FINAL TECHNICAL REPORT

Illinois River Instream Flow Assessment

Physical Habitat Simulation (IFIM Phases 1-3)

Prepared for

Oklahoma Water Resources Board

U.S. Army Corps of Engineers
Tulsa District

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Acronyms and Abbreviations

>	greater than
°C	degree(s) Celsius
°F	degree(s) Fahrenheit
1D	one-dimensional
ADCP	Acoustic Doppler Current Profiler
AF	acre-feet
AFY	acre-feet per year
AWS	area weighted suitability
CFDO	Commercial Flotation Device Operators
cfs	cubic feet per second
CI	confidence intervals
cm	centimeters
cm/s	centimeters per second
CTM	critical thermal maximum
fps	feet per second
ft.	feet
ft/mi	feet per mile
GPS	global positioning system
HSC	habitat suitability criteria
IFG	Instream Flow Group
IFG-4	Instream Flow Group-4 (hydraulic model)
IFIM	Instream Flow Incremental Methodology
ISF	instream flow
LAWPR	Lower Arkansas River Watershed Planning Region
mg/L	milligram(s) per liter
mi	mile
mm	millimeter
NM	not measured
NSI	the normalized suitability index
NWS	National Weather Service
OCC	Oklahoma Conservation Commission
ODWC	Oklahoma Department of Wildlife Conservation
ORW	outstanding resource waters
OSRA	Oklahoma Scenic Rivers Act of 1970
OSRC	Oklahoma Scenic Rivers Commission

OWRB	Oklahoma Water Resources Board
P	proportion of the population under the curve
PHABSIM	Physical Habitat Simulation
SEFA	System for Environmental Flow Assessment
SZF	stage-at-zero-flow
TP	total phosphorus
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VAF	velocity adjustment factor
WUA	weighted usable area
WWTP	wastewater treatment plant

SECTION 1

Introduction

In 2012, the Oklahoma Water Resources Board (OWRB) published its updated *Oklahoma Comprehensive Water Plan* (OWRB, 2012). This plan, as well as previous plans, recommended the evaluation of nonconsumptive uses of water, including instream flows (ISF), for environmental and recreational uses. Based on earlier recommendations, the OWRB had convened an ISF work group in late 2009 to solicit input from stakeholders and establish a path forward to further evaluate the need and options for establishing an ISF policy or program for Oklahoma. The work group developed a report titled Instream Flow Issues and Recommendations (OWRB, 2011). One of the recommendations in the report was to perform an ISF pilot study on a state-designated scenic river. In 2013, following completion of the 2012 *Comprehensive Water Plan*, OWRB created the Oklahoma Instream Flow Advisory Group to continue the efforts of the previous work group. To further define whether and how an ISF program might be implemented, an ISF pilot study approach was prepared and submitted to the OWRB, U.S. Army Corps of Engineers (USACE), and Instream Flow Advisory Group (CH2M HILL, 2014). The state-designated scenic reaches of the Illinois River and its tributaries, Barren Fork Creek and Flint Creeks, were identified as preferred study streams.

The Instream Flow Incremental Methodology (IFIM) (Bovee, 1982; Stalnaker, et al., 1995) was deemed most suitable for addressing the prevailing comments and concerns of the Instream Flow Advisory Group. The IFIM is a decision-support process that provides a comprehensive framework for addressing streamflow needs for fish and other aquatic resources while incorporating consideration of other environmental and nonenvironmental interests (i.e., recreation, wildlife, water quality, and consumptive water uses such as public water supply, crop irrigation, power generation, and industrial uses). The IFIM is the most commonly used and accepted methodology by state and federal agencies in the United States and internationally. The methodology typically is used to assess impacts of specific water development proposals (for example, a water diversion) where alternative streamflow regimes can be assessed. However, this is not the circumstance for the Illinois River, which is largely an unregulated stream with no foreseeable major water development projects being contemplated. Still, the basic steps of the methodology are broad enough that they can be applied to any situation where ISF prescriptions are being considered.

This technical report is part of the larger effort of employing the IFIM to test how the process, perhaps with modifications, might be used in the future for other streams in Oklahoma. As such, the overall process (steps) applied to the Illinois River is considered a pilot study. This “pilot” aspect applies to not only the steps required to obtain technical information (the subject of this report) but also the administrative steps of the decision-making process itself. The ultimate purpose of the pilot study is to gain a better understanding of the implications of a process to deal with ISF issues consistent with the overall goal of managing water resources in Oklahoma for multiple uses.

Before conducting this study, input was sought from various agencies, technical advisors, and the general public with interest in the Illinois River watershed. They assisted in identifying issues, provided useful information on stream-related resources, and helped formulate a technical study plan for obtaining additional information, especially for the fish habitat modeling effort. The results of these consultation and outreach efforts are summarized in various documents available from the OWRB.

This technical report is presented in four sections. The first section is this Introduction. Section 2, Watershed Resources, summarizes available information on the various resources that are associated with the study streams. These resources are hydrology (including water usage), water quality, fisheries, wildlife, recreation, and riparian corridor.

Section 3, Fish Habitat Modeling, presents the results of a fish habitat modeling effort that was used to identify relationships between indices of fish habitat and streamflow for the three study streams. This modeling focused only on fish-rearing needs primarily during the baseflow months, not on spawning or migration needs.

Section 4, Discussion, provides insight on the information presented in Sections 2 and 3. It includes interpretation of the fish habitat modeling results and attempts to integrate those results with the flow considerations identified for the other nonfish resources. A brief discussion of the importance of ecological process flows (also known as environmental flows) is presented in this section.

The next administrative steps that are required to actually establish and implement ISF management prescriptions for the Illinois River and tributaries are still being formulated by OWRB in consultation with the Instream Flow Advisory Group. Those steps will constitute the continuation and hopefully the finalization of the IFIM process for the Illinois River. At that time, the use of the IFIM process, as used in this pilot study, can be evaluated as to its applicability to other streams in Oklahoma being considered for ISF prescriptions.

SECTION 2

Watershed Resources

This section summarizes available information on the various resources that are associated with the study streams. These resources are hydrology (including water usage), water quality, fisheries, wildlife, recreation, and riparian corridor.

2.1 Watershed Overview

The Illinois River watershed encompasses approximately 1,671 square miles (mi) in northwestern Arkansas and northeastern Oklahoma (Figure 2-1). The river originates near Hogeye, Arkansas, approximately 15 mi southwest of Fayetteville. The 145-mi river flows west, crossing the Ozarks of northwest Arkansas and into Oklahoma near Watts, Oklahoma. Major tributaries of the Illinois River include Osage Creek, Clear Creek, Muddy Fork Creek, and Cincinnati Creek in Arkansas, and Flint Creek, Ballard Creek, Caney Creek, and Barren Fork Creek in Oklahoma.

It should be noted that some discrepancies exist to the exact naming of Barren Fork Creek. Depending on the date and original source, Barren Fork Creek has also been referred to as Barren Fork, Baron Fork, and Baron Fork Creek. For this report the waterbody is referred to as Barren Fork Creek, which is consistent with Oklahoma Statute §82-896.5 (formally §82-1452).

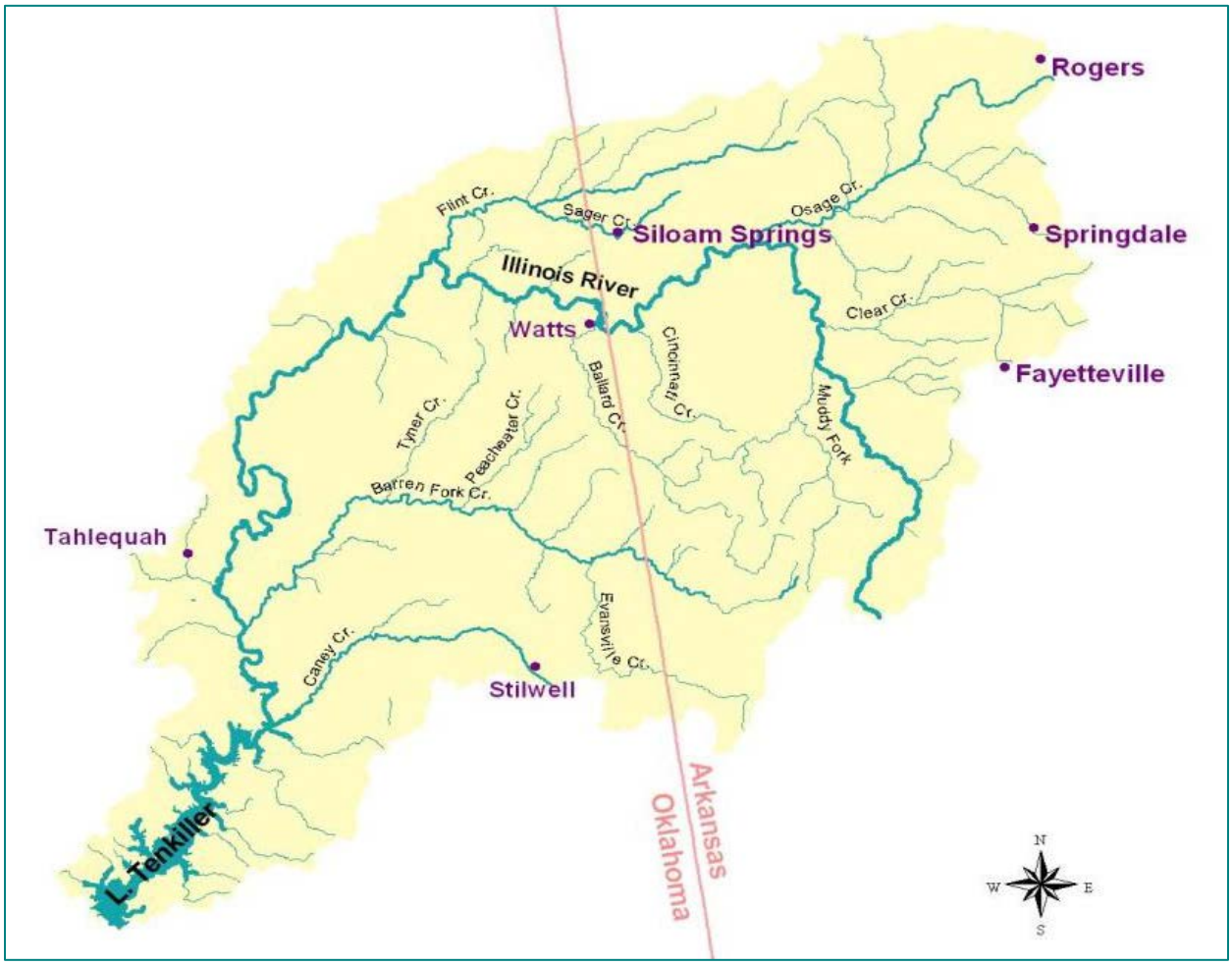


Figure 2-1. Major Tributaries and Towns in the Illinois River Watershed.

