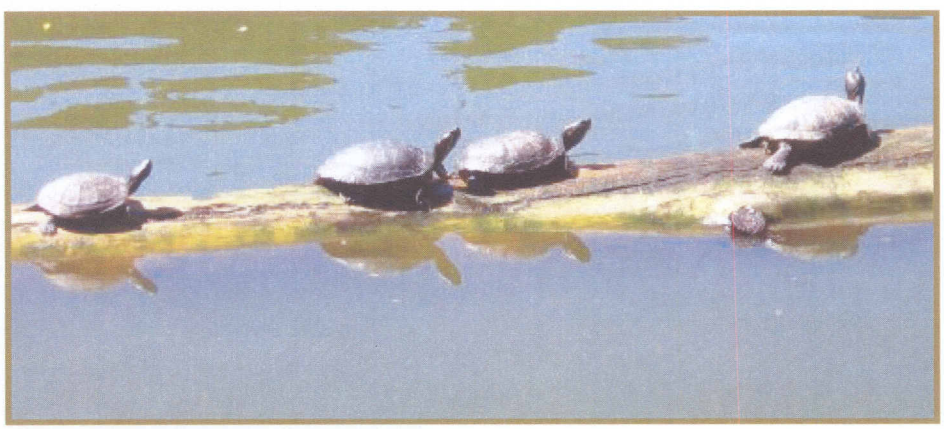
Aquatic Macro Invertebrate Structure & Composition Assessment

FINAL REPORT TASK 3
ENVIRONMENTAL DATA FOR THE ARKANSAS RIVER CORRIDOR PROJECT, TULSA, OKLAHOMA
W912BV-06-P-0303



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FINAL

PURPOSE OF THE STUDY

The Greater Tulsa Area communities recognized that the Arkansas River Corridor (ARC) is an important natural resource that could be developed and greatly improve the quality of life for current and future generations. In August 2004, The Indian Nations Council of Government (INCOG) directed and oversaw the development of an Arkansas River Corridor Master Plan/Phase I Vision Plan. The purpose of this plan was to enhance the aesthetic quality and development opportunities along a 42 mile stretch of the Arkansas River through Tulsa County through the establishment of numerous low-water dams. In October 2005, the U.S. Army Corps of Engineers (USACE), Tulsa District and INCOG developed a Phase II Master Plan and Pre-Reconnaissance Study. Some of the objectives of the Phase II Plan involved addressing potential environmental initiatives. This led to a letter agreement between Tulsa County, the Oklahoma Water Resources Board and the USACE Tulsa District to inventory, assess and evaluate environmental data for the Arkansas River from the Keystone Dam to the Tulsa/Wagoner County line.

In September 2006, the Tulsa District and Tulsa County began Phase III of the Arkansas River Corridor Study. The purpose of the Phase III study was to collect baseline environmental data throughout the Arkansas River Corridor. The Arkansas River Corridor was divided into five sampling segments between Keystone Lake and the community of Broken Arrow (Appendix A). The five sampling segments are shown on maps provided in Appendix B.

The environmental studies conducted included a: 1) faunal and floral inventory; 2) fish community structure and composition assessment; 3) aquatic macroinvertebrate structure and composition; 4) water quality data assessment, and; 5) cultural resource evaluation. This report presents the results of the aquatic macro-invertebrate structure and composition inventory.

INTRODUCTION

The Arkansas River headwaters begin near Leadville, Colorado and flows 1,450 miles across Colorado, Kansas, northeastern Oklahoma and Arkansas to its confluence with the Mississippi River about 600 miles north of New Orleans. The Arkansas River is the fourth longest river in the United

States with a drainage basin of nearly 195,000 miles and is the largest tributary of the Mississippi-Missouri River System.

The Arkansas River enters Oklahoma near Arkansas City on the Kansas-Oklahoma state line north of Kaw Lake in Kay County, Oklahoma. Then flows generally southeast through Tulsa and Muskogee and then veers to the east and flows across the Arkansas State Line to Fort Smith. Numerous dams have created reservoirs and navigation pools on the Arkansas River including Keystone Dam Lake near Tulsa. The Arkansas River is fed by the Salt Fork, Black Bear, Cimarron, Illinois, Verdigris and South Canadian Rivers along with several other smaller rivers, creeks and streams (McCord, 2002).

The climate, geology, and hydrology of the region, in addition to anthropogenic influences, have played a contributing factor with regard to the water quality of the Arkansas River. Climate regulates the temperature and the amount of precipitation that affects the existence of macro invertebrate populations in surface water. The geology of the region dictates the drainage patterns that develop on the surface as well as the dissolved mineral matter found in local streams where aquatic species thrive. The aquatic macroinvertebrate species existing in the Arkansas River corridor study area are a result of the interrelations of climate, geology, hydrology, and anthropogenic influences. The following paragraphs provide a summary of the climatic, geologic, hydrology, and land use characteristics of the Arkansas River Corridor study area.

Climate

The climate of Tulsa County is temperate. The normal annual temperature is about 60 degrees Fahrenheit (F). The average annual maximum and minimum temperatures are 71° and 49° F, respectively. The highest recorded temperature was 115° F and the lowest recorded temperature was -15° F. On average, the relative humidity ranges between 47% and 92%. The normal annual precipitation is about 42 inches with approximately 83 days per year of precipitation. The majority of the annual rainfall (64%) occurs between April and September. Thunderstorms occur predominantly in the spring and summer for about 50 days out of the year. The prevailing winds across Tulsa County are predominantly from the south to southeast and the wind speeds average nearly seven miles per hour on an annual basis (Bennison et al., 1972).

Geomorphology and Geology

Geomorphic features identified in Tulsa County include the Eastern Sandstone Cuesta Plain and the Claremore Cuesta Plain. The Eastern Sandstone Cuesta Plain forms rugged hills with one steep face. The Claremore Cuesta Plain produces less pronounced and frequent hills and is composed of sandstone and limestone on top of the broad shale plains. The Claremore Cuesta Plain occurs throughout the rest of the county (Johnson et al.,1979). These hills form the topographic highs while the Arkansas River forms the topographic lows. These topographic highs and lows define the watersheds and drainage basin boundaries for the Arkansas River within the study area. The relief ranges from 180 to 300 feet when the cuestas are close to the river and 20 to 60 feet when the floodplains dominate the landscape.

The geology of the ARC study area is underlain by rocks of Pennsylvanian age. The hills along the upper reaches of the river are composed of the Dewey Limestone and Nellie Bly Formation. The rock formations become progressively younger downstream and include the Coffeyville, Checkerboard Limestone, Seminole, Holdenville, and Nowata Shale. These rocks were formed in ancient river and sea deposits that include delta; prodelta; subtidal clastics and marine shell banks; shallow marine banks; platform shallow marine, and marine basinal shales (Bennison et al., 1972; Marcher et al., 1988). Quaternary river deposits overlie the Pennsylvanian formations on the broad floodplains along the river. The younger Holocene deposits represent modern floodplain alluvium that overly older Pleistocoene terrace deposits. The deposits consist of unconsolidated gravels, sands, silts and clays.

Hydrology

The Arkansas River throughout Oklahoma is considered to be a mature, late stage river classified as a large sixth to seventh stream order. A late stage river is characterized by the formation of a broad floodplain with large meanders, natural levees, oxbow lakes, point bars, back swamp areas and some Yazoo streams. The river's drainage system is identified by a dendritic pattern which is the most common form of drainage in the world and generally formed on flat lying homogeneous sedimentary rocks. From an aerial perspective, a dendritic pattern has v-shaped junctions, similar to a leaf with its veins representing the tributaries, and the stem representing the main channel. Rivers that flow in a dendritic drainage system usually are on a gentle slope. The Arkansas River has characteristics of a braided stream throughout the study area with the exception of the low-water dam area (Zink Lake).

A braided stream is characterized by alternating flood-stage scouring and the subsequent filling of multiple interconnecting channels within the confines of the river banks. The braids or anastomosing channels are subject to widely fluctuating water discharge and intermittent abundant sediment supply.

The elevation of the Arkansas River is 670 feet above sea level (ASL) at the Keystone Dam or upper most reach of the study area and 577 feet (ASL) at the lower reach of the study area or at the Tulsa/Wagoner County line. This relief difference produces a stream slope of 2.21 feet per mile along the 42 mile long study area.

Watershed

The Arkansas River Basin in Oklahoma is located in five U.S. Geological Survey Hydrologic Unit Codes (HUC) identified with an eight digit code. One of these HUCs is located in the Lower Arkansas River Basin and is called the Polecat-Snake (OK 11110101) Watershed. The Polecat-Snake Watershed extends throughout southern Tulsa County and northeastern Muskogee County. The Arkansas River and its approximate twenty-one tributaries make up the Polecat-Snake watershed which has a drainage area of 280 square miles for the study area.

