the Mississippi Flyway, the refuge helps bring about 2.5 million dollars per day to the area during the sixty day waterfowl hunting season. Thus, the Refuge is a major economic asset to the area. The area provides habitat for wading birds, shorebirds, waterfowl, raptors, reptiles, amphibians, and mammals, including a healthy population of black bears. The refuge also has several active Bald Eagle nests. The Refuge is visited by about 150,000 people annually and offers opportunities for hunting, boating, fishing, wildlife observation and photography, and hiking.

Special Designations

The Three Rivers area is an important component of one of the last remaining large contiguous blocks of bottomland hardwood forest in the Mississippi Alluvial Valley (MAV). With over 80 percent of the forested wetlands of the MAV gone, the value of this area to Neotropical migratory songbirds, waterfowl, and black bear is of primary importance. The wetland functions performed, including flood water retention and nutrient transformation, help to mitigate the flooding downstream, improve water quality, and enhance fish and wildlife habitat.

In recognition of their importance to migratory birds and other wildlife, the wetlands of the Lower White/Cache Rivers are listed as one of only 38 Ramsar Wetlands of International Importance in the United States. The Ramsar Convention is the only international accord dedicated to the worldwide protection of wetlands. Wetlands are selected for inclusion on the List of Wetlands of International Importance based on international significance in terms of ecology, botany, zoology, limnology, or hydrology. The Refuge comprises the largest portion of the Cache-Lower White Rivers Ramsar designated Wetland of International Importance. It has also been designated as an Important Bird Area by the Audubon Society, which is a global effort to identify and conserve areas that are vital to birds and other biodiversity and is on the American Bird Conservancy list of globally important bird areas.

The lower Arkansas River from Dam 2 to its confluence with the Mississippi River has been designated by the state of Arkansas as a natural and scenic waterway and an ecologically sensitive waterbody. It is also listed by the National Park Service on the Nationwide Rivers

Inventory (NRI). The natural and scenic designation recognizes river segments with potential for adoption into the federal wild and scenic rivers system, while the ecologically sensitive designation recognizes river segments known to provide habitat within the existing range of threatened, endangered or endemic species of aquatic or semi-aquatic life forms (Arkansas Pollution Control and Ecology Commission 2001). Rivers are listed on the NRI based on the degree to which they are free flowing, the degree to which the rivers and their corridors are undeveloped, and because they possess one or more "outstandingly remarkable" natural or cultural values judged to be of more than local or regional significance. The lower Arkansas River was listed on the NRI because it is free flowing and possesses outstandingly remarkable scenic, geologic, and wildlife values.

The intent of the NRI is to provide information to assist in making balanced decisions regarding use of the nation's river resources. Section 5(d) of the National Wild and Scenic River Act requires that, "In all planning for the use and development of water and related land resources, consideration shall be given by all federal agencies involved to potential national wild, scenic and recreational river areas." All federal agencies are required to consult with the National Park Service (NPS), which is charged with compilation and maintenance of the NRI, prior to taking actions that could effectively foreclose inclusion into the national system. Additionally, a 1979 Presidential Directive and a related Council on Environmental Quality Directive require federal agencies to seek to avoid or mitigate actions that would adversely affect one or more NRI segments (National Park Service 2003).

The Service recently published a revised mitigation policy (U.S. Fish and Wildlife Service 2016). The revisions implement a recent Presidential Memorandum directing certain federal agencies to adopt a common set of best practices to minimize the harmful impacts to wildlife and other ecological resources caused by land or water-disturbing activities, and to ensure that any remaining harmful effects are appropriately addressed or mitigated. The revisions also implement a recent Secretarial Order on improving mitigation policies and practices within the Department of the Interior. This policy seeks to avoid and minimize impacts to habitats of higher value and minimize and compensate for impacts to habitats of lower value, although it does away with the Resource Category 1-4 system from the previous policy (U.S. Fish and Wildlife Service 1981). It also establishes a goal of achieving a net conservation gain, or at a minimum, no net loss, when recommending project mitigation, whenever the situation merits and doing so is allowed by law.

FISH AND WILDLIFE RESOURCE CONCERNS AND PLANNING OBJECTIVES

The mission of the Service is to work with others to conserve, protect and enhance fish, wildlife and plants and their habitats for the continuing benefit of the American people. To achieve this mission the Service administers a network of national wildlife refuges. Each refuge was created for a specific purpose which contributes to the mission of the refuge system and overall Service mission. The Service attempts to fulfill our mission by identifying and recommending the application of sound environmental stewardship based on ecological principles and scientific knowledge of fish and wildlife to sustainable and appropriate development projects.

Past and Current Water Development Projects

To understand the Service's concerns and planning objectives, it is important to provide a context in which to view the current conditions. This context is provided by examining the history of water development in and around the TRFS area. By carefully and objectively analyzing characteristics of the ecosystem including climate, vegetation, soil characteristics, and fluvial processes among other things, we can discern changes that have occurred or been imposed upon the system, identify conditions that may have contributed to stability or instability, and look for deviations from stable conditions and possibly determine thresholds beyond which conditions deteriorate. This information can then be compared to today's conditions to look for deviations from stable conditions and identify specific alterations that have led to current conditions. The goal of acquiring this information is not to return to some previous time, but rather to avoid continuing to make the same mistakes. In addition, planners and engineers that are armed with this information can craft solutions to problems that work with natural processes, instead of against them while achieving their objectives. Without this knowledge, we are doomed to failure and continual expenditures of precious dollars to address the inevitable consequences and response of the fluvial system and regional hydrology.

Water development projects on the Arkansas, White, and Mississippi Rivers have been ongoing for well over 100 years, with man's ability to construct major projects increasing dramatically with the advent of modern machinery during the 20th century. Navigation and flood control projects have been the primary catalyst for land use changes and have had the most significant effect on hydrology and river morphology. Large scale river engineering projects on the Mississippi River started in earnest following the great flood of 1927, with one of the most significant of these being the Corps of Engineers cutoff program in the lower Mississippi River. This consisted of construction of 14 neck cutoffs between 1929 and 1942 (Winkley 1977; as cited in Pinkard *et al*. 2003), which shortened the river by approximately 150 miles between Memphis, Tennessee and Old River, Louisiana. As a result, the flowline of higher flows at Arkansas City was immediately lowered by 16 feet (Pinkard *et al*. 2003). These actions also created an immediate need for bank revetments to maintain the channel alignment and prevent the river from trying to reestablish its stable plan form or sinuosity. Construction of wing dikes to concentrate flow into the thalweg further altered flow and sediment relationships and increased the need for additional bank stabilization projects.

River engineering works on the White and Arkansas Rivers have been equally ambitious (Figure 1). The major project on these rivers, the MKARNS, uses the first 10 miles of the White River as the entrance channel to the system. The 300 foot wide navigation channel is currently maintained by dredging to provide a minimum nine foot deep channel that is available nearly 100 percent of the time (Barkley 1987). During the 10 year period between 1980 and 1989, 8,807,000 cubic yards of sediment, averaging about 850,200 cubic yards per year, were dredged out of the 10 mile entrance channel to maintain its authorized depth. The maximum amount dredged during a single year was 3,506,000 cu. yds. in 1988 (McCabe 1990). This material is deposited on at least three sites in the study area, two of which are on the Refuge (Figure 5). Until recently, the Corps has been depositing an average of about 250,000 cubic yards of material dredged from White River miles 8 – 10 on these disposal areas on the Refuge (U.S.

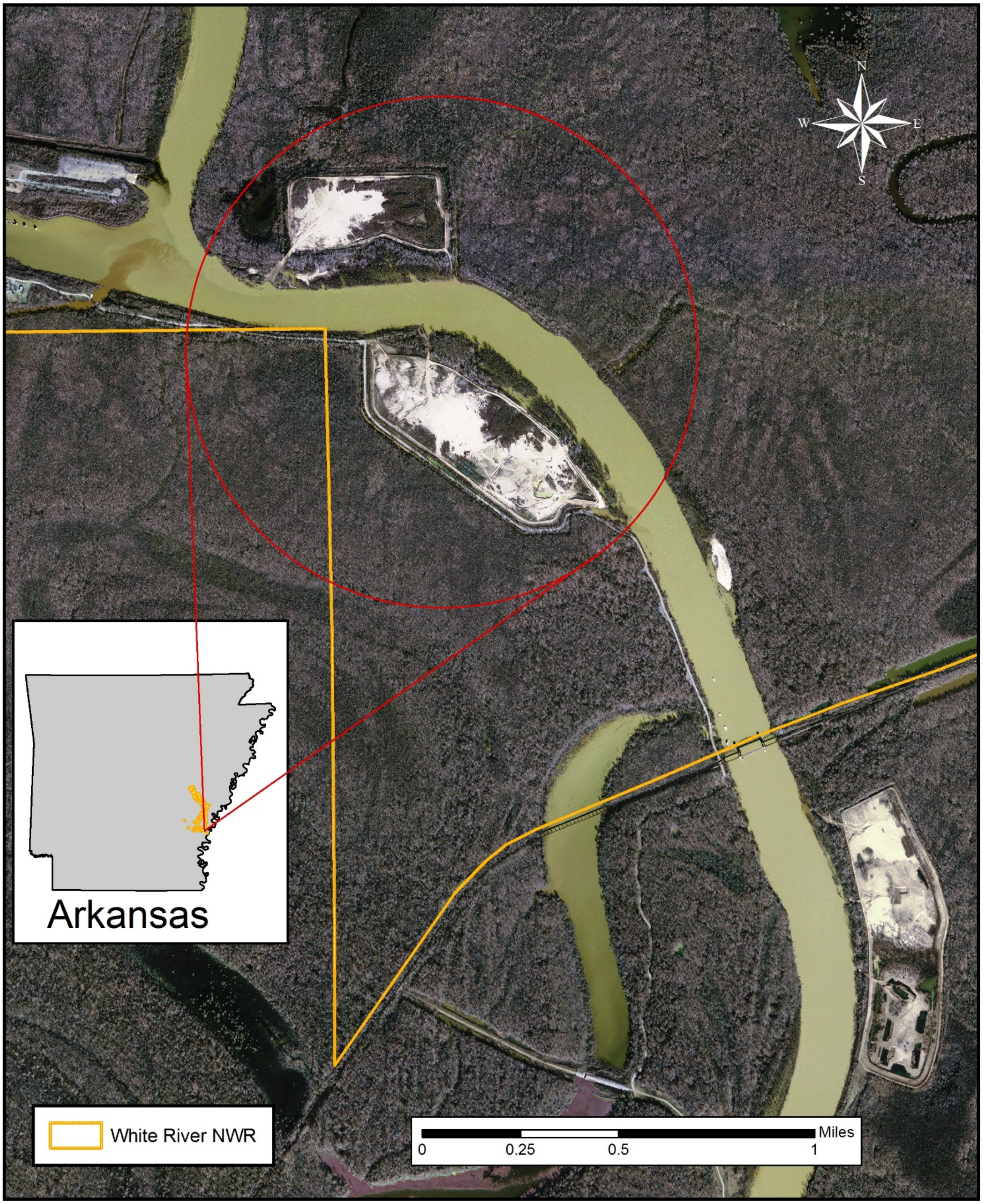

Figure 5. Dredge Disposal Areas on Dale Bumpers White River National Wildlife Refuge, Arkansas.

Army Corps of Engineers 2000) under temporary special use permits since 1965. To date, an estimated seven million cubic yards have been deposited on the two sites on the Refuge, which comprise approximately 260 acres including the buffer area. The actual mounded area is approximately 170 acres. Maps in Barkley (1986) and McCabe (1990) indicate that some quantities may have been deposited in other locations in the study area, but not enough to create a land mass as greatly elevated above the floodplain as these two areas. The Refuge is currently not issuing new special use permits for the use of spoil deposition sites. One of the existing sites has a failed drainage structure and has spilled sand onto the Refuge blocking drainage and resulting in the death of nearby timber. The Refuge is currently under negotiations with the Corps to find a resolution to the issue of spoil deposition on their properties.

The lower Arkansas River below Dam 2 is not part of the inland navigation system; however, significant alterations to the river channel and its associated floodplain have been done. A levee has been constructed along the south and west sides of the Arkansas River from above Dam 2 nearly to the mouth of the river. The distance of the river from the levee varies from about 200 feet at its closest to about 1,370 feet at its farthest location. It widens considerably near the mouth of the river. The most notable river engineering works that have been done on the lower Arkansas River below Dam 2 are the meander cutoffs. The last one, the Morgan Point Cutoff, was done in 1966 for construction of the dam. Other man-made cutoffs include the Red Fork Cutoff (1945), Hopedale Cutoff (1946), Sawmill Bend Cutoff (1960), and Avenue Landing Cutoff (1962-1963) (Pinkard *et al*. 2003). Several natural cutoffs on the Arkansas River also occurred during this time. Bank revetments along the Arkansas River are nearly continuous for approximately 9.5 miles from Dam 2 to the Yancopin Bridge.

Construction for MKARNS in the Three Rivers Area

Before construction of the MKARNS, the Historical Cutoff allowed cross flow between the Arkansas and White Rivers (Figure 3). In 1963, the Corps constructed a closure structure across the historical cutoff (Corps 1988, page I-2) to stop the principal flow between the two river systems (Corps 1988, page III-2). The construction of this approximately 1.3 mile long structure caused an increase in the duration and frequency of stage differential events near elevation 145 to 150 feet (NGVD) (Corps 1987, page 4) and has resulted in the rivers attempting to reestablish a connection (Pinkard *et al*. 2003). The nine mile long Arkansas Post Canal, which connects the White River to the Arkansas River above Dam 2 at Pendleton, was constructed in the mid 1960's.

Two significant hydrologic events occurred in 1971 and 1974 which created large differentials between the two rivers. The 1974 event generated a cross flow and stage differential of over 26 feet. This allowed the river systems to begin to interact more frequently and for longer durations than had been possible previously. The Melinda Channel developed between 1971 and 1984 and had a length of over 3,000 feet and an average width of about 250 feet. Average thalweg elevation was 120 feet (NGVD). The lowest ground elevation between the two rivers was reduced from 150 to 142 feet with only a small clay plug separating Owens Lake and Melinda Channel (Corps 1988, page III-2). Seven major areas of active scour had been identified by 1984.

In 1983, the land between Owens Lake and the White River was breached causing the lake to drain. A temporary dike structure set at elevation 145 feet (NGVD) was constructed in 1984. This structure was flanked in 1985, draining the lake. The temporary dike structure was replaced in 1986, was overtopped in October by a significant rise on the Arkansas River, and breached again. Significant widening of the Melinda Channel occurred at this time (Corps 1988, page III-3). During these events, the minimum elevation of the overland area was reduced to 141 feet in 1985, and 136 feet in 1986.

The Corps constructed the Melinda Headcut Structure in 1989 at an elevation of 142 feet. It suffered damage in 1990 and 1991 and was subsequently repaired. In 1991 and 1992, they constructed the Owens Lake structure to an elevation of 145 feet. This structure included a levee that extended across La Grues Lake to the railroad embankment. Work on the Melinda Headcut Structure has been ongoing: The Melinda revetment was constructed in 1994, slope failure at the structure was repaired in 1998, and the 80 foot deep scour hole that developed below the structure on the Arkansas River side was filled in 2000. Additional damage was done in 2011 when the structure was nearly flanked on the west side by headcutting. This damage was repaired, although additional nearby headcuts continue to grow westward from the Melinda channel towards La Grues Lake.

The Owens Lake and Melinda Headcut structures have been successful in preventing a cutoff from forming; however, they have not prevented continued erosion and associated terrestrial habitat loss. In the Owens-Melinda corridor, there has been a total of more than 41 acres of land lost, with over 30 acres being on White River National Wildlife Refuge (Figure 6), not including land lost to Arkansas River channel migration. In 1991, a containment structure (soil cement levee) was constructed from the Historical Closure Structure to the railroad embankment. With the exception of an overflow crest structure at Owens Lake structure (elevation 145 feet), the containment structure was constructed to a 150 foot elevation (Corps 1987; page 21).

The White River channel immediately below the Arkansas Post Canal was realigned to facilitate barge entrance into the canal. In addition to other in-channel work, a considerable amount of the river banks in the MKARNS entrance channel have been reveted.

Degradation of In-Channel and Floodplain Resources Due to Hydrologic Alteration and Channel instability in the White and lower Arkansas Rivers

The geomorphic instability of both the Arkansas and White Rivers is becoming more evident. Partially in response to Mississippi River channel degradation caused by meander cutoffs and other engineering works, this geomorphic instability is seen beyond the confines of the study area. Excessive bank erosion/channel migration on the White River is evidenced by the multi-layered willow bars on the inside bends in the river above RM 10. This process is also evident on the Arkansas River especially in the vicinity of the Melinda Headcut Channel and Jim Smith Lake. Headcuts are occurring both in the study area and upstream on the White River. Service biologists during July 2002 counted 30 headcuts and gullies in various stages of development between White River miles 10 and 18. Headcuts have also been noted on the Arkansas River.