The Illinois River watershed lies mostly within the Ozark Highlands ecoregion. The Ozark Highland streams drain to the Arkansas River, which is a major tributary to the Mississippi River. The ecoregion is characterized by oak-hickory forests on well-drained soils of slopes, hills, and plains. Areas of exposed rock are common. Bottomland hardwood forests of oak, sycamore, cottonwood, and elm exist along the floodplains of the larger streams (Oklahoma Conservation Commission [OCC], 1998; Woods, et al., 2005). The Illinois River and its major tributaries exhibit a range of conditions from areas with dense riparian forest buffers illustrating exceptional beauty and ecological value, to areas of exposed and eroding stream banks with no vegetated buffers. Presently, rugged areas are forested and nearly level sites are used for pastureland or hay production. Elevation in the Ozark Highlands ranges from 300 feet (ft.) to 1,800 ft.

Average annual precipitation in the Illinois River watershed is approximately 48 to 50 inches, with May, June, and September being the wettest months. Air temperatures average near 58 degrees Fahrenheit (°F), with a range from an average daytime high of 91°F in July to an average low of 27°F in January.

Land use in the Oklahoma portion of the Illinois River watershed is diverse. Nearly half of the land coverage is forested, with most of the remaining land used for hay production or pasture (Table 2-1) (OCC, 2010).

Table 2-1. Land Cover in the Oklahoma Portion of the Illinois River Basin from 2001 LandSat

Land Cover	Fraction of Basin
Forest	45.90%
Hay	15.42%
Well Managed Pasture	24.34%
Poorly Managed Pasture	7.98%
Rangeland	0.60%
Roads	0.16%
Urban	2.91%
Water	2.04%
Row Crop/Small Grains	0.64%

Source: Storm and Smolsen, 2006.

The major agricultural industry in the Oklahoma portion of the watershed is poultry, and a significant number of cattle are also raised. Row crops and small grains comprise a small percentage of the land use (Table 2-1). Wheat, sorghum, soybeans, and various vegetables are grown in small quantities. Nursery plant production, though relatively small, has also remained constant in the region.

The designated beneficial uses for streams in the watershed include some or all of the following: public and private water supply, fish and wildlife propagation (both cool and warm water communities), agriculture, primary body contact recreation, aesthetics, industrial and municipal process and cooling water, and fish consumption (OWRB, 2014). Additionally, numerous streams and rivers in the Illinois River Watershed are classified in the Oklahoma Water Quality Standards as outstanding resource waters (ORW), while the Illinois River, Barren Fork Creek, and Flint Creek are also classified as Scenic Rivers. These special classifications identify those waterbodies as having exceptional ecological or recreational significance deserving of extra protection to maintain their extraordinary existing water quality.

The Illinois River is designated as a state scenic river from the Lake Frances Dam near the Arkansas border down to its confluence with Barren Fork Creek, a distance of approximately 60 mi. A 35-mi

segment of Barren Fork Creek and a 12-mi segment of Flint Creek also are designated as Scenic Rivers upstream from their confluences with the Illinois River. The scenic portions of these streams are administered by the Oklahoma Scenic Rivers Commission (OSRC). The Illinois River Management Plan prepared by OSRC (1999) lists 10 management goals for the river and its corridor. Of these, three relate directly to ISF: (1) conserve and enhance instream biological and physical resources such as native fish and their habitats as well as water quality, (2) maintain long-term protection of important instream and shoreline resources, including free-flowing character, water quality and quantity, and fish habitat, and (3) provide a diversity of high quality recreational opportunities that are compatible with each other and with river resources.

Approximately 243,000 people live in the Illinois River watershed (2010 U.S. Census). About 170,000 (70 percent) live in urban areas, with the majority residing in the eastern portion of the watershed in Arkansas. The population of Oklahoma towns in the Illinois River basin is about 22,000. The largest city in the Oklahoma portion of the watershed is Tahlequah, which lies near the southern downstream portion of the Illinois River study area. The population of Tahlequah is 15,573 according to the 2010 U.S. Census. Although there are rapidly growing urban centers in the eastern headwater areas from south Fayetteville to Rogers and Bentonville, Arkansas, the western portion of the watershed in Oklahoma remains largely rural.

Early occupants of the Illinois River valley included the Caddo Indians who were later succeeded by the Osage Indians (OSRC, 1999). They were followed by the Western Cherokee Indians who moved from Arkansas Territory to the Illinois River valley following the Treaty of 1828. The Cherokees favored the area around the Illinois River because of the productive hunting and fishing. In 1839, the city of Tahlequah became the Cherokee Nation capital. Tahlequah is a historically significant town as it was the end of the “Trail of Tears” for the Cherokee Nation. Members of the Cherokee Nation today continue to value the Illinois River and valley for its historical and cultural significance.

There has been no cultural resources inventory conducted for the Illinois River corridor in Oklahoma, thus any significant cultural resources such as archaeological sites are not known within the study area. Typically, however, the value of these resources does not appear to be dependent on streamflow. Therefore, streamflow relationships would not need to be developed for cultural resource sites. However, some Native American resource values and nonconsumptive water uses associated with the management of the river ecosystem may depend on streamflow quantity. Many tribes traditionally have used water for a range of nonconsumptive purposes, including ceremonial and fishing practices. Many native peoples harvest plants for subsistence, medicinal, or cultural use from wetland and riparian areas. However, there is no publicly available information on any specific practices or sites used by the local Native American tribes in the Illinois River.

The streams of the Ozark Highlands are typically clear, moderate gradient, riffle-and-pool type with coarse gravel, cobble, boulder, and bedrock substrates of limestone, dolomite, and chert. Baseflows usually are maintained during the dry season by springs and seeps. Both habitat diversity and fish species richness are high, and sensitive fish species are common (see Fisheries description). The most important game species is the smallmouth bass (see Recreation section). The Illinois River corridor contains an extensive network of remnant and intermittently-watered side channels and oxbow channels that support important habitat for fish, wildlife, and riparian vegetation. In general, phosphorus, bacteria, and sediment are the primary causes of water quality concerns in the watershed (see Water Quality section).

2.2 Hydrology

It is important to understand a stream’s flow regime, both natural and altered, in order to assess how those flows or proposed alternative flows might affect stream-related resources. Baseflows, especially in the summer, are important components of the flow regime in providing suitable living conditions for fish

and other aquatic organisms. Because summer is often the highest demand period for out-of-stream water uses (e.g., domestic and irrigation), most ISF issues occur in the summer, and the competing demands for instream and out-of-stream water at this time of year are often the focus of ISF studies. However, the higher flows that function to create and maintain the stream's ecological processes are also important to consider when recommending ISF (Annear et al., 2004). Flows that approximate bankfull conditions are particularly important as these help to create and maintain the channel shape, flush and transport streambed material, provide water and nutrients to riparian vegetation, disperse seeds, and recruit woody debris to the steam channel where it provides preferred habitat structure for many fish and other stream-dependent species. Overbank flows that occasionally inundate the low floodplain areas adjacent to the stream also provide important ecological functions, including maintenance of wetlands, recharge of alluvial aquifers, and the exchange of nutrients, organic materials, sediments, and water between the stream and floodplain.

Hydrologic indices that depict the recurrence probability of various high flow events are well suited to describe these ecological process flows in an unregulated stream such as the Illinois River and its tributaries. For this reason, the annual peak flows are described at each gage site, as well as the frequency of recurrence for various high flow events measured at these gage stations. Review of these flow indices will be an important step in developing ISF recommendations that consider the ecological health of the Illinois River and its tributaries consistent with the state's ISF definition presented in the state's Comprehensive Water Plan (OWRB, 2012a) and the goals stated in the Illinois River Management Plan (OSRC, 1999). Average monthly flows are shown to describe general seasonal patterns, but these do not reveal the high year-to-year variability that is inherent in the Illinois River. Recurrence probability flows by month are useful in describing the variability in existing flows especially in the summer recreational period. For this purpose, monthly 25 percent, 50 percent (median), and 75 percent exceedance flows are depicted to represent wet, normal, and dry year conditions, respectively.

Hydrologic data are summarized for four U.S. Geological Survey (USGS) streamflow gages in the study area, two for the Illinois River and one each for Barren Fork Creek and Flint Creek (Table 2-2). Daily flow records are available for at least 60 years for these sites.

Table 2-2. USGS Stream Gage Information for the Illinois River Study Area

Gage Name	USGS Gage Number	County	Drainage Area (square mi)	Elevation (ft)	Period of Record
Illinois River near Watts	07195500	Adair	630	893.8	1956 - 2014
Illinois River near Tahlequah	07196500	Cherokee	950	664.1	1936 - 2014
Barren Fork Creek near Eldon	07197000	Cherokee	312	701.1	1948 - 2014
Flint Creek near Kansas	07196000	Delaware	116	854.6	1956 - 2014

Monthly average flows for these four gage sites are shown on Figure 2-2. Flows are highest in the months of March, April, and May consistent with regional precipitation patterns. The lowest flows occur in September and October.

Monthly median (50 percentile), 25 percentile, and 75 percentile flows for the four gage sites are shown on Figure 2-2. The differences between the dry condition flows (75 percent) and the wet condition flows (25 percent) for each month are indicative of the large differences between these year types.

Annual peak flows at each gage site are shown on Figure 2-4. Analysis of these data were used to determine peak flow recurrence probabilities for the 1.5-year, 2-year, 5-year, 10-year, 50-year, and 100-year events (Table 2-3). For example, the 5-year peak flow event for the Illinois River at Tahlequah is 38,100 cubic feet per second (cfs). This compares to the estimated flood flow conditions as defined by the National Weather Service (NWS) (2015) for this site: minor flooding at 9,008 cfs, moderate flooding

at 17,334 cfs, and major flooding at 33,652 cfs. The peak flow recurrence analysis indicates that at least moderate over-bank flooding occurs nearly every 2 years in the Illinois River.

Table 2-3. Peak Flow Recurrence Intervals Calculated using the Log -Pearson Type 3 Method

		Flow (cfs)			
Peak Flow Return Period (Year)	**Probability (%)**	**Illinois River near Tahlequah**	**Illinois River near Watts**	**Barren Fork Creek at Eldon**	**Flint Creek near Kansas**
1.5	67	14,112	13,912	11,099	2,520
2	50	19,535	18,868	16,250	3,917
5	20	38,289	33,947	29,836	10,234
10	10	53,919	45,185	37,328	16,450
25	4	77,173	60,390	44,675	26,772
50	2	96,925	72,233	48,789	36,274
100	1	118,643	84,362	51,962	47,307

Annual peak flow events that exceed the 1.5-year recurrence probability (14,112 cfs) in the Illinois River at Tahlequah can occur in any month (Table 2-4). However, most occur in the winter and spring months (December – June). The least likely months for these events to occur are August and September.