The Arkansas River tributaries from the upper reach to the lower reach of the study area (42 miles long) and in sequential order, include; Brush Creek (north side of river), Little Sand Creek (north), Sand Creek (north), Mud Creek (south side of river), Shell Creek (north), Fisher Creek (south), Euchee Creek (north), Anderson Creek (south), Freedom Creek (north), Berryhill Creek (south), Harlow Creek (north), Crow Creek (north, 31st.), Cherry Creek (south), Mooser Creek (south), Joe Creek (north), Fred Creek (north), Polecat Creek (south), Posey Creek (south), Haikey Creek (north), Snake Creek (south), and Broken Arrow Creek (north).

Land Use

The land use patterns within a region can have an influence on the water quality of local streams. Streams adjacent to areas of undeveloped land will likely have different water quality than those predominantly adjacent to an urban area or a mixture of both. Generally, streams located in mountainous areas have better water quality and a greater abundance of macroinvertebrate species

than those streams that pass through metropolitan areas.

The University of Oklahoma conducted an urban mapping study of the Tulsa region (McCord 2002). The study involved measuring the percentage of urbanization development verses non-urbanization along the north and south banks of the Arkansas River. Urbanization was defined as developed land that is used for residential, commercial, industrial and other non-agricultural uses with a population density typically greater than 500 persons per square mile and/or possessing significant civic infrastructure. The non-urbanization areas consisted of all other land uses. The study determined that the Arkansas River corridor is approximately 62.5% urbanized and 37.5% non-urbanized along the north side of the river. The south side of the river was determined to be 51% urbanized and 49% non-urbanized.

METHODS

The aquatic macroinvertebrate surveys along the ARC were conducted by the Eagle Environmental field sampling team within the 42-mile survey corridor along the Arkansas River. The survey corridor was divided into 5 segments with four sample points in each segment for a total of 20 individual sample points. Global Position System (GPS) coordinates for each sample point within the survey segments were collected using sub-meter accuracy with hand held Trimble and Sokkia GPS units.

Surveys for aquatic macroinvertebrate species along the Arkansas River corridor were conducted quarterly from October 2006 to April 2008. No samples were collected during the spring quarter of 2007 due to continued high water conditions within the river. The spring quarterly sample was conducted in April 2008. Surveys were conducted each quarter at different times during diurnal periods. Weather conditions at each sampling event were not specifically selected, however, high water levels were considered in selecting quarterly survey timing. In the event water levels and flow velocities were excessive, sampling was postponed until normal or near normal conditions were observed. Ambient temperatures, except for sub-freezing conditions, were not a factor in determining sample periods or timing.

To the extent possible, each sample site was used during each quarterly sampling event, however minor changes in sample site locations were required based on water levels at the time of survey, river bed changes, substrate conditions, and access.

The two objectives of this study were to: (1) create an inventory of the aquatic macroinvertebrates present within the five survey corridor segments of the ARC project area identified to the lowest practical taxa, and (2) spatially and temporally identify the community dynamics at the family/genus/lowest practical taxa level. Sampling methods generally followed the Level II rapid bioassessment protocols in accordance with (EPA 1989) for benthic macroinvertebrates. Based on the rapid bioassessment protocol, the collected specimens were to be identified to the family-level or lower if possible. The sampling technique used varied depending upon the physical characteristics of the river at the sample stations and microhabitats present. Sampling methods and effort was standardized within each sample site and was consistent with the selected protocols, when possible (Caton 1991). Each collected specimen was identified to the lowest level and recorded.

No specimens of known special interest or regulatory status were observed. Although voucher specimens have been retained, no specimens were submitted to zoological museums for the faunal collections. Zink Lake was not sampled during this baseline inventory survey. The rationale was based on the need for data collection and specimen diversity that was currently represented in areas of undisturbed sections of riverbed subject to fluctuating water levels associated with typical flow patterns rather than more consistent water levels and temperatures associated with pool areas. Data collection from the Zink Lake area may be warranted if the USACE determines a comparison of species assemblages between pool (lentic) and riverine (lotic) areas is necessary.

Existing databases and literature reviews for invertebrate communities associated with ARC study area were conducted prior to initiation of field sampling. Specific areas along each of the five survey corridor segments were sampled to ensure that both the shallow and deeper water areas were inventoried. Samples collected incorporate both water column and benthic techniques. Direct collection using active sampling gear was the primary method used to collect the macroinvertebrate samples. Standard industry survey gear used included 100 micro-mesh kick net and D-net along with a 500 micro-mesh Surber Sampler.

Kick net survey methodology involved the use of the double pole-mounted net held by one person. A second person was positioned upstream who disrupted the riverbed sediments dislodging the invertebrates. The dislodged specimens were entrained by the flowing water and collected in the downstream net. This technique was used only in areas where water velocities were sufficient to entrain the dislodged specimens and trap them in the downstream positioned net. D-nets were used in areas of lesser water velocity whereby the upper riverbed sediments were excavated and forced directly into the nets. Collected invertebrates were retained within the extracted sample area sediments. Surber Samplers were used in areas of moderate current and positioned directly into the riverbed. All rocks and debris located within the sample net frame (one square foot in area) were physically scraped and/or rubbed by hand within the water directly in front of the capture net. Flowing water swept the dislodged invertebrates into the capture net for collection. The unit of effort for the collected data is presented in numbers of specimens per square meter for all of the sampling gear. No passive sampling gear was used. All samples and associated specimens were placed into water-tight containers, preserved with 91% ethyl alcohol, and submitted to the laboratory for analysis and identification.

The location of each sample site is provided in Appendix B. Four sample sites were established per sample segment. Photographs of each sample site are located at Appendix C. Three sub samples were collected per sample site. One sample was collected at the head of the riffle, one from the middle of the riffle section, and the third from the tail. The three samples were combined for a single composite for each sample site. Twelve individual samples were collected for each sample segment. A total of 20 composite samples were collected during each quarterly sampling event and submitted to the macroinvertebrate taxonomist for laboratory analysis and identification.

The specimen identification and analysis methods used during this survey were performed in accordance with those presented by the U.S. Environmental Protection Agency in Barbour et al. 1999 (especially Chapter 7: Benthic Macroinvertebrate Protocols). Each sample was stored in fresh 75% ethanol until identification. Each sample was rinsed in a 500 micro-mesh sieve to remove preservation and sediment. The sample was then placed into a white tray marked with a 4 centimeter grid. In samples containing filamentous algae and debris, it was necessary to pick or tease the invertebrates from the sample. Four squares within the grid were randomly sampled.

Samples which appeared to contain 200 or fewer organisms were completely picked and identified. When more than 200 organisms were identified within the four grids, the contents were transferred into a second gridded pan. Randomly selected grids for the second level of sorting were selected. Macroinvertebrates were counted and identified to the lowest practical taxon using a lighted dissecting scope. Subsequently, they were placed in vials with 75% ethanol and appropriately labeled. Voucher specimens were kept separate from the rest of the sample for future reference. These voucher specimens have also been retained for submittal to an accredited museum for archival collection at the discretion of the Tulsa District.

SUMMARY OF SAMPLING LOCATION CHARACTERISTICS

The following provided a summary of the characteristics at each sampling location. The locations of each data collection point along with their respective coordinates are provided on the maps located at Appendix B. The USGS website (Real-Time Water Data) was used per instruction by the USACE to obtain discharge data within the five corridor segments during sampling events. Only two gauging stations were available to identify discharge data along the Arkansas River that reflect conditions at the five sampling stations. Data collected at the gauging station along the Arkansas River at the US Highway 244/75 Bridge in Tulsa was used to identify the mean river discharge in cubic feet per second (cfs) for sampling stations in Corridor Segments 1 and 2. Data collected at the gauging station along the Arkansas River near the State Highway 104 Bridge near Haskell, Oklahoma was used to identify the river discharge for sampling stations in Corridor Segments 3, 4, and 5.

Survey Corridor Segment 1 (3TR11.1 TO 3TR11.4)

The sample site is located near the left descending bank and downstream of Keystone Dam. Water depths in the collection area riffles ranged between 4 and 18 inches. The substrate was comprised of sand, small rocks, and large boulders. Samples were collected in Corridor Segment 1 on November 14, 2006, March 13, 2007, July 24, 2007, and April 28, 2008. The mean Arkansas River discharge in cubic feet per second (cfs) was 31, 90, 45,300, 10,400, respectively.

Survey Corridor Segment 2 (3TR21.1 to 3TR21.4)

Sample site 2 was also located near the left descending bank approximately one mile downstream from the Sand Springs Wastewater Treatment Plant discharge. The sample site substrate was composed of sand and small to medium sized rock. Water depths ranged between 2 and 12 inches however velocities were very minimal to almost non-existent. Samples were collected in Corridor Segment 2 on November 14, 2006, March 13, 2007, July 25, 2007, and April 28, 2008. The mean Arkansas River discharge in cfs was 31, 90, 44,800, 10,400, respectively.