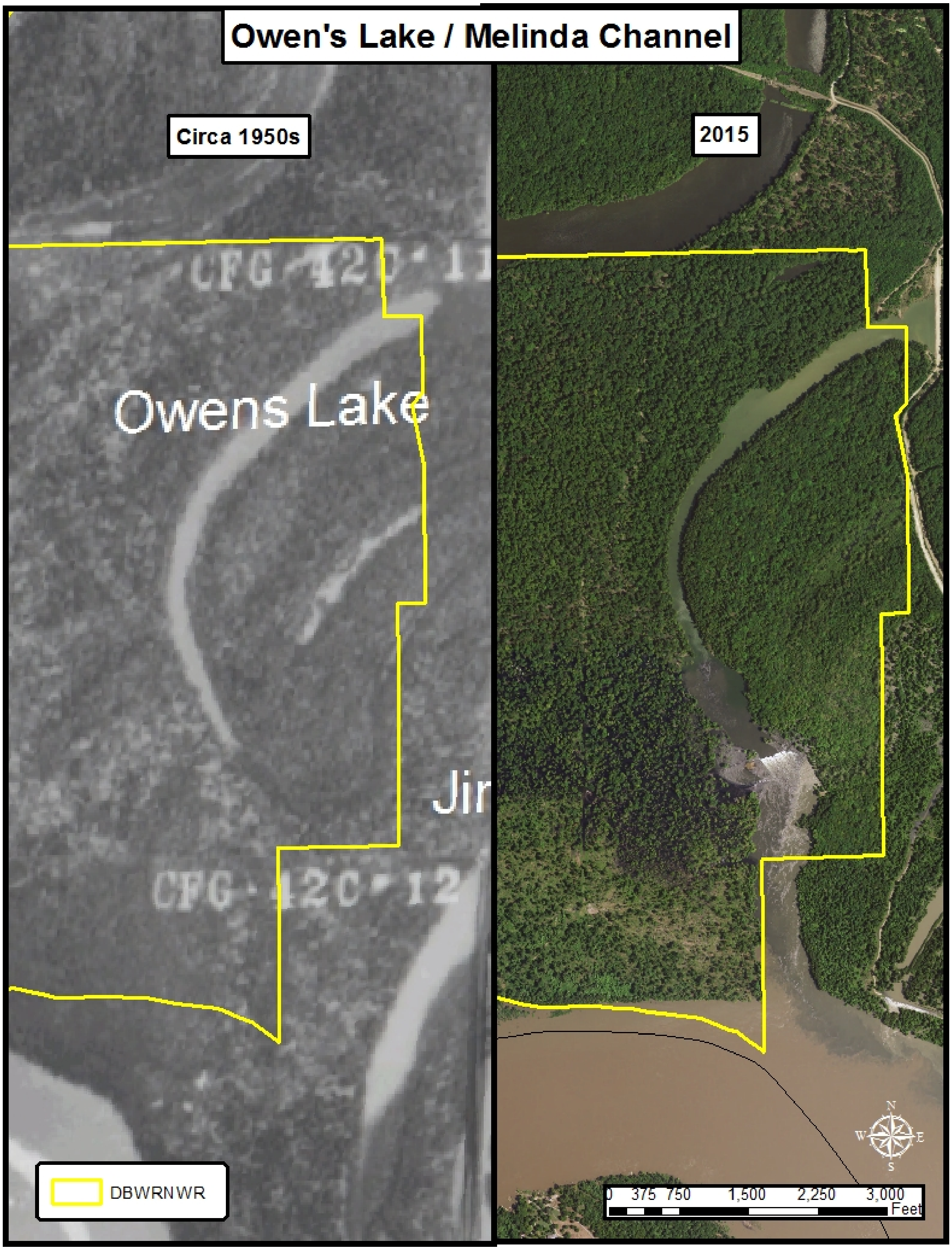

Figure 6. Terrestrial Habitat Loss Around Owens Lake and the Melinda Headcut Channel from circa 1950s to 2015, Arkansas County, Arkansas.

All aspects of the hydrologic cycles of the Arkansas, White, and Mississippi Rivers have been altered from historical conditions. The numerous development projects ranging from dam and levee construction to meander cutoffs and dredging have each contributed to disruption of one or more aspects of the master parameter groups (i.e., landscape including stream gradient; flow regime; and sediment regime) that maintain dynamic equilibrium of fluvial systems. The complex and interconnected hydrology of the three rivers can no longer exploit the numerous sloughs, bayous, channels, swales, and backswamps that historically provided conduits for the movement of the massive quantities of water flowing down the three rivers and converging in the Three Rivers area.

The regulation of rivers by dams reduces channel forming flood flows (Ward and Stanford 1995a), and can interrupt the flow of nutrients downstream, disrupt the timing and duration of flood peaks, and alter the temperature regime of downstream reaches. The five major dams constructed on the main stem and tributaries of the White River and the dams constructed on the Arkansas River between the 1940's and 1960's have greatly altered the hydrograph of these two rivers. The White River dams have flattened the hydrograph (Craig *et al.* 2002), reducing flood peaks while increasing stage and discharge of low flows. These higher flows during lower flow periods persist longer than normal. Dams on the Arkansas River, and the associated hydropower plant on Dam 2, have greatly altered flow and sediment transport patterns on the lower Arkansas River. The lower river experiences wide fluctuations, sometimes daily, in flow as hydropower is ramped up and subsequently turned off. Slugs of sediment mobilized during the peak power production in the low flow summer months rapidly drop out for miles downstream when the turbines are turned off. The effect of this on fish habitat and freshwater mussel resources has not been evaluated. Dams on the White River have cut off the supply of gravel to the system. The dams in combination with dredging for navigation and sand and gravel mining have greatly reduced the occurrence of gravel substrates in the lower White River. Gravel substrates persist in some portions of the lower White River, and gravel is a component of some of the most significant freshwater mussel beds in the river (Christian 1995).

While the dams directly affect discharge, constriction of the floodplain by levees reduces the extent of overbank and backwater flooding while increasing the stage for a given discharge. Historically, the Mississippi River and its tributaries flooded millions of acres in the lower Mississippi Alluvial Valley (MAV). In Mississippi alone, over 4.5 million acres were flooded by the 2 year flood; however, this was reduced to approximately slightly over 1 million acres by construction of the main stem Mississippi River levee system (Galloway 1980 as cited in Reinecke *et al*. 1989). Over 150 miles of flood control levees along the White River and the extensive levees along the Arkansas River have not only reduced the extent of overbank flooding considerably, but have induced forest clearing and conversion to agriculture. The varying distance of the levees from the river channel, along with elevated roadways and railroad embankments across the floodplain with limited bridge openings, create “pinch” points that effectively increase flood heights above these features. These alterations to the floodplain affect all aspects of flood behavior, including biogeochemical processes and physiological stress on woody vegetation.

River engineering projects, primarily meander cutoffs and river training structures along the Mississippi River, have induced channel incision in the reach extending above and below the confluence of the White and Arkansas Rivers with the Mississippi. Biedenharn and Watson (1997) documented a stage reduction of 16 feet in this reach. Being the master trunk, geomorphic changes on the Mississippi have induced headcuts up the Arkansas River, evidenced in part by several recently formed terraces along the lower Arkansas River (Pinkard *et. al.,* 2003). This channel incision on the lower Arkansas River has altered floodplain hydrology requiring greater flows for flood waters to access the floodplain. Along the lower end of the White River near Norrell Lock and Dam, an incision of around 6.5 feet has occurred. However, analysis of bank widening rates indicates that this portion of the river may have reached an equilibrium (King *et al.* 2016).

Instream habitats are affected by dredging and snagging operations. Dredging removes shallow areas that would have historically been shoals or riffles, and along with snagging, removes structure from the channel, alters the flow dynamics, and thus effects the geomorphic relationships between channel width, depth, and flow. In addition, dredging directly impacts benthic habitats, increases turbidity, reduces the heterogeneity of the channel habitat, and may release toxins stored in the sediment (Ebert 1993).

While some of the effects of these various activities are immediately realized, the long term effects of these various hydrologic modifications are neither simple nor obvious when considered cumulatively. Flow regulation and floodplain constriction point to more extensive, prolonged, and deeper inundation at the south end of the White River NWR than that in which the biological components of the system evolved. However, hydrologic modifications to the Mississippi River, including bendway cutoffs and wing dikes, have reduced the stage of low and moderate flows to the point that the lower White River and its tributaries are being unnaturally drained (Yaich 1994; King *et al.* 2016). Thus timing, patterns, flow rates, and frequency of inundation are being governed by these forces, further complicating the hydrologic relationships. Possible consequences of the geomorphic changes of the Mississippi River to the lower White River and its associated ecosystem are channel incision, bank scouring, increased need for dredging to maintain navigation, changes in wetland vegetative communities along the lower White River and tributaries (Yaich 1994), and an increasing number of headcuts on tributaries. Despite these impacts to the lower White River, the system as a whole still maintains many of its vital ecological functions. Paramount among these is the annual winter/spring flood cycle.

The hydrology of the basin continues to be modified by ongoing water development projects, including the Grand Prairie Area Demonstration Project and the Montgomery Point Lock and Dam. Additional modifications are planned for the future, thus further complicating and altering the hydrology and hydrologic relationships in the basin. Channel modification can have dramatic effects on river stages and overbank flooding. Reservoirs, bank stabilization, cutoffs, channel realignments, low water contraction dikes, and dredging have caused a lowering of the discharge rating curve on the Mississippi River at the mouth of the White River (Bayley 1992). Fredrickson (1979) reported significant decreases in river stages on channelized portions of the St. Francis River and minor changes on unchannelized segments. He stated, "The decrease in river stages at maximum discharge was so great that the frequency and depth of inundation of riparian lands was reduced on channelized sites."

The full effect of the many past and current hydrologic modifications to the Arkansas and White River systems has not yet been evaluated, nor have the consequences of modifications to the Mississippi River been determined for its tributaries. It is clear, however, that these actions have affected the morphology of both the White and Arkansas Rivers and the function of the lower Arkansas River and White River ecosystem. These effects are currently manifesting themselves through accelerated bank erosion and the development of numerous headcuts into previously stable drainages and tributaries as the rivers attempt to adjust their form to current hydrologic conditions. It is certain that the combination of past actions with future proposed alterations to White River system will continue to affect its function. Despite this, however, the hydrologic processes previously discussed still regulate the White River system for the time being and may aid in the restoration of the White's highly altered riverine functions in the future.

Direct Loss of Bottomland Hardwood Forested Wetlands and Terrestrial Habitat

The Mississippi Alluvial Valley (MAV) historically comprised approximately 24 million acres that included the floodplains of the lower White and Arkansas Rivers. The expansive bottomland forests of the MAV provided the large expanse of contiguous forests necessary to support wide-ranging species, such as black bear, panthers, and wolves; forest interior neotropical breeding birds; migratory waterfowl; and habitat specialists, such as the endangered Ivory-billed Woodpecker. Forest block size and hydrology are some of the primary factors affecting songbirds in the MAV, and the importance of block or patch size to certain avian species has been widely recognized as a critical factor in their conservation (Mueller *et al.* 2000, Twedt *et al.* 1998, Donovan *et al*. 1995, Whitecomb *et al*. 1981).

The extensive clearing of the bottomland hardwood forests of the MAV, and fragmentation of most of the rest into small blocks, have severely reduced the amount of available habitat for interior forest birds. Construction of flood control levees along these rivers have cut off about 90 percent of their historic floodplain from periodic overbank flooding and facilitated clearing and conversion of over 80 percent of the bottomland hardwood forest in the MAV (Dahl 1990; Twedt and Loesch 1999). In Arkansas' portion of the delta, up to 89 percent of its 8 million acres of the bottomland hardwood forest has been cleared (Yaich 1994). While the Three Rivers area and the lower White River basin are unique within the MAV, in that they have retained a large tract of BLH, it is a fraction of what was here historically and is configured largely in a relatively narrow corridor along the river. In addition, much of what remains represents the lowest and wettest habitats on the floodplain.

Additional losses of bottomland hardwood wetlands have occurred due to excessive bank erosion and channel migration of both the Arkansas and White Rivers. A headcut developed at about White River Mile 14 when the channel migrated westward and captured a small interior drain. The crevasse that this headcut created is approximately 120 feet wide where it meets the White River and extends landward in three branches approximately 1,700 linear feet. This headcut appears to have stabilized in recent years and is no longer growing at a rapid pace. The lower Arkansas River continues to be geomorphically active. High flows during summer 2007 resulted in bank erosion along a bend approximately 2.2 miles south of the Historical Cutoff. The bank along this bend migrated approximately 250 feet. While channel migration is a natural fluvial process, there is concern that the rate of channel migration along both of these rivers has been accelerated in recent years.

A considerable amount of bottomland hardwood and other aquatic and terrestrial habitat in the study area have been lost from construction of MKARNS navigation features, including the Arkansas Post canal; Dam 2; the Historical Cutoff Structure; the containment and La Grues Lake structure; and, the Owens Lake structure. Approximately 150 acres were permanently lost from construction of Montgomery Point Lock and Dam (U.S. Army Corps of Engineers 1990; page 27). Over 170 acres have been lost from the deposition of dredge material on the disposal areas in the study area. Since construction of the MKARNS and the closing of the Historical Cutoff, Owens Lake has become the primary conduit for flows between the White and Arkansas Rivers. As a result, a headcut has developed below the lake (Melinda Headcut Channel) and the bank around Owens Lake has been eroding to accommodate the increased flows. Based on a comparison of aerial imagery, there has been a direct loss of over 30 acres of land on White River National Wildlife Refuge as a result (Figure 6). Some of the habitat losses from construction have been mitigated through forest restoration and green-tree reservoir construction. Other losses have gone unmitigated. Some of the mitigation that was constructed to compensate for these losses is no longer functioning. Total habitat loss on Service property has not been calculated; however, the continued loss of terrestrial habitat from both direct and indirect impacts of construction of the various features is of particular concern to the Service.

Degradation of floodplain aquatic habitats

Degradation of floodplain aquatic habitats from altered hydrology has gone largely unanalyzed; consequently, the effect of altered hydrology on floodplain aquatic resources in most cases can only be qualitatively described. Reservoir releases designed for flood control and hydropower production affect not only the extent of flooding but also the timing and duration of connectivity. However, the impact of land use development and in channel work has been tied to disruption or elimination of many natural processes important to floodplain aquatic resources (Knowlton and Jones 1997; Benke et al. 2000), including reduced connectivity (Ward and Stanford 1995).

Channel migration on the lower Arkansas River, along with channel incision, has completely eliminated some aquatic floodplain habitats or altered their connection to the river. Old River Lake was completely dewatered due to the migration of the Arkansas River channel. Along the White River, an artificial plug, previously constructed to maintain Mossy Lake after the river migrated into the natural high bank, was washed out and resulted in the complete draining of the lake. Mossy Lake is hydrologically connected to three other lakes and dewatering of Mossy also lowered water levels of the other lakes adversely affecting approximately 600 acres of aquatic habitat.

Refuge Issues - Compatibility

The Service is required by the National Wildlife Refuge System Administration Act of 1966, as amended by the National Wildlife Refuge System Improvement Act of 1997 (16 U.S.C. 668dd-668ee) (NWR Improvement Act), to complete compatibility determinations for any new use or expanded, renewed or extended existing use of a national wildlife refuge. We base compatibility determinations on a refuge-specific analysis of reasonably anticipated impacts of a particular use on refuge resources. When completing compatibility determinations, we use sound professional judgment to determine if a use conflicts with any approved refuge goal or objective or will materially interfere with or detract from fulfillment of the Refuge System mission or the purpose(s) of a refuge, while not degrading the ecological integrity of the refuge. We are not allowed to use compensatory mitigation to make a proposed refuge use compatible.

<u>Refuge Compatibility Issues with Previous Recommended Alternative -</u> The Corps previously studied the problem in the Three Rivers area during the development of the AWCS. Alternative 6A, which included raising and extending the containment levee, was the recommended alternative. The Service indicated over the course of the study that it was unlikely that the Alternative 6A could be deemed compatible with the purposes of the Refuge. We later found out that, in addition to construction of the containment dike, Alternative 6A would include acquisition and use of a flowage easement. The resulting impacts were not believed to be appropriate since they did not appear to be beneficial to the refuge's natural or cultural resources. Furthermore, we believed that Alternative 6A would materially interfere with or detract from the fulfillment of the NWRS mission and the purposes of the Refuge. Consequently, we concluded that based on the materials submitted and on our sound professional judgment, it was very unlikely that the proposed uses of the Refuge associated with Alternative 6A would be considered "appropriate" or "compatible."

Red oak communities, particularly Nutall's oak and associated species, are of extreme importance for migratory birds within bottomland hardwood habitats. The seed crops are of high value to wintering waterfowl, as well as other native wildlife. Soil saturation of 100%, with or without standing water, during the growing season and for as short as a two-week period, is enough to kill 100% of red oak seedlings. Without reliable recruitment of young trees, red oak communities will be lost to less desirable, more water tolerant species such as overcup oak and water hickory. Development of the Corps' previously preferred alternative (6A) would have increased flood water depths and durations and potentially resulted in a shift in forest community species composition.

Giant cane communities in bottomland hardwood habitat have received much research attention and are considered a critically imperiled habitat type. This plant species occurs on well drained soils in close association with waterways and is very important to nesting Swainson's Warblers, a trust species of regional importance. These birds appear to be highly associated with giant cane sites on the refuge, and use the cane communities for nesting habitat and the ground leaf layer for feeding. Even short periods of flooding will change the leaf layer structure, likely decrease cane establishment and spread, and subsequently diminish the relevance of these stands in Swainson's Warbler conservation.

The Corps has established two green-tree reservoirs totaling approximately 3,000 acres on the Refuge as part of habitat mitigation for previous MKARNS projects. The previously preferred alternative would have caused increased flooding duration and depth in these sites which would inhibit timely spring drainage, resulting in tree mortality over time. These impacts would serve to invalidate the green-tree reservoirs' role as habitat mitigation for previous Corps navigation projects.