Table 2-4. Month of Occurrence for Annual Peak Flow Events Greater than 14,112 cfs for the Illinois River at Tahlequah, Oklahoma

Month	**Number of annual peak flow events >14,112 cfs**
January	4
February	6
March	5
April	9
May	10
June	4
July	3
August	1
September	1
October	3
November	4
December	6
Total Years	56

Notes:

USGS gage No. 07196500. Data for water years 1936 – 2015.
14,112 cfs corresponds to the 1.5-year recurrence flow at this gage site.
> = greater than

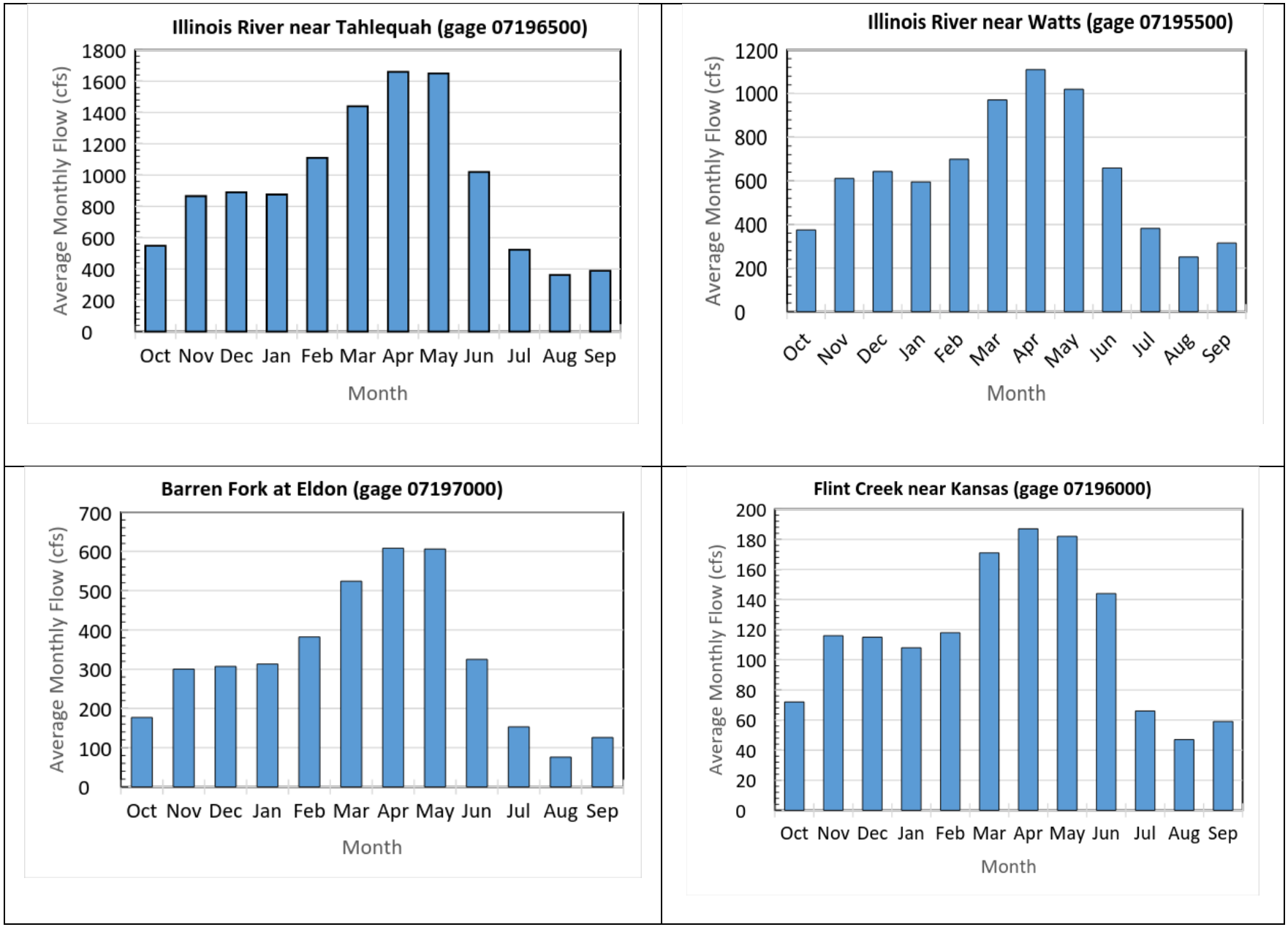


Figure 2-2. Monthly Average Flows (cfs) for the Illinois River (Two sites), Barren Fork Creek and Flint Creek, Oklahoma

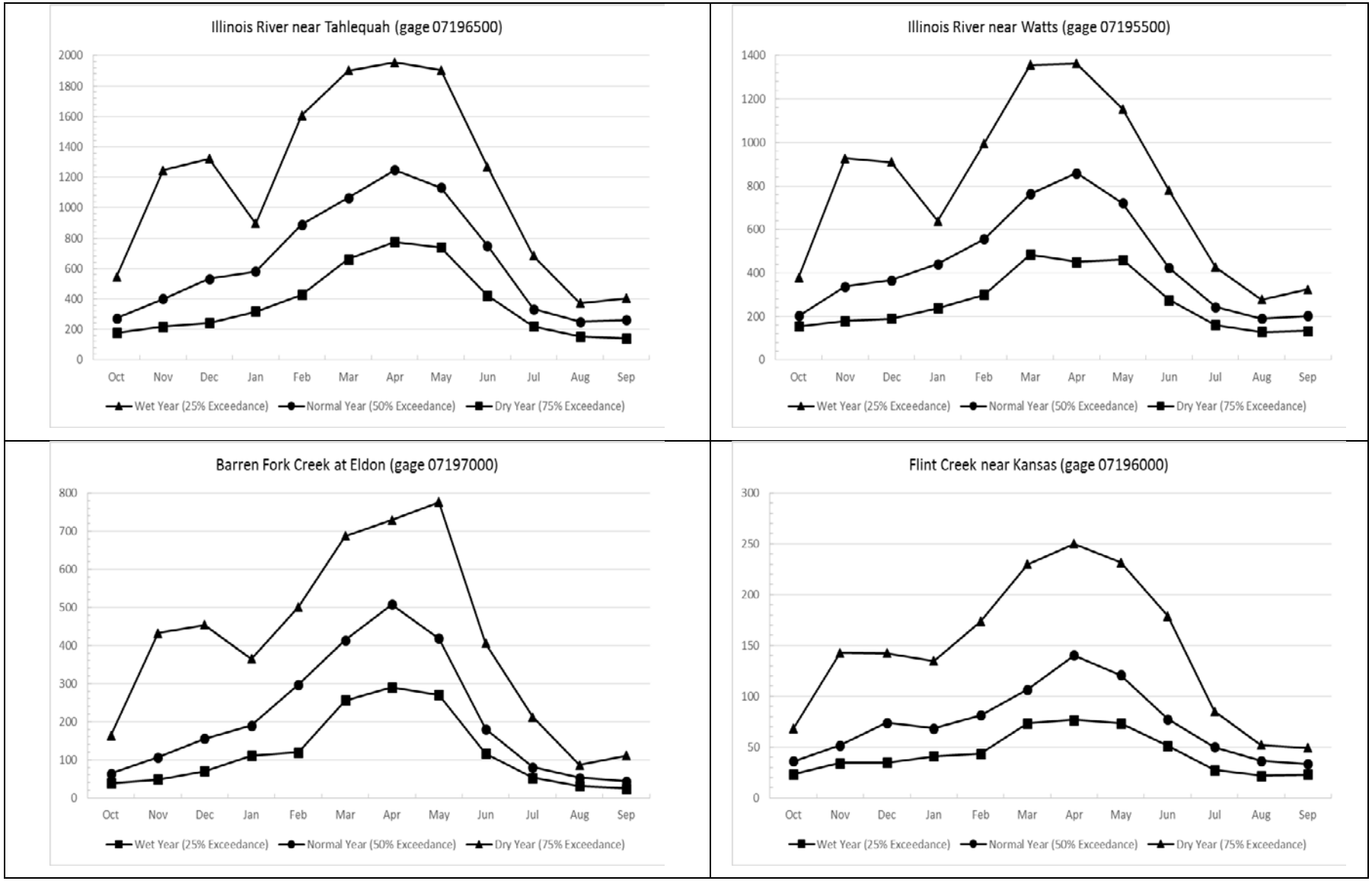


Figure 2-3. Monthly Exceedance Flows for Wet (25%), Normal (50%), and Dry (75%) Conditions

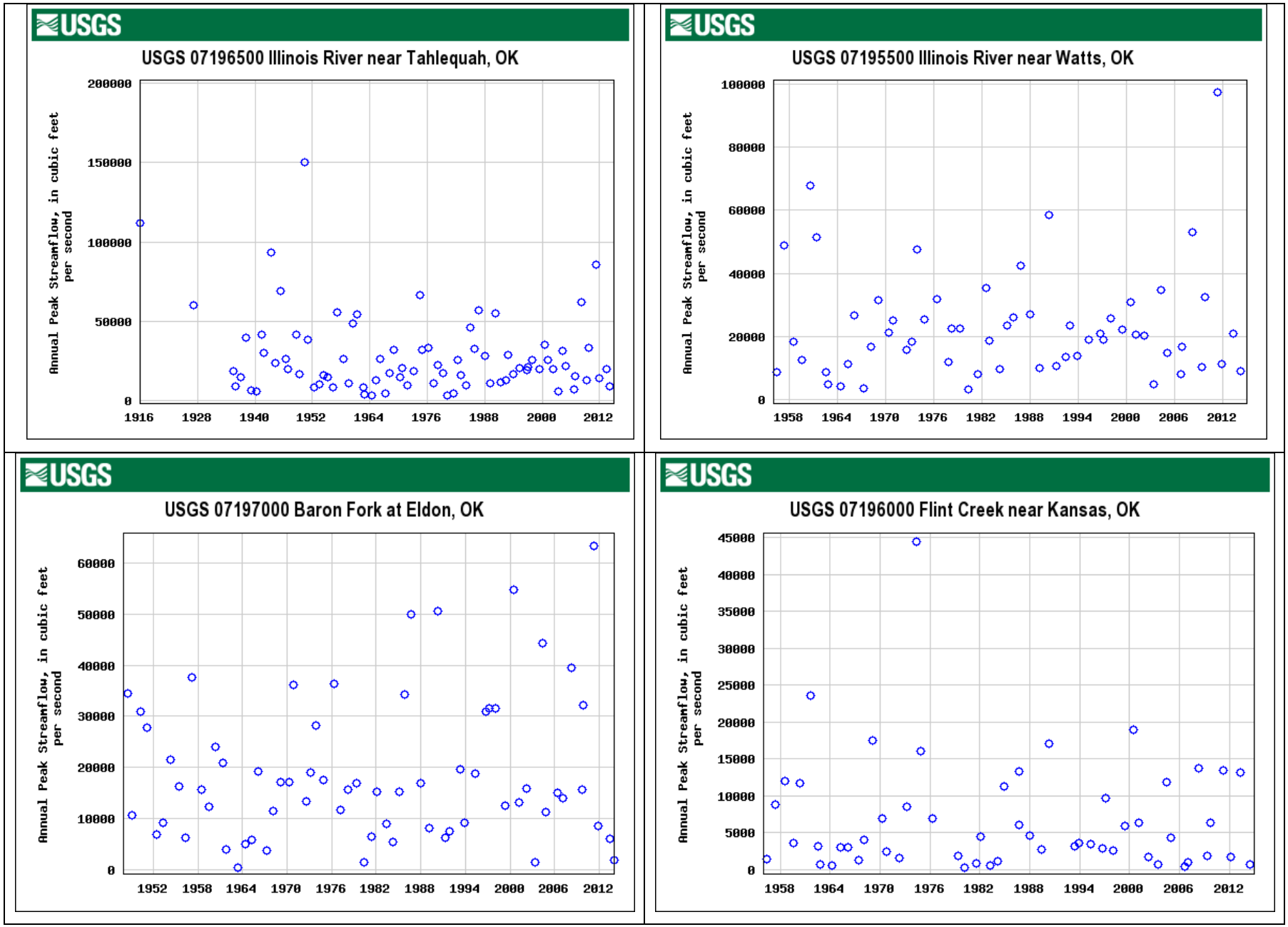


Figure 2-4. Annual Peak Flows for the Illinois River (2 sites), Barren Fork Creek and Flint Creek, Oklahoma

Trends in baseflow, total flow, and base-flow index (ratio of baseflow to total flow) were assessed for streams in Oklahoma, including the Illinois River and Barren Fork Creek, by the USGS (Esralew and Lewis, 2010). No significant trends in annual or seasonal total-flow volume were detected for either stream (since 1936 for the Illinois River and since 1948 for Barren Fork Creek). However, there was a significant upward trend in base-flow volume at both stations. This observed increase in baseflows was likely associated with the substantial wet period that occurred between 1985 and 2000 (Puls, 2015). Several alluvial groundwater wells in the basin that were monitored from the late 1970s to 2008 also showed an increasing trend in water levels, possible reflecting the increase in precipitation and stream baseflows during this period (Esralew and Lewis, 2010).

