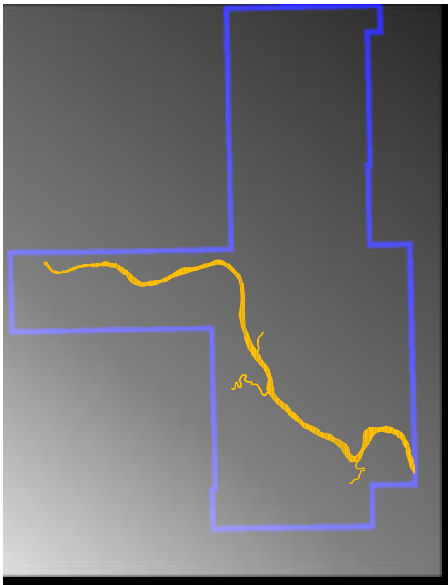

over photos courtesy of the Tulsa World

Final

Arkansas River Corridor Master Plan Phase II Master Plan and Pre-Reconnaissance Study

October 2005

Volume I- Master Plan

Submitted to:
US Army Corps of Engineers
Tulsa District

Prepared by:
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October 31, 2005

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C. H. GUERNSEY & COMPANY
Engineers • Architects • Consultants

RE: Final Report, Phase II Master Plan and Pre-Reconnaissance Study for the Arkansas River Corridor, Tulsa County, OK

Dear Ms. Kitchens:

The C.H. Guernsey & Company (GUERNSEY) Team has addressed the final report for the referenced subject. One again, it is important to recognize the GUERNSEY Team members, as they have been a very important part of the process: ***EDAW; Alaback Design Associates; Adaptive Ecosystems, Inc.; Hydropower International Services Inter-National Consultancy, LLC; and Schnake Turnbo Frank***. These very talented resources assisted the GUERNSEY Team in accomplishing a great deal of creative work for this project.

We also wish to acknowledge the partnership that the GUERNSEY Team developed with the US Army Corps of Engineers, Tulsa District, and the Indian Nations Council of Governments (INCOG). This project was performed in a very short time, was complex, and involved a number of interrelated activities from start to finish. There was a great amount of respect and cooperation amongst all parties involved. The timely completion of this project exemplifies the highest level of teamwork possible. The GUERNSEY Team is proud to have been a part of this great relationship.

Additionally, Cynthia, we extend our appreciation for your guidance and leadership throughout the project. We have truly enjoyed working with you; Andy Kmetz; Gene Lilly; and our INCOG friends, Jerry Lasker, Rich Brierre, and Gaylon Pinc.

We look forward to being involved in future activities relating to the Arkansas River Corridor. Please direct any further communication to me at 405.416.8140, ken.senour@chguernsy.com, or to Jimmie Hammontree at 405.416.8324, jimmie.hammontree@chguernsey.com.

Sincerely
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Final

Arkansas River Corridor Master Plan
Phase II Master Plan and Pre-Reconnaissance Study
Volume I

Prepared for the US Army Corps of Engineers, Tulsa District
1645 South 101st East Avenue
Tulsa, Oklahoma 74128-4609

Contract Number: W912BV-04-C-1013

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October 2005

EXECUTIVE SUMMARY

The Arkansas River is a resource of paramount importance to the Greater Tulsa community. This Master Plan is designed to maximize the beneficial use of this resource in Tulsa County. The Arkansas River Corridor stretches 42 miles from just below the Keystone Dam then east and south through Tulsa County to the Wagoner County line. The objective of this master planning process is to:

> Develop a multi-purpose, conceptual, comprehensive Arkansas River Corridor Plan that addresses flood damage reduction, ecosystem restoration and economic development opportunities consistent with the communities overall vision for growth and development. The Plan identifies projects and design concepts that have potential to stimulate public and private investment in the corridor. The Plan also serves as a guiding framework for the U.S. Army Corps of Engineers working with local public sponsors and other interests to implement projects.

This Master Plan offers a guide to community enrichment through identifying the "highest and best" use of the River Corridor and creating a meaningful connection between the Riverfront and the surrounding communities. Relying heavily on input from the public, the Master Plan establishes a comprehensive system of concepts, features, and goals that allow the River to weave a unique and valuable tapestry for its surrounding communities.

A number of economic, physical, environmental, ecological, and legal constraints and opportunities are addressed in the Master Plan. Some of the opportunities identified include low water dams, new and expanded trails, ecosystem restoration, and proposed bridges. Potential constraints in the project area include floodplains, wastewater treatment facilities, and areas with historical environmental activities.

Opportunities and constraints throughout the whole corridor were examined, with more focused attention provided to selected development opportunity areas. A number of consistent unifying themes have been customized for each individual planning area

based on the history, culture, and goals of each community in the project area.

Several public use areas are included in the Master Plan including recreational and educational amenities. Numerous mixed-use developments are proposed incorporating entertainment, shopping, dining, and tasteful living. These types of developments are envisioned to anchor key nodes of the riverfront and establish a trend for riverfront developments in Tulsa County. Elements including parks, multi-use trails, wildlife habitat, gateways, ball fields, boat ramps, fishing piers and marinas are prominently weaved throughout the conceptual plans.

Low water dams represent a key element of the Master Plan addressing the strong public desire for water in the River. The dams and the river lakes they create provide important wildlife habitat, flow management opportunities, aesthetic qualities, economic development opportunities, and water quality improvement opportunities. The Master Plan includes results from engineering analyses and water quality modeling for several potential dam locations. Based on these analyses two low water dams are initially proposed for development as part of a comprehensive ecosystem restoration project. The identified locations of these top priority low water dams are near the Creek Turnpike Bridge in the south Tulsa/Jenks area and near the State Highway 97 Bridge in the Sand Springs area. Locations are also identified for other low water dams that may be feasible for future implementation. Public safety, sedimentation, fish passage and habitat restoration are important considerations as plans advance for the low water dams.

Natural habitat and ecosystem restoration are vital to sustaining and enhancing biodiversity and aesthetic beauty throughout the River Corridor. A number of protected species utilize habitats associated with the River Corridor, namely the bald eagle, the interior least tern, the piping plover, and the American burying beetle. Consideration for minimizing impacts to these species is an element of the Master Plan.

The Master Plan contemplates several ecosystem restoration concepts including native plantings, constructed wetlands, wildlife habitats, river lakes with fish passage, and stream corridor stabilization measures.

A variety of possible development tools and funding sources have been identified including cost-share scenarios with federal, state, and local entities, funding from non-governmental organizations, and the establishment of tax increment financing districts. River oriented development could also generate its own revenue stream through enhanced property values and induced sales tax thus adding value to the Greater Tulsa area, and attracting visitors from near and far.

The localities along the river, numerous local, State and Federal agencies and businesses and industry in the corridor are key stakeholders that all have important roles in implementing the Master Plan. Enhancing the mission and powers of the River Parks Authority has been suggested as one step in establishing, operating, and maintaining the Arkansas River Corridor as a hallmark of riverfront planning and development, while managing the many sensitive interconnections among its users.

The coordinated implementation of the Arkansas River Corridor Master Plan holds promise to enhance the quality of life in the Greater Tulsa community for current and future residents by capitalizing on our most prominent physical asset --- the Arkansas River.

Table of Contents – Volume I

Table of Contents – Volume I (continued)

Section Page

Table of Contents – Volume I (continued)

Section Page

Table of Contents – Volume I (continued)

Section Page

Table of Contents – Volume I (continued)

Section Page

Table of Contents – Volume I (continued)

Table of Contents – Volume I (continued)

Section Page

List of Figures

List of Tables

ACRONYMS

ABDA	Arkansas Basin Development Association
AES	Aesthetics
AG	Agriculture
ARFCA	Arkansas River Flood Control Association
CCC	Commodity Credit Corporation
CFR	Code of Federal Regulations
cfs	cubic feet per second
CPP	Continuing Planning Process
CRP	Conservation Reserve Program
CSP	Conservation Security Program
CWA	Clean Water Act
dbh	Diameter at breast height
DO	Dissolved Oxygen
EDR	Environmental Data Resources
Elev.	Elevation

EQIP	Environmental Quality Incentives Program
EPA	United States Environmental Protection Agency
EWS	Emergency Water Supply
FEMA	Federal Emergency Management Agency
FIP	Forestry Incentives Program
FIRM	Flood Insurance Rate Maps
FIS	Flood Insurance Study
FWP	Fish and Wildlife Propagation
GRP	Grasslands Reserve Program
HABs	Harmful algal blooms
HEC RAS	Hydrologic Engineering Centers, River Analysis System
I-244	Interstate 244
I-44	Interstate 44
INCOG	Indian Nations Council of Government
lbs	Pounds
LOMR	Letter of Map Revision

NED	National Economic Development
NEPA	National Environmental Policy Act
NGVD	National Geodetic Vertical Datum
OAC	Oklahoma Administrative Code
ODEQ	Oklahoma Department of Environmental Quality
ODWC	Oklahoma Department of Wildlife Conservation
OKWBID	Oklahoma Waterbody Identification
OWQS	Oklahoma Water Quality Standards
PBCR	Primary Body Contact Recreation
Phase I	Phase I Vision Plan
Plan	Arkansas River Corridor Master Plan
PPWS	Public and Private Water Supply
PSO	Public Service Company of Oklahoma
RC&D	Resource Conservation & Development
RPA	River Parks Authority
SHPO	State Historic Preservation Officer
SIOH	Supervisor, Inspection, and Overhead

SIP	Stewardship Incentives Program
SWCA	Soil and Water Conservation Assistance
SWPA	Southwest Power Administration
TDS	Total Dissolved Solids
TIF	Tax Increment Financing
TMDL	Total Maximum Daily Load
USACE	United States Army Corps of Engineers, Tulsa District
USDA	United States Department of Agriculture
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WBID	Waterbody Identification
WQMS	Water Quality Management Segments

1.0 INTRODUCTION

1.1 BACKGROUND

Downtown Tulsa (photo courtesy of Tulsa World)

Vision 2025 is a Tulsa, Oklahoma regional initiative creating a Greater Tulsa Area. Vision 2025 propositions were strongly supported by the communities in the Greater Tulsa Area when voters approved a one-penny, 13-year increase in the Tulsa County tax on September 9, 2002.

One of the four cornerstones of Vision 2025 is Community Enrichment. An important portion of Vision 2025 Proposition 4 devotes sales tax revenues to improvements associated with the Arkansas River Corridor. The Greater Tulsa Area communities recognize that the Arkansas River Corridor is an important natural resource that could be developed to stimulate immense private investment and greatly improve the quality of life for current and future generations.

The Arkansas River Corridor Master Plan/Phase I Vision Plan (Phase I), completed in August 2004, was directed and overseen by the Indian Nations Council of Government (INCOG) and consisted of a series of public meetings and outreach measures to record interest and develop a vision for each community and the corridor as a whole. It addressed privately and publicly owned property within the River corridor and identified potential conservation, development, and redevelopment sites.

The guiding principles for development of the overall Arkansas River Corridor Master Plan (Plan) are:

- Given the applicable voter approved projects identified in Proposition 4, the overarching objective of the Plan is to identify comprehensive opportunities that take into account economic development, environmental quality, and social well-being.
- The Plan will include a comprehensive evaluation of regulatory and legal issues and constraints associated with project implementation.
- The Plan will include a comprehensive evaluation of technical, environmental, and financial issues and constraints associated

with project implementation and will recommend sound alternatives for mitigation where feasible.

- The Plan will recommend phasing priorities and costs for plan implementation including projects identified for early, fast-track implementation through the Vision 2025 process.
- The Plan will include public, private, and partnered development strategies and recommended funding sources and prioritized funding strategies and schedules for implementation.
- The Plan will evaluate existing and conceptual implementation mechanisms and will recommend potential improvements needed for efficient project financing and implementation.
- The Plan shall make recommendations regarding guidance for developing criteria for floodplain development within levied and un-levied areas.
- The Plan will be based on the best available technology and data with independent scientific review as an integral part of its development and implementation.
- The Plan will be developed through an inclusive and open process that engages all stakeholders and interest groups.
- All applicable private, local, State, Tribal, and Federal interests will be partners and their views considered fully.
- Based on the concept of adaptive management, the Plan will be flexible recognizing that modifications may be required in the future based on new information.

1.1.1 PHASE I VISION PLAN

As previously indicated, Phase I was developed under the guidance of INCOG. The purpose of Phase I was to integrate the ideas that are supported by the community into a plan for the Arkansas River Corridor, a stretch of river encompassing 42 miles from Keystone Dam to the Tulsa/Wagoner County line (see Figure 1.1-1).

Phase I was general in its nature and scale and established the framework in which future planning and design work would be undertaken.

ARKANSAS RIVER CORRIDOR OVERVIEW **FIGURE 1.1–1**

Phase I Vision Plan – Upper Reach

Phase I Vision Plan – Middle Reach

Phase I Vision Plan – Lower Reach

Phase I goals included:

- Creating a vision for the project area that would enhance the river and the citizens' lives.
- Engaging in a public participation process to solicit consensus.
- Developing a Vision Plan that will be the basis for technical evaluation.

The Plan was addressed through various activities, each of which was based upon a series of public workshops and meetings to solicit and address consensus:

- Base Mapping
- Inventory and Analysis
- Vision Plan Development

The overall process was funded locally through public and private partnerships and was directed by INCOG. This process was largely completed by July 2004.

Phase I was separated into seven major components including:

- Bridges and Crossings
- Natural Features as Resources
- Low Water Dams
- Multi-use Trails and Parks
- Traffic Network and Gateways
- Community Development Opportunities
- River-Oriented Activities

Phase I considered several challenges. These challenges included technical issues, public relations, funding, and others. During the course of Phase I development, several challenges became apparent that need attention in subsequent phases.

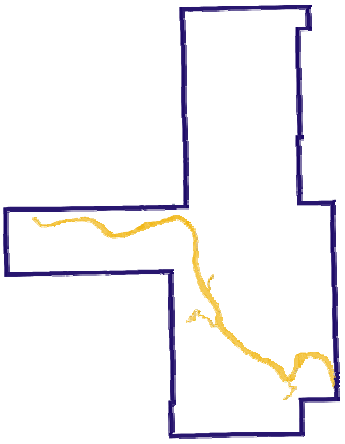
- Consistent delineation, regulation, and control of the 100-year floodplain
- Condition of sediment transport
- Continuity of the riparian corridor and aquatic environments
- Future of existing refineries
- Maintenance of community engagement and support

Upon completion of Phase I, a "Community Wish List" was created based on the information gained through the public involvement process. The wish list represents a summary of the top ten wants and needs presented to INCOG during Phase I. The community wish list consists of the following desires:

- "Riverfront" oriented retail shops and restaurants
- Enhanced preservation of natural resources
- Water in the river – develop river lakes for recreation (rowing, kayaking, fishing, etc.)
- Additional multi-use trails
- Entertainment districts
- Improved access to public lands along the river
- Additional wilderness areas and nature trails
- Boardwalks
- Additional amphitheater/performing arts spaces and related parking
- Improved connections to downtowns and neighborhoods

The Phase I Plan is provided for reference in Appendix A.