Several issues not discussed within the Corps' preliminary documents made it difficult to assess the potential compatibility of the previously preferred alternative. One of the most important oversights was that of habitat conversion. Within the document, the Corps analyzed wetland types at the level of riverine and flat; however, within the riverine type are several habitat types. These habitat types, especially those associated with well drained soils, contain plant communities of great importance to wildlife.

Based on the information provided in the draft reports and our sound professional judgment, it appeared that the induced hydrological alterations associated with the previously preferred alternative would materially interfere with fulfillment of the Refuge System mission and Refuge purposes while degrading the ecological integrity of the Refuge; therefore, the previously proposed use of the Refuge did not appear to be either appropriate or compatible.

<u>Refuge Compatibility Issues and the RP</u> – The RP for the TRFS consists of a mixture of previously studied alternatives. This plan includes construction of a much shorter containment structure, removal of the Melinda Headcut Structure, placement of a drainage culvert through the Owen's Lake Structure, and placement of a passive weir in the Historical Cutoff Closure Structure that will pass flows mimicking the current volume and elevation. To date, a compatibility determination has not been done, nor can one be done until a final project with all associated impacts is presented. That is, the Refuge cannot complete a compatibility determination until they know the Corps' final plan for the TRFS; however, we can offer our general perceptions of compatibility based on information provided in the unsigned draft reports and our sound professional judgment. It is the Corps responsibility to provide sufficient information to show that the action would be beneficial to the Refuge and/or not materially detract from or interfere with meeting Refuge purposes.

The Refuge has incurred habitat loss since initial construction of the MKARNS, and these losses have continued to the present time. Direct habitat loss from construction was mitigated by construction of green-tree reservoirs and land acquisition. However, continued land and habitat loss around Owens Lake and the Melinda Headcut Channel, as well as the loss of ecosystem functions have not been mitigated. As was mentioned previously, over 30 acres of refuge land has been lost due to erosion at this location. The effects of river engineering on the geomorphic instability in the lower White and Arkansas Rivers have not been formally assessed.

The resources of the lower White and Arkansas Rivers are of national and international importance, in part for their value to migratory waterfowl. The Service administers over 250,000 acres of land in the lower White River basin which comprises a significant portion of the largest contiguous block of bottomland hardwood forest remaining on any tributary of the Mississippi River. Therefore, the Service's planning objectives are focused on gaining the knowledge needed to understand and manage this dynamic and complex ecosystem and on conserving and enhancing these important resources.

The restoration of an ecologically sustainable hydrologic regime, as close to natural conditions as possible, while maintaining an efficient and economic navigation system is vital to conserving and managing the resources of the area.

The loss of terrestrial habitat within the study area, including on the Refuge, due to headcutting and bank erosion is of particular concern. Our goal is to work with the Corps and other entities to abate terrestrial floodplain habitat loss, and restore and enhance bottomland hardwood forested wetlands.

The loss and degradation of habitats on the Refuge includes floodplain lakes. Approximately 600 acres of aquatic habitat was lost when the rock plug maintaining water levels in Mossy Lake washed out. It is a goal of the Service to restore and enhance these and other floodplain aquatic habitats and provide fish access to the floodplain.

It is currently our assumption that the RP will provide the stability desired to maintain the MKARNS while having little negative effects and some positive effects on the Refuge and surrounding areas. The RP incorporates both an elevated containment structure (to reduce the head differential during certain flood events) and a passive weir in the Historical Closure Structure to allow controlled interactions between the White and Arkansas Rivers. Achieving stability in this area would abate the losses of terrestrial habitats observed historically and currently ongoing. Allowing interaction of these rivers through the Historical Cutoff at an elevation and volume mimicking current conditions and providing drainage back to the White River through the Owen's Lake Structure should result in very little hydrologic change in either river basin. This reduces the previous concerns about the effects of hydrologic change on the plant communities and management capabilities of the Refuge and other properties. The plan to remove the Melinda Headcut Structure will reunite the divided halves of Owen's Lake and provide more access in and out of these habitats for fishes and other aquatic life.

EVALUATION METHODOLOGY

Hydrology

The effects of project alternatives on hydrology in the project area were evaluated using a two-dimensional HEC-RAS model. The terrain (using USGS 30m Digital Elevation Model 5 ft. contours or LIDAR 2 ft. contours) was modeled as a continuous surface and the water is not constrained to move in one direction only. Water can move downstream or laterally flow into the floodplain. Velocity and water surface elevations were calculated over the entire study area and not just cross-sections. Animated flood inundations, velocity magnitude grids, and duration flooding grids were produced for the entire study area.

In the early stages of this study, several alternatives were considered which had the potential to alter hydrology (flooding depth, duration, and frequency) over significant portions of the refuge. This was of concern to the Service due to the potential for impacts on vegetation communities and associated wildlife. In order to avoid a scenario where Refuge compatibility was unlikely, the Corps, in discussion with federal and state resource agency partners, ultimately crafted a hybrid solution that addresses sustainability of navigation infrastructure and has minimal effects on hydrology within the project area. This became Alternative 1 and ultimately the RP. Detailed designs regarding the width of the Historical Cutoff opening and Owen's Lake drainage/fish passage structures are ongoing, but avoidance of significant hydrologic change is one of the primary constraints in the design.

Wetland Impacts

The Little Rock District Corps of Engineers assembled an Environmental Review Team comprised of federal and state agency, and NGO staff (Table 1) to determine appropriate methods of evaluating potential environmental impacts of project alternatives.

Table 1. Arkansas – TRFS Environmental Review Team Members.

Name	Affiliation
Craig Hilburn	Little Rock District, Corps of Engineers
Jennifer Sheehan	Arkansas Game and Fish Commission
Jason McCallie	Arkansas Game and Fish Commission
Kirbie McCallie	National Park Service
Tom Foti	Arkansas Natural Heritage Commission
Jason Thronebery	Arkansas Natural Heritage Commision
Matt McNair	Arkansas Department of Parks and Tourism
Jason Milks	The Nature Conservancy, Arkansas Field Office
Bo Sloan	U.S. Fish and Wildlife Service
Jason Phillips	U.S. Fish and Wildlife Service

Initial Service concerns about this study centered on potential effects on vegetation communities due to hydrologic alteration. There was little detailed information describing the existing conditions in terms of vegetation. Likewise, there was no detailed study of past hydrologic conditions. This data was crucial in order to describe existing conditions and assess potential impacts. The Corps did not have the time or funding to conduct these studies, so information was drawn from existing sources where possible. Limited vegetation data was available in the form of Continuous Forest Inventory (CFI) plots. Additionally, the Service worked with the AGFC, ANHC, and others in an attempt to further describe existing conditions. We classified habitats on portions of the Refuge and Trusten Holder WMA by landform (backswamp, Holocene point bar deposits, Pleistocene valley train deposits, etc.), microsite type (ridge, swale, flat, natural levee), and elevation (Figure 7). The goal was to collect vegetation data to supplement the CFI plots and ultimately be able to map Potential Natural Vegetation (PNV) throughout the project area. Before we could proceed that far, the Corps announced the development of Alternative 1 and its adoption as the TSP. This negated most of our concerns regarding hydrologic impacts and the PNV mapping effort was halted.

The team decided that the Hydrogeomorphic Approach (HGM) to assessing wetland functions was the best tool currently available for assessing project impacts. Wetland functions assessed

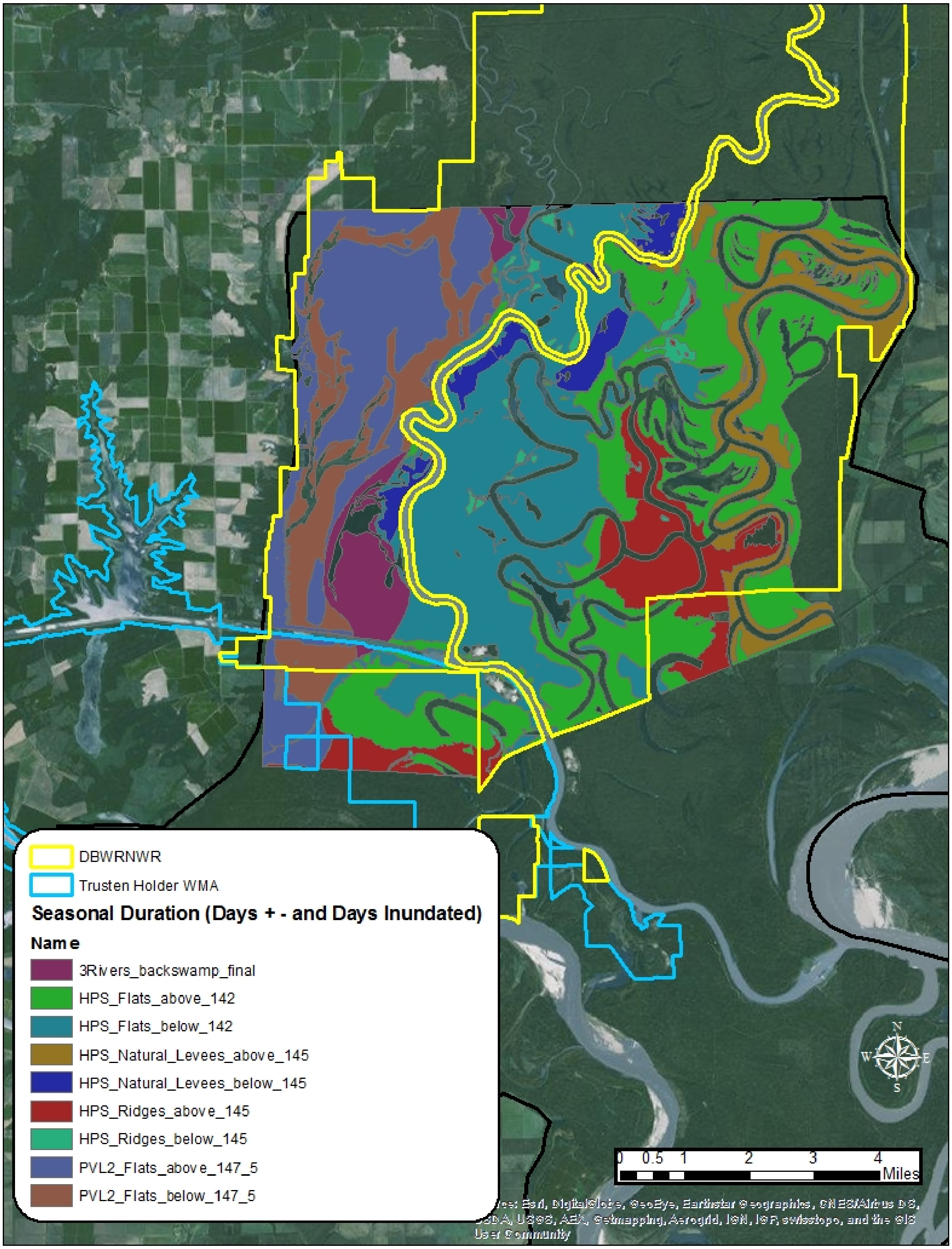

Figure 7. HGM/PNV Classification Map, DBWRNWR and Trusten Holder WMA

by the HGM approach include wetland wildlife habitat, nutrient cycling, plant community maintenance, and floodwater detention. It was assumed that impacts to wetland functions assessed using HGM, while not specific to any particular wildlife species, represent a measure of ecosystem health and thus value to wetland dependent wildlife.

The HGM approach first groups wetlands into regional subclasses based on functional similarities within a given hydrogeomorphic setting. Wetland functions for each subclass are assessed using field collected or other sources of information. This information comprises the function is being performed by the particular wetland subclass. For example, vegetative data may be directly measured using standard forest sampling methods, while flood frequency data may be obtained from gage data, flood zone mapping or other sources. The HGM approach generates a Functional Capacity Index (FCI) which is multiplied by the wetland area to calculate the amount of Functional Capacity Units (FCU) for each assessed function. These FCU can then be used to compare wetlands within the same regional subclass.

Direct impacts involved immediate loss of habitat from construction of project features. Indirect effects were in the form of altered hydrology. Direct impacts were assessed by sampling representative subclasses within the project footprint. Samples were taken in proportion to the variability of wetland condition class (e.g., scrub, young forest, mature forest) and within each wetland subclass. The RP design will not result in measurable changes to hydrology in the study area outside of a small area downstream of the current Melinda Structure, therefore indirect impacts were not considered in the analysis.

The consensus of the environmental team was that impacts to wetlands would best be compensated by restoring agricultural lands in the project area to forested wetlands with the understanding that lands acquired for mitigation would likely include a combination of cleared agricultural and forest land. Compensatory mitigation for impacts of each project alternative was determined by applying the HGM approach to calculate functional gains based on trajectories published in the Delta HGM Guidebook (Klimas et al. 2004). The HGM approach calculated the number of acres needed to compensate wetland impacts by analyzing the change in wetland functionality for a “typical” acre of restored wetland under a variety of different scenarios for the Flats and Riverine Backwater subclasses. Initial calculations indicate the direct impacts associated with the TSP would result in the loss of 4.0 Functional Capacity Units requiring the restoration of approximately 10 acres of farmed wetland.

The team considered the incorporation of “out-of-kind” mitigation for direct impacts. This would be in the form of improved fish passage at several points of connectivity between oxbow lakes and the White River. Culvert size, design, and elevation modifications were considered. However, Corps policy requiring quantitative justification for mitigation, the lack of certified models to compare and quantify losses and gains, and the significantly higher costs resulted in the rejection of this idea in favor of the traditional HGM methodology to quantify mitigation required in the form of restored farmed wetlands.

Waterfowl Impacts

The waterfowl assessment methodology uses available food as an index to the carrying capacity of wintering foraging habitat for dabbling ducks. This index is expressed as duck-energy-days (DED) per acre which represents the capacity of forage available on an acre of land to meet the energy requirements of one duck for one day. The energy value of available forage varies by land use (e.g., forest vs. agricultural) and the plant community composition (% red oak). Calculations used to determine DED account for food availability which is a function of both consumption and deterioration.

The next step in the process is to determine the amount of habitat available. This is based largely on the amount of available habitat flooded 18 inches or less during the winter season. Waterfowl assessments are usually done when significant changes in hydrology are expected over a large area. In this case, the RP should not result in significant changes to the hydrology of the study area. The only impacts to waterfowl would result directly from the construction of the containment structure. Mitigation required to replace all wetland functions (including wildlife habitat) was calculated for this footprint. The value of the proposed footprint for waterfowl is marginal at best, as much of it consists of existing structures, roads, or other cleared areas. Based on the results of previous studies showing that the HGM calculated mitigation normally exceeds that calculated for replacement of DED and the fact that the RP will result in no large-scale changes to hydrology, the Service elected to forgo the development of a waterfowl assessment.

Floodplain Lake Connectivity

The frequency, duration, and timing of lake connectivity to the White and Arkansas Rivers in the project area should not change significantly with implementation of the RP. The incorporation of an opening in the Historical Cutoff Closure Structure which approximates the elevation and capacity of existing flow paths across the isthmus should result in little change to existing hydrology and therefore lake connectivity. The exception to this may be Owen's Lake. It currently receives flows above 145 feet NGVD from the White River over the Owen's Lake Structure and above 140 feet NGVD from the Arkansas River over the Melinda Headcut Structure. The construction of a new containment structure at 157 feet NGVD south of the Melinda Headcut Structure would result in a single outlet to the north over the Owen's Lake Structure. This would affect the vegetation communities in the area immediately adjacent to Owen's Lake and also affect the frequency and duration of fish passage into and out of the lake. The RP will incorporate water and fish passage through the Owen's Lake Structure via a 6 ft. tall by 30 ft. wide arched culvert at an elevation of 140 ft.

FISH AND WILDLIFE RESOURCES

Existing

The lower Arkansas and White Rivers and their associated floodplain ecosystems are extremely valuable for their rich and diverse natural resources. Despite the numerous projects constructed, this area still retains much of its original character and is among the richest, most functional ecosystems left in the MAV. The lower White River basin contains the largest block of bottomland forest remaining on any tributary of the Mississippi River. In addition, the lower White River basin and lower Arkansas Rivers have several state, national, and international designations in recognition of their significant natural resources. It provides habitat for hundreds of species of fish, freshwater mussels, resident and migratory birds, mammals, reptiles, and amphibians.

Aquatic Resources

Aquatic habitats within the study area include the main stem of the White and Arkansas Rivers, Menard Bayou, Honey Locust Bayou, Wild Goose Bayou, Island 73 Chute, and oxbow lakes adjacent to the river system, including Lake Dumond, Owens Lake, Garland Lake, John Smith Lake, Moore Lake, and Pelican Lake (Figure 8). These permanent and seasonal habitats available to fishes in the study area encompass a variety of riverine and floodplain habitat types, including main channels, side channels, tributaries (i.e. sloughs, bayous, creeks), inundated flood plains (i.e., bottomland hardwood forest), and abandoned channel segments (i.e., oxbow lakes) with varying degrees of connectivity to the main channel. More information is available for the lower White River than for the lower Arkansas River; therefore, discussion will focus on this portion of the study area.

At least 24 families and 132 species of fish are documented to inhabit the channel, tributaries, oxbow lakes, sloughs, and inundated floodplain of the lower White River (Table A-1) (Robison and Buchanan 1988, Baker *et al.* 1989, Killgore and Hoover 1992, Buchanan 1997, Layher and Phillips 1999, Layher and Phillips 2000, Killgore 2001). Fishery information for the lower Arkansas River below Dam 2 is scant; however, sampling by Layher and Phillips (1999), Buchanan and Quinn (2001), and others yielded captures of 42 species from 15 families (Table A-2).