Survey Corridor Segment 3 (3TR31.1 to 3TR31.4)

The sample location for segment 3 was located approximately 1.5 miles downstream from the Tulsa Southside Wastewater Treatment Plant discharge and described as a narrow river channel that contained a shallow riffle with medium water velocity. No vegetation was present however, algae covered all of the small rock within the sample area which was otherwise comprised of coarse-grained sand. Water depths ranged between 6 and 12 inches. Samples were collected in Corridor Segment 3 on November 15, 2006, March 14, 2007, July 25, 2007, and April 29, 2008. The mean Arkansas River discharge in cfs was 181, 590, 45,800, and 14,100, respectively.

Survey Corridor Segment 4 (3TR41.1 to 3TR41.4)

The survey sample 4 sample area was characterized as a riffle area associated with the 96th street bridge and the area located immediately upstream. Substrate was primarily comprised of large and small rock beneath the bridge and exhibited a well developed riffle with moderately fast water velocities. Eight to 24 inches of water was typical for this sample site. Samples were collected in Corridor Segment 4 on November 16, 2006, March 14, 2007, July 26, 2007, and April 29, 2008. The mean Arkansas River discharge in cfs was 426, 590, 44,900, and 14,100, respectively.

Survey Corridor Segment 5 (3TR51.1 to 3TR51.4)

Sample site 5 is located approximately one mile downstream from the Bixby South Wastewater Treatment Plant Lagoon discharge and described very similarly to sample site 2 in terms of channel morphology, water depth, and velocity. Sand represented the primary substrate type at this sample site. This sample site was situated approximately ¼ mile downstream of a sand excavation operation.

Samples were collected in Corridor Segment 5 on November 17, 2006, March 15, 2007, July 27, 2007, and April 30, 2008. The mean Arkansas River discharge in cfs was 278, 3,170, 35,500, and 14,100, respectively.

RESULTS

Approximately 30 species of freshwater mussels are known in the Arkansas River system as a whole (including all of its tributaries), only the Asiatic Clam and five native species have been documented in the reach of the Arkansas River between Ponca City and Muskogee: White Heelsplitter (*Lasmigonia complanata*), Fragile Papershell (*Leptodea fragilis*), Giant Floater (*Pyganodon grandis*), Pink Papershell (*Potamilis ohiensis*), and Mapleleaf (*Quadrula quadrula*). It is believed that the shifting substrate of the Arkansas River makes it a poor habitat for freshwater mussels because most species require relatively stable substrate to compensate for their low mobility. This is consistent with data from other river systems with similar substrate and consider how few mussel species have been found in the shifting substrates of the Cimarron, Canadian, and Red Rivers (Howery 2007, personal communication). Species density and diversity may be inherently low because very little macroinvertebrate studies in the Arkansas River are available for two reasons: 1) its difficult to sample in large rivers, and 2) the shifting nature of the substrate, much of which is sand, makes it difficult for many macroinvertebrates to build up in large numbers.

Fall Quarter Sampling (Conducted: November 14 to November 17, 2006)

The first quarter sampling period was between October 15 to December 31, 2006. A total of 2,511 macroinvertebrates were identified at the 5 sample stations. Collected specimen numbers ranged from 13 at station 2.1 to 305 species confirmed at station 5.4. A detailed list of the collected specimens identified to the lowest practicable taxon during the fall sampling effort are provided in Appendix D. Hyalellans, Chironomids, and Naiads represented the majority of the collected specimens during the initial survey effort.

Winter Quarter Sampling (Conducted: March 13 to March 15, 2007)

The second quarter sampling time was between January 15 to March 15, 2007. A total of 2,454 macroinvertebrates were collected. Collected specimen numbers ranged from 23 at sample station 4.2

to 241 species confirmed at station 2.4. A detailed list of the collected specimens identified during the winter sampling effort are provided in Appendix E. Chironomids, and Naiads represented the majority of the collected specimens during the second quarter survey.

Summer Quarter Sampling (Conducted: July 24 to July 27, 2007)

The third quarter sampling period occurred between July to September 2007. A total of 768 macroinvertebrates were identified at the 5 sample stations. Collected specimen numbers range between 203 at station 1.3 to none collected at 4.3. Most of the macroinvertebrates collected during this sampling event were Chironmonids and Naiads. A detailed list of the collected specimens identified during the winter sampling effort are provided in Appendix F.

Spring Quarter Sampling (Conducted: April 28 to April 30, 2008)

Sampling for the fourth and final quarterly survey was between April and June 2008. A total of 4,984 macroinvertebrates were identified at the 5 sample stations. Based on analysis of the Spring 2008 samples, half of the sites have more than 200 organisms and the other half range from 0 (site 4TR 5.4) to 153 (4TR 2.3) organisms. Chironomids and Daphnia represented the majority of the collected specimens. A detailed list of the collected specimens identified during the winter sampling effort are provided in Appendix G.

All invertebrates in these samples were counted due to their very low diversity. The large numbers were due to only one or two taxa suggesting relatively limited diversity. The samples with algae had the large numbers of organisms. Those with sand & gravel or sand & very little organic detritus had few to no organisms. Many of the samples had a dense, light brown organic (algal) mat and also contained the most Daphnia. Some of the collected samples had an alga with very short filaments and contained chironomids and very small worms. Other samples containing organic detritus and sand did not reveal an abundance of collected specimens. The transects containing algae, organic detritus and sand contained the highest number of invertebrates. Typically, those samples which were collected from sand substrate and small gravel had little to no organic material and essentially no invertebrates. Based on a comparison of the number of collected invertebrates relative to the presence of organic material, it appears the percentage of organic material may have a direct correlation of the presence and diversity of macroinvertebrates.

The overall diversity of macroinvertebrates collected during the Fall 2006, Winter 2007, Summer 2007, and Spring 2008 surveys are presented in Table 1 and identified to the lowest practicable taxon.

Table 1
SUMMARY OF MACROINVERTEBRATE TAXA

Phylum	Class	Order	Family	Genus
Annelida				
		Oligochaeta		
			Enchytraeidae	
			Tubificidae	
				Branchiura
			Naididae	
			Lumbriculidae	
		Isopoda		
			Asellidae	
				Lirceus
		Amphopoda		
				Hyalella
		Ephemerotera		
			Tricorythidae	
				Tricorthodes
			Caenidae	
				Brachycerus
		Trichoptera		
			Polycentropodidae	
				Cyrnellus
			Hydroptillidae	
				Hydroptila
			Hydropsychidae	
				Cheumatopsyche
				Potomyia
		Diptera		
			Chironomidae	
			Scathophagidae	
			Ceratopogonidae	
				Dasyhelea
			Simuliidae	
				Simulium
			Empididae	
			Dolichopodidae	
			Chaoboridae	
				Chaoborus
		Odonata:Zygoptera		
			Coenagrionidae	

Table 1
SUMMARY OF MACROINVERTEBRATE TAXA

Phylum	Class	Order	Family	Genus
				Argia
		Lepidoptera		
			Pyralidae	
				Petrophila
		Hemiptera		
			Corixidae	
				Trichocorixa
Mollusca				
		Gastropoda		
			Ancylidae (limpets)	
			Lymnaeidae	
			Physidae	
				Physella
		Pelecypod		
			Sphaeriidae	
			Corbiculoidae	
				Corbicula fluminea
			Dreissenoidae	
				Dressena polymorpha
		Nematoda		
			Mermithidae	
	Turbellaria			
		Triciadida		
				Dugesia
		Collembola		
			Entombryidae	
			Hypogastruridae	
			Poduridae	
				Podura
		Cladocera		
			Daphniidae	
				Daphnia
	Copepoda			
		Cyclopoid copepods		
		Calanoid copepods		
	Hydrachnida			

Source: Eagle Environmental Consulting, Inc. (2007)