Potential climate-change effects on stream flows in Oklahoma to year 2099 were recently evaluated by the Oklahoma Water Survey at the University of Oklahoma (Hong, 2015). While air temperature increases are anticipated, no trends in precipitation are expected on a statewide average basis. However, on a regional basis, precipitation is expected to increase in the northeast corner of the state (Ozark region) by as much as 24 millimeters (mm)/month. This increase in precipitation would be expected to increase the river basin water yields, but it is uncertain how it would manifest in terms of runoff behavior such as flood or drought frequency.

2.3 Water Rights and Water Usage

2.3.1 Sources of Water

In Oklahoma, the upper Illinois River including its major tributaries, Flint and Barren Fork Creeks, are located in Basin 82, which is part of the OWRB's Lower Arkansas River Watershed Planning Region (LAWPR) as defined in the 2012 Oklahoma Comprehensive Water Plan (OWRB, 2012a). Basin 82 only includes the portion of the river basin (approximately 40 percent) that lies in Oklahoma.

The Illinois River basin yields considerable quantities of surface and groundwater. The historical streamflows of the Illinois River near the basin outlet, measured below Tenkiller Dam from 1954 to present, indicate an annual average discharge of 1,548 cfs (1,121,000 acre feet per year [AFY]). However, there are major year-to-year differences in water yield (Figure 2-5). The wettest year average is 3,199 cfs (2,317,000 AFY) and the driest year is only 208 cfs (150,725 AFY). Average monthly flows range from 2,682 cfs in April to 672 cfs in September (Figure 2-6). There is considerable variability in monthly flows between wet and dry years (see Hydrology section).

Mean annual discharges for Flint Creek at Kansas and Barren Fork Creek at Eldon are 116 cfs (83,900 AFY) and 324 cfs (234,700 AFY), respectively. The year-to-year variability and seasonal flow patterns for these tributary streams are similar to those of the Illinois River (see Hydrology section).

A majority of the Illinois River basin overlays two major groundwater aquifers, which are the Roubidoux major bedrock aquifer and the Boone minor bedrock aquifer (OWRB, 2012a). Water storage in these two aquifer basins are estimated to be 8,994,000 acre-feet (AF) and 9,044,000 AF, respectively. The alluvial aquifers along the stream corridors are estimated to store about 7,000 AF of water (OWRB, 2012a), but their yield would be expected to be much greater given their connectivity to the streams.

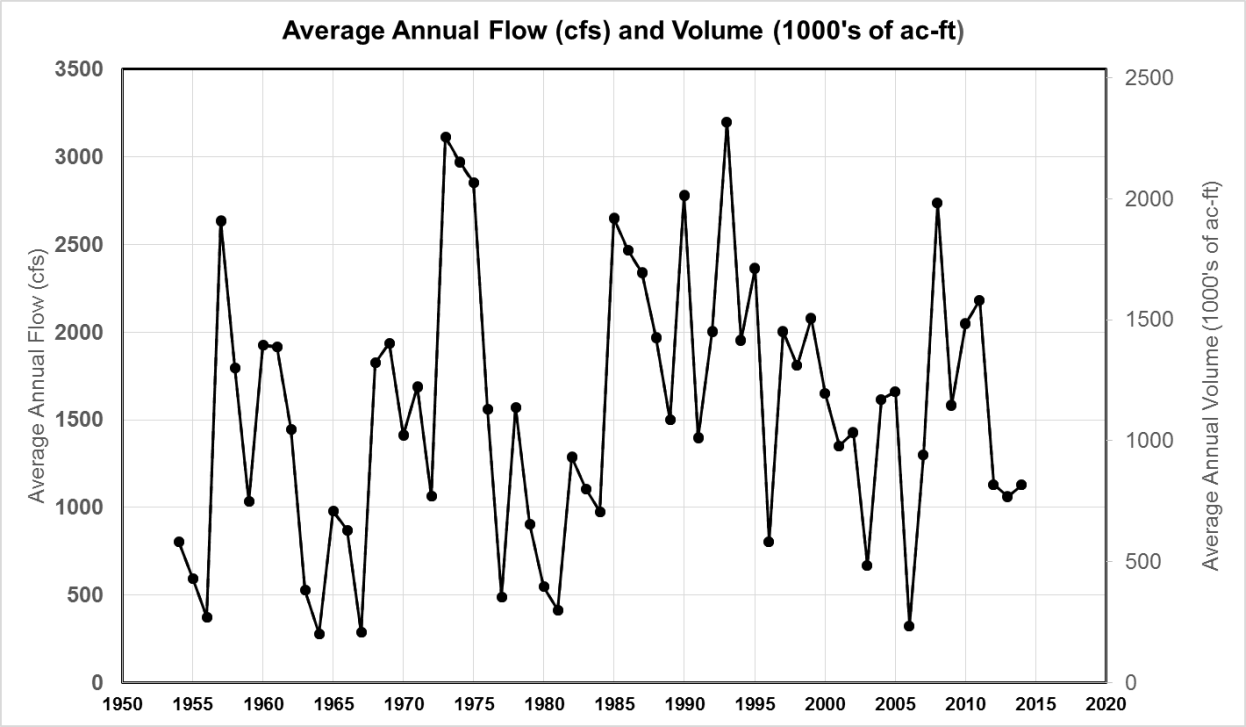


Figure 2-5. Average Annual Flows for the Illinois River near Gore, Oklahoma (USGS gage 0798000)

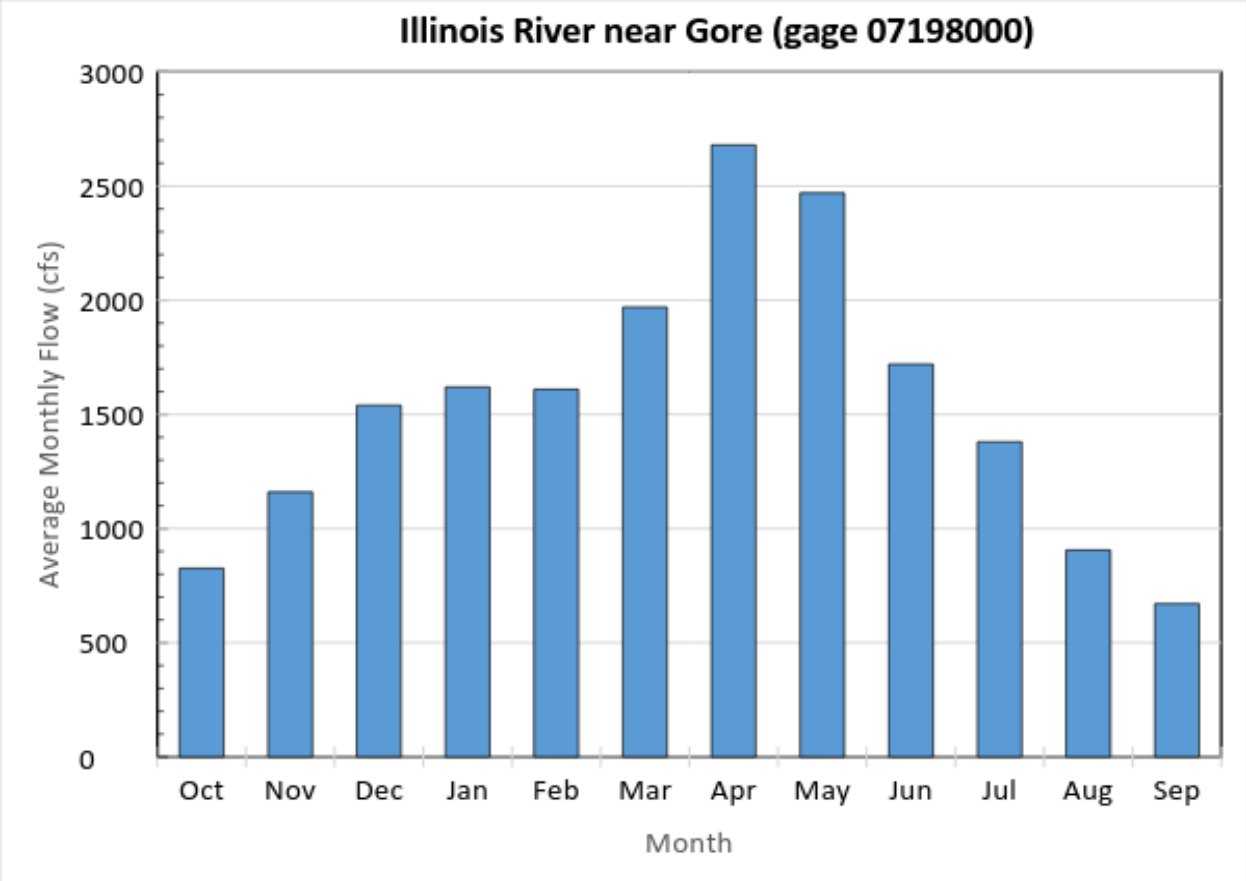


Figure 2-6. Average Monthly Flow (cfs) for the Illinois River near Gore, Oklahoma

2.3.2 Water Rights

OWRB-appropriated surface water rights for the upper Illinois River above the Barren Fork Creek confluence, including Flint and Barren Fork Creeks, total approximately 30,000 AF (Table 2-5). About 90 percent of the appropriations are for public water supply, with most of that for the City of Tahlequah and the nearby communities. Irrigation accounts for the second most appropriated surface water (2,160 AF) in the upper Illinois basin, but it equates to only about 7 percent of the total appropriation.

Table 2-5. Upper Illinois River Basin Surface Water Permits in Oklahoma.