The modern White River supports a sustainable commercial fishery for both fish and mussels, although at levels much lower than the peaks of the early 20th century. The commercial demand for wild freshwater fishes has declined over recent decades due in part to the advent of highly efficient aquaculture techniques and competition from foreign sources. The number of commercial fishermen and amount of fish taken annually from the river depends greatly on fishing conditions (i.e. water levels) and wholesale prices. During the years 1967 to 1998, the statewide sales of commercial fishing licenses fluctuated between approximately 1,900 and 4,600, although the number usually remained near 3,500 (Quinn 1999). The primary commercial fishes inhabiting the lower White River include blue catfish (*Ictalurus furcatus*), channel catfish (*I. punctatus*), flathead catfish (*Pylodictis olivaris*), smallmouth buffalo (*Ictiobus bubalus)*, bigmouth buffalo (*Ictiobus cyprinellus*), black buffalo (*Ictiobus niger*), common carp (*Cyprinus carpio*), river carpsucker (*Carpiodes carpio*), longnose gar (*Lepisosteus osseus*), shovelnose sturgeon (*Scaphirhynchus platorynchus*), bowfin (*Amia calva*), and paddlefish (*Polyodon spathula*). By far the most sought after and profitable commercial species are the catfishes (all three species) and the buffaloes (primarily smallmouth). Surveys conducted in the mid-1980's revealed that nearly 80 percent of the weight and almost 90 percent of the value of fishes harvested commercially from the White River were attributed to these two groups of fishes (Crawford 1985, Farwick 1986, 1987).

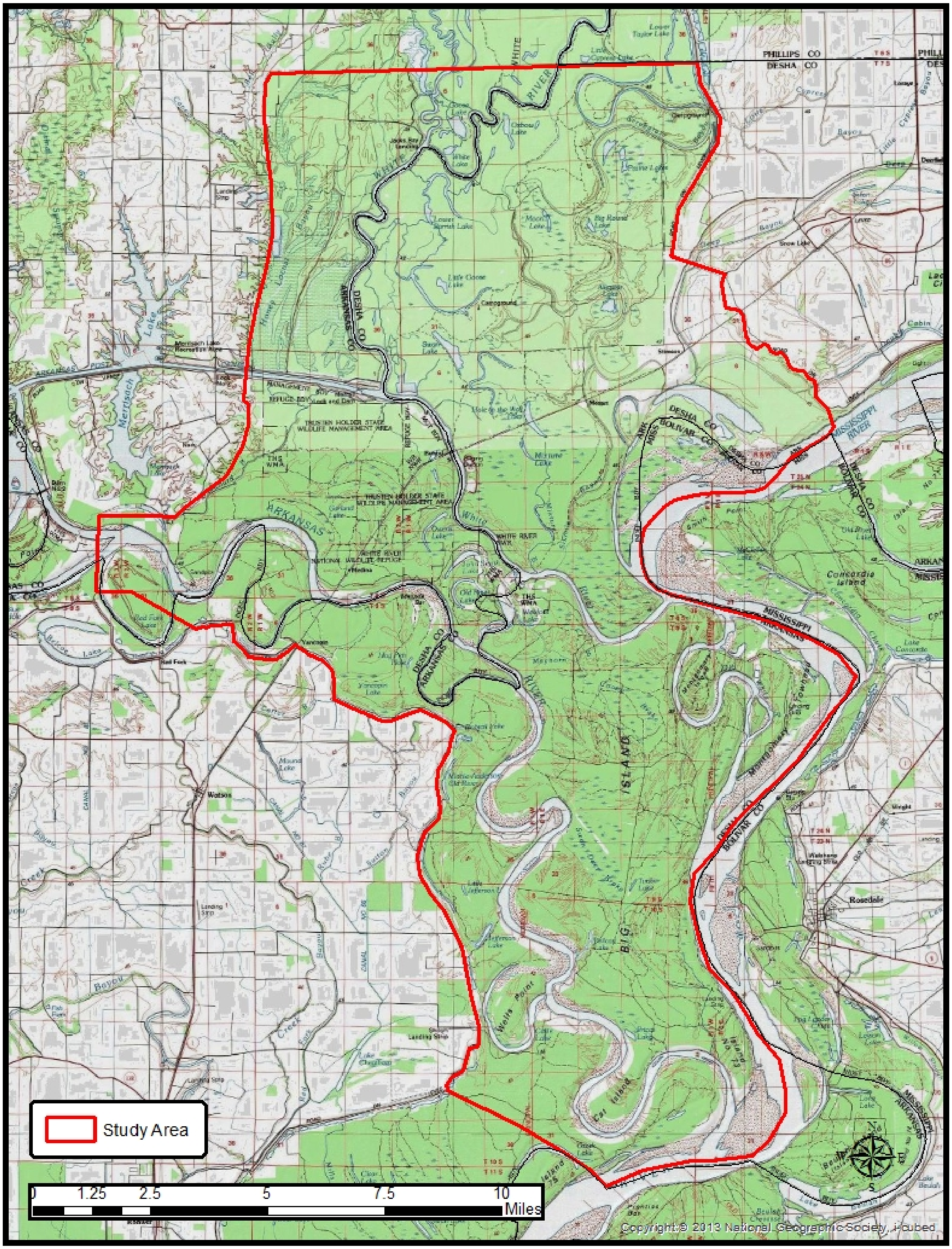

Figure 8. Floodplain Resources and Landmarks in the TRFS area, Arkansas and Desha Counties, Arkansas.

The lower White River has historically supported considerable populations of freshwater mussels. Mussel surveys confirm 37 native species of freshwater mussels inhabiting the White River from Newport to the confluence with the Mississippi River (Christian 1995, Harris and Christian 2000) (Table A-3). Gordon (1980) reported 49 species of mussels from the headwaters to the mouth of the White River. The mussel fauna of the lower White River below Newport includes three endangered species (see endangered species section). Little is known about mussel resources in the White River below the Arkansas Post Canal (RM 10). The closest known mussel bed to the study area in the White River is a major bed having a density above 10 individuals/m^2 located between RM 11 and RM 12. This bed was only discovered in August 2003 (John Harris, pers. comm.). Anecdotal reports from commercial shellers indicate some commercial quality beds in the lower Arkansas River, but these reports have not been verified by qualified malacologists (John Harris, pers. comm.). Harris (2009) found few live mussels in the Melinda Channel and one mile upstream and downstream in the Arkansas River.

In his work on the White River in the early 1990's, Christian (1995) surveyed major beds at nine locations in the lower reach of the lower White River (RM 10-100). Densities averaged 24.1 individuals/m^2 (31.9/m^2 maximum); the number of species per bed ranged from 11 to 21. Major beds were typically located in substrates of sand, hard and soft clay, and gravel, with areas ranging from 570 to 10,300 m^2. The community estimates for major beds in the lower reach ranged from 5,924 ± 2,046 to 189,679 ± 36,127 individuals. Eleven minor mussel beds were located in the lower reach, ranging in area from 200 to 1,200 m^2. The mean density in these beds was 21.5 individuals/m^2 and the number of species per bed ranged from 9 to 19. The mapleleaf (*Quadrula quadrula*) was the dominant species in most major beds, and the threehorn wartyback (*Obliquaria reflexa*) and fragile papershell (*Leptodea fragilis*) also contributed large percentages to the community makeup. Butterfly (*Ellipsaria lineolata*), washboard (*Megalonaias nervosa*), hickorynut (*Obovaria olivaria*), and pimpleback (*Cyclonaias pustulosa*) were also common in the major beds. The mapleleaf also dominated the species composition in the minor beds. Other common species discovered in minor beds included the fragile papershell, threehorn wartyback, washboard, hickorynut, and threeridge (*Amblema plicata*). The deertoe (*Truncilla truncata*), a species that has declined in recent years in the White River (Harris and Christian 2000), was also found in minor beds.

Freshwater mussels historically, and to a much lesser extent presently, served as an important source of income to local shellers and wholesale buyers. The great demand for freshwater mussels that peaked in the early 1900's was fueled primarily by the button manufacturing industry, which sought mussel shells as a source of raw button material (Harris and Gordon 1990). During this period the White River was considered the fourth most productive commercial shelling river in North America (Gordon 1982).

The current market for freshwater mussel shells is driven by the Japanese cultured pearl industry, which depends on native mussel nacre as a seed material for artificially induced pearls. The number of commercial shellers and amount harvested depends largely on fluctuations in this market. The primary species sought by the cultured pearl industry are the washboard, threeridge, mapleleaf, and ebonyshell (*Reginaia ebenus*), although several other species are used to a lesser extent. Several species, including the bleufer (*Potamilus purpuratus*), spike (*Eurynia dilatata*), purple wartyback (*Cyclonaias tuberculata*), and others with a colorful nacre support a small market for polished jewelry used in necklaces and earrings (Harris and Gordon 1990). Currently, the non-endangered freshwater mussels of the White River support a commercial harvest. The White River contributed 17.5 percent of the statewide mussel harvest in 2000, second only to the Cache River, which comprised 29.5 percent of the statewide harvest. The value of mussels harvested statewide in 2000 was $242,868 (Posey 2001).

Terrestrial Resources

Most information on the biota in the lower White and Arkansas River basins is derived from data collected by personnel on state and federally owned lands, unpublished agency reports, and from Yaich (1994). Information from other studies or surveys is generally specific to a particular area and not confined to the bounds of this study area. Therefore, this section provides information on species present, when known, or those expected to occur in the area.

<u>Birds:</u> Birds comprise the largest single group of vertebrates in the study area. At least 265 species of migratory and resident birds including 26 species of waterfowl, 48 species of wading and shorebirds, and over 100 species of songbirds have been documented in the lower White River basin (Table A-4). One hundred twelve species of birds were identified during breeding bird surveys in the lower White River basin and bottomland hardwood forest immediately south of the Arkansas River near the confluence of the White, Arkansas, and Mississippi Rivers. Avian species composition and abundance, as well as the habitats used by this large and diverse group vary widely with season. Waterfowl use both bottomland hardwood forest and open flooded habitats primary during the winter. Neotropical migratory songbirds use the bottomland hardwood forest to meet breeding requirements and as a stopover during migration. Shore and wading birds use open water, mud flats, herbaceous wetlands, and wooded swamps for migratory, wintering, and breeding habitats. Grassland birds use remnant prairie grasslands and pastures. Thus, the breeding, wintering, and migration habitat provided by the bottomland hardwood forest of the area is one of the most important functions of this ecosystem.

The lower White River basin has long been renowned for its winter populations of waterfowl. Based on duck band recoveries, harvest records, and annual waterfowl surveys, the Cache River/Lower White Rivers ecosystem is by far the most important wintering area for waterfowl in Arkansas and the single most important wintering area for Mallards (*Anas platyrhynchos*) in North America (U.S. Fish and Wildlife Service 1997). Aerial surveys during 1970-79 documented an average of 496,103 ducks. Survey results from 1995-1998 ranged from 278,645 to 427,741, 46 to 55 percent of the statewide duck population. In some years, up to 72 percent of the Black Ducks (*Anas rubripes*), 73 percent of Northern Shovelers (*Anas clypeata*), 62 percent of Northern Pintails (*Anas acuta*), 79 percent of Wood Ducks (*Aix sponsa*), 100 percent of Redheads (*Aythya americana*), 97 percent of Canvasbacks (*Aythya valisineria*), and 89 percent of Ring-necked Ducks (*Aythya collaris*) tallied during the midwinter surveys were found in the lower White River basin. The number of Mallards counted during the state's annual midwinter waterfowl surveys ranged from 193,853 to 307,396, 48 to52 percent of the total statewide mallard population from 1995-1998. Additionally, from 1995 to 1998, approximately 47 percent of the Snow Geese (*Chen caerulescens*), 48 percent of White-fronted Geese (*Anser albifrons*), and 31 percent of Canada Geese (*Branta Canadensis*) tallied during the annual midwinter waterfowl surveys were counted in the basin. Waterfowl harvest data specific to the lower White

River basin are unavailable; however, data are compiled by county. An approximation of waterfowl harvest was derived by tallying the harvest in counties in which the major portion of their land base lies within the LWRB. Harvest of dabbling ducks in these counties ranged from 244,168 in 1995 to 771,733 in 1998, which comprised 26 and 43 percent of the statewide harvests, respectively. Diving duck harvest ranged from 5,432 (18.2 percent) in 1999 and 23,686 (29.0 percent) in 1998. These statistics show why the basin is one of six flagship areas identified in the North American Waterfowl Management Plan.

As a group, songbirds include the largest number of species (129) of birds using the project area. At least 65 species of songbirds breed in the lower White and Arkansas River basins. Many of the birds found in the area are further classified as Neotropical migrants. These birds migrate from breeding areas in North America to wintering areas in Central and South America. Songbirds are also dependent on the extensive forests of the lower White and Arkansas River basins. The large unbroken expanse of forest is vital to the maintenance of stable forest breeding bird populations in the Mississippi Alluvial Valley (Mueller *et al.* 2000) (Table A-5).

The Eastern Wild Turkey is the primary resident game bird in the ecosystem; a bird that was once distributed throughout the basin, but which is now generally confined to the larger blocks of forest. The primary limiting factor on turkey populations is the absence of forested lands above the one or two year floodplain. Since most remaining forested land in the basin is on the lowest portion of the floodplain, turkey populations fluctuate dramatically with the incidence and timing of spring floods.

Thirty-one species of shorebirds and 15 species of wading birds have been recorded in the lower White River basin. Shorebirds, which use primarily open habitats with shallow water and/or mudflats, are mostly transitory visitors to the study area. Major use is during spring migration and in late summer/early fall during their southward migration. Wading birds, which use a range of habitats, including open shallow water areas, and the fringes of rivers, lakes, and ponds, can be found throughout the lower White and Arkansas River basins year round.

<u>Mammals</u>: Fifty eight species of mammals are known or likely to occur in the lower White River basin, including 12 species of bats and 24 species of rodents (Table A-6). Little specific information is available on mammals in the lower White and Arkansas River basins. What is available comes mostly from isolated studies on public lands and observations of public land managers. Much of the information on the status of mammals was extracted from Yaich (1994).

White-tailed deer (*Odocoileus virginianus*) are an important species from a public interest and use perspective. Bottomland hardwood forests provide quality habitat for deer, with potential carrying capacity reaching 1 deer per 10 acres (Yaich 1994) or better. AGFC deer population objectives for WMAs in the study area range from 1 per 16 to 1 per 26 acres (Arkansas Game and Fish Commission 1999). Carrying capacity of bottomland hardwoods in the study area varies as a result of prolonged and/or deep flooding in some portions of the area and by their proximity to cropland.

Black bears (*Ursus americanus*) in the study area are descendants of the native black bear population that persisted on the Refuge when black bears were extirpated from the rest of the state, making it home to the only native black bear population in Arkansas. In the late 1950's their population level in the area was estimated at between 10 to 15 animals (Yaich 1994). By 2001, the black bear population in and around the Refuge was estimated at around 500 or more animals (Rick Eastridge, pers. comm.), with estimates of bear density on the southern portion of the White River NWR at one bear per about 300 acres.

The forested wetlands in the study area also support other game and non-game species. Mammals that occur within the study area include raccoon, beaver, river otter, mink, gray squirrel, fox squirrel, and red fox.

Reptiles and Amphibians: The lower White and Arkansas River basins provide habitat for approximately 58 species of reptiles and about 24 species of amphibians (Table A-7). Common amphibians include the marbled salamander (*Ambystoma opacum*), green frog (*Rana clamitans*), American toad (*Bufo americanus*), Woodhouse's toad (*Bufo woodhousei woodhousei*), and southern leopard frog (*Rana utricularia*). Common reptiles include the five-lined skink (*Eumeces fasciatus*), the mud snake (*Farancia abacura reinwardti*), copperhead (*Agkistrodon contortrix contortrix*), and cottonmouth (*Agkistrodon piscivorus leucostoma*). Common turtles include the three-toed box turtle (*Terrapene carolina triunguis*), red-ear turtle (*Chrysemys scripta elegans*), map turtles (*Graptemys* spp.), soft-shell turtle (*Trionyx muticus*), and common snapping turtle (*Chelydra serpentina serpentine)*. Another reptile that occurs in the area is the American alligator (*Alligator mississippiensis*). The Refuge is at the northern edge of its range; consequently, the alligator was always probably somewhat rare in this area. Alligator snapping turtles (*Macroclemys temmincki*) have become increasingly rare, but can still be found in the study area. Population trends of herpetofauna in the lower White and Arkansas River basins are unknown; however, it is expected that population trends would be roughly proportional to loss or retention of the various habitat components upon which they depend.

Hunting and fishing are important activities in Arkansas, for both recreational and economic interests. Arkansas ranks sixth among all states in the percentage (32 percent) of its population which hunts or fishes. Participation by residents of the Cache and Lower White River regions probably exceed the statewide average because wildlife orientated recreation represents the primary recreational opportunity in the area (U.S. Fish and Wildlife Service 1997). In addition to their intrinsic fish and wildlife resource values, the refuges make a significant contribution to the local economy. In 1996, White River NWR had approximately 120,000 visitors; many of these participated in hunting and/or fishing activities during their visit. A non-resident hunter spends an estimated $30.92-52.36 per day depending on the type of hunting, while resident hunters spend $8.37-11.69 per day. Non-resident freshwater sport fishermen spend an average of $44.58 per day and resident fishermen spend an average of $10.95 per day (U.S. Department of the Interior 1997). These are state-wide figures.