1.1.2 PHASE II MASTER PLAN AND PRE RECONNAISSANCE STUDY



Phase II is being administered and directed by the US Army Corps of Engineers, Tulsa District (USACE). The USACE contracted C.H. Guernsey & Company (GUERNSEY) to perform the Phase II Master Plan. GUERNSEY assembled a team of experts in planning, engineering, environmental science, and public relations to perform the study. The GUERNSEY Team consists of GUERNSEY, EDAW, Alaback Design Associates, Adaptive Ecosystems, Hydropower International Services, Inter-National Consultancy (HISINC), and Schnake Turnbo Frank. The GUERNSEY Team addressed the Guiding Principles of the overall Plan as presented in Section 1.1 above.

One of the major objectives of Phase II is to identify opportunities that could leverage local funds with Federal funds. For example, two primary missions of the USACE Civil Works Program are ecosystem restoration and flood damage reduction.

One of the key initiatives to be accomplished during Phase II activities:

View of Turkey Mountain from a bench in River Park

"Identify a conceptual comprehensive Arkansas River Corridor Multi-Purpose Plan including projects that have potential for ***private, local/Federal, and other interests*** and incorporates, to the extent possible, including applicable component features identified in Proposition 4 of Vision 2025. Multi-purpose plans that include ecosystem restoration shall contribute to both National Economic Development (NED) outputs and National Ecosystem Restoration (NER) outputs."

Additionally, Phase II is to focus on other key elements including:

- Creating an opportunities and constraints map
- Inventorying infrastructure components such as highways, roadways, water/wastewater systems, pipelines, and electric utility systems
- Addressing conceptual plans for seven development sites identified by the USACE and INCOG and two low water dam locations
- Preparing a comprehensive report that summarizes the planning process

Other key components to be addressed in Phase II include:

Cyclist on trail near Jenks Bridge

A. The public wants development at key nodes; desires to keep the trails, the green space and the beauty of the corridor; and they want water in the river.
B. The Phase I Plan divided the corridor into three sections. ***Section A*** is the north section from Keystone dam to about 33rd West Avenue. The middle section, ***Section B***, extends downstream to the Creek Turnpike, and ***Section C*** extends to the Wagoner County line. In general, Section A is concerned with wildlife habitat, Section B is development oriented, and Section C is sports oriented.
C. Locks on the low water dams are not a primary concern.
D. Riverside Drive is proposed as a four-lane roadway from Interstate 44 to 21st Street.
E. The whitewater area near Public Service Company of Oklahoma (PSO) would be preserved and enhanced.
F. Sand operators will play a large part in corridor development and must be included in all aspects of the study. Anchor Materials, Watkins and others have been supportive.

Fisherman at Zink Dam

G. Hydrology is one of the most important issues to consider in any development scenario. The current level of protection is designed for a 100 year storm and must be maintained. The 1986 flood (301,800 cubic feet/second [cfs]) is the benchmark for future development. There is concern in areas not protected by levees.
H. Sedimentation in Keystone Lake is an important issue for consideration in the long-range River Plan due to the Arkansas River's high sediment carrying rate. Future studies should evaluate the rate of sediment accumulation and potential mechanisms for addressing sedimentation so that the intended level of flood protection is maintained.
I. Sediment transport and passage will be a key design issue in any corridor plan proposed.
J. Protection of the interior least tern and provisions for fish passage are important issues. Future dams must be environmentally sensitive.
K. Water quality is a major issue. INCOG maintains a water quality model and has updated it using new hydraulic information used in the low-water dam evaluation.
L. The Southwest Power Administration (SWPA) has control over Keystone Dam discharges.
M. There is an emphasis by the USACE on environmental and cultural resources, and infrastructure issues.
N. Focus of the master plan will be shifted from the river sub-reaches (Phase I) to specific projects within the entire corridor.
O. Public involvement is important.
P. Recommendation for a managing authority.

1.2 ARKANSAS RIVER HISTORY

The Arkansas River is the longest tributary in the Mississippi-Missouri River system. The river is over 1,450 miles long and drains approximately 160,500 square miles. The river is named after the Arkansas Indians.

The river's source is near Leadville, Colorado on the eastern slopes of the Rocky Mountains. It flows generally to the southeast from Leadville through Colorado, Kansas, Oklahoma, and Arkansas. Major tributaries of the Arkansas River include the Cimarron, Canadian, Neosho, Verdigris, and White Rivers. Through these

tributary systems, the Arkansas River transports water from Colorado, New Mexico, Texas, Kansas, Oklahoma, Missouri, and Arkansas. The headwaters area in Colorado contains the Royal Gorge (near Canon City) that is characterized by canyon walls that rise more than 1,000 feet above the River. Major cities located on the river include Pueblo, Colorado; Wichita, Kansas; ***Tulsa, Oklahoma***; and Fort Smith and Little Rock, Arkansas. The river is further characterized in the upper reaches as a "prairie river" and in Arkansas and Oklahoma by the 17 locks and dams on the McClellan-Kerr Arkansas River Navigation System.

The river's history is documented on Table 1.2-1. As shown, it was discovered in 1541 and has an intriguing story. Navigation issues began to be highlighted in 1881 (establishment of the USACE, Little Rock District), 1905 (Arkansas River Navigation Club), and in 1920 (advocates of river development). Flood control became an issue in 1927. The USACE, Tulsa District was established in 1939. In 1946, the Rivers and Harbors Act authorized the development of the McClellan-Kerr Arkansas River Navigation System and the waterway was finally realized in 1970. Construction of Keystone Dam began in 1956. The lake became operational in 1968 and has produced a cumulative flood damage reduction benefit of approximately $592 million through September 2004.

1961 Photograph of Keystone Dam under construction

Table 1.2-1
Arkansas River Chronology

Date	Event
1541	The Arkansas River is discovered by Europeans. Franco Vasquez de Coronado crossed the Arkansas near present day Dodge City, Kansas.
1682	La Salle claimed the Arkansas in the name of the King of France
1802	Jean Pierre Chouteau establishes the first permanent white settlement along the Arkansas, in what would eventually become Oklahoma
1803	The United States of America purchases the Louisiana Territory which includes the Arkansas River Basin
1819	Auguste Chouteau built a boatyard in the Three Forks area (near present day Muskogee), to accommodate the shipping of furs to New Orleans
1820	The first steamboat on the Arkansas was the Comet
1824	The steamboat *Florence* carried 100 recruits to the new military post at Fort Gibson. The establishment of Fort Gibson brought heavier river traffic. As supplies for delivery along tributaries of the Arkansas came in at Fort Smith, they were unloaded and reshipped by keelboats and ox wagons to their destination
1829	The *James O'Hara* – at 200 tons – the biggest recorded steamboat to have plied the Arkansas, brought recruits and 100 Cherokee emigrants to Fort Gibson
1832	First River Act authorizes work on the Arkansas River to maintain a channel to the mouth of the Grand (Neosho) River, granting $15,000 for that work
1837	The Chickasaws came up the Arkansas River and landed at Fort Coffee on the way to their new homes in the western Choctaw lands
1838	The Cherokee on the "Trail of Tears," as the Creeks before them, come up the Arkansas on flatboats
1872	The Arkansas Gazette published an incomplete list of 117 steamboats that had been lost on the Arkansas
1880	From 1880 to 1905, twelve irrigation canals constructed to divert water from the Arkansas River between the Colorado state line and Great Bend. These 12 canals were intended to irrigate from 5,000 to 100,000 acres
1881	The Army Corps of Engineers established an office at Little Rock
1890	20,818 acres of land are irrigated by Arkansas River water

Table 1.2-1, continued
Arkansas River Historical Information

Date	Event
1905	Two years before Oklahoma statehood, the Muskogee Commercial Club organized the Arkansas Navigation Company. The reasoning was that river navigation could take advantage of the oil boom in Indian Territory
1908	Flooding along the Arkansas in Tulsa. The railroads are hit hard
1920	In the 1920s, there were advocates in Arkansas and Oklahoma who looked to river development as an achievable goal for the future. Chief among them were Newt Graham of Tulsa and Clarence Byrns of Fort Smith. Both men were considered major leaders for river development
1923	Disastrous floods struck Oklahoma in June and October of 1923. The Canadian River shattered Oklahoma City's water supply dam. In Tulsa, the Arkansas destroyed the city waterworks and drove 4,000 from their homes. Nearly every wagon and railroad bridge in central Oklahoma was washed out. There were proposals to create reservoirs on the Arkansas and Red Rivers to help prevent future flooding. The Tulsa Chamber of Commerce leads an effort to form a seven state commission to investigate flood control methods in the Arkansas and Red River Basins.
1927	"The 1927 flood on the Arkansas river, the greatest ever known, came out of a little area here in southeastern Kansas." This occurrence led to the formation of the Arkansas River Flood Control Association (ARFCA). The focus of the organization was to lobby members of Congress for a comprehensive flood control program. The next year, a flood control act is passed by Congress. The Arkansas and Red Rivers are included for survey as part of this comprehensive study.
1930	56,939 acres of land now irrigated by Arkansas River in Kansas
1933	From 1933 to 1937, Dust Bowl and drought in the Arkansas River Basin and Great Plains

First bridge across the Arkansas River in Tulsa - 1904

Migrant agricultural worker encamped on Arkansas River, Wagoner County - 1939

Historical Arkansas River flood event near Fort Smith, Arkansas

Table 1.2-1, continued
Arkansas River Historical Information

Date	Event
1936	Congress passes the Flood Control Act of 1936 authorizing 211 flood control projects in 31 states
1937	July 14. Southwestern Division begins work in territory that includes the upper Arkansas, Red, White, and Black River basins, among others
1939	July 1. Tulsa District of U. S. Army Corps of Engineers is formed from the Little Rock District, and received $11,000,000 for work on eight authorized projects
1943	Flooding – 24 inches of rain in six days from McAlester to Muskogee. Some reports state that "half of Arkansas" was under water
1944	Flood Control Act authorizes recreation facilities at reservoirs
1946	Arkansas Basin Development Association (ABDA) established. Organized by Newt Graham and John Dunkin. The ABDA lead the effort for Arkansas River navigation legislation
1946	July 24. Rivers and Harbors Act authorizing the building of the McClellan-Kerr Arkansas River Navigation System is passed by Congress. The plan includes hydropower, flood control, recreation, and navigation from Catoosa, Oklahoma to the Mississippi River
1950	Acreage in Kansas irrigated by the Arkansas River now reaches 260,000
1954	Arkansas River navigation is placed in a "deferred for further study" category. A major engineering problem needs to be solved – 100 million tons of silt flowing down the Arkansas annually could prevent navigation. A study conducted by Professor Hans Albert Einstein, son of the famous scientist, proposed a way for the river to clean itself, thus reducing sedimentary flow. Major reaches of the river would be deepened, straightened, and narrowed. This would stabilize the banks and make the river flow faster. The faster waters would flush out sediment that would otherwise settle and require constant dredging. This plan was tested by Waterways Experiment Station and was found to work. The system would work so well that $31,000,000 could be stricken from the budget for three upstream dams which had been designed to trap sediment.

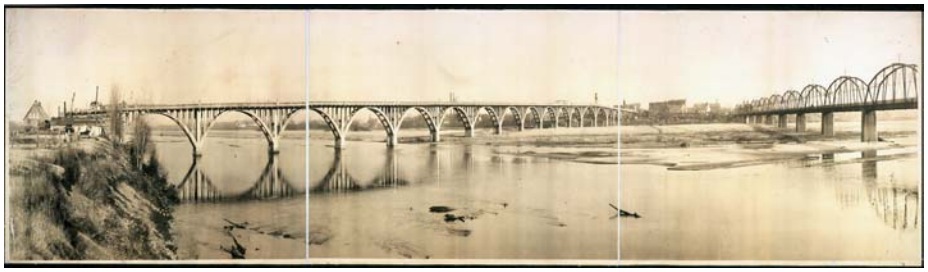
Table 1.2-1, continued
Arkansas River Historical Information

Date	Event
1956	Oklahoma Senator, Robert S. Kerr wins funds for three reservoirs vital to the navigation system in return for throwing his support to the popular Federal Aid Highway Act (which authorized the interstate highway system). Work resumes on the Oologah Reservoir and begins on Keystone and Eufaula Reservoirs. These upstream lakes are vital to the navigation system. In addition to providing flood control, hydroelectric power, and recreation, these reservoirs were designed as one means to regulate the depth of water in the navigation channel.
1960	1,010,000 acres of land now irrigated in Kansas by the Arkansas River
1961	A report on recreation and beautification potential for the Arkansas River is completed by the Tulsa Metropolitan Planning Commission.
1964	Construction begins on Webbers Falls Lock and Dam No. 16
1965	The Development Plan for River Lakes Park is completed by the Tulsa Metropolitan Area Planning Commission. This is considered to be the original Master Plan for the Arkansas River corridor.
1967	August 22, people of the city of Tulsa passed a $17.5 million bond issue for port development. This was joined by funds from Rogers County to develop the site for the 2,000 acre Tulsa Port of Catoosa. Construction starts include Chouteau Lock and Dam No. 17 and Newt Graham Lock and Dam No. 18. In August of this same year, the Preliminary Sketch Plan for River Lakes Park was completed.
1968	Navigation is opened to Little Rock October 4. A US postage stamp is issued boasting "Arkansas River Navigation" to commemorate the occasion

Table 1.2-1, continued
Arkansas River Historical Information

Port of Catoosa - 1975

Date	Event
1970	December 30. The waterway is ready for use, 448 miles, 17 locks and dams. The Arkansas River Navigation project provides a minimum nine foot deep channel with a total lift of 420 feet, 450 miles long, from the Mississippi River to the head of navigation at Catoosa, near Tulsa, Oklahoma. The navigation project begins at the confluence of the White and Mississippi Rivers, goes 10 miles up the White River, then 10 miles up the man-made Arkansas Post Canal, where it flows into the Arkansas River. The system continues up the Arkansas River to Muskogee, Oklahoma then turns up the Verdigris River for the last 50 miles before reaching the head of navigation at the Tulsa Port of Catoosa. To make the Arkansas navigable, 17 locks and dams were constructed. The dams from a series of "navigation pools" each of which is connected to the next by a lock which enables vessels to move from one pool to another. "It is the locks and pools which create the "staircase" that permits vessels to climb 420 feet in elevation from the Mississippi River to the head of navigation at the Tulsa Port of Catoosa. The capability to generate hydroelectric power was built into Webbers Falls, Robert S. Kerr, Ozark, and Dardanelle dams.
1987	The USACE completes a Water Management Analysis Report analyzing the record 1986 flood event.
1989	The USACE publishes maps depicting the flooded areas and degree of flows that occurred during the 1986 flood.
2004	The Phase I Vision Plan is completed under the guidance of INCOG. The Phase II Master Plan was initiated by the USACE, Tulsa District and INCOG.