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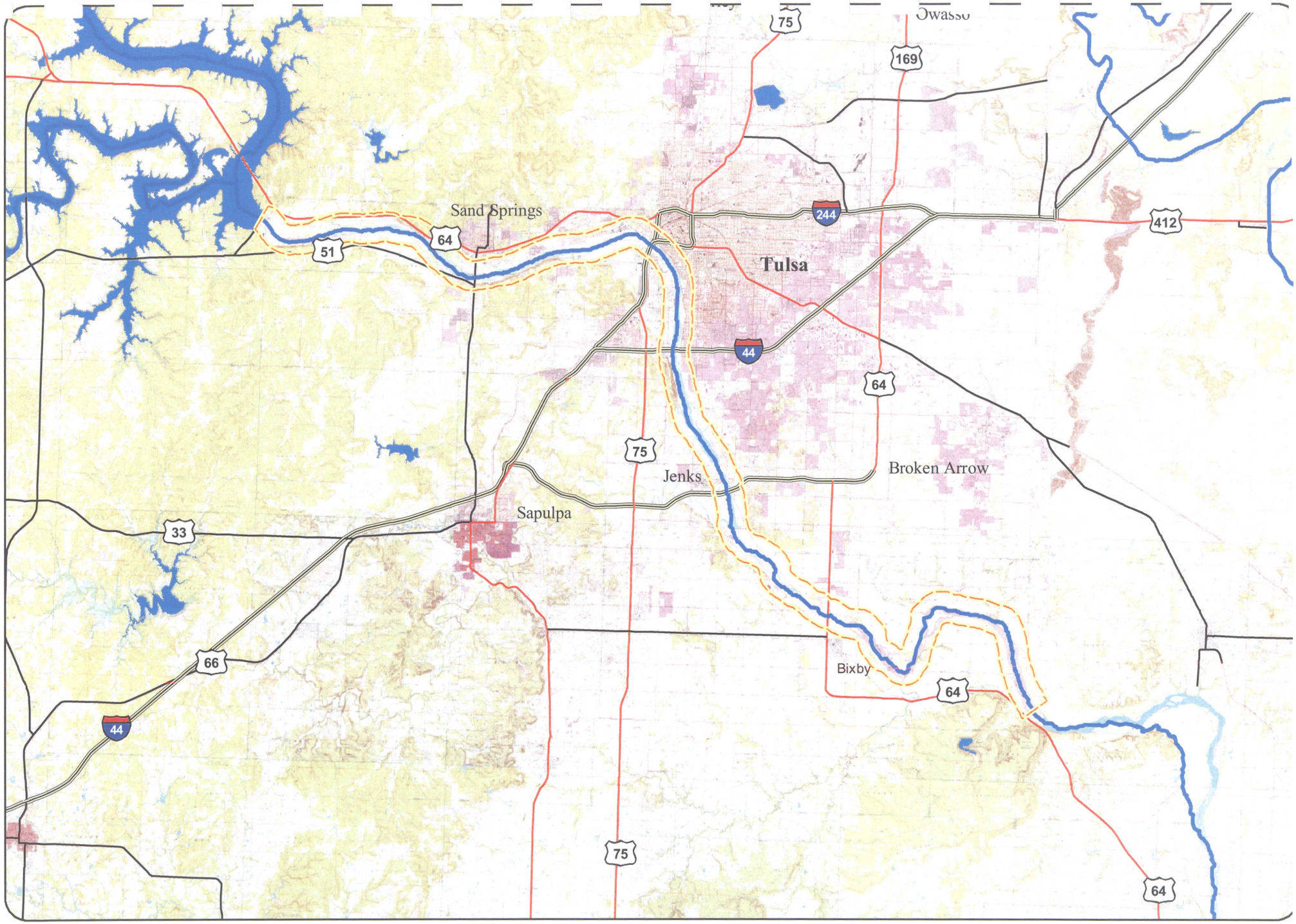
Appendix A

Project Location Map



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Survey Area
Lakes
Interstate
US Hwy

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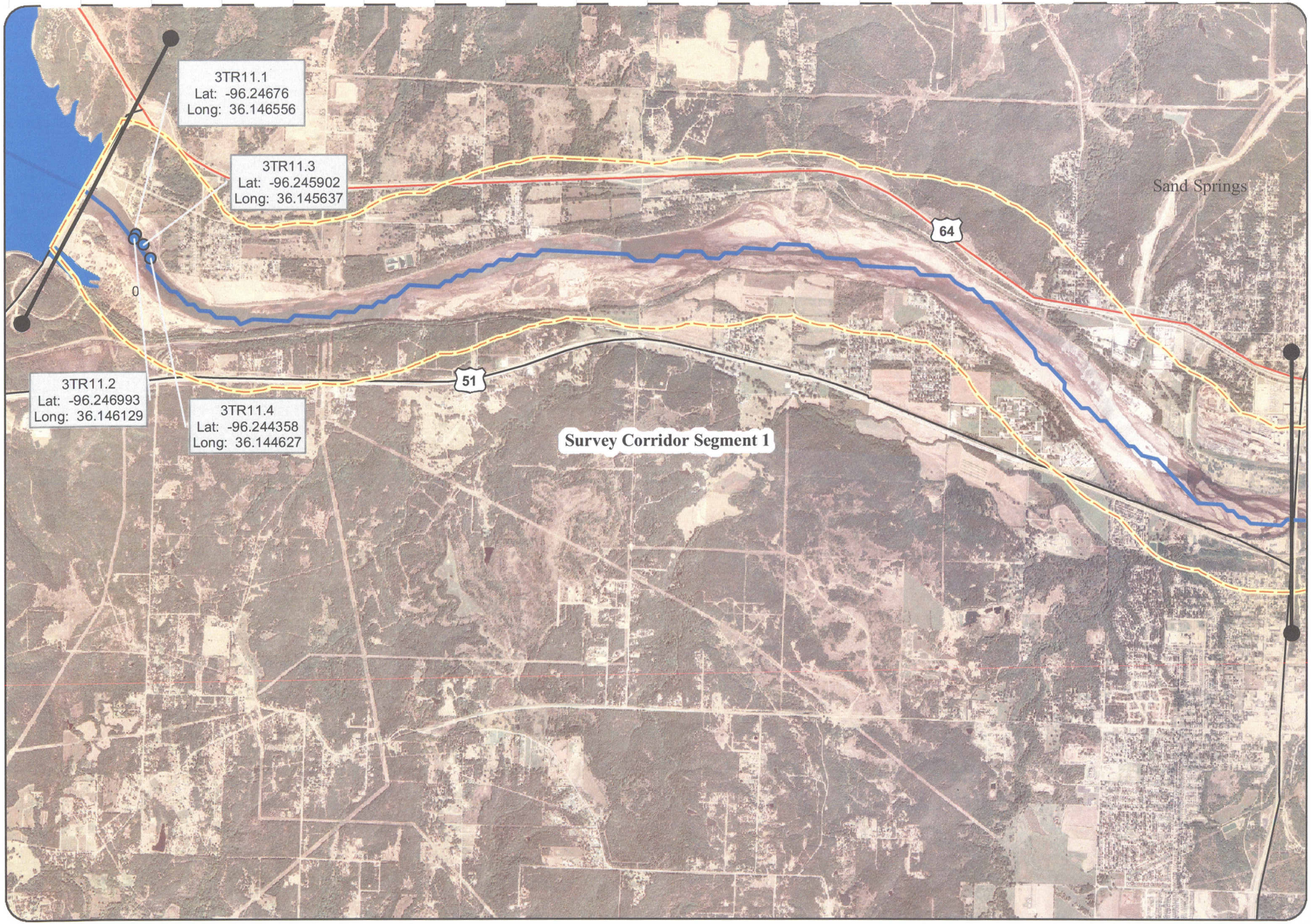
Oklahoma Vicinity Map

Location Map

Arkansas River Corridor Baseline Inventory
Arkansas River, Tulsa County, OK

Appendix B

Sample Station Location Maps



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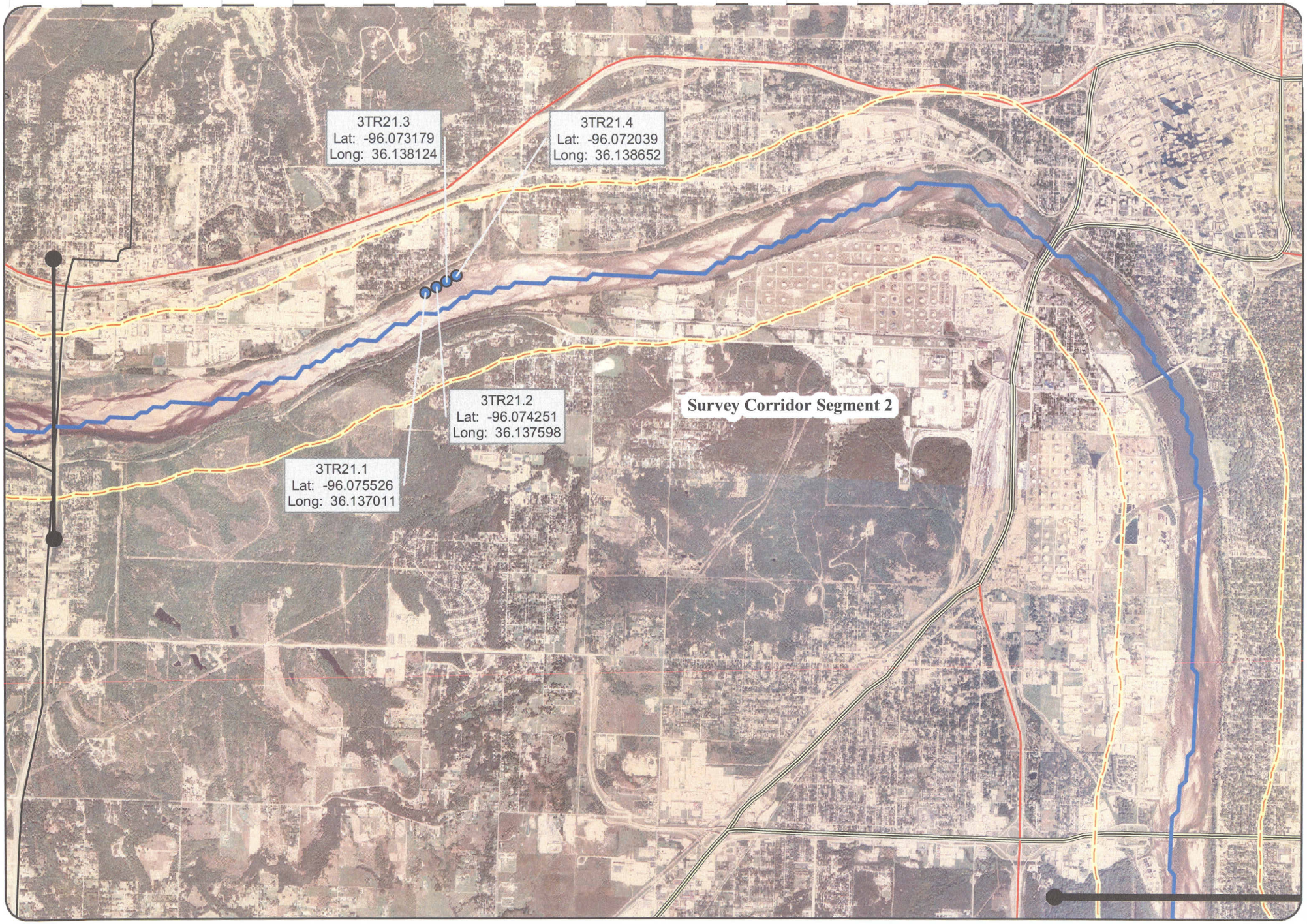
Survey Area Task 3 Sites