Endangered Species

The Endangered Species Act (ESA) requires that an official list of endangered and threatened species be provided for any potential federal construction project. The endangered pink mucket (*Lampsilis abrupta*) and scaleshell (*Leptodea leptodon*) have been found in the White River above the project area. The threatened rabbitsfoot (*Theliderma cylindrica*) also occurs in the river upstream of the project area. The endangered fat pocketbook (*Potamilis capax*) was found between RM 11 and RM 12 during a mussel survey performed in August 2003. This is the first record of this species for the White River since 1965. This species could occur in the Arkansas River, although surveys in 2009 revealed none present in the Melinda Channel or the Arkansas River one mile upstream and downstream (Harris 2009). Freshwater mussels in general were rare in the area surveyed (only one live individual encountered).

The endangered Interior Least Tern *(Sternula antillarum)* has been observed along the White River within the project reach, but there are no known nest sites on this river. This bird is commonly observed during the summer along the Mississippi and lower Arkansas Rivers. They nest on large sandbars and are frequently observed foraging for small fish along these rivers. The Melinda Sandbar directly across the Arkansas River from the Melinda Channel is commonly used for nesting by this species. They are also known to use other large sandbars on the Arkansas and Mississippi Rivers at several sites within the project area.

The endangered pallid sturgeon *(Scaphirhynchus albus)* has been captured in the Mississippi at the mouth of the White River. This species has long been presumed to possibly enter the lower Arkansas and White Rivers. In recent years, individuals tagged in the Mississippi River have been documented as far upstream on the Arkansas River as Dam 2. There is still no documentation of use in the White River.

In February 2004, the Ivory-billed Woodpecker (IBWO) was rediscovered on Bayou De View in the Cache River National Wildlife Refuge. After confirmation of this sighting two weeks later, and an initial search effort led by Cornell Lab of Ornithology (CLO) during winters 2004 and 2005, enough evidence was gathered to positively conclude the bird's existence and a public announcement of the rediscovery was made on April 28, 2005 (Rohrbaugh *et al.* 2006). Searchers expended thousands of hours searching unsuccessfully for additional confirmation during the following years. The current status of this species is uncertain and debated by scientists, but the Service currently assumes the species could be present in appropriate habitats in eastern Arkansas.

The delisted Bald Eagle *(Haliaeetus leucocephalus)* nests in the forest lands along the river. Five verified active Bald Eagle nests and one additional unverified nest have been reported in the lower White River basin. It is important to note that while the Bald Eagle is no longer a federally listed threatened species it is still afforded protection under the Bald and Golden Eagle Protection Act (16 USC 668a). It is the responsibility of the action agency (Corps) to determine if any proposed actions would adversely affect this species or any species listed under the ESA.

Without Project

The without project (i.e., No Action) alternative entails continued maintenance of existing structures, eventual construction of up to three new structures, and reconstruction of the Melinda Headcut Structure in the vicinity of the Historical Cutoff, Jim Smith Lake, and the Melinda Channel. The Corps has estimated 156 acres (-120 FCU) of direct impacts from construction and habitat loss associated with future headcutting. However, total acres of impacts could be lower.

Impacts associated with this alternative would be mitigated. However, locating enough suitable mitigation sites in the study area may be problematic because most of the land in the study area is publicly owned and managed for fish and wildlife conservation as Wildlife Management Areas and National Wildlife Refuge. Most of the private lands within the study area are owned by a timber company or by individuals interested in the land for its hunting value. These entities will continue to manage forest in the area for commercial timber production and for hunting, so habitat conditions are expected to remain favorable for a diversity of wildlife. Agricultural lands in the project area are likely to remain in production.

Continued channel adjustment in the lower Arkansas River and erosion in the Three Rivers area is expected to occur with resultant loss of terrestrial habitat. New sandbars formed as the Arkansas River moves across its floodplain will provide habitat for endangered Least Terns and will eventually develop into willow bars, cottonwood forests, and finally riverfront hardwood communities.

SUMMARY OF PLAN SELECTION PROCESS AND IDENTIFICATION OF EVALUATED ALTERNATIVES

The TRFS was conducted to address problems associated with headcutting and erosion in the vicinity of the Historical Cutoff between the White and Arkansas Rivers subsequent to construction of the MKARNS. Several years after construction of the Historical Cutoff Closure Structure, the rivers began trying to reestablish a cutoff, which led the Corps to construct a series of new structures to prevent a cutoff between the two rivers from reforming.

The Corps attributes the cause of the problem to a difference in water surface stage between the Arkansas and White Rivers. While the role of stage differentials is a critical element of the problem, the problems caused by disruption of hydrologic processes from construction of the MKARNS, including closure of the Historical Cutoff, other alterations to the area's topography which prevented the rivers from distributing flow to the many sloughs, bayous, depressions, and low channels, as well as other river engineering work must be recognized as other important contributing factors. The concentration of flow in the Owens Lake / Melinda channel corridor is a prime example of one component of the problem. We believe that properly defining the problem is an essential guide to developing viable solutions and greatly influences the study and eventual proposed solution to said problem. Therefore, it is important to acknowledge and address the many complex factors that converge in the study area.

The initial array of measures discussed during early meetings included 16 suggestions. Most of these were screened out early in the study because they would not meet study objectives, were too costly, or environmentally unacceptable. Four measures were carried forward including no action, raising of the existing containment structure, opening of the Historical Cutoff, and opening of multiple flow paths (Historical Cutoff, Owen's Lake, LaGrues Lake, J. Smith Lake). These measures were then further refined and combined to result in three final alternatives including no action, combination of raising the containment structure and opening the Historical Cutoff (Alternative 1), and opening of multiple flow paths (Alternative 2).

No Action – This alternative entails maintaining and repairing existing structures, and reconstructing structures when repairs are no longer practical to reduce the risk of a cutoff and maintain reliable navigation. It also includes construction of three new structures in the future and immediate reconstruction of the Melinda Headcut Structure at a location in the Melinda Headcut Channel close to the Arkansas River. In the event of a cutoff, the Corps would close it with a structure intended to restore the risk of a cutoff to the original risk prior to the cutoff.

Alternative 1 (RP) – This alternative is a combination of measures to raise the containment structure and construct an opening in the Historical Cutoff Closure Structure. A new constructed containment structure would be built at an elevation of 157 feet NGVD and extend 2.5 miles from high ground west of the Melinda Headcut eastward across this channel to a connection with the existing containment structure. It would then follow this existing alignment east and tie into the Historical Cutoff Closure Structure. This alternative would also incorporate an opening in the Historical Cutoff Closure Structure at an elevation of 145 feet NGVD. An optimum width has not been determined yet, but it will attempt to mirror the current capacity of flow paths through Owen's and J. Smith Lakes. Passing flows through this structure while delaying flows through the old pathways until an elevation of 157 feet NGVD will reduce or maintain the maximum head differential, reduce the duration of head differentials, force overtopping flows through the Historical Cutoff instead of the undersized channels of Owen's Lake and J. Smith Lake, and reduce velocities across the isthmus. Headcutting currently underway in the Melinda Channel and Webb Foot Lake, as well as bank erosion and scour within Owen's Lake, should be reduced or eliminated. The existing Melinda Headcut Structure will be removed by pushing the material into the associated downstream scour. This will prevent damage to the new containment structure and have the ancillary benefit of reconnecting the two limbs of Owen's Lake. This alternative would not change the overall hydrology of the study area and would allow existing navigation to continue uninhibited.

Alternative 2 – This alternative is a combination of measures that open the Historical Cutoff and provide multiple flow paths across the isthmus through Owen's Lake/Melinda Channel, La Grues Lake, and possibly J. Smith Lake. Controlling elevations of 115 feet, 125 feet, and 135 feet NGVD were considered, though final elevations would be determined during design. It would require the construction of multiple step down structures along the length of the lakes/channels. This alternative would minimize the duration and magnitude of head differentials and control the location of overtopping during such events. Navigation might continue with no change, but additional investigation using a ship tow simulator would be required to determine the potential effects of cross currents. The overall hydrology of the study area would be changed from existing conditions depending upon the elevation of the structures. Some flood events on the Refuge and other lands along the White River could be shorter in duration due to increased flows across the isthmus into the Arkansas River. Alternatively, flood frequency and duration in some portions of the Refuge may increase due to lowered connection elevations and reverse flows from the Arkansas River into the White River, causing a backing effect. A full understanding of these changes and their effects on the vegetation communities of the Refuge and nearby areas would require more study.

COMPARISON OF SELECTED PLAN WITH EVALUATED ALTERNATIVES

Evaluating impacts of the selected plan with evaluated alternatives is complicated by the cumulative impacts of past and current river engineering and landscape alterations that have occurred in the Arkansas River, White River, and Mississippi River basins and by the complex hydrology of the Three Rivers area.

The no action alternative would not change existing hydrology but would likely have greater direct impacts than Alternatives 1 and 2. These direct impacts would result from the eventual construction of structures in the Melinda Channel, west of the Melinda Channel, and La Grues Lake. This alternative would also likely result in the continued loss of terrestrial habitats due to channel instability in the area of Owen's Lake. Losses would be highest in the event of an uncontrolled capture of the White River by the Arkansas River. This event is most likely to occur with this alternative.

Alternative 1 (RP) will have minimal impacts on the hydrology of the study area and has significantly less direct impacts in comparison to both the originally recommended plan (9+ miles of raised containment) and the preferred alternative (no action) derived during the Ark-White Containment Study. It accomplishes the goal of controlling the peak and duration of head differentials during flood events while not significantly modifying the depth and duration of flooding in the study area. By allowing flows through the larger Historical Cutoff and preventing high velocity flows from passing through the narrow Owen's Lake corridor, this alternative should result in an abatement of terrestrial habitat losses on the Refuge and nearby lands. It also has the ancillary benefit of reconnecting the two limbs of Owen's Lake due to the removal of the current Melinda Headcut Structure.

Alternative 2 would require modifications to the existing Owen's Lake and Melinda Headcut Structures, as well as construction of additional step down structures in Owen's Lake and the Melinda Channel. It would also open the Historical Cutoff. While this alternative would also have minimal effects on the hydrology of the study area, it would potentially have other negative effects. The biggest concern would be continuing to allow high velocity flows to pass through the Owen's Lake/Melinda Channel corridor. Velocity modeling indicates that erosion could continue to occur in this region and would likely require additional bank armoring and repairs. Additionally, Owen's Lake would continue to serve as a conduit for flows between the White and Arkansas Rivers and not provide the lentic backwater habitat that it did historically. The Melinda Headcut Structure would remain in place and additional structures above and below it would be constructed. This would eliminate the potential for reconnecting the limbs of Owen's Lake and further segment these aquatic habitats.

While a compatibility determination has not yet been done, Alternative 1 (RP) could potentially be found compatible. It would not substantially change the hydrology of the Refuge or surrounding properties. This is important because studies have not been carried out to determine whether changes in hydrology would be a benefit or detriment to Refuge habitats. Lacking such a study, the best option is not to institute additional changes. This alternative accomplishes that goal, maintains connectivity between the White and Arkansas Rivers via the Historical Cutoff, and has minimal direct impacts on the Refuge (0.63 miles of containment structure/ < 10 ac).

This alternative also has the best chance to address the issue of continued erosion, headcutting, and loss of terrestrial habitat. It also has the ancillary benefit of reconnecting the limbs of Owen's Lake that were severed by the construction of the Melinda Headcut Structure.

RECOMMENDATIONS

The Service supports the Corps' decision to adopt Alternative 1 as the RP. Of the alternatives studied, this plan will accomplish the goals regarding navigation along the MKARNS while having insignificant hydrologic impacts and the least amount of direct impacts. This plan should also lessen the risk of future terrestrial losses in the Owen's Lake/Melinda Headcut Corridor. The installation of a 6 ft. by 30 ft. arched culvert at an elevation of 140 feet MGVD in the Owen's Lake Structure will provide fish passage in and out of Owen's Lake and drainage of most forests in the immediate vicinity to compensate for the drainage and passage currently provided over the Melinda Structure. The removal of the Melinda Structure will result in the reconnection of the severed limb of Owen's Lake and provide enhanced access to this habitat by aquatic organisms.

SUMMARY AND SERVICE POSITION

All alternatives evaluated for the TRFS would incur some environmental impacts. The fewest impacts are associated with the RP, Alternative 1. This plan includes construction of a new containment structure, opening of a connection through the Historical Cutoff, and installation of new drainage structures in the Owen's Lake area. The no action alternative would involve continuing to repair existing structures as required, reconstruction of the Melinda Headcut Structure, and construction of up to three additional structures as needed to prevent the formation of an uncontrolled cutoff. Alternative 2 consists of providing multiple flow pathways between the White and Arkansas Rivers. An opening would be constructed in the Historical Cutoff and controlled pathways with multiple step down structures would be constructed in La Grues, Owen's, and J. Smith Lakes.

The Service's initial primary concern regarding the TRFS centered on the alteration of hydrology over a potentially large area including much of the Refuge. We worked with the Corps and other partners to attempt to describe the existing resources of concern (primarily vegetation communities) and evaluate the potential impacts of various proposals. An overarching theme, similar to that of the previous AWCS, was that we did not have enough studies or data to accurately describe existing habitat conditions nor how hydrology and habitats have changed over the years due to watershed and river alterations. The lack of accurate baseline data, historical data, and accurate elevation data across the project area made it very questionable that we would be able to reliably predict expected impacts associated with hydrologic change.

The Service supports the choice of Alterative 1 as the RP. Although there are some minor direct and indirect impacts associated with this alternative, they are greatly reduced from previously studied plans (AWCS) that focused on a longer containment structure. More importantly, this alternative incorporates an opening in the Historical Cutoff that will be sized to ensure that little large-scale hydrologic change will occur on the Refuge or other lands. Other drainage features will be designed to address areas that may see change (Owen's Lake and vicinity) due to the construction of the new containment structure. By focusing the controlled exchange of floodwater to the new opening in the Historical Cutoff, this alternative should greatly reduce erosion in the Owen's Lake corridor and thus greatly reduce the amount of terrestrial habitat that will be lost in the future. It also has the ancillary benefit of reconnecting the limb of Owen's Lake that was severed by the construction of the Melinda Headcut Structure. We look forward to working with the Corps to complete the TRFS and refine the design of the Historical Cutoff opening and Owen's Lake drainage/fish passage features. By working together we hope to present a fully compatible project design to the Refuge for evaluation following completion of this study.

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APPENDIX

FISH AND WILDLIFE RESOURCES

Table A-1. Fish Species Known to Occur or Possibly Occurring Within the Lower White River, Tributaries, and Associated Floodplain Waters*.

Family and Species	Residence (a)	Major Habitat (b)	Migratory? (c)	Status (d)
Petromyzontidae				
Chestnut lamprey** (*Ichthyomyzon castaneus*)	R	Y	C	
American brook lamprey (*Lampetra appendix*)				R
Acipenseridae				
Lake sturgeon (*Acipenser fulvescens*)	T	M	Y?	R?+
Pallid sturgeon** (*Scaphirhynchus albus*)	T	M	Y?	R?+
Shovelnose sturgeon** (*S. platorynchus*)	R		Y? C	
Polyodontidae				
Paddlefish** (*Polyodon spathula*)	T?	M	Y	U?+
Lepisosteidae				
Spotted gar** (*Lepisosteus oculatus*)	T	F	N	U
Longnose gar** (*L. osseus*)	R		N	A
Shortnose gar** (*L. platostomus*)	R		N	A
Alligator gar** (*Atractosteus spatula*)	T	M	N	R+
Amiidae				
Bowfin** (*Amia calva*)	R	N		C
Anguillidae				
American eel** (*Anguilla rostrata*)	R		Y	C
Clupeidae				
Alabama shad (*Alosa alabamae*)	T	M	Y	R+
Skipjack herring** (*A. chrysochloris*)	R		Y	C
Gizzard shad** (*Dorosoma cepedianum*)	R		N	A
Threadfin shad** (*D. petenense*)	R		N	A
Hiodontidae				
Goldeye** (*Hiodon alosoides*)	R		N	C
Mooneye** (*H. tergisus*)	R		Y	R?
Esocidae				
Grass pickerel** (*Esox americanus*)	T	F	N	U
Chain pickerel** (*E. niger*)	T	F	N	U
Cyprinidae				
Common carp** (*Cyprinus carpio*)	R		Y	A

Table A-1. Fish Species Known to Occur or Possibly Occurring Within the Lower White River, Tributaries, and Associated Floodplain Waters*, Continued.