1912 panoramic view of the Arkansas River at Ft. Smith, Arkansas

2.0 DESCRIPTION OF STUDY AREA

The intent of this section is to broadly address the various physical, social, and natural resources available to the Tulsa area, mainly in Tulsa County. More detailed discussions of some of these attributes are addressed later in this report.

2.1 LOCATION

This planning effort is focused on the Arkansas River Corridor from Keystone Dam to the Tulsa/Wagoner county line and includes the Tulsa metropolitan area. It encompasses approximately 42 river miles and also includes the communities of Sand Springs, Tulsa, Jenks, Bixby, and Broken Arrow respectively, upstream to downstream. This 42-mile corridor extends from river mile 538.96 to river mile 497.68 and is depicted on Figure 1.1-1.

2.2 GENERAL SETTING

Tulsa County (County) is in northeastern Oklahoma and has an area of 376,320 acres (588 square miles). All the communities identified above are located in Tulsa County and reflect the following characteristics:

Table 2.2-1
Project Corridor Area and Population

Community	Area (Square Miles)	Population
Sand Springs	21	17,642
Tulsa	187	383,764
Jenks	15	12,079
Bixby	25	17,729
Broken Arrow	46	84,399
Corridor Community Totals	**294**	**515,613**

2.2.1 CLIMATE

Climate in the region is characterized by cold winters and long, hot summers. Heavy rains are prevalent in the spring and early summer, as moist air from the Gulf of Mexico interacts with dry continental air. Temperature data for the County is as follows:

Season	Average	Ave. Daily Min.	Ave. Daily Max.
Winter	39	28	49
Summer	81	71	91

Average annual precipitation is approximately 39 inches, with an average annual snowfall of 10 inches. Tornadoes and heavy thunderstorms are characteristic weather events during the spring and summer.

2.2.2 HISTORIC SETTLEMENT

The Cherokee Indians were the earliest known settlers in the County. These early inhabitants were small subsistence farmers with land allotted to them based on its cash value. A more detailed historical account of the Tulsa area is provided in Section 4.2.

2.2.3 TOPOGRAPHY AND DRAINAGE

The elevation ranges in the study corridor are 1044 feet National Geodetic Vertical Datum (NGVD) representing the top of the flood control pool at Keystone Dam and approximately 575 feet NGVD at the Tulsa County/Wagoner County line. The top of bank downstream of Keystone Dam is approximately 660 feet NGVD. Soils in the region tend to slope very gradually from north to south. Most of the County is drained by the Arkansas and Caney Rivers. Arkansas River drainage is to the south-southeast. Major tributaries in the County include Bird, Crow, Duck, Fisher, Fred, Haikey, Joe, Mingo, Polecat, Snake, and Vensel creeks.

2.2.4 NATURAL RESOURCES

View between 96th Street Bridge and Pedestrian Bridge at Jenks

Tulsa County and surrounding counties have an abundance of natural resources that contribute to the economy as well as to the enjoyment of citizens in the Tulsa metropolitan area. These resources include numerous water resources, oil, limestone, sand, and wildlife.

2.2.5 INFRASTRUCTURE

All metropolitan areas must have the infrastructure in place to support the population. Several major highways are present in the area including Interstate 44 (I-44) which runs southwest to

northeast and connects Tulsa to Oklahoma City, Oklahoma and Joplin, Missouri. The Creek Turnpike is another important major highway in the area providing a southern arterial that connects I-44 to South Tulsa, Broken Arrow, and Jenks. Other heavily used highways include the Gilcrease Expressway; US Highways 64, 75, 169; and State Highways 11, 20, 33, 51, 66, 67, and 97. All of the five major communities identified for this effort have utility systems in place for water, wastewater, electric, and natural gas that are continually being evaluated and upgraded to meet the needs of their respective citizenry.

3.0 STUDY METHODOLOGY

Sand Springs public meeting – January 2005

Tulsa public meeting – June 2005

GUERNSEY Team workshop

This study has been undertaken in a methodical and logical sequence of events. The key to any planning effort is the collection and compilation of good data from reliable resources. Activities that have been addressed to gather beneficial information include the following:

- Meetings with appropriate agencies, communities, and private interests including the USACE, INCOG, all involved communities, federal agencies, and state agencies
- Site visits and reconnaissance tours of the river, communities, and facilities; recording of observations, discussions with officials, and taking photographs
- Distribution of solicitation letters to various interested parties and stakeholders; an example letter, distribution list, and responses received are included in Appendix B
- Two distinct sessions of public meetings were conducted to convey findings/concepts and obtain input from the public. Public involvement is further addressed in Section 9.0.
- Creation of a project email address to obtain input from the public. Thirty-five responses were received via the email address.
- Team workshops to address needs and issues involving GUERNSEY, EDAW, Alaback Design Associates, Adaptive Ecosystems, and HISINC.

4.0 STUDY AREA CONDITIONS

The project corridor is a 42-mile portion of the Arkansas River from the Keystone Dam at Highway 151, southward to the Tulsa/Wagoner County line. The study area within the corridor includes resources from the Arkansas River and up to ½ mile from the center of the river. The following discussion includes a general description of the ecoregion, major vegetation associations, land use patterns, cultural resources, infrastructure, and utilities within the corridor. Detailed discussions on biological resources are contained in Section 5.0.

4.1 ENVIRONMENTAL FEATURES AND CONDITIONS

4.1.1 GENERAL ECOREGION DESCRIPTION

The Arkansas River Corridor lies within the Central Oklahoma/Texas Plains ecoregion. In the more level northern and southern portions of the ecoregion, prairie communities cover most of the landscape, with woodlands on slopes, in draws, and along streams and rivers. Throughout the central part of the ecoregion, dry upland forests blanket the hills and bottomland forests occur along streams. Prairies are scattered throughout this ecoregion. Upland forests occurring in this ecoregion are called crosstimbers. Unburned stands may develop into dense forests of post oak and blackjack oak. Grasslands composed of big and little bluestem, Indiangrass, and switchgrass are predominant in this ecoregion. In more open sites, cottonwoods, willows, sedges, and rushes line rivers and streams. Bottomland forests of this ecoregion also serve as a transition from eastern to western natural communities. Bottomland forests in eastern Oklahoma, where rainfall is abundant, are very diverse in the number of species. Willows and cottonwoods dominate bottomland forests in the west. Also, more sunlight reaches the forest floor at some western sites, resulting in greater amounts of herbaceous vegetation development. A few sandstone caves are scattered throughout the ecoregion (Oklahoma State University, 1998).

4.1.2 VEGETATION ASSOCIATIONS IN THE PROJECT CORRIDOR

Field assessments were completed in the project corridor to determine the general vegetative cover associated with undisturbed areas. Two general vegetative associations were identified and are described below.

- **Cottonwood /Willow Association**

Cottonwood (*Populus deltoides*), and black willow (*Salix nigra*) were found to be the dominant cover of the areas adjacent to the river. The hackberries (*Celtis occidentalis*, *Celtis laevigata*) also comprised a large part of this association. These areas are confined to the lowlands, where subsurface hydrology dictates the floral component of the corridor. Snag trees provide bald eagle nesting and perching opportunities.

- **Oak/Hickory Association**

Dominated by oaks, this forest system is comprised of a high diversity of hardwood trees. The following is a list of species found therein: Chinkapin oak (*Quercus muhlenbergii*), post oak (*Quercus stellata*), blackjack oak (*Quercus marilandica*), northern red oak (*Quercus rubra*), winged elm (*Ulmus alata*), white ash (*Fraxinus americana*), persimmon (*Diospyros virginiana),* hickory (*Carya spp.*), cedar (*Juniperus spp.*), hackberry (*Celtis occidentalis*), sugarberry (*Celtis laevigata*), redbud (*Cercis canadensis*), cottonwood (*Populus deltoids*), black willow (*Salix nigra,* and black walnut (*Juglans nigra*).

4.1.3 LAND USE

Existing land use along the corridor is a mix of urban and rural utility. Land use/land cover maps were obtained from the United States Geological Survey (USGS) to conduct a planning level analysis on the existing land use throughout the project corridor. Some discrepancies were noted due to development that has occurred since the maps were created. ***A more detailed land use analysis will be conducted in future phases of this study***. The following land use statistics occur within one-half mile of the river banks in the project corridor.

Land use in the northern half of the study corridor is primarily associated with urban land use practices including; residential (2,966 acres), commercial (493 acres), industrial (1,641 acres), and deciduous forest land (3,745 acres). Land use in the southern portion of the project corridor is primarily agricultural with croplands and pasture dominating (9,176 acres). Table 4.1.3-1 provides approximate acreages for each land use type identified in the project corridor.

Table 4.1.3-1
Land Use within the Project Corridor *

Land Use Type	Acreage
Residential	2,966
Commercial and Services	493
Industrial	1,641
Transportation, Communications and Utilities	372
Other Urban or Built-up Land	132
Cropland and Pasture	9,176
Orchards, Groves, Vineyards, Nurseries, and Ornamental Horticultural Areas	19
Deciduous Forest Land	3,745
Streams and Canals	3,948
Reservoirs	2,514
Beaches	100
Sandy Areas Other than Beaches	164
Strip Mines, Quarries, and Gravel Pits	267
Transitional Areas	260
** Within one-half mile of the river banks*	

4.2 CULTURAL RESOURCES

The cultural history of the Tulsa area is as important as it is mysterious. The presence of a major navigable waterway, the Arkansas River, provided a means and a motive for a variety of peoples to pass through this area, often leaving behind signs of their activity.

A great deal of the historical and cultural documentation and research has been compiled and provided by Mr. William M. O'Brien of Jenks, Oklahoma and his work is heavily referenced in this report.

4.2.1 PREHISTORIC ERA

The prehistoric period is commonly understood to include the approximate time that modern man arrived on this continent, circa 12,000 BC, to the time that European explorers permeated the continental interior, approximately 1500 AD.†

Currently very little formal dig-based archeological and paleontological research has been carried out in the Arkansas River basin where it passes through Tulsa County. Archeological information from this region is usually derived from a disturbance associated with construction or flooding. Some of the pre-history that has been revealed includes evidence of prehistoric animals in the Tulsa area. The Arkansas River basin is known to contain the fossils of megafauna dating to the time of early humans in the area, approximately 12,000 BC; and, sandstone along the River contains numerous fossilized invertebrates from a much earlier time. The Arkansas River sands have also revealed a variety of vertebrate fossils from the time of the dinosaurs – 300 million years ago to 65 million years ago (O'Brien 2001; Wyckoff & Rippy 1999).

In addition to the evidence of prehistoric creatures in the Arkansas River basin, it is known that early man traveled along and lived near the River near present-day Tulsa. Numerous points or arrowheads from Clovis, Folsom, and Dalton peoples have been and continue to be discovered in the River banks and sediments and whenever construction disturbs the subsurface in the Arkansas River floodplain. These points date back to 12,000 BC (O'Brien 2001; Wyckoff & Rippy 1999).

Additional evidence of early human activity in the Arkansas River comes in the form of inscriptions on rocks believed to be made by Vikings or similar exploratory early Europeans around 1,000 AD (O'Brien 1996).

† There is a degree of debate in the historical community regarding the date ranges or time frames of the various periods. The purpose of this document is not to present the sides of the debate nor attempt to establish one point of view or the other. Therefore this document uses the somewhat generic terms 'Prehistoric' and 'Historic' and divides them at approximately 1500 AD.

Such petroglyphs have been found at Turkey Mountain[††] which is adjacent to the Arkansas River in the Middle Reach of the planning area (O'Brien 1996).

Evidence of long-term or seasonal encampments exists in the form of mortar holes, or holes drilled into large boulders or rocky outcrops. The exact use of these holes is unknown; however, one theory suggests that they could have been used to monitor astronomical events – such as those important to seasons like solstices and equinoxes. If that was indeed the purpose of these holes, then it is probable that early humans were living near the Arkansas River in permanent or semi-permanent scenarios (O'Brien 1996).

4.2.2 HISTORIC ERA

The 1500s and 1600s saw a flurry of exploration from the major European powers of the age, namely the Spanish and French. These explorers sought riches, trade, and lands to claim for their kings. This exploration reached the middle of the continental United States and the Tulsa area by the mid-1500s. Engravings attributed to these explorers have been found at Turkey Mountain (O'Brien 1996).

Through the 1700s and early 1800s a variety of Native American peoples moved into the Tulsa area due to either pressure on their lands from Europeans in the east or to forced relocation by the federal government. These people lived and traveled up and down the River leaving evidence of their existence. The cliffs above Shell Creek are painted with images attributed to the Osage people and numerous bone tools, pottery, gun parts, and arrowheads have been found along the River basin (O'Brien 1996; Bailey 1999).

A location at present-day 131st and Yale was discovered to be rich in archeology during the construction of the Kimberley-Clark facility in 1988. The Lasley Vore Site, as it became known, was quickly excavated and hundreds of artifacts were discovered. Most of the items date to 350 years before present (BP) (circa 1650 AD) and

[††] Turkey Mountain is home to several other interesting cultural features such as a primitive constructed cave-like shelter carved from the rock, an old quarry, and a number of so called 'locator rocks'. The historic dates associated with these items are not well understood or researched.

include stone and bone tools, pottery, gun parts, knife parts, beads, and metal trinkets (Odell 1999; O'Brien 2004).

While the water in the River itself is not suitable for drinking, a number of springs along the River produced plenty of good drinking water. It is likely that these springs attracted travelers, explorers, and traders and evidence of long-term campsites and fords - low water River crossings - have been found associated with the springs (O'Brien 2003).

The Osage, through clever trading and aggressive tactics, became the dominate people in this area by the early 1700s. A primary hunting trail, the Osage High Plains Hunting Trail, passed along the Arkansas River in the Tulsa area. The power of the Osage decreased in the early 1800s allowing more people moving west to come through this area. The area was explored as a possible site for relocating Native Americans from the east, and in the 1830s and 1840s the Creek people were relocated to the Tulsa area. From 1836 to 1840 the Lochapokas and Talasee Creeks settled the community which became present-day Tulsa (O'Brien 2003).

The federal government constructed a military post known as Old Fort Arbuckle in 1834. It was quickly abandoned for unknown reasons, but the site was built overlooking the Osage High Plains Hunting Trail (O'Brien 2003).