Oklahoma Vicinity Map

Task III Macro Invertebrates
Survey Corridor Segment 1
Arkansas River Corridor Baseline Inventory
US Army Corps of Engineers



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Survey Area Task 3 Sites

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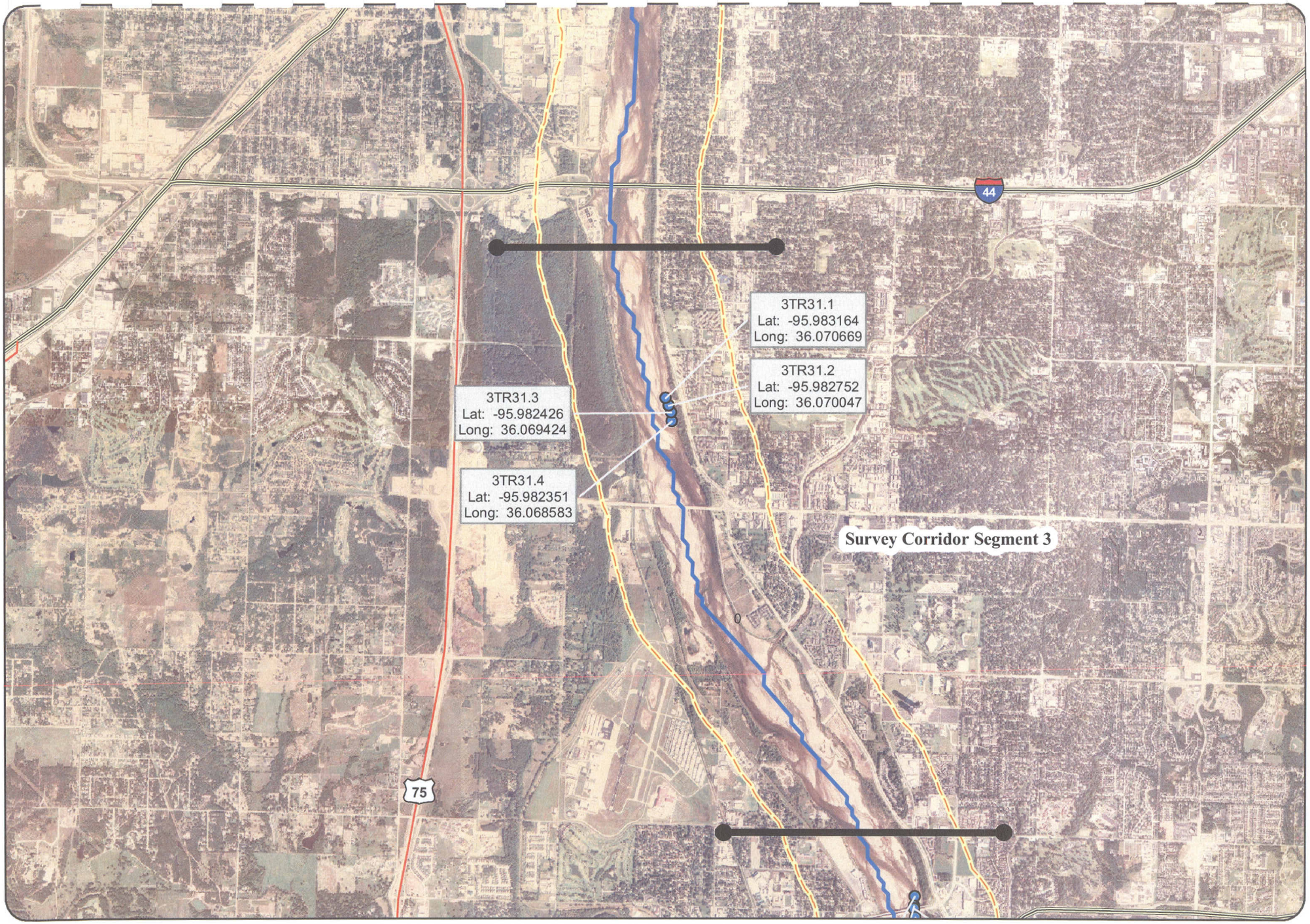
Oklahoma Vicinity Map

Task III Macro Invertebrates
Survey Corridor Segment 2
Arkansas River Corridor Baseline Inventory
US Army Corps of Engineers



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Survey Area Task 3 Sites

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Oklahoma Vicinity Map

Task III Macro Invertebrates
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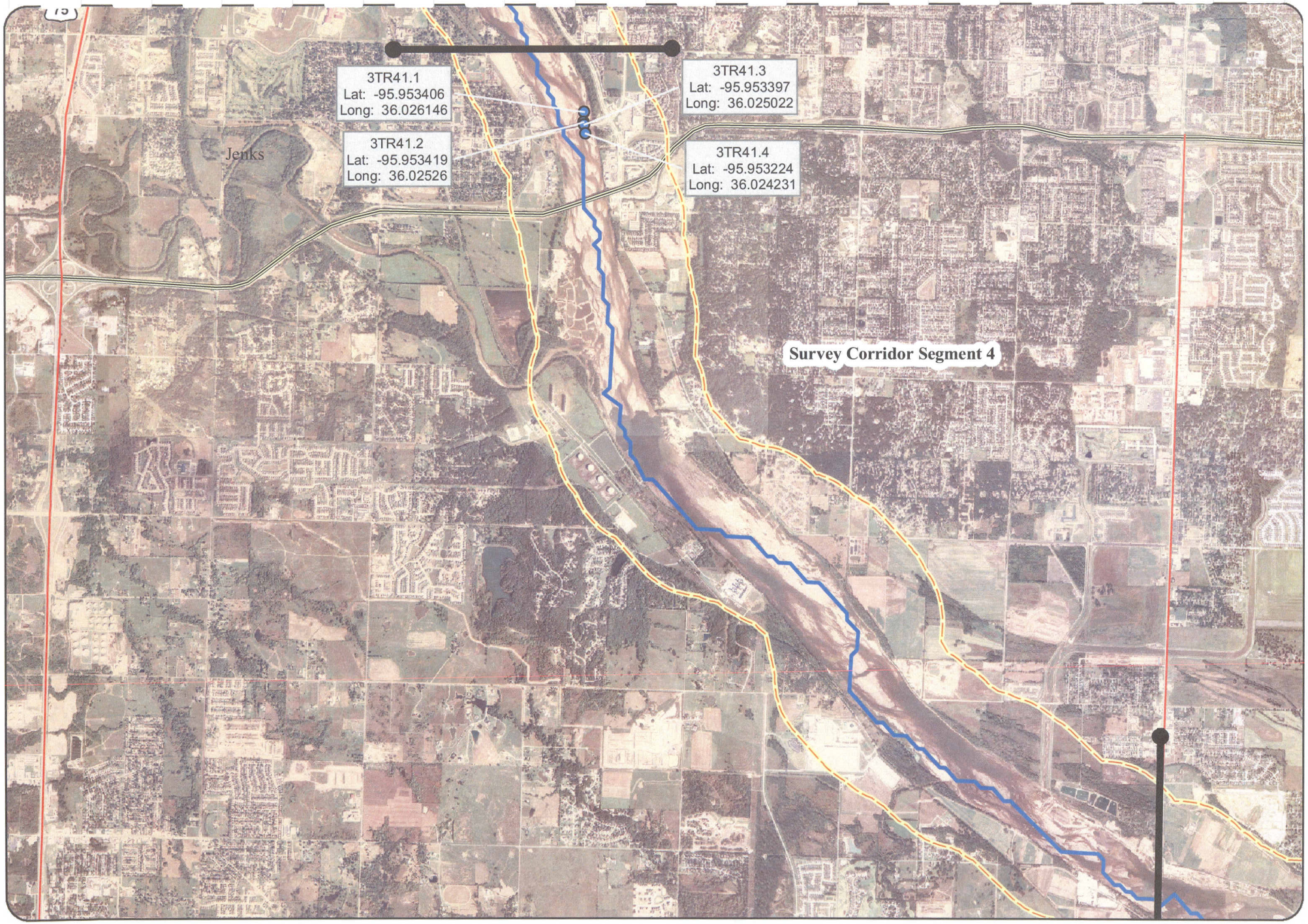
Arkansas River Corridor Baseline Inventory
US Army Corps of Engineers