Family and Species	Residence (a)	Major Habitat (b)	Migratory? (c)	Status (d)
Cyprinidae (continued)				
Grass carp (*Ctenopharyngodon idella*)	T?	M	N?	U?
Silver carp (*Hypophthalmichthys molitrix*)	R		N?	U?
Central Stoneroller (*Campostoma anomalum*)	T	T	N	U
W. silvery minnow (*Hybognathus argyritis*)	T	M	N?	R
Cypress minnow** (*H. hayi*)	T	F	N	R
Mississippi silvery minnow** (*H. nuchalis*)	R		N	A
Plains minnow (*H. placitus*)	T	M	N	R+
Bigeye chub** (*H. amblops*)	R		N	U
Pallid shiner** (*Hybopsis amnis*)	R?		N	U?+
Flathead chub (*Platygobio gracilis*)	T	M	N	R
Speckled chub** (*Extrarius aestivalis*)	R		N	C
Sturgeon chub (*Macrhybopsis gelida*)	T	M	N	R+
Silver chub** (*M. storeriana*)	R		N	C
Sicklefin chub (*M. meeki*)	T	M	N	R+
Gravel chub (*Erimystax x-punctatus*)	R		N	U?
Golden shiner** (*Notemigonus crysoleucas*)	R		N	C
Duskystripe shiner (*Luxilus pilsbryi*)	T	T	N	R?
Emerald shiner** (*Notropis atherinoides*)	R		N	A
River shiner** (*N. blennius*)	R?		N	U
Ghost shiner** (*N. buchanani*)	R?		N	U
Red shiner** (*N. lutrensis*)	T	T	N	U
Taillight shiner** (*N. maculatus*)	T	F	N	R
Silverband shiner** (*N. shumardi*)	T?	M	N	U
Weed shiner** (*N. texanus*)	T	T	N	U
Ironcolor shiner** (*N. chalybaeus*)	T	T	N	U*
Mimic shiner** (*N. volucellus*)	R		N	C
Sabine shiner** (*N. sabinae*)	R	N	U	
Ozark minnow** (*N. nubilus*)	T	T	N	R?
Rosyface shiner** (*N. rubellus*)	T	T	N	R?
Telescope shiner** (*N. telescopus*)	T	T	N	R?
Pugnose minnow** (*Opsopoeodus emiliae*)	T	F	N	U
Ribbon shiner** (*Lythrurus fumeus*)	T?	T	N	U
Redfin shiner** (*L. umbratilis*)	T	T	N	U
Blacktail shiner** (*Cyprinella venusta*)	R		N	C
Whitetail shiner** (*C. galacturus*)	T	T	N	R
Steelcolor shiner** (*C. whipplei*)	T	T	N	C?
Bullhead minnow** (*Pimephales vigilax*)			N	
Bluntnose minnow** (*Pimephales notatus*)		N		

Table A-1. Fish Species Known to Occur or Possibly Occurring Within the Lower White River, Tributaries, and Associated Floodplain Waters*, Continued.

Family and Species	Residence (a)	Major Habitat (b)	Migratory? (c)	Status (d)
Catostomidae				
Blue sucker** (*Cycleptus elongatus*)	T	M	Y	U+
River carpsucker** (*Carpiodes carpio*)	R	N	C	
Quillback** (*C. cyprinus*)	T?	M?	N?	R
Highfin carpsucker** (*C. velifer*)	T?	M?	N?	R
Smallmouth buffalo** (*Ictiobus bubalus*)	R		Y	A
Black buffalo** (*I. niger*)	R		Y	U
Spotted sucker** (*Minytrema melanops*)	T?	F,T	N	R
Shorthead redhorse** (*Moxostoma macrolepidotum*)	R?		Y?	R
Golden redhorse** (*M. erythrurum*)	T	T	Y	U
Bigmouth buffalo** (*I. cyprinellus*)	R		Y	C
Lake chubsucker** (*Erimyzon sucetta*)	T	T	N	R
Northern hog sucker** (*Hypentelium nigricans*)	T	T	Y	R
Ictaluridae				
Blue catfish** (*Ictalurus furcatus*)	R		Y?	A
Channel catfish** (*I. punctatus*)	R		Y?	A
Black bullhead (*Ameiurus melas*)	T	T	N	R
Yellow bullhead** (*A. natalis*)	T	F,T	N	R
Brown bullhead (*A. nebulosus*)	T	F	N	R
Stonecat (*Noturus flavus*)	T	M?	N	R
Tadpole madtom** (*N. gyrinus*)	T	T	N	C
Freckled madtom** (*N. nocturnus*)	T	T	N	C?
Mountain madtom** (*N. eleutherus*)	T	T	N	R
Flathead catfish** (*Pylodictis olivaris*)	R		N	C
Aphredoderidae				
Pirate perch** (*Aphredoderus sayanus*)	T	F	N	R
Fundulidae				
Golden topminnow** (*Fundulus chrysotus*)	T	F	N	R
Blackstripe topminnow** (*F. notatus*)	R?		N	U
Blackspotted topminnow** (*F. olivaceus*)	R?		N	U
Northern Starhead Topminnow (*F. dispar*)				
Poeciliidae				
Mosquitofish** (*Gambusia affinis*)	R		N	C

Table A-1. Fish Species Known to Occur or Possibly Occurring Within the Lower White River, Tributaries, and Associated Floodplain Waters*, Continued.

Family and Species	Residence (a)	Major Habitat (b)	Migratory? (c)	Status (d)
Atherinidae				
Brook silverside** (*Labidesthes sicculus*)	T	F,T	N	U
Inland silverside** (*Menidia beryllina*)	R		N	C
Moronidae				
White bass** (*Morone chrysops*)	R		Y	C
Yellow bass** (*M. mississippiensis*)	R?		Y	U
Striped bass** (*M. saxatilis*)	T?		Y	U
Centrarchidae				
Flier** (*Centrarchus macropterus*)	T	F	N	R
Green sunfish** (*Lepomis cyanellus*)	R?		N	U
Warmouth** (*L. gulosus*)	R		N	U
Orangespotted sunfish** (*L. humilis*)	R		N	U
Bluegill** (*L. macrochirus*)	R		N	C
Redear sunfish** (*L. microlophus*)	R?		N	U
Longear sunfish** (*L. megalotis*)	R		N	C
Redspotted sunfish** (*L. miniatus*)	T	F	N	R
Dollar sunfish** (*L. marginatus*)				
Bantam sunfish** (L. symmetricus)	T	F	N	R
Shadow bass** (*Ambloplites ariommus*)	T	T	N	U?
Largemouth bass** (*Micropterus salmoides*)	R		N	U
Spotted bass** (*M. punctulatus*)	R		N	C
Smallmouth bass** (*M. dolomieu*)	T	T	N	R
White crappie** (*Pomoxis annularis*)	R		N?	C
Black crappie** (*P. nigromaculatus*)	R?		N?	U
Elassomatidae				
Banded pygmy sunfish** (*Elassoma zonatum*)	T	F	N	R
Percidae				
Crystal darter** (*Crystallaria asprella*)	R?		N	R+
Scaly sand darter** (*Ammocrypta vivax*)	R		N	U
Western sand darter** (*A. clara*)	R		N	U+
Mud darter** (*Etheostoma asprigene*)	T	F	N	R
Bluntnose darter** (*E. chlorosomum*)	R		N	U
Slough darter** (*E. gracile*)	T	F	N	R
Cypress darter** (*E. proeliare*)	T	F	N	R

Table A-1. Fish Species Known to Occur or Possibly Occurring Within the Lower White River, Tributaries, and Associated Floodplain Waters*, Concluded.

Family and Species	Residence (a)	Major Habitat (b)	Migratory? (c)	Status (d)
Percidae (continued)				
Swamp darter** (*E. fusiforme*)	T	F	N	U?
Harlequin darter** (*E. histrio*)	T	T N	C?	
Speckled darter** (*E. stigmaeum*)	T	T N	U?	
Greenside darter** (*E. blennioides*)	T	T	N	R
Rainbow darter** (*E. caeruleum*)	T	T	N	R
Logperch** (*Percina caprodes*)	T?	F,T	N	R
Blackside darter** (*P. maculata*)	T T	N	U?	
Dusky darter** (*P. sciera*)	T	T	N	U?
Saddleback darter** (*P. vigil*)	T	T	N	C?
River darter** (*P. shumardi*)	R		N	U
Stargazing darter** (*P. uranidea*)	T	T	N	U?+
Gilt darter** (*P. evides*)	T	T	N	R
Sauger (*Stizostedion canadense*)	R		Y?	U?
Walleye (*S. vitreum*)	R		Y	R
Sciaenidae				
Freshwater drum** (*Aplodinotus grunniens*)	R		Y?	A
Mugilidae				
Striped mullet** (*Mugil cephalus*)	T	M	Y	R

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* From Robison and Buchanan 1988, Baker *et al*. 1989, Killgore and Hoover 1992, Yaich 1994, Buchanan 1997, Layher and Phillips 1999, Layher and Phillips 2000, Biggins *et al.* 2000, Killgore 2001

** Indicates actual capture by one of the referenced authors.

+ Species is among the list of Southeastern Imperiled Freshwater Fishes (Biggins *et al*. 2000)

(a) Residence: R = resident of lower White River proper; T = transient in study area.

(b) Major Habitat (if transient): F = lower White River floodplain; T = regular invader from tributaries; M = Mississippi River.

(c) Migratory?: Y = yes; migrants may be residents that move further upstream or species moving through from Mississippi River.

(d) Status: (in the lower White River Basin) R = rare; U = uncommon; C = common; A = abundant. Question mark indicates uncertainty of classification.

Table A-2. Fish Species Collected Within the Lower Arkansas River, Tributaries, and Associated Floodplain Waters.*

Family and Species	**Residence (a)**	**Major Habitat (b)**	**Migratory? (c)**	**Status (d)**
Acipenseridae				
Shovelnose sturgeon (*S. platorynchus*)	R		Y?	C
Polyodontidae				
Paddlefish (*Polyodon spathula*)	T?	M	Y	U?+
Lepisosteidae				
Spotted gar (*Lepisosteus oculatus*)	T	F	N	U
Longnose gar (*L. osseus*)	R		N	A
Shortnose gar (*L. platostomus*)	R		N	A
Anguillidae				
American eel (*Anguilla rostrata*)	R		Y	C
Clupeidae				
Skipjack herring (*A. chrysochloris*)	R		Y	C
Gizzard shad (*Dorosoma cepedianum*)	R		N	A
Threadfin shad (*D. petenense*)	R		N	A
Hiodontidae				
Goldeye (*Hiodon alosoides*)	R		N	C
Cyprinidae				
Common carp (*Cyprinus carpio*)	R		Y	A
Mississippi silvery minnow (*H. nuchalis*)	R		N	A
Speckled chub (*Extrarius aestivalis*)	R		N	C
Emerald shiner (*Notropis atherinoides*)	R		N	A
Blacktail shiner (*Cyprinella venusta*)	R		N	C
Catostomidae				
Blue sucker (*Cycleptus elongatus*)	T	M	Y	U+
River carpsucker (*Carpiodes carpio*)	R		N	C
Quillback (*C. cyprinus*)	T?	M?	N?	R
Highfin carpsucker (*C. velifer*)	T?	M?	N?	R
Smallmouth buffalo (*Ictiobus bubalus*)	R		Y	A
Spotted sucker (*Minytrema melanops*)	T?	F,T	N	R
Shorthead redhorse (*Moxostoma macrolepidotum*)	R?		Y?	R

Table A-2. Fish Species Collected Within the Lower Arkansas River, Tributaries, and Associated Floodplain Waters*, Concluded.

Family and Species	**Residence (a)**	**Major Habitat (b)**	**Migratory? (c)**	**Status (d)**
Ictaluridae				
Blue catfish** (*Ictalurus furcatus*)	R		Y?	A
Channel catfish** (*I. punctatus*)	R		Y?	A
Yellow bullhead** (*A. natalis*)	T	F,T	N	R
Flathead catfish** (*Pylodictis olivaris*)	R		N	C
Atherinidae				
Inland silverside (*Menidia beryllina*)	R		N	C
Moronidae				
White bass (*Morone chrysops*)	R		Y	C
Yellow bass (*M. mississippiensis*)	R?		Y	U
Striped bass (*M. saxatilis*)	T?		Y	U
Hybrid striped bass (*M. saxatilis* x *chrysops*)				
Centrarchidae				
Green sunfish (*Lepomis cyanellus*)	R?		N	U
Orangespotted sunfish (*L. humilis*)	R		N	U
Bluegill (*L. macrochirus*)	R		N	C
Longear sunfish (*L. megalotis*)	R		N	C
Largemouth bass (*Micropterus salmoides*)	R		N	U
Spotted bass (*M. punctulatus*)	R		N	C
White crappie (*Pomoxis annularis*)	R		N?	C
Black crappie (*P. nigromaculatus*)	R?		N?	U
Percidae				
Sauger (*Stizostedion canadense*)	R		Y?	U?
Sciaenidae				
Freshwater drum (*Aplodinotus grunniens*)	R		Y?	A
Mugilidae				
Striped mullet (*Mugil cephalus*)	T	M	Y	R

* From Layher and Phillips 1999; Buchanan 2001; Reid Adams, Jason Phillips, and Lindsey Lewis, unpubl. data. This does not represent a complete list of fish species that occur in the lower Arkansas River, backwaters, or tributaries.
+ Species is among the list of Southeastern Imperiled Freshwater Fishes (Biggins *et al*. 2000)
(a) Residence: R = resident of lower White River proper; T = transient in study area.

(b) Major Habitat (if transient): F = lower White River floodplain; T = regular invader from tributaries; M = Mississippi River.
(c) Migratory?: Y = yes; migrants may be residents that move further upstream or species moving through from Mississippi River.
(d) Status: (in the lower White River Basin) R = rare; U = uncommon; C = common; A = abundant. Question mark indicates uncertainty of classification.

Table A-3. Native Freshwater Mussel Species Known to Occur Downstream of Newport, AR (Christian 1995, Harris 2000, Arkansas Natural Heritage Commission 2002).

Family and Species	**Status***
Bankclimber (*Plectomerus dombeyanus*)	U
Fluted shell (*Lasmigona costata*)	R,I
Mapleleaf (*Quadrula quadrula*)	A
Monkeyface (*Theliderma metanevra*)	A,I
Pimpleback (*Cyclonaias pustulosa*)	A
Rabbitsfoot (*Theliderma cylindrica*)	R,S,I
Southern mapleleaf (*Quadrula apiculata*)	U,I
Wartyback (*Cyclonaias nodulata*)	U
Pistolgrip (*Tritogonia verrucosa*)	C
Purple wartyback (*Cyclonaias tuberculata*)	R,I
Rock pocketbook (*Arcidens confragosus*)	U,W
Threehorn wartyback (*Obliquaria reflexa*)	A
Threeridge (*Amblema plicata*)	C
Washboard (*Megalonaias nervosa*)	C,W
Western fanshell (*Cyprogenia aberti*)	R,S,I
Black sandshell (*Ligumia recta*)	R,I
Scaleshell (*Leptodea leptodon*)	R,E,I
Fragile papershell (*Leptodea fragilis*)	A
Giant floater (*Pyganodon grandis*)	C
Spike (*Eurynia dilatata*)	R
Louisiana fatmucket (*Lampsilis hydiana*)	R,W
Pink mucket (*Lampsilis abrupta*)	R,E,I
Yellow Sandshell (*Lampsilis teres*)	C
Plain pocketbook (*Lampsilis cardium*)	U
Butterfly (*Ellipsaria lineolata*)	A,W
Deertoe (*Truncilla truncata*)	A
Ebonyshell (*Reginaia ebenus*)	A,W
Wabash pigtoe (*Fusconaia flava*)	U
Fawnsfoot (*Truncilla donaciformis*)	U,W
Flat floater (*Utterbackiana suborbiculata*)	U,W
Hickorynut (*Obovaria olivaria*)	A,I
Mucket (*Actinonaias ligamentina*)	R
Fat pocketbook (*Potamilus capax*)	R,E,I
Pink papershell (*Potamilus ohiensis*)	U,W
Bleufer (*Potamilus purpuratus*)	C
Pyramid pigtoe (*Pleurobema rubrum*)	R,I
White heelsplitter (*Lasmigona complanata*)	U,W

* Status: **R**= Rare; **U**= Uncommon; **C**= Common; **A**= Abundant; **S**= State species of concern; **E**= Federally endangered species; **I**= State inventory element; **W**= State watch list species. **R**, **U**, **C** or **A** status refers only to populations inhabiting the mainstem of the lower White River.

Table A-4. Birds Identified in the Lower White River Basin, Arkansas.

Family and Species	Area Found*							
Gaviidae								
Common Loon (*Gavia immer*)								8
Podicipedidae								
Pied-billed Grebe (*Podilymbus podiceps*)					5	6	7	8
Pelecanidae								
American White Pelican (*Pelecanus erythrorhynchos*)						6	7	8
Phalacrocoracidae								
Double-crested Cormorant (*Phalacrocorax auritus*)					5	6	7	8
Anhingidae								
Anhinga (*Anhinga anhinga*)						6	7	8
Ardeidae								
American Bittern (*Botaurus lentiginosus*)				4		6	7	8
Least Bittern (*Ixobrychus exilis*)						6	7	8
Great Blue Heron (*Ardea herodias*)				4	5	6	7	8
Great Egret (*Ardea alba*)					5	6	7	8
Snowy Egret (*Egretta thula*)						6	7	8
Little Blue Heron (*Egretta caerulea*)						6	7	8
Tricolored Heron (*Egretta tricolor*)						6	7	8
Cattle Egret (*Bubulcus ibis*)					5	6	7	8
Green Heron (*Butorides virescens*)	1				5	6	7	8
Black-crowned Night-heron (*Nycticorax nycticorax*)						6	7	8
Yellow-crowned Night-heron (*Nycticorax violacea*)						6	7	8
Threskiornithidae								
White Ibis (*Eudocimus albus*)						6		8
White-faced Ibis (*Plegadis chihi*)						6		
Glossy Ibis (*Plegadis falcinellus*)						6		
Roseate Spoonbill (*Platalea ajaja*)								
Ciconiidae								
Wood Stork (*Mycteria americana*)						6	7	8
Anatidae								
Tundra Swan (*Cygnus columbianus*)						6		8
Greater White-fronted Goose (*Anser albifrons*)	1			4	5	6	7	8
Snow Goose (*Anser caerulescens*)	1				5	6	7	8

Table A-4. Birds Identified in the Lower White River Basin, Arkansas, Continued.