The Creeks constructed a variety of buildings near the Arkansas River; most noteworthy included a ceremonial place at the Council Oak and a community center at the mouth of Euchee Creek near present-day Sand Springs (O'Brien 2003). The Council Oak is now the centerpiece of the Council Oak Park and is listed on the National Registry of Historic Places. The Lochapokas and other Creeks spread their community out from the town square, especially favoring the rich bottom lands of the Arkansas River basin to the west, toward present-day Sand Springs (O'Brien 2003). The Creek people provided stability in the area and traffic along the river and trails increased as people moved west to Santa Fe and California through the 1850s. Artifacts from this period are routinely discovered on property that adjoins the old trails in the area. Several fords in present-day Tulsa provided passage from one side of the Arkansas River to the other, and in a few locations Native Americans operated ferries to provide crossing for wagons and larger shipments (O'Brien 2003).

It is suspected that activity through the Tulsa area decreased substantially during the Civil War, although not enough to spare the people here from the ravages of war. After federal troops were ordered back east and abandoned their western outposts, a group of Creeks and other Native Americans who wished to protect themselves and remain at peace without choosing sides, built a fortified structure at the location of Old Fort Arbuckle. In 1861 a series of battles drove these Native Americans from their homes and they fled to Kansas. The Battle of Round Mountain and the Battle of Chusto-Talasah were fought between a group of Native Americans and the Confederate army late in 1861 (O'Brien 1997).

After the Civil War, the Creeks reoccupied the area around Tulsa and rebuilt their settlement and the cattle trade returned to the area (O'Brien 2003).

In the 1830s through the 1850s the economics of cattle persuaded ranchers in Texas and Indian Territory to move their stock to markets in the east for sale and to collection points for wagon trains heading west to California. To accomplish this, the cattle were trailed across the land to locales in western Kansas, Kansas City, and St. Louis. Many of these trailways lead across the Creek territory near Tulsa and the Creeks, with a long tradition of ranching cattle and hogs, prospered. The Civil War closed the trails heading north but the demand for cattle in the south redirected the drives across Louisiana to the southeast. Texas soldiers returning from war found their ranches overflowing with cattle ready for market (O'Brien 2003).

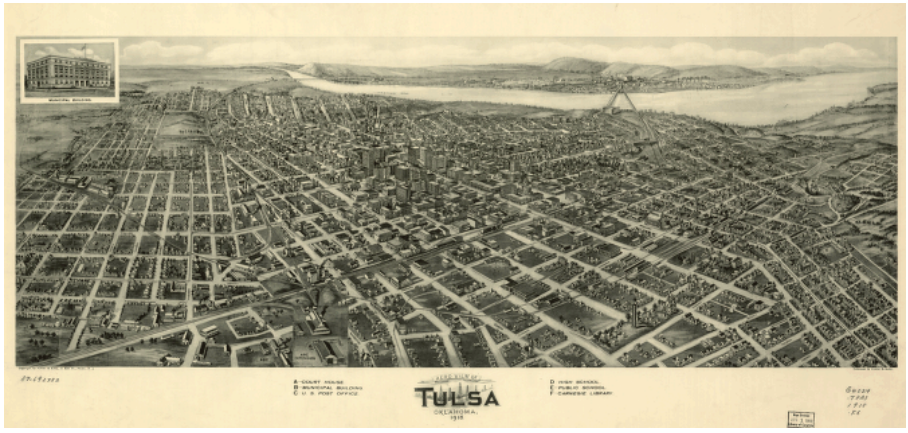
The post-Civil War era saw an increase in the cattle trade and Creek lands filled up with Texas Longhorns grazing on the lush prairie grass. The railroad became the new mode of transport for cattle going east and the railheads in Kansas buzzed with the activity of the cattle trade through the 1880s (O'Brien 2003).

Traffic and population in the region increased to the point where the federal government established a post office at the residence of a local cattleman and businessman. In 1879 the Tulsa Creek Nation Indian Territory Tulsa Post Office opened for service (O'Brien 2003). In August 1882 the railroad came to Tulsa allowing the shipment of cattle to the east. Prosperous activities associated with the cattle and railroad businesses included the Creeks leasing lands to cattleman, excavation of shallow coal beds, and the timber black market (Goble 1997).

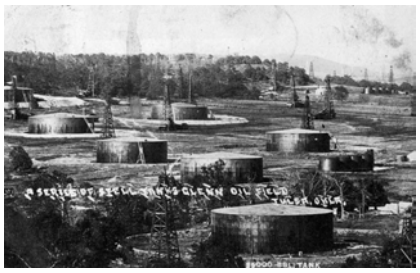
This level of activity trailed off at the end of the nineteenth century as improved transportation methods and demand for higher quality beef reduced the need and demand for the Texas Longhorn to be driven to market (O'Brien 2003).

4.2.3 MODERN ERA

The City of Tulsa was incorporated on January 18, 1898. A survey and plat was created in 1901 using the Frisco Railroad as the base. Lots were created and deeds were transferred mostly from Creeks to whites and many under suspect circumstances and Tulsa, the city, was born (Goble 1997).



Aerial map of Tulsa from 1918 showing the Arkansas River
Image obtained from the Library of Congress



Tank Farm
Glenn Oil Field - Tulsa

In the early 1900s oil was discovered at a variety of locations in and around Tulsa and the city grew up almost overnight. In 1907 the first tank farm for the Glenn Pool oil was constructed just south and west of the Arkansas River. Pipelines and refineries were built and designed to remove, process, and transport as much of the easily extractable oil as possible in the shortest time possible. The Arkansas River, serving as a convenient conduit, assimilated wastewater from as many as 18 refineries constructed on the western bank of the River (Goble 1997).

Affirming Tulsa's place as the center of oil industry many petroleum companies and related businesses began to relocate to Tulsa as early as 1908 when the *Oil and Gas Journal* relocated its publication center from Oil City, Pennsylvania to Tulsa. Also noteworthy was J. D. Rockafeller's relocation of Prairie Oil and Gas' headquarters to Tulsa in 1909 (Goble 1997).

Former Gosden Refinery
West Tulsa

As the oil boom continued, downtown Tulsa was transformed from a cowtown to a boomtown, soon displaying numerous architectural triumphs in the form of hotels, banks, and offices. World War I provided much of the oil revenue used to build and support the thriving neo-metropolis (Goble 1997).

A large and active black community had grown up on the north side of Tulsa by 1921. In that year a riot nearly destroyed their community and racial politics would plague the City for the rest of the century (Goble 1997).

The predatory and 'buccaneer' practices of oilmen in early 20th century lead to the near-collapse of the industry as large reserves in Texas and Oklahoma City were tapped in the early 1930s on the heels of the stock market crash in 1929. The result left thousands of Tulsans out of work and millionaires penniless. Franklin D. Roosevelt's New Deal civil projects brought a level of stability to the area with the construction of schools, sidewalks, stadiums, armories, parks, and so forth (Goble 1997).

Regulation by the federal government eventually saved the oil industry from the oilmen, but by that time, Tulsa had largely moved on to other pursuits (Goble 1997).

B-24 Liberator Assembly - 1943

The City leaders dedicated themselves to obtaining lucrative federal contracts to support the war effort in the early 1940s. As most of the Tulsa oil had been tapped and used, the Allied forces' demand was largely met by reserves in Texas and California. However, Tulsa successfully landed a contract to build a Douglas Aircraft Company bomber plant in 1941. The building and its support runways were constructed east of the existing municipal airport. Many of the businesses that had supplied material and equipment to the oil industry were able to convert and refit their products to meet the needs of the growing military industrial complex and Tulsa successfully transformed its World War II economy into a Cold War economy (Goble 1997).

In 1943 a major flood on the Arkansas River brought the issue of navigation to the attention of Oklahoma's governor, Robert Kerr. A Tulsa resident and businessman, Newton Graham, had been promoting river navigation for several years and welcomed Governor Kerr as a powerful ally. A series of political posturing caused the navigation of the Arkansas River to be approved in the 1946 Rivers and Harbors Act. The project to connect Tulsa, via waterway, to the Mississippi River was ushered along by Kerr after

1943 Tulsa Flood

he was elected to the US Senate in 1948. The project, completed in 1971, ultimately cost $2 billion and provides immeasurable economic support in the form of raw material delivery and product shipment to and from Tulsa (Goble 1997).

The Arkansas River, so long a resource and motive for the development of the region, is set to undergo yet another historical development with the vision outlined in this Master Plan.

4.2.4 LISTED CULTURAL RESOURCE SITES

Based upon preliminary research conducted at the Oklahoma Archeological Survey, there are 47 listed cultural resource sites within the project corridor. These sites include prehistoric and historic sites and are largely located in the undeveloped and more natural areas of the river. Due to the sensitive nature of many cultural resource sites, the specific locations are not presented in this Master Plan. Any future developments in the project corridor should be coordinated with the State Historic Preservation Officer (SHPO) to ensure that project plans do not impact known cultural resources. No undocumented cultural resources were observed during site reconnaissance efforts. A detailed report on cultural resources is provided in Appendix C.

4.3 INFRASTRUCTURE

The project corridor transects the greater Tulsa metropolitan area. As such, a vast network of infrastructure exists throughout including a transportation framework of roadways/highways, railroads, trails, and airports. This infrastructure effectively weaves together a fabric of residential, commercial, industrial, recreational, and undeveloped areas throughout the project corridor. A dense network of utilities is present throughout most of the corridor and includes distribution systems for electricity, water, and natural gas. Seven wastewater treatment facilities and their collection systems are also included within the project corridor; five are in the lower reach of the river. Numerous power transmission lines and oil/gas pipelines traverse the area supporting operations along the river.

5.0 HABITAT ASSESSMENT/ECOSYSTEM RESTORATION

GUERNSEY Team member Adaptive Ecosystems performed an ecological opportunities and constraints study as a part of the Phase II activities. The contents of the ecological report are incorporated throughout this Master Plan. A copy of the original report is provided in Appendix D.

5.1 ARKANSAS RIVER CORRIDOR HABITATS

The Arkansas River Corridor aquatic and terrestrial habitats are discussed below.

5.1.1 AQUATIC HABITATS

Aquatic habitats include perennial streams, rivers, floodplain wetlands, and sand bars of the Arkansas River. A brief summary of each aquatic habitat found in the corridor is described below.

- Open Water Habitats – Open water habitats include both pooled and flowing water resources. Open water habitat provides valuable resources for numerous fish, insect, amphibian, reptile, bird and human uses.
- Sandbars – Sandbar habitats in the project corridor are important resources for migratory birds such as the interior least tern, spawning fish, and the reproductive cycle of numerous mussels and river invertebrates.
- Wetlands - Generally, wetlands are lands where saturation with water is the dominant factor determining the nature of soil development and the types of plant and animal communities living in the soil and on its surface (Cowardin, 1979). Wetland function includes protecting and improving water quality, providing fish and wildlife habitats, storing floodwaters, and maintaining surface water flow during dry periods.

5.1.2 TERRESTRIAL HABITATS

Terrestrial habitats in the project corridor include riparian and upland habitats. A brief summary of each terrestrial habitat found in the project corridor is described below.

- Riparian habitats – Riparian habitats occur in lands adjacent to river channels and on deposits from past floods or meanderings of the watercourse. Riparian buffers preserve the natural breeding, foraging, and resting areas of native wildlife species.
- Upland habitats – Unlike riparian habitats, upland habitats occur outside of the natural floodplain. Upland habitats provide natural buffers to riparian areas and aquatic resources.

5.2 AGENCY COORDINATION

The US Fish and Wildlife Service [USFWS] (Brabander, Martinez, Stubbs, 2004), Oklahoma Department of Wildlife Conservation [ODWC] (Gordon, 2004), and the US Army Corps of Engineers (Clyde, 2004; Knack, 2004; Nolen, 2004; Sturdy, 2004) were contacted regarding threatened and endangered species in the project corridor. Solicitation letters were forwarded to: the USGS, the Oklahoma Conservation Commission, the US Department of Agriculture, the USFWS, and the Oklahoma Department of Environmental Quality (ODEQ). Future agency coordination will be conducted during the impact assessment process to be addressed in accordance with the National Environmental Policy Act (NEPA) phase of the Plan.

5.3 BIOLOGICAL RESOURCES

The following sections provide a summary of protected species/habitats in the project corridor. Each species is addressed with regard to life history, habitat usage, constraints, and mitigation opportunities.

5.3.1 PROTECTED SPECIES

The Endangered Species Act provides broad protection for species of fish, wildlife, and plants that are listed as threatened or endangered in the US or elsewhere. Provisions are made for listing species, as well as for recovery plans and the designation of critical habitat for listed species. The Act outlines procedures for federal agencies to follow when taking actions that may jeopardize listed species, and contains exceptions and exemptions. Criminal and civil penalties are provided for violations of the Act and the Convention. Section 7 of the Endangered Species Act requires Federal agencies to insure that any action authorized, funded, or

carried out by them is not likely to jeopardize the continued existence of listed species or modify their critical habitat.

The USFWS cited that there are four threatened or endangered species within the Tulsa County project area (USFWS, 2004). As presented in Table 5.3.1-1, federally protected species include the Interior Least Tern (*Sterna antillarum*), the Bald Eagle (*Haliaeetus leucocephalus*), the Piping Plover (*Charadrius melodus*), and the American Burying Beetle, (*Nicrophorus americanus*).

Table 5.3.1-1
Threatened and Endangered Species in Tulsa County

Common Name	Scientific Name	Federal Status	State Status
BIRDS			
Bald eagle	*Haliaeetus leucocephalus*	T*	E**
Interior least tern	*Sterna antillarum*	E	
Piping plover	*Charadrius melodus*	T	T
INSECTS			
American burying beetle	*Nicrophorus americanus*	E	

** Threatened*
*** Endangered*

5.3.1.1 Bald Eagle

The bald eagle is a federally threatened and state endangered species which prefers wintering in deciduous woodland habitat adjacent to aquatic environments. The eagle prefers large trees, greater than 12-inches diameter at breast height (dbh), for perching and roosting. Several areas have been previously identified as bald eagle nesting habitat within the project corridor. They are riparian areas that have access to extensive exposed sandbars. These include the Keystone Dam outlet park, the Mackey Sandbar in the Jenks/South Tulsa area, and areas near 96th Street and Memorial Avenue. These areas have been either avoided or identified for protection during the planning process for Phase II. Areas of high quality riparian forests should be identified and preserved. The nest incubation and fledgling period, January 1 through May 15, is a sensitive time for this species and human disturbance to known nesting areas should be limited during this stage.

Mitigation opportunities which would benefit this species were discussed with the USFWS (USFWS, 2004). The construction of the proposed dams will have little impact on the bald eagles nesting and feeding requirements. Restoration opportunities exist within the project corridor which would benefit this species. Agricultural fields adjacent to the river are potential riparian forest restoration areas which could be purchased and preserved. The dominant trees in these forests are cottonwoods. These trees are fast growing and are thus able to provide habitat in a relatively short time.