	Flint Creek		Barren Fork Creek		Upper Illinois River	
Water-Use Sector	**Permits**	**Acre-Feet**	**Permits**	**Acre-Feet**	**Permits**	**Acre-Feet**
Irrigation	3	320	13	412	10	1,429
Agriculture	1	20	0	0	0	0
Public Supply	0	0	4	580	8	27,375
Rec, Fish, & Wildlife	0	0	1	22	0	0
Mining	0	0	1	320	0	0
Total	**4**	**340**	**19**	**1,334**	**18**	**28,804**

2.3.3 Water Usage

2.3.3.1 Oklahoma

The OWRB maintains records of surface water use for the upper Illinois River basin as reported by permitted water users. Average use by sector for the latest four years of available data (2010 through 2013) is shown in Table 2-6. Use of water for domestic purposes, generally defined as water for household purposes, for farm and domestic animals up to the normal grazing capacity of the land, and for the irrigation of land not exceeding a total of three acres in area (plus several other minor water uses not to exceed a total of five acre-feet annually), does not require a permit and is not included in the table. The total average use of 12,088 AFY (16.7 cfs equivalent) is approximately 40 percent of the appropriated amount (see Table 2-6). Similar to the appropriation, water is used primarily for public supply (89 percent) and irrigation (11 percent). Most of the public supply use is by the City of Tahlequah, which diverts water from the Illinois River approximately 6 mi above the Barren Fork Creek confluence. However, much of this water following treatment is discharged back to the river via Tahlequah Creek, which is located about 3 mi below the city's diversion.

The 2012 Oklahoma Comprehensive Water Plan (OWRB, 2012) estimates that total water demand in the Illinois River basin is expected to increase about 50 percent by 2060.

Table 2-6. Average Annual Surface Water Usage (acre-feet) in the Upper Illinois River Basin above Barren Fork Creek Confluence in Oklahoma, 2010-2013

Water Use	Flint Creek	Barren Fork Creek	Upper Illinois River	Total	Percent of Total
Irrigation	3.1	200.0	1,098.3	1,301.4	10.8
Agriculture	0	0	0	0	0.0
Public Supply	0	398.0	10,353.4	10,751.4	88.9
Recreation, Fish, and Wildlife	0	0	0	0	0

Table 2-6. Average Annual Surface Water Usage (acre-feet) in the Upper Illinois River Basin above Barren Fork Creek Confluence in Oklahoma, 2010-2013

Water Use	Flint Creek	Barren Fork Creek	Upper Illinois River	Total	Percent of Total
Commercial	0	0	0	0	0
Industrial	0	0	0	0	0
Mining	0	0	0	0	0
Other	0	35.1	0	35.1	0.3
Total	**3.1**	**633.1**	**11,451.7**	**12,087.9**	**100.0**

Source: OWRB

The total surface water demand in the Oklahoma portion of the watershed above (and including) Barren Fork Creek currently represents only about 1.3 percent of the available water in an average water year. However, most of this water use is for Tahlequah's public supply, which primarily affects only a 3 mile reach of river. Water usage as a proportion of available surface water increases during the summer when demand is about twice the annual average (OWRB, 2012a) and streamflows are at their seasonal low.

For groundwater, the majority of the Oklahoma water rights (3,900 AFY) for the Illinois River basin are from the Boone minor bedrock aquifer. Water extracted from this deep bedrock aquifer has little if any effect on streamflows. For the alluvial aquifers along basin streams, OWRB has issued less than 50 AFY of groundwater rights (OWRB, 2012a). However, domestic wells using the alluvial groundwater do not require a water right. It is estimated that 8 percent of the total basin demand currently comes from alluvial groundwater (OWRB, 2012a). This equates to approximately 1,050 AFY (1.5 cfs daily average flow). Some of this water returns to streams via groundwater seepage. Use of groundwater in the Oklahoma portion of the basin has a very minimal effect on surface water flows.

2.3.3.2 Arkansas

The quantity of surface water used in the Arkansas portion of the Illinois River basin is similar to that used in Oklahoma (Andrews, et al., 2010). Like in Oklahoma, the greatest proportion (86 percent) is used for public water supply especially in the upper Flint Creek and Osage Creek basins. A portion of this public supply water returns to the streams following treatment. Irrigation and livestock use constitute the second largest demand in Arkansas.

The Arkansas River Basin Compact, Arkansas-Oklahoma, gives the State of Arkansas the right to develop and use the waters of the Illinois River (only in Arkansas) sub-basin subject to the limitation that the annual yield shall not be depleted by more than 60 percent. However, municipal water needs for the major urban areas (Fayetteville, Springdale, Rogers) in the eastern portion of the Illinois River basin are provided by water imported from the White River basin to the east. In 2011 this imported amount averaged 37.1 cfs (26,870 AFY) (Arkansas River Compact Commission, 2013). Most of this water, following use and treatment, is discharged into tributaries to the Illinois River. According to the Compact Commission 2012 Annual Report for water year 2011, the total of surface water depletions and increases from inter-basin transfers into the Illinois Basin resulted in an average net increase in flow of 32.2 cfs (23,312 AFY). The effect of this increase is most pronounced in the summer when natural streamflows are lowest.

Preliminary discussions have occurred in Arkansas to consider reuse of water from the Fayetteville area wastewater treatment plants as a means to reduce phosphorous loading into the Illinois River. If implemented, such reuse would reduce the amount of water currently augmenting flows in the river. However, the water reuse concept appears to be a low-priority alternative because it has a low benefit-

to-cost ratio compared to other alternatives being considered to reduce phosphorous loading (Ammons, 2016, pers. comm.).

2.3.3.3 Summary

Current water use compared to the total available water in the Illinois River basin is minimal on average. Most of the water demand in Oklahoma is for public supply use, and most of that is located near the lower end of the designated Scenic River reach. In Arkansas, flow augmentation into the upper Illinois River system from water imported from the White River basin may more than compensate for the other surface withdrawals from the basin in both states, particularly in the summer when natural flows are lowest.

2.4 Water Quality

While much of the Illinois River and many of its tributaries are state-designated as "outstanding resource" waters, water quality problems in the basin have been recognized since at least the early 1980s. These problems were initially perceived as decreased water clarity and frequent algal blooms in Lake Tenkiller. Substantial water quality research since then has been undertaken by both Arkansas and Oklahoma. An excellent chronology of the historical water quality problems in the basin and descriptions of the various measures to address these problems is presented in the *Watershed Based Plan for the Illinois River Watershed* prepared by the OCC, Water Quality Division (2010). Numerous studies concluded that the watershed was being most impacted by excess nutrient loading, primarily phosphorous. Sources have included both point sources such as wastewater treatment plant discharges, and nonpoint sources such as those associated with the substantial poultry operations in the basin. Streambank erosion due to degraded riparian zones and cattle access to streams also contribute to increased phosphorous loading and increased sedimentation. Most of the human population (approximately 90 percent) in the basin as well as most cattle grazing and poultry operations occur in the Arkansas portion of the watershed (OCC, 2010).

Water quality at several locations on the Illinois River and its tributaries is listed as impaired under section 303d of the Clean Water Act (Oregon Department of Environmental Quality, 2012). Most of these impairments are for elevated total phosphorous or enterococcus bacteria (Table 2-7). Flint Creek and Lake Tenkiller are also listed for low dissolved oxygen levels, which are likely a consequence of occasional eutrophic conditions associated with the high phosphorous concentrations.

Table 2-7. Impaired Waters on the Oklahoma 303 (d) List for the Illinois River Basin

OKWBID	Name	Listed on 303(d) for Impairments
121700020020	Tenkiller Ferry Lake	*Dissolved Oxygen, TP*
121700020110	Chicken Creek	*Fish Bioassessment*
121700020220	Tenkiller Ferry Lake, Illinois River Arm	*Chlorophyll-a, TP*
121700030010	Illinois River – Tahlequah	*TP, Enterococcus*
121700030040	Tahlequah Creek (Town Branch)	*Eschericia coli*
121700030080	Illinois River	*TP, Lead, Eschericia coli*
121700030280	Illinois River – Chewey Bridge	*TP, Escherichia coli. Turbidity Enterococcus*
121700030290	Flint Creek	*TP, Dissolved Oxygen*
121700030350	Illinois River – Watts	*TP, Turbidity, Enterococcus Escherichia coli*
121700030370	Ballard Creek	*Enterococcus*

Table 2-7. Impaired Waters on the Oklahoma 303 (d) List for the Illinois River Basin

OKWBID	Name	Listed on 303(d) for Impairments
121700040010	Caney Creek	*Enterococcus*
121700050010	Illinois River - Barren Fork Creek	*TP, Enterococcus*
121700050090	Tyner Creek	*Enterococcus*
121700050120	Peacheater Creek	*Enterococcus*
121700050170	Illinois River - Barren Fork Creek	*Enterococcus*
121700060010	Flint Creek	*TP, Enterococcus*
121700060040	Battle Creek (Battle Branch)	*Enterococcus*
121700060080	Sager Creek	*Enterococcus*

Note:

TP = total phosphorus

Considerable efforts have already been made to address water quality problems in the Illinois River basin. These efforts include reductions in point source loading, primarily from wastewater treatment plants (WWTPs). The states of Arkansas and Oklahoma continue to work cooperatively to seek solutions to nonpoint-source pollution problems by funding programs, including riparian protection, watershed education, streambank stabilization, and alternative uses and more effective uses of poultry waste. Perhaps reflecting some successes in these programs, estimated total phosphorous loading since 1999 (from samples excluding targeted high flows) have demonstrated a significant downward trend in the Illinois River at Watts and Tahlequah and in Barren Fork Creek (Arkansas-Oklahoma Arkansas River Compact Commission, 2014). No significant trend in phosphorus loading has been observed for Flint Creek.

Streamflow has a substantial effect on surface water quality in the Illinois River basin. While greater volumes of water can act to dilute and assimilate wastes and contaminants, higher streamflows associated with storm events increase surface runoff and flushing of nutrients, bacteria, and sediments into the streams (Andrews, et al., 2010). Large streamflows from storms may scour and re-suspend streambed and riparian-source sediments containing phosphorous. Total phosphorous concentrations have been observed to generally increase with suspended sediment concentrations greater than 20 milligram(s) per liter (mg/L), which corresponds to streamflows of about 150 cfs in the Illinois River at both Watts and Tahlequah (Andrews, et al., 2010).

The lower portion of the Illinois River watershed, especially the Illinois River and Flint and Barren Fork Creeks in Oklahoma, supports a local economy strongly reliant on tourism. This tourism is highly dependent on aesthetically pleasing water and water quality that is safe for body contact. To minimize eutrophication of its Scenic Rivers, Oklahoma established a total phosphorous criterion of 0.037 mg/L as a 30-day geometric mean. It has been implemented as a 3-month rolling geometric mean (OWRB, 2014), with not more than 25 percent of the calculated means allowed to exceed the standard (OWRB, 2012b). The standard was derived from an analysis of nutrient values in undeveloped stream basins (Clark, et al., 2000), and compared favorably to median phosphorus concentrations seen in the Barren Fork Creek and Mountain Fork Rivers (0.045 mg/L and 0.028 mg/L, respectively). Between 2009 and 2013, more than 90 percent of the water samples from the Illinois River and Flint Creek exceeded the state criterion of 0.037 mg/L phosphorous. For the Barren Fork Creek only 32 percent of the samples exceeded the criterion, reflecting the better overall water quality in that basin.

Water temperature is an important water quality condition that has a major influence on fish communities. The water temperature regime shapes fish behavior, growth, condition, and distribution.