Family and Species	Area Found*							
Anatidae, continued								
Ross's Goose (*Anser rossii*)						6	7	
Canada Goose (*Branta canadensis*)				4	5	6	7	8
Black-bellied Whistling-Duck (*Dendrocygna autumnalis*)							7	
Fulvous Whistling-Duck (*Dendrocygna bicolor*)						6		
Wood Duck (*Aix sponsa*)	1			4	5	6	7	8
Green-winged Teal (*Anas crecca*)						6	7	8
American Black Duck (*Anas rubripes*)						6	7	8
Mallard (*Anas platyrhynchos*)					5	6	7	8
Mottled Duck (*Anas fulvigula*)						6		
Northern Pintail (*Anas acuta*)					5	6	7	8
Blue-winged Teal (*Spatula discors*)					5	6	7	8
Northern Shoveler (*Spatula clypeata*)					5	6	7	8
Gadwall (*Mareca strepera*)					5	6	7	8
American Wigeon (*Mareca americana*)						6	7	8
Canvasback (*Aythya valisineria*)						6	7	8
Redhead (*Aythya americana*)						6	7	8
Ring-necked Duck (*Aythya collaris*)						6	7	8
Lesser Scaup (*Aythya affinis*)						6	7	8
Common Goldeneye (*Bucephala clangula*)						6		8
Bufflehead (*Bucephala albeola*)						6	7	8
Hooded Merganser (*Lophodytes cucullatus*)						6	7	8
Common Merganser (*Mergus merganser*)								8
Red-breasted Merganser (*Mergus serrator*)							7	8
Ruddy Duck (*Oxyura jamaicensis*)						6	7	8
Cathartidae								
Black Vulture (*Coragyps atratus*)						6	7	8
Turkey Vulture (*Cathartes aura*)				4		6	7	8
Accipitridae								
Northern Harrier (*Circus hudsonius*)				4		6	7	8
Mississippi Kite (*Ictinia mississippiensis*)					5	6	7	8
Swallow-tailed Kite (*Elanoides forficatus*)								8
Sharp-shinned Hawk (*Accipiter striatus*)						6	7	8
Cooper's Hawk (*Accipiter cooperii*)						6	7	8
Red-shouldered Hawk (*Buteo lineatus*)				4	5	6	7	8
Broad-winged Hawk (*Buteo platypterus*)						6	7	8
Swainson's Hawk (*Buteo swainsoni*)						6	7	8
Red-tailed Hawk (*Buteo jamaicensis*)				4	5	6	7	8
Rough-legged Hawk (*Buteo lagopus*)								8

Table A-4. Birds identified in the lower White River basin, Arkansas, continued.

Family and Species	Area Found*							
Accipitridae, continued								
Golden Eagle (*Aquila chrysaetos*)						6	7	8
Bald Eagle (*Haliaeetus leucocephalus*)						6	7	8
Osprey (*Pandion haliaetus*)						6	7	8
Falconidae								
American Kestrel (*Falco sparverius*)				4		6	7	8
Peregrine Falcon (*Falco peregrinus*)						6	7	8
Odontophoridae								
Northern Bobwhite (*Colinus virginianus*)				4	5	6	7	8
Phasianidae								
Eastern Wild Turkey (*Meleagris gallopova*)						6	7	8
Rallidae								
Purple Gallinule (*Porphyrio martinicus*)						6	7	8
Common Moorhen (*Gallinula chloropus*)								8
American Coot (*Fulica americana*)						6	7	8
King Rail (*Rallus elegans*)						6	7	8
Virginia Rail (*Rallus limicola*)						6		8
Sora (*Porzana carolina*)						6		8
Charadriidae								
Black-bellied Plover (*Pluvialis squatarola*)						6		8
American golden-Plover (*Pluvialis dominica*)						6	7	8
Piping Plover (*Charadrius melodus*)						6		
Semipalmated Plover (*Charadrius semipalmatus*)						6		8
Killdeer (*Charadrius vociferus*)	1			4	5	6	7	8
Recurvirostridae								
American Avocet (*Recurvirostra americana*)						6		8
Black-necked Stilt (*Himantopus mexicanus*)						6		
Scolopacidae								
Greater Yellowlegs (*Tringa melanoleuca*)					5	6	7	8
Lesser Yellowlegs (*Tringa flavipes*)						6	7	8
Solitary Sandpiper (*Tringa solitaria*)					5	6	7	8
Willet (*Tringa semipalmata*)						6		
Spotted Sandpiper (*Actitis macularius*)						6	7	8
Upland Sandpiper (*Bartramia longicauda*)						6		8

Table A-4. Birds Identified in the Lower White River Basin, Arkansas, Continued.

Family and Species	Area Found*					
Scolopacidae, continued						
Hudsonian Godwit (*Limosa haemastica*)				6		
Marbled Godwit (*Limosa fedoa*)				6		
Ruddy Turnstone (*Arenaria interpres*)				6		
Red Knot (*Calidris canutus*)				6		
Sanderling (*Caladris alba*)				6		
Dunlin (*Calidris alpina*)				6		
Pectoral Sandpiper (*Calidris melanotos*)				6		8
White-rumped Sandpiper (*Caladris fuscicollis*)				6		
Baird's Sandpiper (*Caladris bairdii*)				6		
Western Sandpiper (*Calidris mauri*)				6		8
Semipalmated Sandpiper (*Calidris pusilla*)				6	7	8
Least Sandpiper (*Calidris minutilla*)				6		8
Stilt Sandpiper (*Calidris himantopus*)				6		8
Long-billed Dowitcher (*Limnodromus scolopaceus*)				6	7	8
Short-billed Dowitcher (*Limnodromus griseus*)				6	7	8
Buff-breasted Sandpiper (*Calidris subruficollis*)				6		
American Woodcock (*Scolopax minor*)		4	5	6	7	8
Common Snipe (*Gallinago gallinago*)				6	7	8
Wilson's Phalarope (*Phalaropus tricolor*)				6		8
Red Phalarope (*Phalaropus fulicarius*)				6		
Laridae						
Franklin's Gull (*Leucophaeus pipixcan*)				6		
Ring-billed Gull (*Larus delawarensis*)				6		8
Herring Gull (*Larus argentatus*)						8
Caspian Tern (*Hydroprogne caspia*)				6		8
Forster's Tern (*Sterna forsteri*)				6		
Interior Least Tern (*Sternula antillarum*)				6		8
Black Tern (*Chlidonias niger*)				6		8
Columbidae						
Mourning Dove (*Zenaida macroura*)	3	4	5	6	7	8
Rock Dove (*Columbia livia*)					7	8
Cuculidae						
Yellow-billed Cuckoo (*Coccyzus americanus*)	3		5	6	7	8
Black-billed Cuckoo (*Coccyzus erythropthalmus*)						8
Tytonidae						
Barn Owl (*Tyto alba*)				6	7	8

Table A-4. Birds Identified in the Lower White River Basin, Arkansas, Continued.

Family and Species	Area Found*							
Strigidae								
Long-eared Owl (*Asio otus*)					5			
Short-eared Owl (*Asio flammeus*)						6		8
Great Horned Owl (*Bubo virginianus*)	1			4	5	6	7	8
Barred Owl (*Strix varia*)	1			4	5	6	7	8
Eastern Screech-Owl (*Megascops asio*)	1			4	5	6	7	8
Caprimulgidae								
Chuck-will's-widow (*Antrostomus carolinensis*)					5	6		8
Whip-poor-will (*Antrostomus vociferus*)						6	7	8
Common Nighthawk (*Chordeiles minor*)					5	6	7	8
Apodidae								
Chimney Swift (*Chaetura pelagica*)	1		3	4	5	6	7	8
Trochilidae								
Ruby-throated Hummingbird (*Archilochus colubris*)			3	4	5	6	7	8
Alcedinidae								
Belted Kingfisher (*Megaceryle alcyon*)						6	7	8
Picidae								
Red-headed Woodpecker (*Melanerpes erythrocephalus*)			3	4	5	6	7	8
Red-bellied Woodpecker (*Melanerpes carolinus*)	1		3	4	5	6	7	8
Yellow-bellied Sapsucker (*Sphyrapicus varius*)	1		3			6	7	8
Downy Woodpecker (*Picoides pubescens*)			3	4	5	6	7	8
Hairy Woodpecker (*Picoides villosus*)			3	4		6	7	8
Red-cockaded Woodpecker (*Picoides borealis*)					5			
Northern Flicker (*Colaptes auratus*)	1		3		5	6	7	8
Pileated Woodpecker (*Dryocopus pileatus*)	1		3	4	5	6	7	8
Tyrannidae								
Olive-sided Flycatcher (*Contopus cooperi*)						6		8
Eastern Wood-pewee (*Contopus virens*)			3	4	5	6	7	8
Acadian Flycatcher (*Empidonax virescens*)			3	4		6	7	8
Willow Flycatcher (*Empidonax traillii*)					5A	6		
Eastern Phoebe (*Sayornis phoebe*)			3	4	5	6	7	8
Great crested Flycatcher (*Myiarchus crinitus*)			3	4	5	6	7	8
Eastern Kingbird (*Tyrannus tyrannus*)			3		5	6	7	8
Western Kingbird (*Tyrannus verticalis*)								
Scissor-tailed Flycatcher (*Tyrannus forficatus*)						6		

Table A-4. Birds Identified in the Lower White River Basin, Arkansas, Continued.

Family and Species	Area Found*							
Laniidae								
Loggerhead Shrike (*Lanius ludovicianus*)				4	5	6	7	8
Vireonidae								
Red-eyed Vireo (*Vireo olivaceus*)			3	4		6	7	8
Warbling Vireo (*Vireo gilvus*)						6		8
Philadelphia Vireo (*Vireo philadelphicus*)			3			6	7	8
Bell's Vireo (*Vireo bellii*)						6		8
White-eyed Vireo (*Vireo griseus*)			3	4	5	6	7	8
Yellow-throated Vireo (*Vireo flavifrons*)			3	4	5	6	7	8
Blue-headed Vireo (*Vireo solitarius*)						6		8
Corvidae								
Blue Jay (*Cyanocitta cristata*)	1		3	4		6	7	8
American Crow (*Corvus brachyrhynchos*)				4	5	6	7	8
Fish Crow (*Corvus ossifragus*)				4		6	7	8
Alaudidae								
Horned Lark (*Eremophila alpestris*)				4		6	7	8
Hirundinidae								
Purple Martin (*Progne subis*)						6	7	8
Northern Rough-winged Swallow (*Stelgidopteryx serripennis*)						6		8
Bank Swallow (*Riparia riparia*)						6		8
Tree Swallow (*Tachycineta bicolor*)						6	7	8
Cliff Swallow (*Petrochelidon pyrrhonota*)						6	7	8
Barn Swallow (*Hirundo rustica*)				4		6	7	8
Paridae								
Tufted Titmouse (*Baeolophus bicolor*)	1		3	4	5		7	8
Carolina Chickadee (*Poecile carolinensis*)	1		3	4	5	6	7	8
Sittidae								
Red-breasted Nuthatch (*Sitta canadensis*)			3		5		7	8
White-breasted Nuthatch (*Sitta carolinensis*)			3	4		6	7	8
Brown Creeper (*Certhia americana*)			3			6	7	8
Troglodytidae								
Carolina Wren (*Thryothorus ludovicianus*)	1		3	4	5	6	7	8
Bewick's Wren (*Thryomanes bewickii*)						6		8
House Wren (*Troglodytes aedon*)						6		8

Table A-4. Birds Identified in the Lower White River Basin, Arkansas, Continued.

Family and Species	**Area Found***							
Troglodytidae, continued								
Winter Wren (*Troglodytes hiemalis*)				4		6	7	8
Sedge Wren (*Cistothorus platensis*)						6		8
Marsh Wren (*Cistothorus palustris*)						6		8
Regulidae								
Golden-crowned Kinglet (*Regulus satrapa*)			3		5	6	7	8
Ruby-crowned Kinglet (*Regulus calendula*)	1		3	4	5	6	7	8
Polioptilidae								
Blue-gray Gnatcatcher (*Polioptila caerulea*)			3	4	5	6	7	8
Turdidae								
Eastern Bluebird (*Sialia sialis*)			3	4		6	7	8
American Robin (*Turdus migratorius*)			3	4	5	6	7	8
Wood Thrush (*Hylocichla mustelina*)			3		5	6	7	8
Veery (*Catharus fuscescens*)						6	7	8
Swainson's Thrush (*Catharus ustulatus*)			3			6	7	8
Gray-cheeked Thrush (*Catharus minimus*)			3			6	7	8
Hermit Thrush (*Catharus guttatus*)			3		5	6	7	8
Mimidae								
Gray Catbird (*Dumetella carolinensis*)			3			6	7	8
Northern Mockingbird (*Mimus polyglottos*)				4	5	6	7	8
Brown Thrasher (*Toxostoma rufum*)					5	6	7	8
Sturnidae								
European Starling (*Sturnus vulgaris*)			3	4		6	7	8
Motacillidae								
Sprague's Pipit (*Anthus spragueii*)				4		6		8
American Pipit (*Anthus rubescens*)				4		6		8
Bombycillidae								
Cedar Waxwing (*Bombycilla cedrorum*)					5	6	7	8

Table A-4. Birds Identified in the Lower White River Basin, Arkansas, Continued.

Family and Species	Area Found*							
Parulidae								
Northern Parula (*Setophaga americana*)			3	4		6	7	8
Orange-crowned Warbler (*Oreothlypis celata*)						6		8
Tennessee Warbler (*Oreothlypsis grina*)			3			6	7	8
Blue-winged Warbler (*Vermivora cyanoptera*)						6		8
Golden-winged Warbler (*Vermivora chrysoptera*)			3			6	7	8
Nashville Warbler (*Oreothlypis ruficapilla*)						6		8
Yellow Warbler (*Setophaga petechia*)						6		8
Chestnut-sided Warbler (*Setophaga pensylvanica*)			3			6	7	8
Magnolia Warbler (*Setophaga magnolia*)			3		5	6	7	8
Cerulean Warbler (*Setophaga cerulea*)						6		8
Blackburnian Warbler (*Setophaga fusca*)			3			6	7	8
Yellow-rumped Warbler (*Setophaga coronata*)					5	6		8
Black-throated green Warbler (*Setophaga virens*)			3			6	7	8
Prairie Warbler (*Setophaga discolor*)						6		8
Palm Warbler (*Setophaga palmarum*)						6		8
Pine Warbler (*Setophaga pinus*)					5	6		
Bay-breasted Warbler (*Setophaga castanea*)			3			6	7	8
Blackpoll Warbler (*Setophaga striata*)						6		8
Yellow-throated Warbler (*Setophaga dominica*)			3			6	7	8
Worm-eating Warbler (*Helmintheros vermivorum*)						6		8
Prothonotary Warbler (*Protonotaria citrea*)			3			6	7	8
Black-and-white Warbler (*Mniotilta varia*)			3			6	7	8
American Redstart (*Setophaga ruticilla*)			3			6	7	8
Swainson's Warbler (*Limnothlypis swainsonii*)						6		8
Ovenbird (*Seiurus aurocapillus*)			3			6	7	8
Northern Waterthrush (*Parkesia noveboracensis*)			3			6	7	8
Louisiana Waterthrush (*Parkesia motacilla*)						6		8
Kentucky Warbler (*Geothlypsis formosus*)			3			6	7	8
Mourning Warbler (*Geothlypsis philadelphia*)			3			6	7	8
Common Yellowthroat (*Geothlypis trichas*)			3	4	5	6	7	8
Wilson's Warbler (*Cardellina pusilla*)						6		8
Canada Warbler (*Cardellina canadensis*)			3				7	8
Hooded Warbler (*Setophaga citrina*)			3			6	7	8
Cardinalidae								
Summer Tanager (*Piranga rubra*)	1		3	4	5	6	7	8
Scarlet Tanager (*Piranga olivacea*)	1		3				7	8
Northern Cardinal (*Cardinalis cardinalis*)	1		3	4	5	6	7	8
Rose-breasted Grosbeak (*Pheucticus ludovicianus*)						6	7	8
Blue Grosbeak (*Passerina caerulea*)			3			6		8

Table A-4. Birds Identified in the Lower White River Basin, Arkansas, Continued.

Family and Species	Area Found*
Cardinalidae, continued	
Indigo Bunting (*Passerina cyanea*)	3 4 5 6 7 8
Painted Bunting (*Passerina ciris*)	6 8
Dickcissel (*Spiza americana*)	4 6 7 8
Passerellidae	
Eastern Towhee (*Pipilo erythrophthalmus*)	5 6 8
Field Sparrow (*Spizella pusilla*)	5 6 7 8
Chipping Sparrow (*Spizella passerina*)	5 6 8
Grasshopper Sparrow (*Ammodramus savannarum*)	6 8
LeConte's Sparrow (*Ammodramus leconteii*)	6 8
Henslow’s Sparrow (*Ammodramus henslowii*)	
Nelson’s Sparrow (*Ammodramus nelsoni*)	6 8
Savannah Sparrow (*Passerculus sandwichensis*)	4 6 8
Vesper Sparrow (*Pooecetes gramineus*)	6 8
Lark Sparrow (*Chondestes grammacus*)	6 7 8
Harris' Sparrow (*Zonotrichia querula*)	6 8
White-throated Sparrow (*Zonotrichia albicollis*)	3 4 5 6 7 8
White-crowned Sparrow (*Zonotrichia leucophrys*)	4 6 7 8
Fox Sparrow (*Passerella iliaca*)	6 8
Song Sparrow (*Melospiza melodia*)	4 5 6 8
Lincoln's Sparrow (*Melospiza lincolnii*)	4 6 8
Swamp Sparrow (*Melospiza georgiana*)	5 6 8
Dark-eyed Junco (*Junco hyemalis*)	4 5 6 8
Calcariidae	
Smith’s Longspur (*Calcarius pictus*)	
Lapland Longspur (*Calcarius lapponicus*)	4 6 8
Icteridae	
Yellow-breasted Chat (*Icteria virens*)	3 5 6 7 8
Eastern Meadowlark (*Sturnella magna*)	4 6 7 8
Bobolink (*Dolichonyx oryzivorus*)	6 7 8
Brown-headed Cowbird (*Molothrus ater*)	1 3 6 7 8
Red-winged Blackbird (*Agelaius phoeniceus*)	3 4 5 6 7 8
Brewer's Blackbird (*Euphagus cyanocephalus*)	6 8
Rusty Blackbird (*Euphagus carolinus*)	5 6 7 8
Common Grackle (*Quiscalus quiscula*)	3 5 6 7 8
Baltimore Oriole (*Icterus galbula*)	3 4 5 6 7 8
Orchard Oriole (*Icterus spurius*)	5 6 8

Table A-4. Birds Identified in the Lower White River Basin, Arkansas, Concluded.