5.3.1.2 Interior Least Tern

The interior least tern is a federally endangered species. The common name refers to the interior population of the least tern, defined as the members of the species which nest greater than 50 miles from the ocean. Interior least terns migrate in small, loose flocks arriving in Oklahoma in the spring and leaving in the fall. Terns nest in colonies and begin laying eggs in late spring. Nests are small scrapes in sand and contain one to four eggs. Both parents feed the young and remain with them until fall migration. Terns will travel four or more miles from their breeding colonies to find small fish that are a major part of their diet, prefer shallow water for fishing, and historically nest on shallow sandbars of shallow pools within the Arkansas River corridor. Terns prefer the island surface area to be about two to three acres in size. Aside from minimum size, the following island criteria are required for Tern breeding habitat:

- Concentrated in the center of the channel
- Island should have gently sloping, sandy beaches
- Less than 10% vegetation
- Withstand high flows, yet be able to scour

The creation of the Keystone Dam has affected the amount of nesting habitat that can be used by the interior least tern. The daily flow patterns are created when water is released to generate electricity. Flow patterns inundate significant areas of shallow sandbars, making them unavailable to the terns. Thus, ecological impacts regarding the loss of nesting habitat for the tern should only consider those areas which occur above the high water line for power generation and below the elevation the pool would inundate.

Impacts to least tern were discussed with the USACE (USACE, 2004), USFWS (USFWS, 2004) and ODWC (ODWC, 2004). Artificial islands have been created as mitigation projects to offset the loss of habitat. Zink Island, associated with the low water dam at 31st street, has supported nesting terns. Terns prefer native fish species which occur in shallow braided settings. Pools support less desirable fish for terns which may affect nesting success. Low water dam pools may also support striped bass populations which would compete for food available to the terns. Islands offer protection from predators and human disturbance but require maintenance. Maintenance is performed in the form of woody vegetation removal.

Studies indicate that areas covered by as little as 10-20% vegetation become unsuitable habitats for terns (Crawford et al. 2003). It was concluded that islands whose height allows for yearly flooding at the 30,000-40,000 cfs will be naturally scoured of vegetation to an acceptable minimum coverage for terns. It is likely that even these improved islands will eventually support significant vegetation over time and will require maintenance.

5.3.1.3 Piping Plover

The piping plover is listed as a federally threatened species. Historically, piping plovers breed along the Atlantic Coast, around the Great Lakes, and on the Northern Great Plains. Piping plovers winter along the southern Atlantic and Gulf Coasts. They can also winter in the Bahamas and West Indies (Peterson, 1980). Although drastically reduced, remnant populations occur throughout their historic range. Piping plovers migrate through Oklahoma each spring and fall. This species could use the Arkansas River as a waypoint between its breeding grounds in the Northern Great Plains and wintering grounds on the Gulf Coast (USFWS, 2004). Migration periods include April-May, and August-September. As they migrate they use mudflats, sandbars, and wet open fields for resting. Plovers feed on beetles, spiders, crustaceans, mollusks, and other small aquatic animals.

5.3.1.4 American Burying Beetle

Critical habitat for this insect has not been designated. It is thought to be a habitat generalist, occurring from oak forests and open grasslands to edge habitat. This beetle buries small vertebrate carcasses in the ground. Eggs are then laid adjacent to the carcass and upon hatching feed upon this food source. Any terrestrial habitat which supports small vertebrates could possibly support the Burying Beetle.

5.3.2 SPORT FISHERIES

The Arkansas River Corridor project area supports a variety of sport fish. Striped bass, paddlefish, sand bass, largemouth bass, catfish, sauger, and sunfish are the major sport fish pursued. The ODWC would like to ensure the current role of the states sport fisheries program within the project area (ODWC, 2004). Project designs should recognize the importance of the striped bass collection point below Zink Dam. Project designers should coordinate with the ODWC to develop a system that protects this state resource.

5.3.2.1 Striped Bass

The striped bass or 'striper' *(Morone saxatilis)* is native to the Atlantic Ocean and adapted to reservoirs of the central United States. Serving as an excellent sport fish, the striped bass has been aggressively stocked in reservoirs throughout the state. The striped bass prefers to feed in large schools in open water and can weigh as much as 40 pounds (lbs) but are generally much smaller. Their diet consists of shad, minnows, and insects. Although these fish can be stocked in reservoirs, they require moving water for successful reproduction. Striped bass move upstream to lay their eggs. The eggs then tumble down river, absorbing oxygen until the embryo matures. At this time the fry are able to swim on their own. If an egg gets stranded in a pooled water habitat, it will sink to the bottom and suffocate. Successfully reproducing populations of striped bass occur in Keystone Lake, Lake Texoma, and in the Arkansas River Navigation System (ODWC, 2004).

Striped bass within the project corridor respond to positive flows and travel upstream in the spring to lay their eggs. Without a fish passage to allow for continued upstream migrations, the Keystone

Dam presents an upstream barrier to this species (ODWC, 2004). As part of Oklahoma's fisheries program, striped bass females are currently collected below Zink Dam. Collected fish are used to live stock bodies of water throughout Oklahoma, for hatchery operations which require eggs and milt, and for hybrid striped bass production. The hybrid striped bass is stocked throughout Oklahoma and is traded with nearby states. Lake Texoma has been an alternative site for collecting this species. However, Lake Texoma has suffered harmful algal blooms (HABs) caused by the species known as the golden alga. These HABs result in localized fish kills due to toxins produced by the abundance of the golden alga. To reduce the risk of spreading golden alga, Lake Texoma no longer provides stripers for stocking or hybrids, making Zink Dam the only collection area for this species.

The striped bass was discussed with the ODWC (ODWC, 2004). Fish sampling data from the Zink Lake has revealed no striped bass. This would indicate that striped bass habitat needs are not met and the dam is inappropriately designed for striped bass usage and fish passage. The ODWC recommends that a study of fish passage and future spawning practices be completed for the assessment of low water dams within the corridor.

The ODWC offers a cost-share plan that would match 25% of the installation of an angling access point. If dams are designed with angling access points, this would be a good source for funding (ODWC, 2004).

5.3.2.2 Paddlefish

In 1989 the USFWS was petitioned to list the paddlefish, *(Polyodon spathula)*, as threatened under the Endangered Species Act. Lack of information for this petition resulted in no action taken. Currently the paddlefish is a "species of concern" within Oklahoma. Paddlefish run the Arkansas River in spring and have been collected from the Keystone Dam area. These fish are termed "living fossils." Having changed little from their fossilized imprints dating back to the age of dinosaurs, these fish are cartilaginous, like a shark, but feed on zooplankton. Historically, they occur in the big river regions of the Mississippi and its tributaries. In springtime, the paddlefish swims up tributaries of the larger bodies of water they reside in to find gravel

bars for spawning. After spawning, they return to deeper, slower moving water for the remainder of the year (ODWC, 2004).

The Arkansas River supports a population of paddlefish which are termed as "self-sustaining" (ODWC, 2004). This means that the paddlefish are naturally reproducing within this river system. This is of importance because many populations of paddlefish in the Midwest are not able to sustain themselves and rely on put and take methods of population control. Paddlefish can weigh up to 100 pounds and can be trapped in the pooled environments when the Keystone Dam is releasing little or no water The design of low water dam gates which allow fish passage at all river stages is optimal.

5.3.2.3 Golden Algae

The golden alga *(Prymnesium parvum)* is a microscopic flagellated algae that typically occurs in estuarine waters around the world. It is unknown whether it is native to inland bodies of freshwater. Since 1985, it has been documented that this organism occurs in reservoirs throughout western Texas. Under certain environmental stresses, this alga can produce toxins which can cause massive fish and bivalve kills. There is no evidence these toxins harm other wildlife or humans. It is not known whether pooled water created by the dams will accommodate this species or exactly what triggers the HABs.

In Oklahoma, the only documented HAB of golden alga occurred in the upper Red River arm of Lake Texoma from January to March 2004. Since that time, Lake Texoma has been subjected to monthly monitoring and a Golden Alga Research Team has been formed and charged with further study. Due to the risk of transmission, Lake Texoma no longer provides fish to the state fisheries or hatcheries.

5.3.2.4 Zebra Mussels

An exotic species, this mussel can quickly populate an area causing a variety of problems. This species (*Dreissena polymorpha*) can cluster together at densities of thousands per square meter. Zebra mussels can clog water inlet pipes of municipal or industrial facilities. Native species of mussels are displaced and species

diversity is lowered. The zebra mussel has been documented to occur in Lynn Lane Lake, Kaw Lake and A.B. Jewel Lake. It is unknown whether the creation of dams will support a population of zebra mussels.

5.4 OTHER SPECIES

This section will focus on those peripheral species which have prevalent economic and recreational benefits. Birds seem to comprise the bulk of these peripheral species, including shorebirds, migratory fowl, and Neotropical migrants.

Tulsa lies within the Central Flyway of the United States, which is described as the land lying between the Mississippi Valley and the Rocky Mountains. The flyway is utilized by three main groups of bird species; shore birds, migratory waterfowl and Neotropical migrants. An active chapter of the Audubon Society is located in Tulsa County. The Chapter's 2004 Christmas Bird Count Survey documented 117 species in the region.

5.4.1 SHORE BIRDS

These birds are known for their formidable distances traveled during migration. Wintering on the coastal range of the southern United States and even in South America, the summer range of these birds lies in the northern reaches of Canada. They lay a few eggs, usually in shallow depressions on the ground. Feeding mainly on invertebrates that live on mudflats, these birds require non-vegetated expanses in which to nest and feed on. The complex of sandbars offered by the Arkansas River may be used by a variety of migrating shore birds. Loss of this habitat would affect this group of birds the most. Although sandy expanses are locally common, similar habitats of this magnitude elsewhere are limited, and the local areas should be viewed as "stepping stones" for these migrating birds.

5.4.2 MIGRATORY WATERFOWL

Economically important to most states' hunting programs, these birds' migration routes are less dramatic than those of the shorebird. The Central Flyway is the conduit through which the waterfowl of Oklahoma pass. The diet of waterfowl ranges from

invertebrates, to plant seeds, to fish. Usually nests are created, either on the ground or in hollow trees, and about half a dozen eggs are laid. A variety of aquatic habitats are used by migrating waterfowl. Ponds, wetlands, and backwaters of river systems are their preferred choice..

5.4.3 NEOTROPICAL MIGRANTS

Neotropical migrants are described as birds that breed in the United States and Canada during spring/summer and winter in Mexico, Central America, South America, and the Caribbean. These include over 160 species of songbirds found the United States. There are recreational activities associated with this group of birds including bird feeding and bird watching. They make nests in trees and lay about four eggs per clutch. Their diet consists of insects, fruits, seeds, etc. Dense stands of vegetation, undisturbed grasslands, forests, etc. provide habitat for these birds. The riparian corridor in the project area is used for resting, nesting, and feeding.

5.5 RESTORATION OPPORTUNITIES

The following is a discussion of the ecological opportunities in the project area. Ecosystem restoration and recreational opportunities have been identified.

Ecosystem restoration opportunities in the project area include the creation of aquatic habitats, riparian corridor enhancement, and wetland restoration. Recreational opportunities such as trails and river access are also discussed. Table 5.5-1 addresses mitigation activities.

Table 5.5-1
Restoration Opportunities in the Project Corridor

Resource Opportunity	Mitigation Measure	Benefits
Aquatic Habitat	1) Creation of pools with two planned low water dams. 2) Creation of in-stream island and sandbar habitats.	Improved sport fish opportunities and the development of island habitat for use by least tern and migrating shorebirds

Table 5.5-1, continued
Restoration Opportunities in the Project Corridor

Resource Opportunity	Mitigation Measure	Benefits
Riparian Enhancements	1) Preserve and enhance approximately 3,700 acres of existing riparian corridor. 2) Restoration opportunities within 9,200 acres of floodplain.	Stream shading, contaminant filtration, reduced nutrient load to adjacent aquatic resources, reduced erosion, increased riparian wildlife habitat, improved aquatic food webs and recreational opportunities
Wetlands	Restoration, enhancement and creation of wetlands adjacent to 3,948 acres of existing water resources and within the existing 9,176 acre floodplain of the river.	Floodwater runoff detention, nutrient recycling and waste assimilation, and filtration of sediments into the Arkansas River
Uplands	Restoration of upland habitats within the corridor through native plantings in the planning area.	Improved wildlife habitat and recreational opportunities.
Recreation	Construction of trails, boat ramps, wildlife viewing observation points, whitewater kayaking rapids, riverside picnic, parking, and camping areas.	General public use including; boating, kayaking, fishing, birding, and educational opportunities

Restoration opportunities are further described in the Ecosystem Restoration Conceptual Plan, presented in Section 8.10. The overall concept would be to create connectivity throughout the project corridor through ecosystem restoration projects and ensure important riparian habitat is maintained.

5.5.1 AQUATIC HABITAT

Phase II proposes the development of in the immediate future two low water dams. Creation of pools, sandbar islands, and fish passage through low water dams could benefit area wildlife. The creation of sandbar islands may result in nesting habitat for interior least tern and usage by migrating piping plover. Fish passage through the low water dams would provide continuation of the annual paddle fish spawn and other fish species interactions. Improvements to the Zink Dam could also increase fish passage into Zink Lake and upper reaches of the river.

5.5.2 RIPARIAN CORRIDOR RESTORATION

The project area consists of approximately 3,700 acres of existing forested riparian corridor. Enhancements to the riparian areas along the corridor may include enhancements to the existing 3,700 acres of existing riparian bottomland hardwoods and/or restoration of historic riparian bottomland hardwoods. Enhancements may also include terrestrial and upland habitats in the corridor. Riparian corridor restoration could be accomplished in the 9,200 acres of floodplain currently used for agricultural purposes. Riparian enhancements would provide stream shading, contaminant filtration, reduced nutrient load to adjacent aquatic resources, reduced erosion, increased riparian wildlife habitat, improved aquatic food webs, and recreational opportunities. Riparian corridor restoration/enhancement should provide nesting and roosting benefits to the federally threatened bald eagle.

5.5.3 WETLANDS

Restoration, enhancement, and creation of wetlands adjacent to 3,948 acres of existing water resources and within the existing 9,200 acre floodplain of the river may provide the benefits of floodwater runoff detention, nutrient recycling, and waste assimilation, and filtration of sediments into the Arkansas River.

5.5.4 UPLAND HABITATS

Restoration, enhancement, and creation of prairie meadow and other terrestrial habitats could occur adjacent to trails and in open

areas throughout the project corridor. These areas can provide important habitat for a variety of native flora and fauna.