Regulated streams that experience alterations in streamflow or are influenced by reservoirs always have altered temperature regimes, which in turn affects the fish community. As a result, potential temperature regime change is a common issue of concern associated with any proposal to modify streamflows or construct reservoirs.

Water temperatures in the Illinois River basin generally follow the seasonal pattern with the highest temperatures observed in July or August. Temperatures measured by OWRB staff since 1998 concurrent with water quality sampling indicate the flowing daily maximums:

- Illinois River at Watts – 31.5 degrees Celsius (°C) (88.7°F)
- Illinois River at Tahlequah – 31.7°C (89.1°F)
- Barren Fork Creek at Eldon – 28.6°C (83.5°F)
- Flint Creek at Flint – 28.7°C (83.7°F)

Maximum temperatures are higher in the Illinois River compared to the tributaries, as expected based on stream length, as well as decreased canopy cover in the larger Illinois River. Water temperatures only slightly warmer than those noted above have been documented during conditions of extreme air temperature and drought (Musselman, 2014).

Temperature modeling has been done for the Illinois River (near Chewey), Barren Fork Creek, and Flint Creek to compare water temperatures under different flow conditions and then to compare these predicted temperatures to known “critical thermal maximum” (CTM) for fish species found in the Illinois River watershed (Musselman, 2014). The comparative baseline temperatures and flows were those observed during the 2012 summer drought. Several arbitrary flow deviations (e.g., 50 percent and 200 percent) from these baseline conditions were modeled. For the Illinois River a reduction in the drought-condition baseflow of 50 percent predicted an increase in maximum daily water temperature of 0.32°C, which in turn slightly increased the probability for some fish species being exposed to their associated CTM. Modeling results for Flint Creek followed a similar pattern as the Illinois River except maximum water temperatures were much cooler and the influence of flow changes was less. The probability of fish being exposed to their CTM in Flint Creek was minimal under all flow scenarios because of the lower baseline temperatures. Water temperature predictions for Barren Fork Creek differed from those for the Illinois River and Flint Creek in that reductions in baseflow actually reduced maximum water temperatures, albeit slightly. It should be noted that these temperature modeling studies were done at the stream-reach scale and thus did not reflect possible temperature changes at the smaller patch-scale, where fish often seek temperature refuge during periods of warm weather. The fact that Flint Creek is noticeably cooler than the Illinois River during the summer suggests that it could be an important thermal refuge area in the future.

2.5 Fisheries

The Illinois River watershed supports a highly diverse fish community. Based on fish collections by OWRB staff over the previous decade, more than 75 species of fish have been enumerated throughout the watershed. These species represent nearly half of the fish families found in Oklahoma. The banded sculpin, northern hog sucker, cardinal shiner, bigeye chub, rock bass, and stippled darter are found in Oklahoma only in Ozark streams in the northeastern part of the state. Throughout the watershed, the most commonly occurring fish (i.e., species occurring in the most collections), include both orangethroat and stippled darters, cardinal shiner, central stoneroller, longear and green sunfish, slender madtom, smallmouth bass, and banded sculpin. Of particular note is the fact that nearly all of the observed fish species in the Illinois River basin (except common carp) are native to the region.

Fish collection data for the Illinois River, Barren Fork Creek, and Flint Creek for the 10-year period from 2003 through 2012 are shown in Table 2-8. These collections were all made during low flow conditions using electrofishing gear per OWRB’s standardized protocol (OWRB, 2013). Each sampling event covered

a pre-established stream length based on the wetted stream width. Therefore, the surface area covered by the sampling differed among sites. Most fish were netted by field crew wading in or below the effective electrical field. Fish were collected from the deeper pools of the Illinois River via a boat mounted electrofisher. The fish collections summarized in Table 2-8 represent 14 single-day sampling events in the Illinois River, 7 in Flint Creek, and 15 in Barren Fork Creek.

For the overall sampling of the three streams, 68 species of fish were collected (Table 2-8). When comparing the 10 most common species in each stream (in bold in Table 2-8), six occurred in all three streams. These included cardinal shiner, central stoneroller, longear sunfish, Ozark minnow, orangethroat darter, and slender madtom. Fish that were collected only in the larger Illinois River include several suckers, such as bigmouth buffalo, river and shorthead redhorse, river carpsucker, as well as spotted gar, black crappie, channel catfish, freshwater drum, steelcolor and wedgespot shiners, and threadfin shad. Species collected only in Barren Fork Creek include the pallid chub, emerald shiner, shortnose gar, and spotted sucker. Those observed only in Flint Creek included the Ozark shiner, redfin shiner, mimic shiner, northern studfish, southern redbelly dace, and the white sucker. Many of the species which occurred only in Barren Fork Creek or Flint Creek are present in other systems.

Fish sampling using a combination of boat electrofishing, seining, gill nets, and hoop nets was conducted over several days in the Illinois River near No Head Hollow in 2014 by Oklahoma State University students and staff (unpublished data provided by Shannon Brewer, Oklahoma State University). While not presented here, the fish community data comprised of 27 species were generally consistent with those seen in the OWRB data.

Table 2-8. Mean Abundance (Numbers per Sampling Event) of Fish Species Collected in the Illinois River, Barren Fork Creek, and Flint Creek during 2003-2012

Common Species Name (alphabetic order)	Scientific Species Name	Illinois River	Flint Creek	Barren Fork Creek
Banded darter	*Etheostoma zonale*	14	2	9
Banded sculpin	*Cottus carolinae*	4	**34**	**26**
Bigeye chub	*Hybopsis amblops*	**17**	ND	8
Bigeye shiner	*Notropis boops*	6	1	11
Bigmouth Buffalo	*Ictiobus cyprinellus*	1	ND	ND
Black crappie	*Pomoxis nigromaculatus*	2	ND	ND
Black redhorse	*Moxostoma duquesnei*	9	1	**22**
Blackspotted topminnow	*Fundulus olivaceus*	2	3	2
Blackstripe topminnow	*Fundulus notatus*	1	3	2
Bluegill sunfish	*Lepomis macrochirus*	14	15	16
Bluntnose minnow	*Pimephales notatus*	13	ND	1
Brook silverside	*Labidesthes sicculus*	12	1	1
Cardinal shiner	*Luxilus cardinalis*	**127**	**142**	**104**
Central stoneroller	*Campostoma anomalum*	**82**	**136**	**130**
Channel catfish	*Ictalurus punctatus*	6	ND	ND
Chestnut lamprey	*Ichthyomyzon castaneus*	1	ND	2
Common carp	*Cyprinus carpio*	1	ND	1

Table 2-8. Mean Abundance (Numbers per Sampling Event) of Fish Species Collected in the Illinois River, Barren Fork Creek, and Flint Creek during 2003-2012

Common Species Name (alphabetic order)	Scientific Species Name	Illinois River	Flint Creek	Barren Fork Creek
Creek chub	*Semotilus atromaculatus*	2	12	2
Emerald shiner	*Notropis atherinoides*	ND	ND	1
Fantail darter	*Etheostoma flabellare*	1	1	ND
Flathead catfish	*Pylodictis olivaris*	2	ND	3
Freshwater drum	*Aplodinotus grunniens*	4	ND	ND
Gizzard shad	*Dorosoma cepedianum*	**37**	ND	2
Golden redhorse	*Moxostoma erythrurum*	4	9	5
Gravel chub	*Erimystax punctatus*	**16**	ND	ND
Green sunfish	*Lepomis cyanellus*	8	8	**23**
Greenside darter	*Etheostoma blennioides*	5	2	14
hybrid sunfish	*Lepomis*	3	ND	ND
Largemouth bass	*Micropterus salmoides*	6	9	2
Logperch	*Percina caprodes*	13	1	4
Longear sunfish	*Lepomis megalotis*	**67**	**49**	**58**
Longnose gar	*Lepisosteus osseus*	3	ND	2
Mimic shiner	*Notropis volucellus*	ND	4	ND
Mosquitofish	*Gambusia affinis*	9	2	2
Northern hog sucker	*Hypentelium nigricans*	7	12	11
Northern studfish	*Fundulus catenatus*	ND	3	ND
Orangebelly darter	*Etheostoma radiosum*	2	**136**	ND
Orangespotted sunfish	*Lepomis humilis*	2	ND	ND
Orangethroat darter	*Etheostoma spectabile*	**22**	**39**	**35**
Ozark minnow	*Notropis nubilus*	**38**	**20**	**77**
Ozark shiner	*Notropis ozarcanus*	ND	**59**	ND
Pallid chub/shiner	*Hybopsis amnis*	ND	ND	3
Redear sunfish	*Lepomis microlophus*	4	ND	2
Redfin shiner	*Lythrurus umbratilis*	ND	1	ND
Redspot chub	*Nocomis asper*	3	17	9
River carpsucker	*Carpiodes carpio*	1	ND	ND
River redhorse	*Moxostoma carinatum*	8	ND	ND
Rock bass	*Ambloplites rupestris*	8	16	7

Table 2-8. Mean Abundance (Numbers per Sampling Event) of Fish Species Collected in the Illinois River, Barren Fork Creek, and Flint Creek during 2003-2012

Common Species Name (alphabetic order)	Scientific Species Name	Illinois River	Flint Creek	Barren Fork Creek
Rosyface shiner	*Notropis rubellus*	13	4	1
Shadow bass	*Ambloplites ariommus*	1	**21**	6
Shorthead redhorse	*Moxostoma macrolepidotum*	1	ND	ND
Shortnose gar	*Lepisosteus platostomus*	ND	ND	1
Slender madtom	*Noturus exilis*	**35**	**19**	**31**
Smallmouth bass	*Micropterus dolomieui*	**17**	10	**17**
Smallmouth buffalo	*Ictiobus bubalus*	9	ND	1
Southern brook lamprey	*Ichthyomyzon gagei*	1	ND	2
Southern redbelly dace	*Phoxinus erythrogaster*	ND	4	ND
Spotted bass	*Micropterus punctulatus*	9	ND	2
Spotted gar	*Lepisosteus oculatus*	1	ND	ND
Spotted sucker	*Minytrema melanops*	ND	ND	1
Steelcolor shiner	*Cyprinella whipplei*	4	ND	ND
Stippled darter	*Etheostoma punctulatum*	4	13	8
Threadfin shad	*Dorosoma petenense*	6	ND	ND
Warmouth sunfish	*Lepomis gulosus*	7	2	3
Wedgespot shiner	*Notropis greenei*	7	ND	ND
White crappie	*Pomoxis annularis*	2	6	ND
White sucker	*Catostomus commersoni*	ND	2	ND
Yellow bullhead	*Ameiurus natalis*	1	5	3
Number of Sampling Events		14	7	15
Average Number of Fish/Event		644	587	584
Total Number of Species		58	39	45
Average Species Richness		34	22	21

Notes:

Numbers in **bold** are the 10 most commonly observed species in each stream.
D = species not collected on the waterbody.

Total species richness (number of species) appeared to increase with watershed size. The number of species collected in the Illinois River, Barren Fork Creek, and Flint Creek were 58, 45, and 39, respectively (Table 2-8). The lower number of species observed in Flint Creek may be an artifact of fewer sampling events. When the average number of species captured per sampling event was compared, Flint Creek and Barren Fork Creek were nearly the same (21 Barren Fork Creek, 22 Flint Creek). Average species richness for the Illinois River was 34. These differences in species richness are consistent with stream ecosystem concepts whereby nutrient cycling, physical conditions, habitat diversity, and associated

biotic responses tend to change progressively as the streamflows from its headwaters to its mouth (Vannote, et al., 1980).