Family and Species	Area Found*
Fringillidae	
Purple Finch (*Haemorhous purpureus*)	8
Red Crossbill (*Loxia curvirostra*)	5
Pine Siskin (*Spinus pinus*)	8
American Goldfinch (*Spinus tristis*)	3 4 5 6 7 8
Passeridae	
House Sparrow (*Passer domesticus*)	4 5 6 7 8

* Numbers indicate the species was observed and recorded at that particular area.
1 = Louisiana Purchase State Park; 2 = Henry Gray/Hurricane Lake Wildlife Management Area; 3 = Rex Hancock/Black Swamp Wildlife Management Area; 4= Benson Creek Natural Area;5 = Pine City Natural Area; 5A = Konecny Grove Natural Area; 6= Bald Knob National Wildlife Refuge;7 = Cache River National Wildlife Refuge; 8 = White River National Wildlife Refuge. Absence of an actual recorded record does not indicate that the species does not occur at that location.

Table A-5. Breeding Bird Species Priorities in the Mississippi Alluvial Valley*.

Common Name	Scientific Name	Score[a]
Bachman's Warbler	(*Vermivora bachmanii*)	35 – BLH[b]
Ivory-billed Woodpecker	(*Campephilus principalis*)	35 - BLH
Swainson's Warbler	(*Limnothlypis swainsonii*)	29 - BLH
Cerulean Warbler	(*Dendroica cerulea*)	28 - BLH
Swallow-tailed Kite	(*Elanoides forficatus*)	26 - BLH
Prothonotary Warbler	(*Protonotaria citrea*)	24 - BLH
Painted Bunting	(*Passerina ciiis*)	24
Bell's Vireo	(*Vireo bellii*)	23
Worm-eating Warbler	(*Heimitheros vermivorus*)	23
Northern Parula	(*Parula americans*)	23 - BLH
Kentucky Warbler	(*Oporomis formosus*)	23 - BLH
Orchard Oriole	(*Icterus spurius*)	23 - BLH
White-eyed Vireo	(*Vireo griseus*)	23 - BLH
Yellow-billed Cuckoo	(*Coccyzus americanus*)	22 - BLH
Wood Thrush	(*Hylocichla mustelina*)	22 - BLH
Red-headed Woodpecker	(*Melanerpes erythrocephalus)*	21 - BLH
Dickcissel	(*Spiza americans*)	21
Prairie Warbler	(*Dendroica discolor*)	21
Yellow-breasted Chat	(*Icteria virens*)	21 - BLH
Chuck-will's-widow	(*Caprimulgus carolinensis*)	21
Hooded Warbler	(*Wilsonia citrina*)	21 - BLH
Hooded Merganser	(*Lophodytes cucullatus*)	21 - BLH
Louisiana Waterthrush	(*Seiurus motacilla*)	21 - BLH
Scissor-tailed Flycatcher	(*Tyrannus forficatus*)	21
Mississippi Kite	(*Ictinia mississippiensis*)	21 - BLH
White Ibis	(*Eudocimus albus*)	21 - BLH
Acadian Flycatcher	(*Empidonax virescens)*	20 - BLH
Eastern Wood-Pewee	(*Contopus virens*)	20 - BLH
Northern Bobwhite	(*Colinus virginianus*)	20
Yellow-throated Vireo	(*Vireo flavifrons*)	20 - BLH
Yellow-throated Warbler	(*Dendroica dominica*)	20 - BLH
Baltimore Oriole	(*Icterus galbula*)	20 - BLH
Carolina Chickadee	(*Poecile carolinensis*)	20 - BLH
Loggerhead Shrike	(*Lanius ludovicianus*)	20
Field Sparrow	(*Spizella pusilia*)	20

* From Mueller *et al.* 1999.

[a]Breeding bird species priority in the MAV based on Partners in Flight prioritization process (Hunter *et al*. 1993, Carter *et al*. 2000).
[b]BLH = Breeds in or requires bottomland hardwood forest as a component of breeding habitat.

Table A-6. Mammals Known to or Likely to Occur in the Lower White River Basin, Arkansas.

Family and Species	Area Found*							
	1	2	3	4	5	6	7	8
Didelphidae								
Virginia Opossum (*Didelphus virginiana*)	1		3		5	6	7	8
Soricidae								
Southeastern Shrew (*Sorex longirostris*)								
Southern Short-tailed Shrew** (*Blarina carolinensis*)								
Least Shrew (*Cryptotis parva*)								
Talpidae								
Eastern Mole (*Scalopus aquaticus*)								
Vespertilionidae								
Little Brown Bat (*Myotis lucifugus*)								
Southeastern Bat (*Myotis austroriparius*)								
Gray Bat (*Myotis grisescens*)								
Indiana Bat (*Myotis sodalis*)								
Silver-haired Bat (*Lasioncyteris noctivagans*)								
Tricolored Bat** (*Perimyotis subflavus*)								
Big Brown Bat (*Eptesicus fuscus*)								
Red Bat (*Lasiurus borealis*)								
Seminole Bat (*Lasiurus seminolus*)								
Hoary Bat (*Lasiurus cinereus*)								
Evening Bat** (*Nycticeius humeralis*)								
Rafinesque's Big-eared Bat (*Plecotus rafinesquii*)						6	7	8
Dasypodidae								
Nine-banded Armadillo** (*Dasypus novemcinctus*)			3			6	7	
Leporidae								
Eastern Cottontail** (*Sylvilagus floridanus*)					5	6	7	8
Swamp Rabbit** (*Sylvilagus aquaticus*)	1				5	6	7	8
Sciuridae								
Eastern Chipmunk (*Tamius striatus*)						6	7	8
Woodchuck** (*Marmota monax*)						6	7	
Gray Squirrel** (*Sciurus carolinensis*)	1		3			6	7	8
Fox Squirrel** (*Sciurus niger*)	1					6	7	8
Southern Flying Squirrel (*Glaucomys volans*)						6	7	
Geomyidae								
Baird's Pocket Gopher (*Geomys breviceps*)								

Table A-6. Mammals Known to or Likely to Occur in the Lower White River Basin, Arkansas, Continued.

Family and Species	**Area Found***
Castoridae	
Beaver** (*Castor canadensis*)	1 3 6 7 8
Muridae	
Marsh Rice Rat (*Oryzomys palustris*)	
Eastern Harvest Mouse (*Reithrodontomys humulis*)	
Fulvous Harvest Mouse** (*Reithrodontomys fulvescens*)	
Deer Mouse** (*Peromyscus maniculatus*)	
White-footed Mouse** (*Peromyscus leucopus*)	
Cotton Mouse** (*Peromyscus gossypinus*)	
Golden Mouse (*Ochrotomys nuttalli*)	
Hispid Cotton Rat (*Sigmodon hispidus*)	
Eastern Woodrat** (*Neotoma floridana*)	
Prairie Vole (*Microtus ochrogaster*)	
Woodland Vole (*Microtus pinetorum*)	
Muskrat (*Ondatra zibethicus*)	6 7 8
Southern Bog Lemming (*Synaptomys cooperi*)	
Black Rat (*Rattus rattus*)	
Norway Rat (*Rattus norvegicus*)	
House Mouse** (*Mus musculus*)	
Capromyidae	
Nutria (*Myocastor coypus*)	6 7 8
Canidae	
Coyote (*Canis latrans*)	6 7 8
Red Fox (*Vulpes vulpes*)	
Gray Fox** (*Urocyon cinereoargenteus*)	6 7 8
Ursidae	
Black Bear (*Ursus americanus*)	7 8
Procyonidae	
Raccoon** (*Procyon lotor*)	1 3 4 5 6 7 8
Mustelidae	
Long-tailed Weasel (*Mustela frenata*)	
Mink** (*Mustela vison*)	1 6 7 8
Eastern Spotted Skunk (*Spilogale putorius*)	*6 7 8*
Striped Skunk** (*Mephitis mephitis*)	1 5 6 7 8
River Otter (*Lutra canadensis*)	3 6 7 8

Table A-6. Mammals Known to or Likely to Occur in the Lower White River Basin, Arkansas, Concluded.

Family and Species	Area Found*
Felidae	
Mountain Lion*** (*Felis concolor*)	
Bobcat* (*Felis rufus*)	1 3 4 5 6 7 8
Suidae	
Feral Hog** (*Sus scrofa*)	
Cervidae	
White-tailed Deer** (*Odocoileus virginianus*)	1 2 3 4 5 6 7 8

* Numbers indicate the species was observed at that particular area. Absence of an actual recorded record does not indicate that the species does not occur at that location. 1 = Louisiana Purchase State Park; 2 = Henry Gray/Hurricane Lake Wildlife Management Area; 3 = Rex Hancock/Black Swamp Wildlife Management Area; 4= Benson Creek Natural Area;5 = Pine City Natural Area; 6= Bald Knob National Wildlife Refuge;7 = Cache River National Wildlife Refuge; 8 = White River National Wildlife Refuge.
Species not having recorded observations are expected to occur.
** Captured in LWRB by Gulf South Research Institute (1973).
*** Presumed extirpated from LWRB

Table A-7. Amphibians and Reptiles Known or Expected to Occur in the Lower White River Basin, Arkansas.

Family and Species	Area Found*
<u>Amphibians</u>	
Cryptobranchidae	
Ozark hellbender (Cryptobranchus alleganiensis bishopi) (WR – Batesville)	
Ambystomatidae	
Spotted salamander (*Ambystoma maculatum*)	8
Marbled salamander (*Ambystoma opacum*)	8
Mole salamander (*Ambystoma talpoideum*)	
Small-mouthed salamander (*Ambystoma texanum*)	8
Eastern tiger salamander (*Ambystoma tigrinum tigrinum*)	
Amphiumidae	
Three-toed amphiuma (*Amphiuma tridactylum*)	8
Proteidae	
Louisiana waterdog (*Necturus maculosus louisianensis*)	8
Red River waterdog (*Necturus maculosus*)	8
Salamandridae	
Central newt (*Notophthalmus viridescens louisianensis*)	8
Sirenidae	
Western lesser siren (*Siren intermedia nettingi*)	6 8
Bufonidae	
Dwarf American toad (*Bufo americanus charlesmithi*)	3 6 8
Fowler's toad (*Bufo fowleri*)	3 6 8
Hylidae	
Northern cricket frog (*Acris crepitans crepitans*)	6 8
Bird-voiced tree frog (*Hyla avivoca*)	1
Gray treefrog (*Hyla chrysoscelis* or *Hyla versicolor*)	8
Green treefrog (*Hyla cinerea*)	3 6 8
Northern spring peeper (*Pseudacris crucifer crucifer*)	8
Upland chorus frog (*Pseudacris triseriata feriarum*)	8
Microhylidae	
Eastern narrow-mouthed toad (*Gastrophryne carolinensis*)	6 8

Table A-7. Amphibians and Reptiles Known or Expected to Occur in the Lower White River Basin, Arkansas, Continued.

Family and Species	Area Found*
Ranidae	
American bullfrog (*Rana catesbeiana*)	3 6 7 8
Bronze frog (*Rana clamitans clamitans*)	6 8
Pickerel frog (*Rana palustris*)	8
Southern leopard frog (*Rana sphenocephala*)	3 6 7 8
<u>Reptiles</u>	
Order Crocodilia	
American alligator (*Alligator mississippiensis*)	1 8
Chelydridae	
Common snapping turtle (*Chelydra serpentina serpentina*)	1 6 7 8
Alligator snapping turtle (*Macrochelys temmincki*)	6 7 8
Emydidae	
Southern painted turtle (*Chrysemys picta dorsalis*)	8
Painted turtle (*Chrysemys picta*)	6 8
Western chicken turtle (*Deirochelys reticularia miaria*)	8
Ouachita map turtle (*Graptemys pseudogeographica ouachitensis*)	8
Mississippi map turtle (*Graptemys pseudogeographica kohni*)	8
False map turtle (*Graptemys pseudogeograhica*)	
Three-toed box turtle (*Terrapene carolina triunguis*)	6 7 8
Ornate box turtle (*Terrapene ornata ornata*)	5B
Red-eared slider (*Trachemys scripta elegans*)	3
Slider (*Chrysemys concinna hieroglyphica*)	6 7 8
Missouri slider (*Chrysemys floridana hoyi*)	
Red-eared turtle (*Chrysemys scripta elegans*)	6 7 8
Kinosternidae	
Mississippi mud turtle (*Kinosternon subrubrum hippocrepis*)	3 8
Razor-backed musk turtle (*Sternotherus carinatus*)	8
Stinkpot (*Sternotherus odoratus*)	3 8
Trionychidae	
Midland smooth softshell (*Apalone mutica mutica*)	8
Western Spiny softshell** (*Apalone spiniferus hartwegi*)	8
Eastern spiny softshell (*Apalone sinifera spinifera*)	6 8
Smooth softshell (*Apalone mutica*)	

Table A-7. Amphibians and Reptiles Known or Expected to Occur in the Lower White River Basin, Arkansas, Continued.

Family and Species	Area Found*
<u>Reptiles</u>	
Anguidae	
Slender glass lizard (*Ophisaurus attenuatus*)	
Phrynosomatidae	
Northern fence lizard (*Sceloporus undulatus hyacinthinus*)	8
Polychrotidae	
Green anole (*Anolis carolinensis*)	8
Scincidae	
Five-lined skink (*Eumeces fasciatus*)	8
Broadhead skink (*Eumeces laticeps*)	3 8
Ground Skink (*Scincella lateralis*)	3 8
Teiidae	
Prairie racerunner (*Cnemidophorus sexlineatus viridis*)	8
Six-lined racerunner (*Cnemidophorus sexlineatus sexlineatus*)	8
Colubridae	
Northern scarlet snake (*Cemophora coccinea copei*)	8
Southern black racer (*Coluber constrictor priapus*)	6 7 8
Western rat snake (*Elaphe obsoleta*)	6 7 8
Black rat snake (*Elaphe obsoleta obsoleta*)	3 8
Prairie kingsnake (*Lampropeltis calligaster calligaster*)	8
Speckled kingsnake (*Lampropeltis getulus holbrooki*)	6 7 8
Red milk snake (*Lampropeltis triangulum syspila*)	8
Rough green snake (*Opheodrys aestivus*)	6 8
Mississippi green water snake (*Nerodia cyclopion cyclopion*)	8
Yellowbelly water snake (*Nerodia erythrogaster flavigaster*)	6 7 8
Broad-banded water snake (*Nerodia fasciata confluens*)	3 6 7 8
Diamondback water snake (*Nerodia rhombifer rhombifer*)	1 6 8
Midland water snake (*Nerodia sipedon pleuralis*)	3
Graham's crayfish snake (*Regina grahamii*)	8
Midland brown snake (*Storeria dekayi wrightorum*)	8
Northern redbelly snake (*Storeria occipitomaculata occipitomaculata*)	8
Western ribbon snake (*Thamnophis proximus proximus*)	6 8
Eastern garter snake (*Thamnophis sirtalis sirtalis*)	6 8
Rough earth snake (*Virginia striatula*)	8
Western smooth earth snake (*Virginia valeriae elegans*)	8

Table A-7. Amphibians and Reptiles Known or Expected to Occur in the Lower White River Basin, Arkansas, Concluded.

Family and Species	Area Found*
Colubridae	
Midwest worm snake (*Carphophis amoenus*)	8
Mississippi ringneck snake (*Diadophis punctatus stictogenys*)	8
Western mud snake (*Farancia abacura reinwardti*)	8
Eastern hognose snake (*Heterodon platyrhinos*)	6 7 8
<u>Reptiles</u>	
Viperidae	
Southern copperhead (*Agkistrodon contortrix contortrix*)	3 6 7 8
Western cottonmouth (*Agkistrodon piscivorus leucostoma*)	1 3 6 7 8
Canebrake rattlesnake (*Crotalus horridus atricaudatus*)	3 6 7 8
Western pygmy rattlesnake (*Sistrurus miliarius streckeri*)	3 8

* Herpetiles identified on specific public lands are identified by number. Absence of an actual recorded record does not indicate that the species does not occur at that location.
1 = Louisiana Purchase State Park; 2 = Henry Gray/Hurricane Lake Wildlife Management Area; 3 = Rex Hancock/Black Swamp Wildlife Management Area; 4= Benson Creek Natural Area; 5 = Pine City Natural Area; 5B = Konecny Prairie Natural Area; 6= Bald Knob National Wildlife Refuge;7 = Cache River National Wildlife Refuge; 8 = White River National Wildlife Refuge.
** Captured in LWRB by Gulf South Research Institute (1973).