5.5.5 RECREATION

Construction of trails, boat ramps, wildlife viewing observation points, whitewater kayaking rapids, riverside picnic, parking and camping areas may all be components of project mitigation. Incorporation of these amenities would provide a unique opportunity to incorporate nature-related recreational and aesthetic benefits to Tulsa County.

Cyclist on trail in New Block Park

6.0 TECHNICAL EVALUATION OF LOW WATER DAMS

Aerial photographs provided by INCOG and the Phase I Vision Plan were reviewed for the purpose of evaluating the potential low water dam locations on the Arkansas River between Keystone Dam and the Tulsa/Wagoner County line. This information was used in conjunction with data obtained through Project team meetings, agency consultation, technical evaluations, and preliminary environmental information collected for Phase II. GUERNSEY Team member HISINC performed the hydrologic and hydraulic (H/H) analyses for the Phase II study.

6.1 SUMMARY OF HYDROLOGY AND HYDRAULICS

Tulsa County requested that the USACE, Tulsa District update the hydraulics and hydrology model in conjunction with the Master Plan. The Tulsa District completed the update to the Hydrologic Engineering Centers River Analysis System (HEC RAS) hydraulic model of backwater elevations and floodplain limits for the Arkansas River in late December 2004 and the Corps' "Super" hydrology model of flows in early January 2005. FEMA and Tulsa County jointly sponsored the creation of a new hydraulic backwater model for the Arkansas River.

This new model will result in new FEMA maps being issued for Tulsa County. The new maps will replace the existing Flood Insurance Rate Maps (FIRMs). The previous backwater model was developed in 1977 as part of the initial FEMA Flood Insurance Study (FIS) and has not been thoroughly reviewed since that time.

The new backwater model is based on new cross sections derived from 2002 aerial topography, on-site field survey cross sections, and Arkansas River sedimentation range data. The cross section locations in the new model are different than the original model; however, the bridge locations and river mile designations are very similar.

Additionally, the Tulsa District has updated the existing "Super" hydrology model and re-evaluated the hydraulic spillway capacity of Keystone Dam. The Tulsa District made a specific request to Tulsa County representatives to release the new backwater model to the Phase II study group for use in the Vision 2025

development. A detailed review of the new model has not been performed as part of this study. However, based on discussions with the Tulsa District's modelers, there is very little change in the water surface elevations from the 1977 model, and floodplain limits are being revised primarily based on new more detailed topographic mapping.

The Tulsa District indicates that the new hydrology shows the originally accepted 170,000 cubic feet per second (cfs) for the Base or 100-Year Flood flows will be raised to 205,000 cfs. However, the Arkansas River has been degraded and eroded over the past 25 years leading to increased channel storage. The increased channel storage allows the River to handle a larger flow without a noticeable increase in water surface elevation.

A copy of the April 2001 Flood Emergency Plan for Keystone Lake was provided by the Tulsa District for H/H studies. This document addresses the flooding limits on the Arkansas River for the maximum spillway discharge, 940,000 cfs, and the flooding limits in the event of a dam breach. The previously identified maximum historical inflow to Keystone Lake was 344,000 cfs during the October 1986 flood. The maximum recorded flow at the USGS Tulsa gage was 301,800 cfs from this same flooding event.

Floodplain mapping for the new Arkansas River backwater model is currently in process at the Tulsa District. As stated, this new mapping will be submitted to FEMA for replacement of the existing FEMA FIRMs which will be issued after the new hydrology study, new backwater modeling, and proposed changes to the FEMA FIRM floodplain limits have been accepted by FEMA. This will establish the new floodplain boundaries for the Arkansas River between Keystone Dam and the Tulsa/Wagoner County Line. When complete, these boundaries will provide the basis for preparing maps to illustrate the elevations of the Base 100-Year Flood event, as well as flood elevations for the maximum release rate from Keystone Dam that can be maintained by the current levee system along the Arkansas River Corridor. The 100-Year floodplain and floodway limits are depicted on the Opportunities and Constraints Maps included in Section 7.1.

6.2 LOW WATER DAM LOCATIONS

The Phase I Vision Plan identified eight potential low water dam locations for further analysis in Phase II. These locations were identified based upon aesthetic considerations, associated development potential, necessary mixing zones associated with wastewater treatment plant discharges in the corridor, and proximity to large tributary confluences. The potential locations identified in Phase I are as follows:

- Dam 1 – Broken Arrow (between 145th and 161st East Avenue)
- Dam 2 – Bixby (downstream of Memorial Bridge)
- Dam 3 – Jenks/South Tulsa (Yale Avenue)
- Dam 4 – Jenks/South Tulsa (downstream of Creek Turnpike)
- Dam 5 – Tulsa (upstream of 81st Street)
- Dam 6 – Tulsa (upstream of Interstate 44)
- Dam 7 – Sand Springs (near Main Street)
- Dam 8 – Sand Springs (downstream of 177th West Avenue)

A detailed engineering evaluation was performed at each of the potential low water dam locations to assist in the determination of the technical feasibility and sequencing of the low water dams. INCOG performed water quality modeling in conjunction with the engineering analysis. A copy of the H/H Report conducted as part of Phase II is provided in Appendix E.

Three low water dam locations were determined to be technically infeasible due to negative hydraulic and/or water quality impacts. The infeasible dam locations include:

- Dam 2 – Bixby (downstream of Memorial Bridge)
- Dam 3 – Jenks/South Tulsa (at Yale Avenue)
- Dam 5 – Tulsa (upstream of 81st Street)

The remaining potential low water dam locations were classified into three categories based upon the timeframe in which a low water dam might be feasible in each location. Factors that were considered when categorizing the low water dam locations included existing infrastructure, adjacent land use, environmental

constraints, and economics. The technically feasible dam locations are classified as follows:

- Tier 1 – Short range development, less than five years
  - Jenks/South Tulsa (downstream of the Creek Turnpike)
  - Sand Springs (near Main Street)
- Tier 2 – Mid-range development, less than five-15 years
  - Tulsa (upstream of I-44)
- Tier 3 – Long-range development, greater than >15 years
  - Broken Arrow (between 145th and 161st East Avenues)
  - Sand Springs (downstream of 177th West Avenue)

Figure 6.2-1 depicts the limits of the existing Zink Lake created by the Zink Lake Low Water Dam and the proposed limits of the two Tier 1 low water dams proposed for development in the Phase II Master Plan. Conceptual plans for the two proposed low water dams are provided in Sections 8.1 and 8.2 of this Mater Plan. The possibility of implementing the Tier 2 low water dam upstream of I-44 has garnered significant local interest. Although a conceptual plan for this low water dam location was not developed as part of the Master Plan, local authorities and private interests may move forward with this location. Preliminary analysis indicates that a dam in this location could be no higher than six feet tall to avoid impacting the existing kayaking area. There may also be issues with odors at this low water dam location due to the proximity of the Southside Wastewater Treatment Plant. A detailed analysis of the low water dam locations can be found in Appendix E.

View of the Arkansas River at the I-44 Bridge

6.3 WATER QUALITY

The portion of the Arkansas River being evaluated lies within the section known as the Polecat-Snake Creek watershed. This watershed drains the southern portion of Tulsa County as well as eastern Creek County, northern Okmulgee County, southwestern Wagoner County and western Muskogee County. The Polecat-Snake Creek watershed lies downstream from the Lower Verdigris and Black Bear-Red Rock watersheds and upstream from the Dirty-Greenleaf watershed.

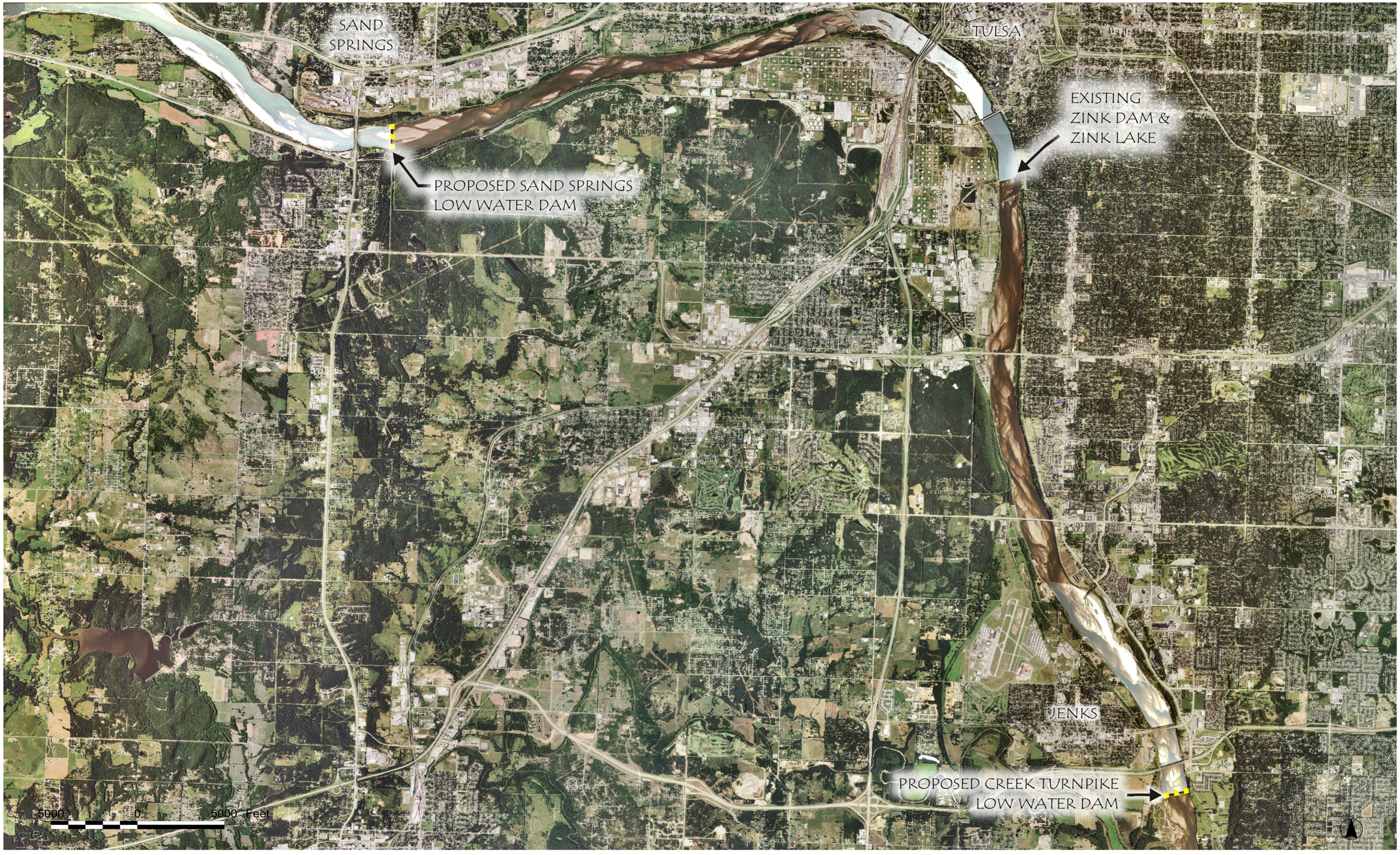
Information presented herein was gathered from the draft 2004 Water Quality Assessment Integrated Report produced by the ODEQ and information presented in the Environmental Protection

Agency (EPA), Office of Water website, and the Oklahoma Water Resources Board 2004 Report of the Oklahoma Beneficial Use Monitoring Program (BUMP) Streams Report.

Pursuant to Section 303(d) and Section 305(b) of the Clean Water Act (CWA), states are required to develop lists of water bodies that do not meet water quality standards and to submit updated lists to the EPA every two years. Water quality standards, as defined in the Code of Federal Regulations, include beneficial uses, narrative and numerical water quality objectives and antidegredation requirements. The EPA is required to review impaired water body lists submitted by each state and approve or disapprove all or part of the list.

Waterbody identification (WBID) numbers are established based on a waterbody's location in the State Water Quality Management Plan. WBIDs are unique identifiers that offer a convenient, unambiguous method of referencing waterbodies within the State of Oklahoma (OKWBID).

Water flowing over the ogee weir at Zink Lake



TIER 1 LOW WATER DAMS **FIGURE 6.2–1**

The section of the Arkansas River covered in the Master Plan lies within the following OKWBID numbers:

- OK120420010130_00 – Keystone Dam to Sand Springs, approximately 13 miles in the upper reach of project corridor
- OK120420010010_00 – Sand Springs to Broken Arrow, approximately 19 miles in the middle reach of project corridor
- OK0120410010080_00 – Broken Arrow south past County line, approximately 29 miles in the lower reach of project corridor
- OK120420010090_00 – Crow Creek, approximately 4 miles in the middle reach of project corridor

The BUMP report indicates that the Oklahoma Water Quality Standards (OWQS) beneficial uses assigned to these three water quality management segments (WQMS) include: fish and wildlife propagation (FWP); primary body contact recreation (PBCR); public and private water supply (PPWS); agriculture (AG); Emergency Water Supply (EWS),and aesthetics (AES). Table 6.3-1 lists the assigned OWQS beneficial uses and the support codes for each of the three WQMS per the OWQS, Appendix A, Table 6 of the Oklahoma Administrative Code (OAC) 785:45 as identified in the BUMP for this section of the Arkansas River.

Table 6.3-1
BUMP OWQS BENEFICIAL USES

WIBD #	FS	PS	NS/T	CBD
OK120420010010_00	AG, FWP, AES, EWS	NONE	PBCR	NONE
OK120420010080_00	FWP, AES, EWS	AG	PBCR	NONE
OK120410010130_00	AG, FWP, AES, PBCR, EWS	NONE	NONE	NONE

Assigned OWQS Beneficial Uses and Support Codes	
FWP = fish & Wildlife Propagation (Warm Water Aquatic Community)	PBCR = Primary Body Contact Recreation
PPWS = Public and Private Water Supply	AG = Agricultural
AES = Aesthetics	EWS = Emergency Water Supply
FS = Fully Supporting	PS = Partially Supporting
NS/T = Not Supporting/ Threatened	CBD = Cannot Be Determined

6.3.1 Section OK120420010130_00, Keystone Dam to Sand Springs

This section of the Arkansas River is listed as a Category 2 waterbody according to the 2004 303(d) listing. This means it is attaining some of the designated uses; no use is threatened; and insufficient or no data and information is available to determine if the remaining uses are attained or threatened.

Waterbodies listed in this category are characterized by data and information which meet the requirements of the ODEQ Continuing Planning Process (CPP) to support a determination that some, but not all uses are attained and none are threatened. Attainment status of the remaining uses is unknown because there is insufficient information. Monitoring shall be scheduled for these waterbodies to determine if the uses previously found to be in attainment remain in attainment, and to determine the attainment status of those uses for which information was previously insufficient to make a determination.