Smallmouth bass is the most sought-after game fish in the upper Illinois River and tributaries (see Recreation section) and is a valuable recreational and ecological asset to streams throughout the southeast United States, including Oklahoma. Catch and harvest rates in Barren Fork Creek, Oklahoma are some of the highest reported in the literature (Martin and Fisher, 2008). Ecologically, smallmouth bass is noted for its role as a top predator within Ozark streams (Pflieger, 1997; Brewer and Orth, 2015). Two subspecies and an Ouachita lineage of smallmouth bass are recognized, including the Neosho subspecies (see Brewer and Orth, 2015 for distributions; and Stark and Echellee, 1998 for genetic descriptions) that, within Oklahoma, is restricted to the northeast part of the state (Brewer and Long, 2015). The high conservation value of this unique species within Oklahoma is recognized by management agencies within Oklahoma (Ahlert, et al., 1995; Malloy, et al., 2000; Boxrucker, et al., 2004).

2.6 Wildlife

The wildlife within the Illinois River corridor is quite diverse. Typical of the Ozark region, the animals in this area are associated with the eastern deciduous forest. Climate, terrain, and the abundance of water combine to support the diversity of animal species.

Common mammals in the Illinois River corridor include the white-tailed deer, bobcat, raccoon, opossum, striped skunk, muskrat, eastern cotton tail, fox squirrel, gray squirrel, southern flying squirrel, red and gray fox, and coyotes (OSRC, 1999). A large number of bats of several species are found in the basin because of the abundant habitat provided by nearby limestone caves and sinks. The most common bat species include the big brown bat, red bat, tri-colored bat, and the evening bat. Federally listed bats that have been observed in the Illinois River basin are the endangered gray bat, the Ozark big-eared bat, and the threatened northern long-eared bat. The gray bat feeds on small insects over forested areas and wetlands and their decline in numbers has been attributed to the clearing of forests along streams and lakes as well as human disturbance of their breeding and hibernating caves (Oklahoma Department of Wildlife Conservation [ODWC], 2016a). The Ozark big-eared bat forages above the forest canopy and in forest clearings. They are associated with the oak-hickory forest types (ODWC, 2016b). Human disturbance of caves is believed to be the primary reason for their decline. The northern long-eared bat feeds on insects caught in the forest understory or picked from the surface of waterbodies. It is threatened primarily by the continued spread of a disease known as white-nose syndrome (U.S. Fish and Wildlife Service [USFWS], 2015a).

A great number and variety of birds are found within the Illinois River corridor. Those most commonly seen on or near the river include the great and little blue heron, bald eagle, osprey, killdeer, belted kingfisher, and many common species of waterfowl. Other bird species commonly seen in the corridor include turkey vulture, red-tailed hawk, American kestrel, red-bellied and red-headed woodpecker, and cliff swallow. Songbirds include the Carolina chickadee, tufted titmouse, white breasted nuthatch, Bewick’s wren, mockingbird, robin, wood thrush, red-winged blackbird, and northern oriole. The primary game birds found in the Illinois River and tributary corridors are the turkey, bobwhite quail, and mourning dove.

The numerous limestone caves and sinks as well as wetlands in the Illinois River watershed provide good habitat for many species of amphibians. Salamander species include smallmouth, tiger, slimy, cave, ringed, Oklahoma dwarf, and Ozark blind salamander. Other amphibians include the Louisiana waterdog, central newt, bull frog, green frog, gray tree frog, southern leopard frog, and Blanchard’s cricket frog. Toad species include the American, Hunter’s spadefoot, and the eastern narrow-mouthed toads.

Aquatic species found in the streams of the Illinois River watershed include as many as 72 species of fish. These are discussed in the Fisheries section of this report. None of these fish is listed as federally or

state endangered or threatened species. The watershed also provides habitat for certain nonfish aquatic species that are both dependent on high water quality and are of special conservation status. One notable group consists of pearly freshwater mussels, also known as unionid mussels or simply "mussels." This group is of special interest, in part because of significant ecosystem services they provide, but also because their sensitivity to environmental changes makes them good indicators of ecological health (Strayer et al., 2004). Environmental factors that are important in determining mussel occurrence include various components of streamflow. Studies of mussels of the Illinois River and its tributaries have found a moderately rich assortment of species (approximately 25; Isely, 1924, Vaughn, 1998, Mather, 2005). One freshwater mussel, the Neosho Mucket, is both state-listed and federally-listed as an "endangered" species. The Illinois River population (upstream of Tenkiller Ferry Reservoir) supports 1 of only 9 surviving populations of the Neosho Mucket (ODWC, 2016c; USFWS, 2015b). The USFWS recently included only the Illinois River upstream of the Barren Fork Creek confluence within its critical habitat designation area (USFWS, 2015b). Reasons for its decline throughout its historic range are believed to include past pesticide use, water pollution, and construction of reservoirs. The Rabbitsfoot mussel is also a federally-listed "threatened' species that has been observed in the Illinois River. The Illinois River upstream of Tenkiller Ferry Reservoir supports 1 of only 28 surviving populations of the Rabbitsfoot. However, its recent critical habitat listing did not include the Illinois River or its tributaries (USFWS, 2015b). Reasons for the decline of the Rabbitsfoot include construction of reservoirs and navigation projects, landscape modifications, and water pollution.

2.7 Recreation

The Illinois River and its two major tributaries, Barren Fork and Flint Creeks, are popular destinations for canoeists, kayakers, and fishermen. The nearby towns, including the city of Tahlequah, rely strongly on tourism to support the local economy. The amount of tourism and economic effect of tourism in the basin is highly dependent on aesthetically pleasing water and water quality that is safe for primary body contact recreation. Each year more than 150,000 persons float the Illinois River by canoe, raft, or kayak. Monthly visitor counts of floaters in the Illinois River watershed between 2003 and 2008, as reported by commercial and private float operators, are summarized in Table 2-9. In addition, a total estimated 350,000 visitors enjoy equestrian tours, mountain biking, road biking, swimming, fishing, camping, hiking, nature watching, and hunting opportunities. Annual visitation is approximately 400,000 primarily from Oklahoma, Arkansas, Kansas, Missouri and Texas. Recreational boaters spend an average of about $60 per float trip per person on gas, food, lodging, and other amenities.

The Illinois River, Barren Fork Creek, and Flint Creek are considered free-flowing streams (refer to Hydrology section for additional information). Both the Illinois River Management Plan (1999) and the Oklahoma Scenic Rivers Act of 1970 (OSRA) aim to preserve the free-flowing nature of the river to protect the unique natural scenic beauty, water conservation, fish, wildlife, and outdoor recreational values. The Illinois River Management Plan set a specific recreational goal to "Provide the opportunity for a high-quality recreation experience while protecting the river's outstanding resources and recognizing the needs of river outfitters and individual users."

The Illinois River offers swift to gentle currents for recreational boaters that support Class I and Class II waters throughout most of the year. The Illinois River has a sufficient volume of water to support floating year-round except under drought conditions. According to the OSRC (Fite, pers. comm.), Commercial Flotation Device Operators (CFDO) will float canoe and kayak customers at flows as low as 150 cfs (Tahlequah gage) but with the expectation that boats will need to be dragged through some of the shallow riffle areas (Table 2-10). Rafts require higher flows of at least 250 cfs. Flows greater than about 1,200 cfs can pose safety risks to inexperienced boaters, although knowledgeable rafters sometimes float the river at flows up to about 4,000 cfs. Overall, a flow range from about 400 cfs to 1,200 cfs offers scenic and easy boating and seems to be the optimal range enjoyed. When flows start exceeding 1,600–1,800 cfs, the river becomes turbid, which poses safety concerns (unable to see

submerged snags) and is aesthetically less enjoyable. The peak floating season is summer (June through August). Barren Fork and Flint Creeks are floatable from the early spring to early summer.

The Illinois River is navigable for about 65 mi from Twin Falls at the Watts, Oklahoma Public Access Area where US Highway 59 crosses the river down to Carter's Landing at the headwaters of Tenkiller Ferry Reservoir. Floating trips of various lengths are available, ranging from 6- to 60-mi-long stretches. The upper river in Oklahoma includes 15 commercial rental operations. Most of them are located along State Highway 10. In recent years, the use of canoes has declined in popularity while the use of rafts and kayaks has increased exponentially (Fite, pers. comm.). Rafting is currently the most popular means of floating the river. No airboats, hovercrafts, or jet-driven watercraft are allowed on the river except for purposes of search and rescue, navigational hazard removal, and law enforcement.

Table 2-9. Illinois River Monthly Float Users, 2003-2008, as Reported by Commercial and Private Float Operators in Oklahoma.

	2003		2004		2005		2006		2007		2008	
	Commercial	Private	Commercial	Private	Commercial	Private	Commercial	Private	Commercial	Private	Commercial	Private
January	0	162	0	0	2	0	0	0	0	46	0	0
February	0	0	0	200	8	0	2	5	0	0	0	0
March	1	10	184	60	167	17	268	9	37	20	0	0
April	161	22	338	65	611	86	644	193	334	121	0	0
May	4,109	224	14,549	690	16,021	568	10,653	481	14,294	505	0	0
June	9,194	462	23,235	550	28,613	795	28,617	871	23,283	824	23,461	585
July	27,760	1,028	33,174	668	48,945	1,614	41,260	1,128	35,265	1,181	38,240	942
August	19,539	1,185	26,149	749	23,846	929	18,531	729	27,963	603	31,214	626
September	7,493	233	11,875	408	9,646	312	7,037	414	11,249	753	4,641	277
October	2,814	45	402	43	379	23	477	164	620	49	576	232
November	425	10	6	23	0	2	18	90	0	0	8	18
December	38	2	0	3	0	4	0	65	0	182	0	31
TOTAL	**71,534**	**3,383**	**109,912**	**3,459**	**128,238**	**4,350**	**107,507**	**4,149**	**113,045**	**4,284**	**98,140**	**2,711**

Source: OSRC

Table 2-10. Streamflow Considerations for Recreational Boating/Floating Activity on the Illinois River Based at the USGS Tahlequah Gage

Activity	Flow (cfs)
Minimum Flow for Canoe and Kayak Passage	150
Minimum Flow for Raft Passage	250
Optimal Flow Range for All Flotation Devise Use	400 – 1,200
Maximum Safe Flow for General Public	1,200
Maximum Safe Flow for Experienced Users	4,000

Source: Ed Fite, OSRC

Each time a rented flotation device is launched on the Illinois River a user fee is collected. People using private flotation devices such as canoes, kayaks, rafts and inner tubes, must also purchase a user fee wristband for each separate trip.

The OSRC maintains eight public access areas with convenient river access for swimming, fishing, boating, and primitive camping. Public access areas are available to campers and recreationists,

according to the designating signage. A $7.00 to $12.00 daily camping fee is collected by OSRC Park Rangers (OSRC Floaters Guide).