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Survey Area ● Task 3 Sites

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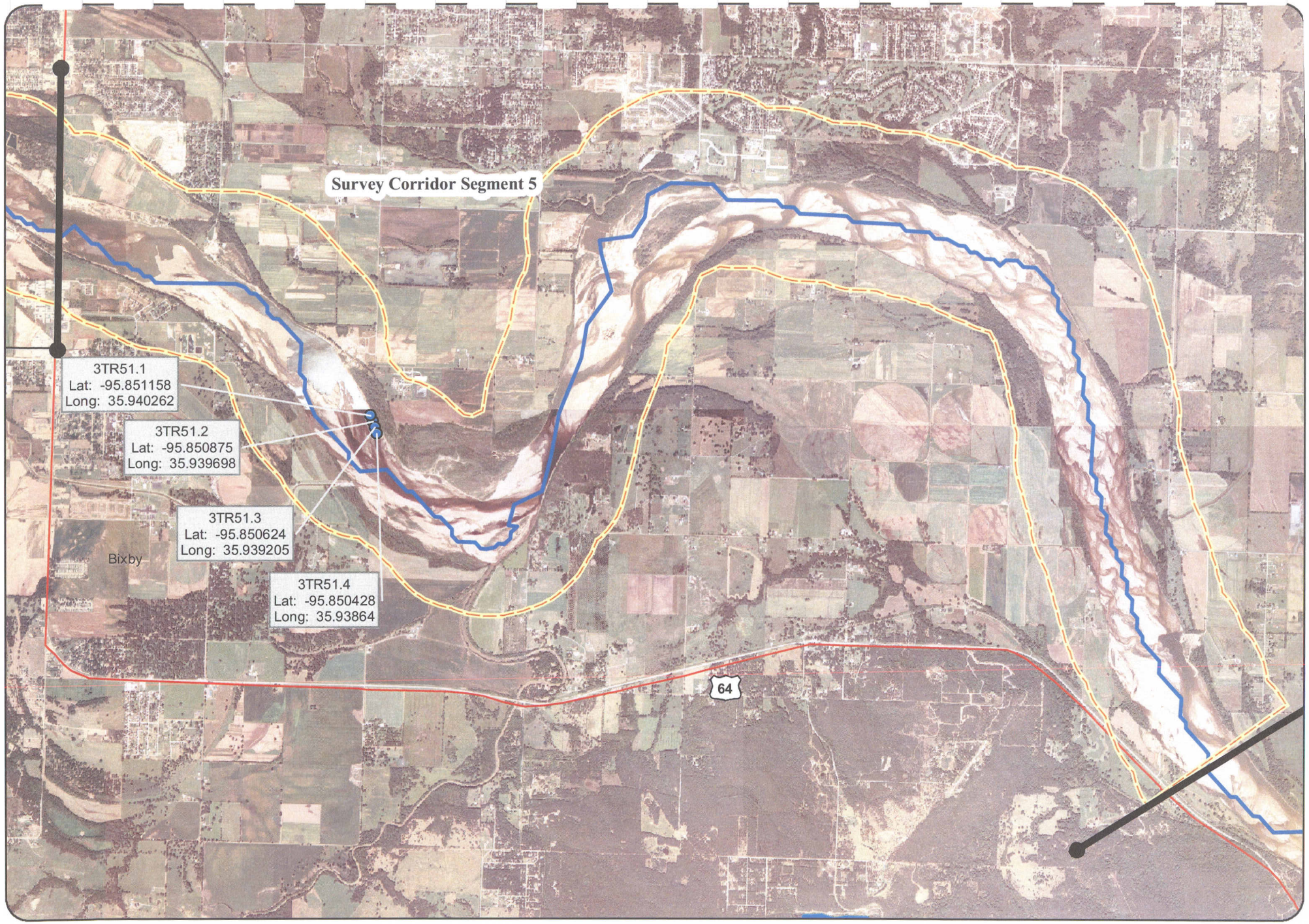
Oklahoma Vicinity Map

Task III Macro Invertebrates
Survey Corridor Segment 4
Arkansas River Corridor Baseline Inventory
US Army Corps of Engineers



EAGLE ENVIRONMENTAL CONSULTING, Inc.

0 0.25 0.5 0.75 1

Legend

Survey Area ● Task 3 Sites

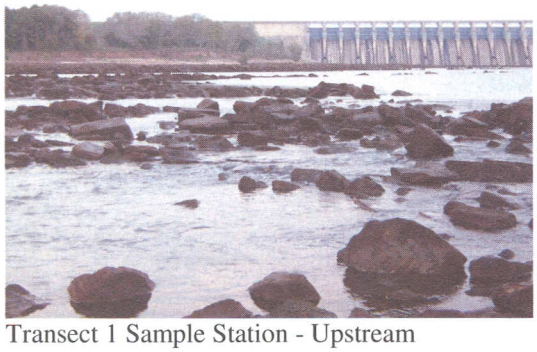
N

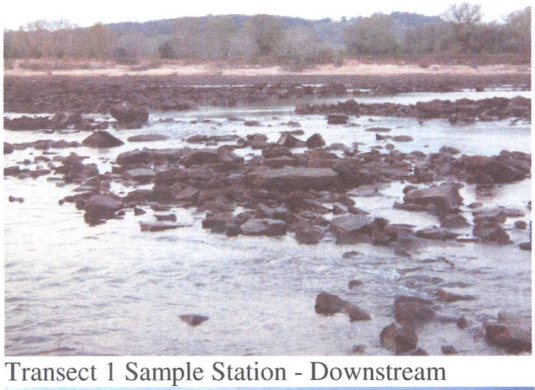
Oklahoma Vicinity Map

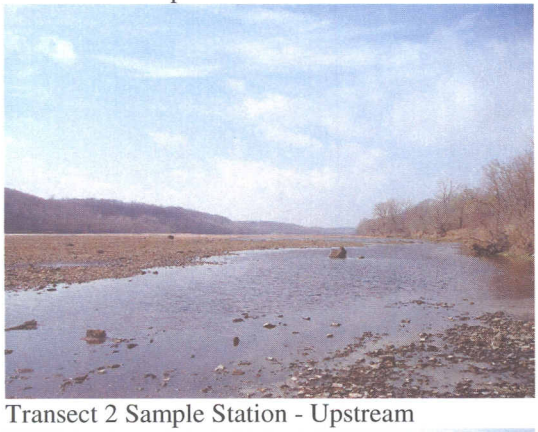
Task III Macro Invertebrates
Survey Corridor Segment 5
Arkansas River Corridor Baseline Inventory
US Army Corps of Engineers

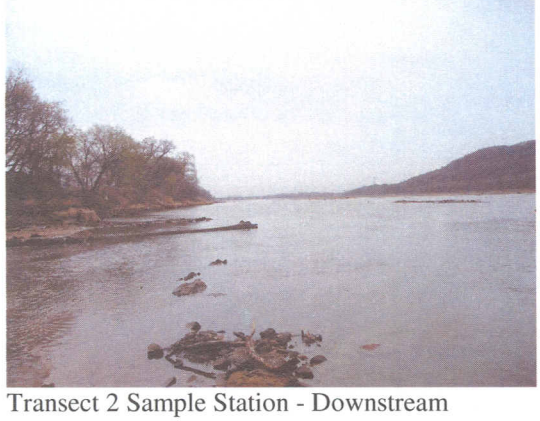
Appendix C

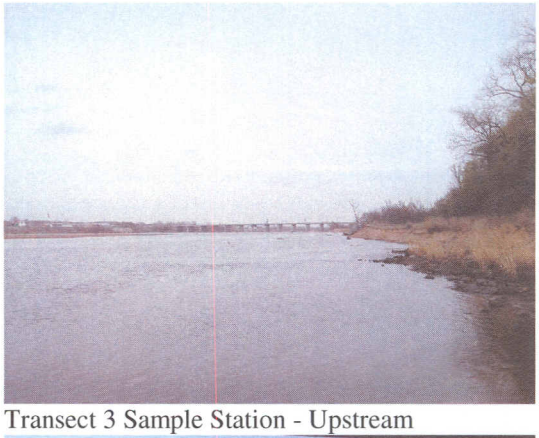
Selected Photographs of Sampling Stations