Table 6.3-1 shows that the BUMP indicates this WQMS is fully supporting of the following OWQS beneficial uses: EWS, FWP, AG, AES, and PBCR. Dissolved oxygen, pH, turbidity, and toxicant samples meet the criteria for the FWP beneficial use. AG is supportive for total dissolved solids, chloride, and sulfates although 12% of the sulfate concentrations exceeded the sample standard of 186.0 milligrams per liter (mg/L), the values are below the prescribed minimum standard of 250 mg/L. The PBCR is supportive of fecal Coliform, enterococci, and E. coli concentrations. This WQMS is not nutrient-threatened and the total phosphorus and nitrate/nitrite median values are below the threshold medians of 0.36 mg/L and 5.0 mg/L respectively.

6.3.2 Section OK120420010010_00, Sand Springs to Broken Arrow

In the 2002 and 2004 Water Quality Assessment Integrated Report this section of the Arkansas River is defined as a Category 5 waterbody according to the 303(d) listing. A Category 5 waterbody is defined as a waterbody having a quality standard that is not attained. The waterbody is impaired or threatened for one or

more designated uses by pollutant(s), and requires a Total Maximum Daily Load (TMDL) to be developed.

In 2002, this segment of the Arkansas River failed the water quality criteria for lead. The segment of the river was resampled and only two of 44 samples exceeded the screening criteria. Therefore, this segment was removed from the 303(d) list for lead. However, sampling did reveal exceedance for pathogens, specifically, Enterococus, E. Coli and fecal coliforms. Consequently, this segment remains on the 303(d) list as an impaired waterbody or Category 5 for the 2004 cycle.

Table 6.3-1 shows that the BUMP indicates this WQMS is fully supporting of the following OWQS beneficial uses: EWS, FWP, AG, and AES. PBCR is not supported. Dissolved oxygen, pH, turbidity, and toxicant samples meet the criteria for the FWP beneficial use. AG is supportive for total dissolved solids, chloride, and sulfates although 12% of the sulfate concentrations exceeded the sample standard of 186.0 mg/L, the values are below the prescribed minimum standard of 250 mg/L. The PBCR is not supportive. Eight (36.36%) of the 22 fecal Coliform concentrations exceed the prescribed screening level of 400 cfu/mL and the geometric mean of 884.8 cfu/mL exceeded the prescribed mean standard of 400 cfu/mL. Three (13.64%) of the 22 enterococci concentrations were in excess of the prescribed screening level of 406 cfu/mL and the geometric mean of 415.5 cfu/mL exceed the prescribed mean standard of 33 cfu/mL. Of the E. coli concentrations, 3 (13.64%) of the 22 exceeded the prescribed screening level of 406 cfu/mL and the geometric mean of 141.8 cfu/mL is in excess of the 126 cfu/mL prescribed mean standard. This WQMS is not nutrient-threatened and the total phosphorus and nitrate/nitrite median values are below the threshold medians of 0.36mg/L and 5.0 mg/L respectively.

6.3.3 Section OK0120410010080_00, Broken Arrow to Past County Line

This is the southernmost section of the Arkansas River in the project corridor. In the 2002 Water Quality Assessment Integrated Report, this section of the River was listed as a Category 5 or impaired waterbody. This was due to pathogens, total dissolved solids (TDS) and chlorides. According to the 2004 Water Quality

Assessment Integrated Report, this segment remains listed as a Category 5 waterbody due to pathogens, TDS, and turbidity. INCOG will be developing TMDLs for pathogens in this segment of the River.

Table 6.3-1 shows that the BUMP indicates this WQMS is fully supporting of the following OWQS beneficial uses: EWS, FWP, and AES. AG is partially supporting and PBCR is not supporting/ threatened. Dissolved oxygen, pH, turbidity, and toxicant samples meet the criteria for the FWP beneficial use. The AG beneficial use is only partial supporting. Nine (20%) of the 45 total dissolved solids concentrations exceeded the minimum standard of 1,168 mg/L. The chlorides and sulfides concentrations were within the prescribed standards and yearly means. The PBCR is not supporting. One (0.61%) of the 22 enterococci concentrations exceeded the prescribed mean standard (406 cfu/mL), and the geometric mean of 36.0 cfu/mL was in excess of the mean standard of 33 cfu/mL. This WQMS is not nutrient-threatened and the total phosphorus and nitrate/nitrite median values are below the threshold medians of 0.36 mg/L and 5.0 mg/L respectively.

6.3.4 Section OK0120420010090_00, Crow Creek

This stream is located in the middle reach of the project corridor just below Zink Dam. According to the 2004 Water Quality Assessment Integrated Report, Crow Creek is listed on the 303(d) list as Category 5 with impairments including E. Coli and dissolved oxygen. The stream is scheduled to have TMDLs developed in 2009.

No BUMP data is available for this stream section.

6.3.5 Water Quality Modeling

As part of Phase II, INCOG evaluated the potential impacts on dissolved oxygen (DO) in the Arkansas River due to the potential for locating several proposed new low water dams in the project corridor. Of the eight potential low water dam locations previously identified, the upper-most and lower-most potential dam locations (Dams 8 and 1, respectively) were determined to be inappropriate for this evaluation due to their location and anticipated timing for

implementation, and were not studied as part of this water quality evaluation. Since Zink Lake already exists, it too was modeled.

The modeling indicated that the two recommended low water dam locations would not cause a reduction in DO concentrations below the target, nor the water quality standards for all four seasons. The modeling also indicated that Dam 6 (upstream of Interstate 44) did not exhibit water quality impacts below regulated levels for any season. The infeasible dams previously identified caused DO to drop below target levels. The INCOG report on water quality is presented in Section 7.0 of the reference material in Appendix E.

View north along the Arkansas River toward the Creek Turnpike and Jenks Bridges

7.0 OPPORTUNITIES AND CONSTRAINTS

7.1 OPPORTUNITIES AND CONSTRAINTS MAPS

A series of opportunities and constraints maps were developed for the project corridor to identify any areas that may enhance or impede the implementation of ideas presented in Phase I. The maps were created utilizing the same three sub-reaches of the River as identified in Phase I. The upper reach includes the portion of the Arkansas River between Keystone Dam and South 41st West Avenue in Tulsa. The middle reach begins at South 41st West Avenue and continues downstream to East 121st Street South in Jenks/South Tulsa. The lower reach continues from this point to the Tulsa County/Wagoner County line. The "planning area" generally addresses the water and land resources within one-half mile of the centerline of the River on either side.

The general locations of the key development sites originally identified in Phase I, and presented in Section 8.0 of this Master Plan, are overlaid on aerial photography provided by INCOG. Major roadways, tributaries, parks, and landmarks are identified on the maps for orientation. Potential opportunities illustrated on the maps include the following items:

- Technically feasible low water dam locations
- Proposed bridges at 177th West Avenue, 41st Street, Yale Avenue, and 193rd East Avenue
- Proposed Gilcrease Expressway Bridge
- Existing and/or funded pedestrian and bike trails
- Proposed pedestrian and bike trails
- Potential wetland/riparian areas that could be combined with public use activities
- Potential areas for ecosystem restoration
- Potential areas that would be suitable for the creation of new wetlands
- Eagle habitat
- Proposed least tern habitat
- Potential view corridors

The constraints identified on the maps include the following items:

- FEMA 100 year floodplain and floodway
- Areas with historical environmental activities (primarily hazardous waste and petroleum issues)
- Utilities and pipelines
- Wastewater treatment facilities
- Active railroads

The Phase II Opportunities and Constraints maps are depicted on the following pages. Figures 7.1-1, 7.1-2, and 7.1-3 depict the upper, middle, and lower reaches of the project corridor, respectively.

7.2 OPPORTUNITIES

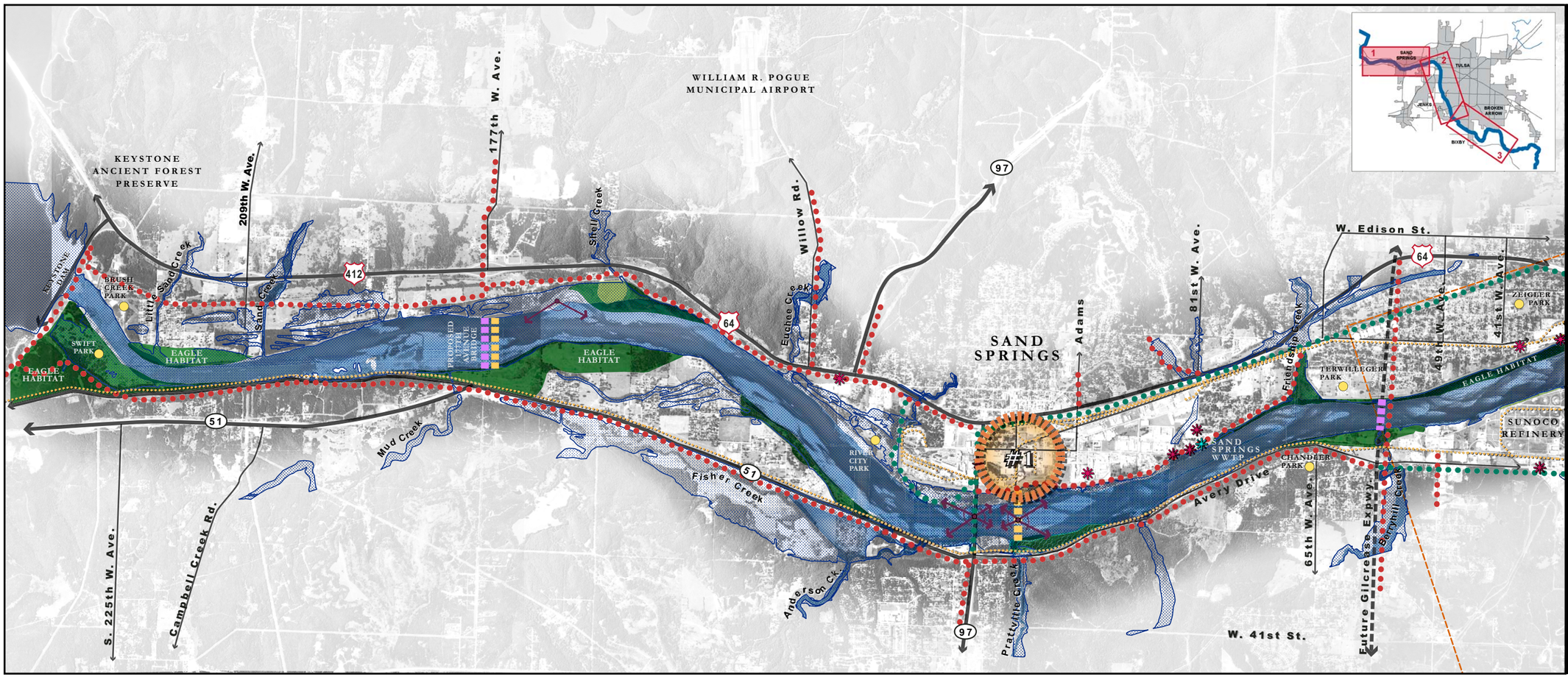
Numerous opportunities were identified for the project corridor and are addressed throughout this Master Plan. As previously discussed in Section 5.5, there is a significant opportunity for ecosystem restoration projects involving aquatic, riparian, and prairie meadow habitats as stand alone projects or in conjunction with recreational/educational amenities. An ecosystem restoration conceptual plan has been generated to address the global restoration opportunities throughout the project corridor. This plan is provided in Section 8.10.

River Parks trail near 41st Street

There are many other opportunities for urban development, reuse, aesthetic enhancements, and infrastructure improvements throughout the project corridor. Opportunities include the creation of additional river crossings for vehicular/pedestrian traffic, bridge enhancements, Riverside Drive West, traffic calming elements on the current Riverside Drive, gateways, and additional trails and parks. Such opportunities played a key role in the conceptual planning process for Phase II, and have been a driving factor in the development of the concept plans contained in Section 8.0 of this Master Plan. Many of these opportunities were also presented in Phase I. The scope of the Phase II planning process did not specifically address development beyond the boundaries of the key development sites. As such, the opportunities, and recommendations presented in Phase I should remain under consideration as viable and important elements in the overall Plan. A copy of the Phase I Vision Plan is provided in Appendix A of this Master Plan.

The planning process for Phase II focuses heavily on concept development for several specific sites rather than planning the corridor as a whole. As such, an opportunity was identified to develop a comprehensive ecosystem restoration plan and a comprehensive floodplain management plan. These documents area included in Section 8.0 and address the corridor as a whole.

Looking south along the Arkansas River toward Turkey Mountain



LEGEND

OPPORTUNITIES

- Key Development Sites
  1. Sand Springs Riverfront
- Proposed Bridge
- Potential Low Water Dam Locations
- Existing / Funded Pedestrian / Bike Trail
- Proposed Pedestrian / Bike Trail
- Potential Wetland/ Riparian Areas with Public Use
- Potential for Ecosystem Restoration
- Potential Wetland Areas
- View Corridors

CONSTRAINTS

- FEMA 100 Yr. Floodplain
- Historical Environmental Activities
- Waste Water Treatment Plants
- Arkansas River Floodway
- Railroads

OPPORTUNITIES AND CONSTRAINTS

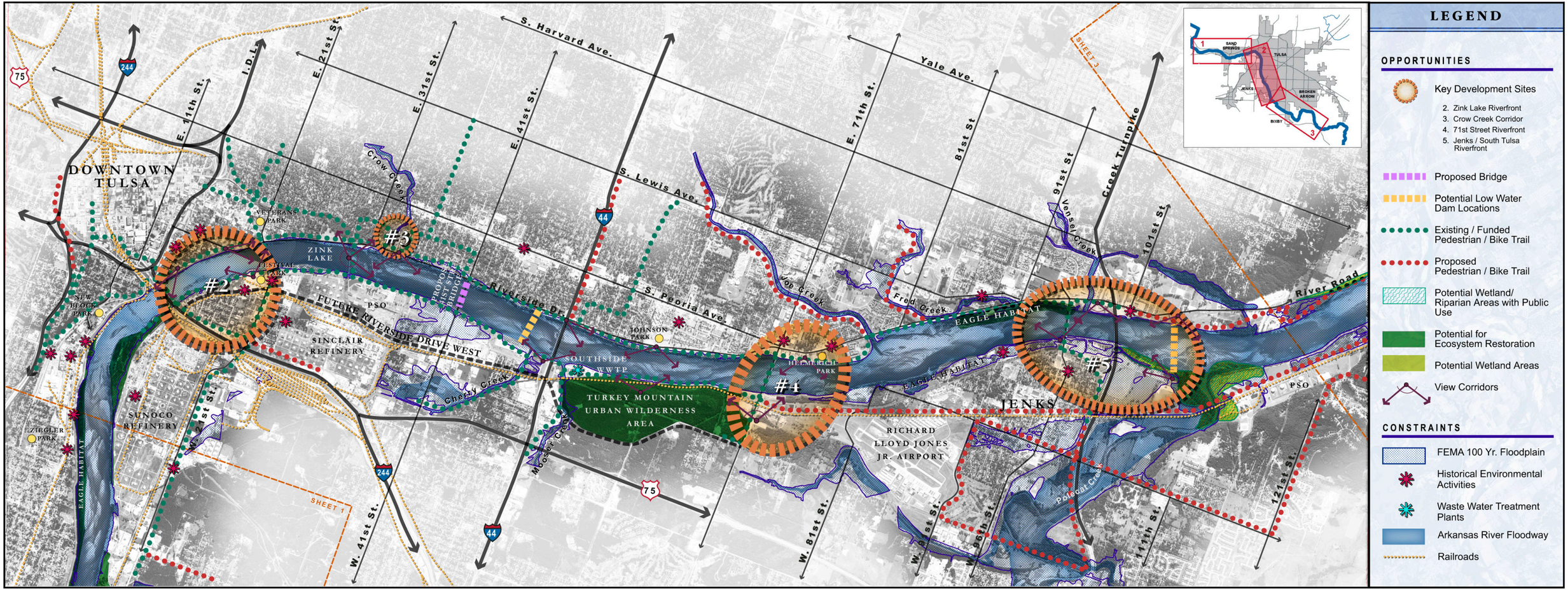
FIGURE 7.1-1

ARKANSAS RIVER CORRIDOR MASTER PLAN AND PRE-RECONNAISSANCE STUDY, TULSA COUNTY, OK

0 300m 900m 1 Mile 2 Miles 3 Miles

C.H. GUERNSEY EDAW ALABACK DESIGN

SEPTEMBER 2, 2005



LEGEND

OPPORTUNITIES

- Key Development Sites
  2. Zink Lake Riverfront
  3. Crow Creek Corridor
  4. 71st Street Riverfront
  5. Jenks / South Tulsa Riverfront
- Proposed Bridge
- Potential Low Water Dam Locations
- Existing / Funded Pedestrian / Bike Trail
- Proposed Pedestrian / Bike Trail
- Potential Wetland/ Riparian Areas with Public Use
- Potential for Ecosystem Restoration
- Potential Wetland Areas
- View Corridors

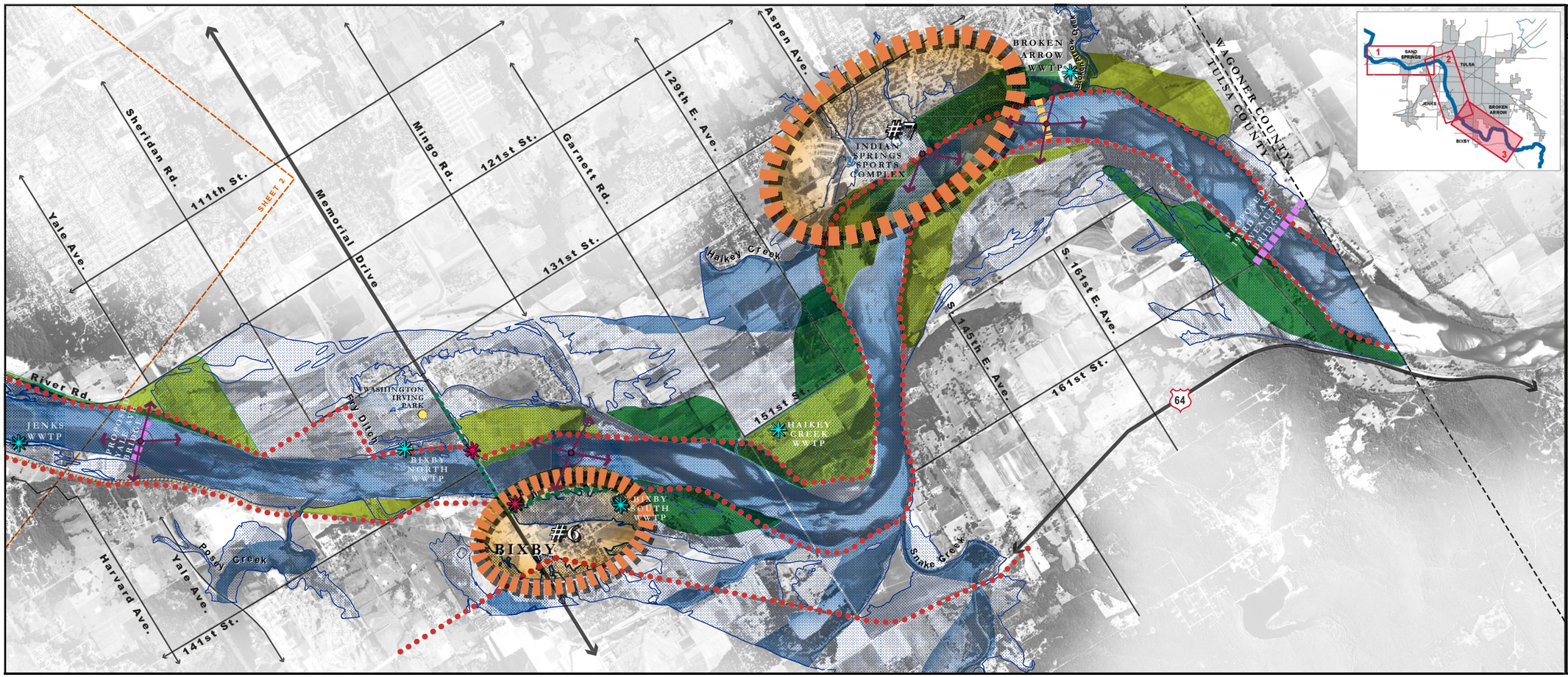
CONSTRAINTS

- FEMA 100 Yr. Floodplain
- Historical Environmental Activities
- Waste Water Treatment Plants
- Arkansas River Floodway
- Railroads

OPPORTUNITIES AND CONSTRAINTS

FIGURE 7.1-2

0 300m 900m 1 Mile 2 Miles 3 Miles



LEGEND

OPPORTUNITIES

- Key Development Sites
  6. Bixby Riverfront
  7. Broken Arrow Riverfront
- Proposed Bridge
- Potential Low Water Dam Locations
- Existing / Funded Pedestrian / Bike Trail
- Proposed Pedestrian / Bike Trail
- Potential Wetland/ Riparian Areas with Public Use
- Potential for Ecosystem Restoration
- Potential Wetland Areas
- View Corridors

CONSTRAINTS

- FEMA 100 Yr. Floodplain
- Historical Environmental Activities
- Waste Water Treatment Plants
- Arkansas River Floodway
- Railroads

OPPORTUNITIES AND CONSTRAINTS

FIGURE 7.1-3

0 300m 900m 1 Mile 2 Miles 3 Miles

7.3 INFRASTRUCTURE CONSTRAINTS

The project corridor was reviewed for potential constraints associated with existing or planned roadways/highways and utility infrastructure. Each of the five communities was contacted to identify current or future public projects that may have an impact on the conceptual planning process for the key development sites described in Section 8.0. Infrastructure constraints are specifically addressed for each location identified in Section 8.0. Where possible the conceptual plans remedy existing infrastructure constraints involving vehicular/pedestrian circulation and access to the River. However, some constraints cannot be avoided at this time, such as existing municipal wastewater treatment facilities.

7.4 GENERAL ENVIRONMENTAL CONSTRAINTS

Environmental constraints are specifically addressed for each development site in Section 8.0. The environmental constraints identified throughout the project corridor and concept boundaries generally include:

- FEMA floodplains,
- Proximity to industrial sites such as refineries that may impact aesthetics and air/water quality,
- The location and size of existing tributaries,
- Sand and gravel operations' impacts to aesthetics and land use,
- Wetland areas,
- Soils designated as prime farmland,
- Pipelines and/or other oil and gas activities,
- Water quality in the Arkansas River
- Effects of releases from Keystone Dam on flows,
- Threatened and endangered species, and
- Cultural resources.

A regulatory database review was performed to identify sites with historical environmental activities. Such activities may include installing/removing underground/aboveground storage tanks, hazardous waste or petroleum releases, environmental investigations, remediation, or hazardous waste generation.

Numerous sites were identified throughout the project corridor; however, only a few exist within the conceptual plan boundaries. None of the historical environmental sites occurring within the concept plan boundaries would impede or prevent the plans illustrated. However, other identified sites in the project corridor should be considered during planning and/or design activities that may occur subsequent to this Master Plan. An excerpt of the regulatory database report provided by Environmental Data Resources (EDR) is provided in Appendix F. Due to the large size of the document, a complete hard copy is not provided in this Master Plan. However, the EDR report in its entirety is included with the electronic version of this Master Plan.

7.5 ECOLOGICAL CONSTRAINTS

Ecological constraints include impacts to threatened and endangered species, and flora and fauna impacts that may be associated with project implementation as summarized in Table 7.5-1 for protected species, sport fishes, and introduced species.

Table 7.5-1
Ecological Constraints in the Project Corridor

Constraint / Species	Design Considerations
Impacts to Sensitive Species in the Project Area	May require Section 7 Consultation and issuance of an Incidental Take Permitting by the USFWS.
Bald Eagle (Federally Threatened)	Many acres of bald eagle nesting habitat are known to exist in the corridor. These areas are not proposed for development in this Master Plan.
Interior Least Tern (Federally Endangered)	Construction of dams removes the nesting and foraging sandbar habitat from within the corridor. Additional sandbar islands are proposed in the conceptual plans.
Piping Plover (Federally Threatened)	Construction of dams removes the mudflats and sandbars that the piping plover may frequent during winter and summer migrations through the area. Additional sandbar islands are proposed in the conceptual plans. Construction of dams would also change feeding habitat in certain areas by changing from a shallow river to deep pools.

Table 7.5-1, continued
Ecological Constraints in the Project Corridor

Constraint / Species	Design Considerations
Paddle Fish (Species of Concern)	Construction of low water dams could restrict the annual spawning migration of the paddle fish if the gates are not opened during the spawning season. Zink Dam is a significant migration impediment for this species within the project corridor. Recommendations to retrofit Zink Dam with additional gates to enhance fish passage are included in this Master Plan.
Golden Algae Blooms	Has the potential for massive fish and bivalve kills in impounded areas. This species is not known to occur in Tulsa County.
Zebra Mussels	May clog municipal and industrial intake structures and reduce species diversity in impounded areas. Zebra mussels can cluster together in densities of thousands per meter. This species is known to occur in Lynn Lane Lake in Tulsa County.
Striped Bass	The aggressive nature of this fish may further reduce native fish populations if confined to an impoundment environment. Fish passage is an important consideration for the migration of striped bass during spawning seasons.
Floodplain/Floodway Alterations	There are no significant changes to the floodplain or floodway as a result of the proposed low water dams. Any significant changes to the concepts or locations of the low water dams described in the Master Plan would require a re-determination of floodplain/floodway impacts.

7.6 LEGAL CONSTRAINTS

The Arkansas River Corridor project should be completed in full compliance with applicable environmental statutes and regulations. Legal constraints include the regulatory permits that may be required for impacts to ecological resources. Table 7.6-1 includes a summary of the applicable environmental statutes and regulations that may be required for project implementation (USACE, 2000).

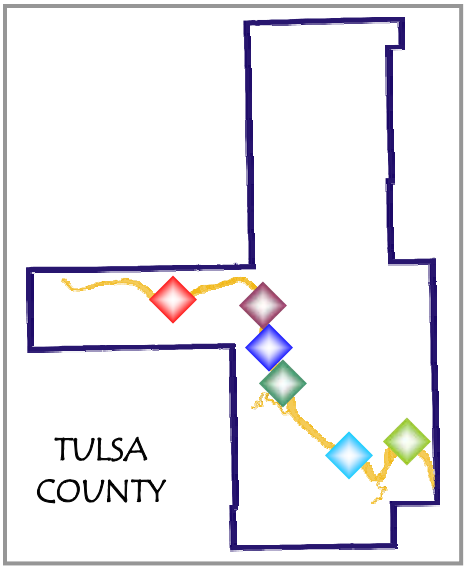
Table 7.6-1
Major Environmental Statutes and Regulations

Archaeological and Historic Preservation Act, 1974, as amended, 16 U.S.C. 469
Clean Air Act, as amended, 42 U.S.C. 7609
Clean Water Act, 1977, as amended (Federal Water Pollution Control Act), 33 USC 1251
Endangered Species Act, 1973, as amended, 16 USC 1531
Farmland Protection Policy Act, 7 USC 4201
Federal Water Project Recreation Act, as amended, 16 USC 460-1-12
Fish and Wildlife Coordination Act, as amended, 42 USC 661
Land and Water Conservation Fund Act, 1965, as amended, 16 USC 4601
National Historic Preservation Act, 1966, as amended, 16 USC 470a
National Environmental Policy Act, as amended, 42 USC 4321
Rivers and Harbors Act, 33 USC 401
Watershed Protection and Flood Prevention Act, 16 USC 1001
Water Resources Planning Act, 1965
Floodplain Management (E.O. 11988)
Protection of Wetlands (E.O. 11990)
Environmental Health and Safety (E.O. 13045)
National Invasive Species Act
Comprehensive Environmental Response, Compensation, and Liability Act of
Invasive Species (E.O. 13112)
Federal Actions to Address Environmental Justice in Minority Populations and Low Income Populations (E.O. 12948)

8.0 CONCEPTUAL PLANS

This section contains conceptual plans that were prepared as a part of Phase II. Conceptual plans were prepared for seven key development sites and two low water dam locations. Phase I originally identified eight key development sites; however, the east and west bank redevelopment sites adjoining Zink Lake were combined into one plan for Phase II. The image below depicts the approximate geographic locations of the conceptual plans along the project corridor. Some of the locations are in very close proximity to each other; therefore, there is not a unique symbol depicted on the map for each site. Refer to the key below when referencing the map. More detailed site location maps are provided within each conceptual plan. The Phase II conceptual plans address the following sites in the project corridor:

- Sand Springs Main Street Low Water Dam
- Creek Turnpike Low Water Dam
- Sand Springs Riverfront
- Zink Lake Riverfront
- Crow Creek Corridor
- 71st Street Riverfront
- Jenks/South Tulsa Riverfront
- Bixby Riverfront
- Broken Arrow Riverfront



This section also includes conceptual plans for ecosystem restoration and floodplain management that address the project corridor as a whole. The conceptual plans are a product of a continuous process of the Plan refinement, and were prepared based upon a wide variety of resources and public/agency input summarized in this Master Plan and the Phase I Vision Plan. The conceptual plans in this section were created such that they can stand alone if removed from this Master Plan. Each plan contains background information, design criteria/limitations, a description of the design concept, conclusions/recommendations, and supporting graphics.