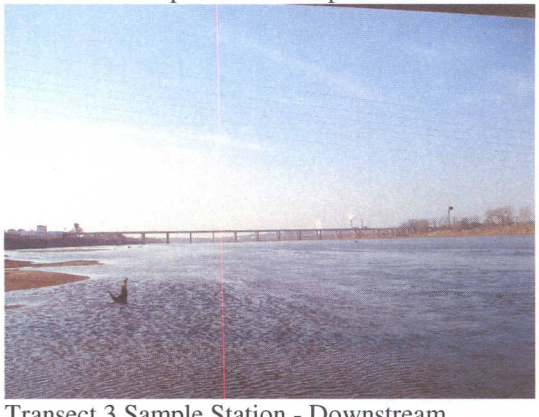

Transect 1 Sample Station - Upstream

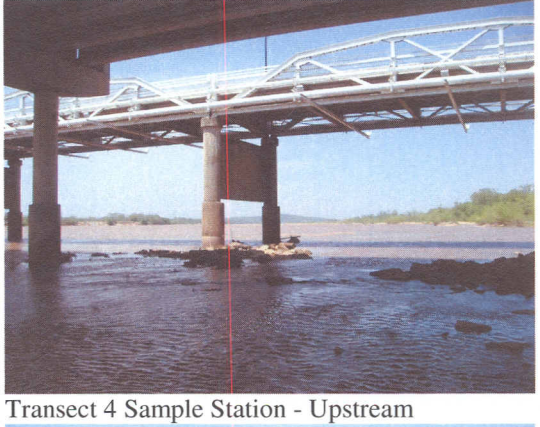

Transect 1 Sample Station - Downstream

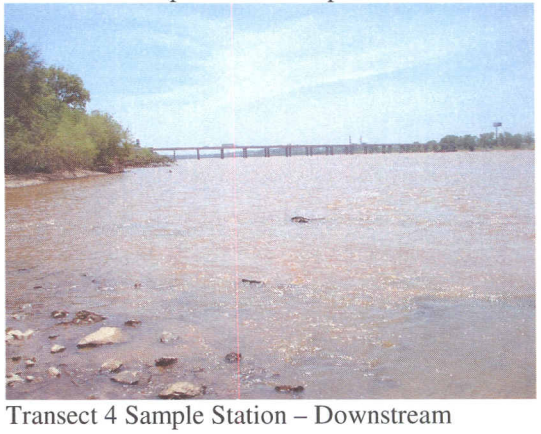

Transect 2 Sample Station - Upstream

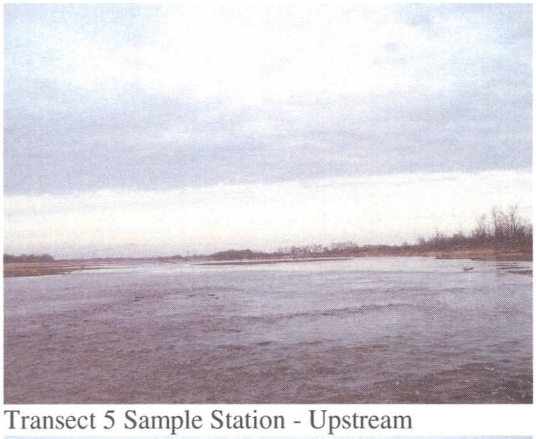

Transect 2 Sample Station - Downstream


Transect 3 Sample Station - Upstream

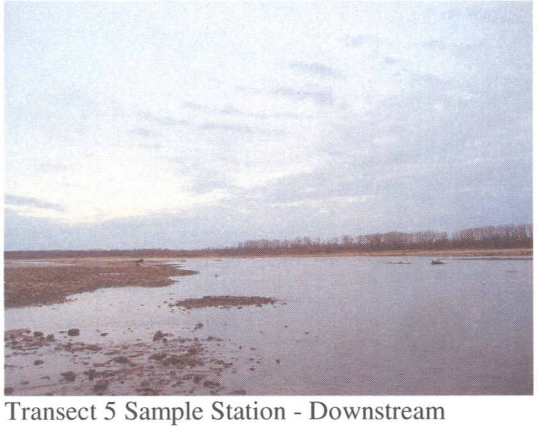

Transect 3 Sample Station - Downstream


Transect 4 Sample Station - Upstream


Transect 4 Sample Station – Downstream



Transect 5 Sample Station - Upstream



Transect 5 Sample Station - Downstream

Appendix D

Fall Quarter Sampling
November 2006
List of Observed Species

Arkansas River Corridor Baseline Inventory Task III; Macro Invertebrate Inventory - October 15 - December 31, 2006								
	TR1-1.1	TR1-1.2	TR1-1.3	TR1-1.4	3TR-2.1	3TR-2.2	3TR-2.3	3TR-2.4
Taxon								
Oligochaeta								
Enchytraeidae		3		20				
Tubificidae								
Branchiura				1				
Naididae						20	10	49
Isopoda				1				
Lirceus	22	10	21					
Hyalella	177	126	212	11				
Tricorythidae								
Tricorythodes	17	5	17					
Caenidae							1	
Brachycercus								1
Polycentropodidae			1					
Cyrnellus	3	2						
Hydroptilidae								
Hydroptila	1		1					
Hydropsychidae			1					
Cheumatopsyche								
Hydropsyche								
Potomyia								
Chironomidae larvae	26	39	53	22	12	36	29	63
Chironomidae pupae	1	4	8	5	1		1	4
Chironomidae adults				2				
Scathophagidae								
Argia								
Petrophila								
Ancyclidae		2		1				
Sphaeriidae								
Corbicula								
Dreissena	5	28	2	1				
Nematoda								
Mermithidae						2		1
Tricladida		2		1				
Entomobryidae								
Hypogastruridae				1				
Copepoda								
Cladocera								
non-aquatic adults				55				

Appendix E

Winter Quarter Sampling
March 2007
List of Observed Species

Arkansas River Corridor Baseline Inventory Project - Benthic Macroinvertebrates								
Collection Date - March 2007 (Sample Quarter 2: Winter 2007)								
	Sample Site Number - Unit of Effort # of Specimens/sq. meter							
	Substrate Type: Lg. & Sm. Rock				Substrate Type: Sm. Rock & Gravel			
Taxon	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4
Oligochaeta								
Enchytraeidae	11		2					
Tubificidae	5	23						3
Branchiura								
Naididae		1	44		165	114	36	220
Lumbriculidae			7	7		4	1	
Isopoda								
Lirceus								
Hyalella								
Tricorythidae								
Tricorythodes								
Caenidae								
Brachycercus								
Polycentropodidae								
Cyrnellus								
Hydroptilidae								
Hydroptila								
Hydropsychidae								
Cheumatopsyche								
Hydropsyche								
Potomyia								
Chironomidae larvae		2	1		17	15	10	13
Chironomidae pupae					1		2	1
Chironomidae adults							1	
Ceratopogonidae larvae	4	3		4		2		
Ceratopogonidae pupae					1		2	
Dasyhelea			4		4	1	3	1
Simuliidae								
Simulium					4	1		
Empididae				1				
Dolichopodidae			1					
Chaoborus								
Scathophagidae								
Argia								1
Petrophila								
Trichocorixa						1		
Staphylinidae		1						
Ancyclidae								
Lymnaeidae								
Physella							1	
Sphaeriidae								
Corbicula			1					
Dreissena								
Nematoda								
Mermithidae								
Tricladida								
Collembola		1	3					
Entomobryidae		3						
Hypogastruridae								
Poduridae	1						1	
Copepoda								
Cyclopoid copepod	54	109	101	30	1	3	11	2
Calanoid copepod	13	15	23	12	1	9	19	
Cladocera								
Daphnia	5	39	19	7				
Hydrachnidae		1	1	2				
non-aquatic adults	93							

Arkansas River Corridor Baseline Inventory Project - Benthic Macroinvertebrates												
Collection Date - March 2007 (Sample Quarter 2: Winter 2007)												
Sample Site Number - Unit of Effort # of Specimens/sq. meter												
Substrate Type: Sm. Rock and Sand				Substrate Type: Lg. & Sm. Rock				Substrate Type: Sand				
3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4	5.1	5.2	5.3	5.4	Taxon
												Oligochaeta
14	25	12	39									Enchytraeidae
			1			1						Tubificidae
												Branchiura
	1	6	2	51	10	7	17	170	180	161	146	Naididae
												Lumbriculidae
												Isopoda
											1	Lirceus
												Hyalella
												Tricorythidae
												Tricorythodes
												Caenidae
												Brachycercus
												Polycentropodidae
												Cyrnellus
												Hydroptilidae
												Hydroptila
												Hydropsychidae
												Cheumatopsyche
												Hydropsyche
												Potomyia
	5			4				45	38	24	9	Chironomidae larvae
	1								3	2	2	Chironomidae pupae
1												Chironomidae adults
1	3			1				1				Ceratopogonidae L
					1		1					Ceratopogonidae P
				1							4	Dasyhelea
								1				Simuliidae
												Simulium
												Empididae
1												Dolichopodidae
						1						Chaoborus
												Scathophagidae
												Argia
												Petrophila
												Trichocorixa
		1										Staphylinidae
												Ancyclidae
				1	1							Lymnaeidae
												Physella
												Sphaeriidae
	1											Corbicula
												Dreissena
			2									Nematoda
											1	Mermithidae
												Tricladida
												Collembola
	1											Entomobryidae
												Hypogastruridae
				1								Poduridae
												Copepoda
10	1	7	40	8	7	9	3		1		6	Cyclopoid copepod
2		4	4	2		2	1					Calanoid copepod
												Cladocera
	3	3	1		4	5	2					Daphnia
												Hydrachnidae
												non-aquatic adults

Appendix F

Summer Quarter Sampling
July 2007
List of Observed Species

Arkansas River Corridor Baseline Inventory Project - Benthic Macroinvertebrates								
Collection Date - July 2007 (Sample Quarter 3: Summer 2007)								
	Sample Site Number - Unit of Effort # of Specimens/sq. meter							
	Substrate Type: Lg. & Sm. Rock				Substrate Type: Sm. Rock & Gravel			
Taxon	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4
Oligochaeta								
Enchytraeidae				1				
Tubificidae								
Branchiura								
Naididae		6	1	2		1		
Lumbriculidae								
Isopoda								
Lirceus	2	2	14	13				
Amphipoda								
Hyalella			2	1				
Ephemeroptera								
Leptohyphidae								
Tricorythodes		3	9	2		1		
Heptageniidae								
Maccaffertium								
Caenidae								
Caenis								
Baetidae								
Fallceon						1	1	
Trichoptera								
Polycentropodidae							1	
Cyrnellus		6	5	1				
Hydroptilidae								
Hydroptila								
Hydropsychidae	1						1	
Cheumatopsyche		12	84	22		1		
Hydropsyche		1	6				1	2
Potomyia								
Megaloptera								
Corydalus								
Coleoptera								
Diptera								
Chironomidae larvae		26	45	22	3	7	3	2
Chironomidae pupa		8	14	4				
Ceratopogonidae					2	5	6	2
Empididae								
Hemerodromia								
Odonata: Zygoptera								
Coenagrionidae								
Argia								
Mollusca								
Gastropoda								
Ancylidae								
Planorbidae				1				
Pelecypoda								
Corbiculoidae								
Corbicula			1					
Dreissenoidea								
Dreissena polymorpha		15	15	14		2		
Turbellaria								
Tricladida								
Dugesiidae		3	7	8				
Collembola								
Poduridae								
Isotomidae								
Copepoda								
Cyclopoid copepods		1		1	2			
Calanoid copepods				2				
Cladocera								
Daphniidae								
Daphnia		1		4				
	3	84	203	98	7	18	13	6

Arkansas River Corridor Baseline Inventory Project - Benthic Macroinvertebrates												
Collection Date - July 2007 (Sample Quarter 3: Summer 2007)												
Sample Site Number - Unit of Effort # of Specimens/sq. meter												
Substrate Type: Sm. Rock and Sand				Substrate Type: Lg. & Sm. Rock				Substrate Type: Sand				
3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4	5.1	5.2	5.3	5.4	Taxon
												Oligochaeta
2					1							Enchytraeidae
												Tubificidae
	1	1										*Branchiura*
9	40	38	7	5	4		3	3				Naididae
					4			4	3			Lumbriculidae
												Isopoda
												Lirceus
												Amphipoda
												Hyalella
												Ephemeroptera
												Leptohyphidae
		1										*Tricorythodes*
												Heptageniidae
		1										*Maccaffertium*
												Caenidae
					1							*Caenis*
												Baetidae
												Fallceon
												Trichoptera
												Polycentropodidae
			1									*Cyrnellus*
							1					Hydroptilidae
												Hydroptila
					1							Hydropsychidae
	3	6		19	22		1	2				*Cheumatopsyche*
				1	2							*Hydropsyche*
												Potomyia
												Megaloptera
				1								*Corydalus*
							1					Coleoptera
												Diptera
5	12	18	4	15	16		5	2	2	2	1	Chironomidae larvae
	6	9			1		1	1				Chironomidae pupa
												Ceratopogonidae
												Empididae
				1								*Hemerodromia*
												Odonata: Zygoptera
												Coenagrionidae
		3	2									*Argia*
												Mollusca
												Gastropoda
1	2											Ancylidae
												Planorbidae
												Pelecypoda
												Corbiculoidae
10	18	1		2			3		1			*Corbicula*
												Dreissenoidea
												Dreissena polymorpha
												Turbellaria
												Tricladida
				1	1							Dugesiidae
												Collembola
												Poduridae
								1				Isotomidae
												Copepoda
												Cyclopoid copepods
												Calanoid copepods
												Cladocera
												Daphniidae
												Daphnia
27	82	78	14	45	53	0	15	13	6	2	1	768

Appendix G

Spring Quarter Sampling
April 2008
List of Observed Species

Arkansas River Corridor Baseline Inventory Project - Benthic Macroinvertebrates								
Collection Date - April 2008 (Sample Quarter 4: Spring 2008)								
	Sample Site Number - Unit of Effort # of Specimens/sq. meter							
	Substrate Type: Lg. & Sm. Rock				Substrate Type: Sm. Rock & Gravel			
Taxon	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4
Oligochaeta								
Enchytraeidae								
Tubificidae								
Branchiura								
Naididae	1		1		78	77	82	58
Lumbriculidae								
Isopoda								
Lirceus								
Amphipoda								
Hyalella	2							1
Ephemeroptera								
Leptohyphidae								
Tricorythodes								
Heptageniidae								
Maccaffertium								
Caenidae								
Caenis								
Baetidae								
Fallceon								
Trichoptera								
Polycentropodidae								
Cyrnellus								
Hydroptilidae								
Hydroptila								
Hydropsychidae								
Cheumatopsyche								
Hydropsyche								
Potomyia								
Megaloptera								
Corydalus								
Coleoptera								
Diptera								
Chironomidae larvae	108	69	55	18	65	147	48	32
Chironomidae pupa	1	2	1	2	2	3	2	
Ceratopogonidae								
Empididae								
Hemerodromia								
Chaoboridae								
Chaoborus	3	4	7	4	4	3		
Simuliidae								
Simulium								
Odonata: Zygoptera								
Coenagrionidae								
Argia								
Mollusca								
Gastropoda								
Ancylidae								
Planorbidae								
Physidae								
Pelecypoda				2				
Corbiculoidae								
Corbicula							1	1
Dreissenoidea								
Dreissena polymorpha								
Turbellaria								
Tricladida								
Dugesiidae								
Collembola								
Poduridae								
Isotomidae								
Copepoda								
Cyclopoid copepods	3	2	3	5	3	3		
Calanoid copepods	1	1				1	1	1
Cladocera								
Daphniidae								
Daphnia	271	285	542	557	141	165	19	7
Nematoda								
Mermithidae								
Cnidaris								
Hydra								
	390	363	609	588	293	399	153	100

Arkansas River Corridor Baseline Inventory Project - Benthic Macroinvertebrates												
Collection Date - April 2008 (Sample Quarter 4: Spring 2008)												
Sample Site Number - Unit of Effort # of Specimens/sq. meter												
Substrate Type: Sm. Rock and Sand				Substrate Type: Lg. & Sm. Rock				Substrate Type: Sand				
3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4	5.1	5.2	5.3	5.4	Taxon
												Oligochaeta
		1	2	1								Enchytraeidae
					7	1	2					Tubificidae
												Branchiura
4	8	7	10	63	106	186	78					Naididae
												Lumbriculidae
												Isopoda
												Lirceus
												Amphipoda
										1		*Hyalella*
												Ephemeroptera
												Leptohyphidae
												Tricorythodes
												Heptageniidae
												Maccaffertium
												Caenidae
												Caenis
												Baetidae
												Fallceon
					1							Trichoptera
												Polycentropodidae
												Cyrnellus
												Hydroptilidae
												Hydroptila
							1					Hydropsychidae
												Cheumatopsyche
												Hydropsyche
												Potomyia
												Megaloptera
												Corydalus
						1						Coleoptera
												Diptera
5	14	10	6	206	361	323	262	1				Chironomidae larvae
			1	2	16	9	11			1		Chironomidae pupa
						1						Ceratopogonidae
												Empididae
												Hemerodromia
												Chaoboridae
				1	2	4						*Chaoborus*
												Simuliidae
					3		1					*Simulium*
												Odonata: Zygoptera
												Coenagrionidae
												Argia
												Mollusca
												Gastropoda
												Ancylidae
												Planorbidae
					1							Physidae
												Pelecypoda
												Corbiculoidae
												Corbicula
												Dreissenoidea
												Dreissena polymorpha
												Turbellaria
												Tricladida
												Dugesiidae
												Collembola
												Poduridae
								1				Isotomidae
												Copepoda
				3	2	1	14					Cyclopoid copepods
	1			4			3					Calanoid copepods
												Cladocera
												Daphniidae
3	16	8	16	48	122	74	37	1	2	2		*Daphnia*
												Nematoda
					1							Mermithidae
												Cnidaria
						3	6					*Hydra*
12	39	26	35	328	622	603	415	3	2	4	0	4984