Outstanding fishing opportunities are available in the upper Illinois River, including its major tributaries, Barren Fork and Flint Creeks. More than 60 species of fish occur in these waters but most are nongame species. Major game fish include a variety of bass species as well as sunfish and catfish. Smallmouth bass is the most sought-after sport fish in the upper Illinois River and tributaries. Guides and anglers fish year-round, but the majority of the fishing pressure is from mid-March through October, depending on water and weather conditions. Gig fishermen target sucker species in the upper reaches of the Illinois River from December 1 through March 1, the legal season.

State regulations for bass species in the Illinois river system allow a catch possession of six combined per day, of which only one may be a smallmouth bass, and all must be 14-inches or longer. These restrictive regulations help maintain healthy bass populations and a quality fishing experience. Adding to this experience is the scenic nature of the stream and its natural unregulated streamflow regime in the designated scenic reach. Angler access to the Illinois River is good with multiple public access areas established along the stream. Fishing from canoes and rafts is popular throughout the Illinois River. Most fishing access to Barren Fork and Flint Creeks is via private land and clubs.

Angler survey data (creel checks) are available only for the Barren Fork Creek (Martin and Fisher, 2008). The smallmouth bass fishery in Barren Fork Creek was characterized by relatively high catch and harvest rates, and the yield was among the highest reported in the literature for smallmouth bass stream fisheries in the country. Approximately 80 percent of the bass caught by anglers in the Barren Fork Creek were released. These high angler catch rates are consistent with the biological studies of the stream that found that smallmouth bass were abundant and exhibited good year-class success and low annual mortality (Balkenbush and Fisher, 1999). The authors attributed the health of Barren Fork Creek smallmouth bass population to the relatively stable baseflow regime and nutrient enrichment from agricultural activities in the basin.

2.8 Riparian Corridor

During the first stakeholder meeting held in Tahlequah on January 22, 2015, the topic of side channels and other off-channel waters (secondary channels) along the Illinois River was raised regarding their importance for fish and wildlife resources and associated ecological values. The existence of extensive side channels is not obvious to those viewing the river from the road or from the main river channel. However, review of the aerial photographs available on Google Earth reveal numerous secondary stream channels and other associated water features along the river's riparian corridor.

Streamflows that create and maintain these secondary channels are critically important for maintaining the ecological processes associated with them. Terms commonly used to describe these flows include channel formation, channel maintenance, habitat maintenance, dominant discharge, effective discharge, flushing flow, bankfull flow, and riparian maintenance. If the frequency of these bankfull flow events is diminished, the entrances to these secondary channels will tend to close up over time via encroachment of perennial vegetation, thus diminishing or eliminating the ecological values associated with these channels.

As a means to quantify these secondary channels, the aerial photographs highlight those channels that appeared to be active at the time the photographs were made, which seemed to correspond to a typical summer baseflow. Many of these channels had only intermittent flows or backwaters at their downstream end at the time photographed. Results of this mapping effort are appended to this report. An example map for a 4 mile reach of the river near Tahlequah is shown on Figure 2-7. The maps in

Appendix A are sequenced from downstream to upstream starting at Tahlequah, and there is some overlap in coverage between maps.

For the 53 mile reach of the Illinois River from the Highway 10 bridge in Tahlequah upstream to the Arkansas border, a total of 31.4 miles of secondary channels was identified (Table 2-11). The ratio of secondary-to-main channel length is nearly 60 percent. The ratio tends to decrease somewhat moving upstream. While comparable data were not readily available for other streams, it is clear that the extent of secondary channels and ponds along the Illinois River is impressive, especially when considering the importance of these features in supporting fish, wildlife, water quality, and other ecological processes.

Table 2-11. Ratio of Secondary Channel Length to the Main Channel Length in the Illinois River between Watts and Tahlequah, Oklahoma

River Reach	Watts to Flint Creek	Flint Creek to Peavine	Peavine to Tahlequah	Total
River Reach Length (mi)	13.3	16.3	22.9	53.0
Secondary Channel Length (mi)	7.1	7.0	17.3	31.4
Ratio of secondary channel to main channel length	**53.1 %**	**42.9%**	**75.6%**	**59.2%**

Although not delineated, it is apparent on the aerial photographs that these secondary channels consist of a wide variety of habitat types, including flowing water, intermittent pools, backwaters connected to the river, backwaters disconnected from the river, and old oxbow ponds. These different channel types represent the evolution over time of their formation during the stream's natural meander process.

The flow of the main Illinois River at which water begins to enter the side channels differs for each side channel. However, most of the secondary channels on the Illinois River appear to contain water (standing or flowing) even during the summer baseflow conditions. In some cases, water appears only in the lower portions of the channels via emergence of interstitial flow from the main river. While some secondary channels are fully flowing even when river is at baseflow (active side channels), others are disconnected except during flood events and even then may only experience inundation (rather than significant channel flow). However, based on principals of fluvial geomorphology and natural stream processes, it is reasonable to assume that most of these secondary channels contain flowing water when the main river achieves bankfull conditions (Dunne and Leopold, 1978).

These riparian areas and associated water features provide numerous ecological values (Annear, et al., 2004). Biologically, they support refuge habitat for fish during floods and drought, preferred habitat for some fish and macroinvertebrates, and important habitat for frogs, salamanders, water-dependent birds, some bat species, otter, mink, muskrat, beaver, and many other wetland-dependent species.

In addition to numerous biological benefits, these channels provide hydrological benefits during flood events. If these channels were allowed to close up, they would not be able to convey some of the flood water from the main channel. The greater energy from increased flow in the main channel would alter the dynamics of sediment movement and deposition, typically leading to greater bank erosion and increased lateral migration. Maintaining the healthy riparian areas associated with these secondary channels can further reduce flood water velocities by providing increased resistance or roughness. Riparian areas also collect debris and thus help prevent flood debris from being deposited on crop fields in the floodplain.

These secondary channels and ponds also provide water quality benefits. As water enters these areas it tends to infiltrate into the gravel and then emerge downstream in the lower portions of these side channels, backwaters, and main river channel. This process produces areas of clear water with attenuated temperature fluctuations. This in turn provides preferred or important refuge habitat for many fish and wildlife species.

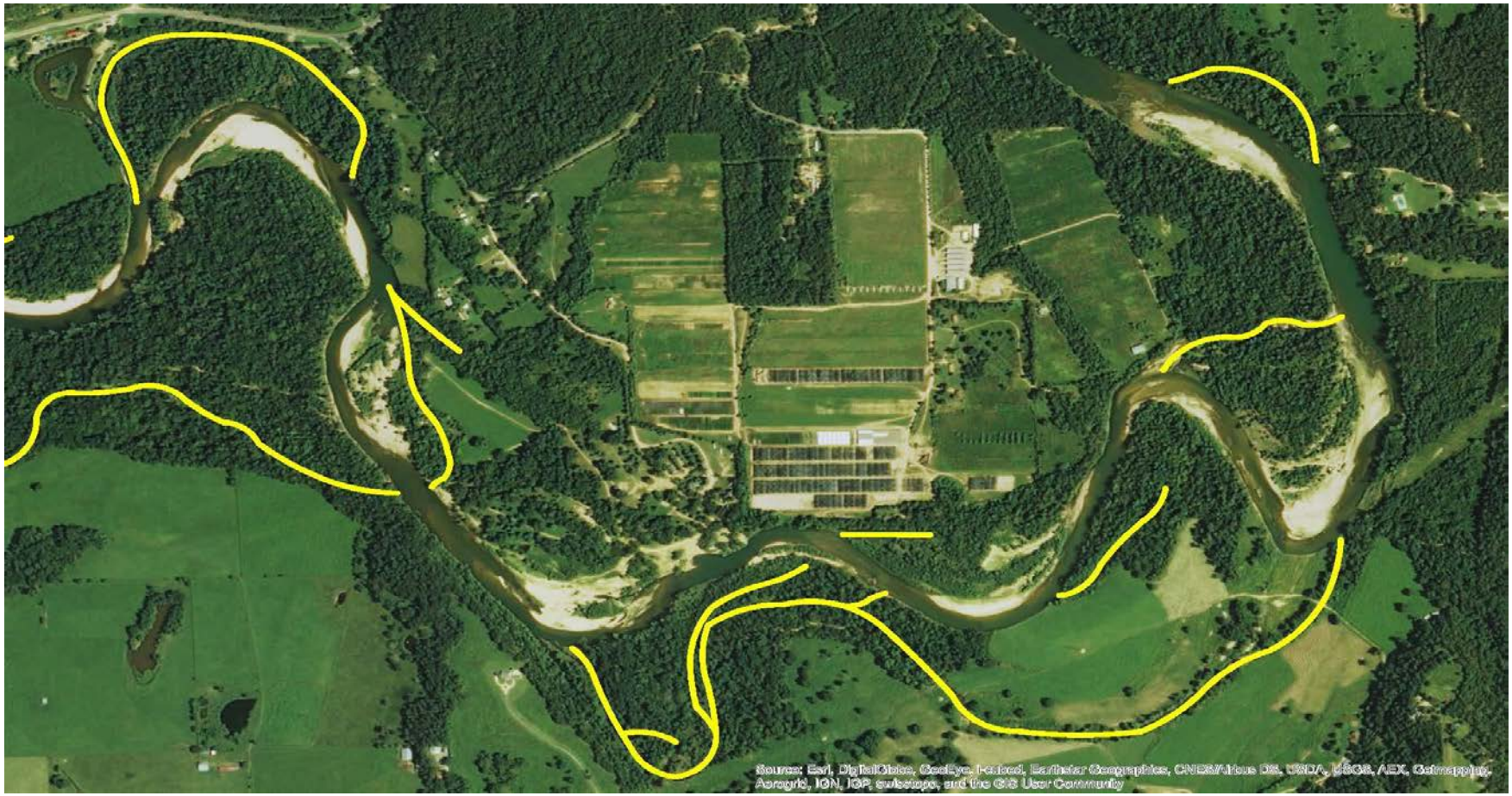


Figure 2-7. Highlighted Secondary Channels along a 4-mile Reach of the Illinois River near Tahlequah, Oklahoma

SECTION 3

Fish Habitat Modeling

3.1 PHABSIM Study Objectives

The Physical Habitat Simulation (PHABSIM) modeling system was used to determine the incremental relationship between streamflow and an index of habitat suitability, referred to as weighted usable area (WUA) or area weighted suitability (AWS), for life stages of selected fish species and groupings (guilds) in the study area.

PHABSIM relies on collection of empirical hydraulic data, which are used in the calibration and computer simulation models, plus incorporation of fish species/life stage suitability criteria (also referred to as habitat suitability criteria [HSC]) for the major habitat component variables of velocity, depth, and substrate/cover. The AWS index can be interpreted in the context of stream hydrology and species life history to evaluate impacts, and serves as a partial basis for determining alternatives and mitigation. Since AWS does not represent actual physical area, it is more accurately described as an index that can be used comparatively to assess flow relationships with physical habitat.

The PHABSIM study objectives follow:

- Verify and/or develop habitat index-flow relationships (AWS) for selected life stages of target fish species or groupings of fish species (guilds)
- Provide a calibrated hydraulic data file for potential application to habitat suitability indices for subsequently identified fish species, habitat guilds, or fish passage needs
- Provide additional physical habitat information for application to other studies (such as riparian vegetation, water quality, recreational boating, or substrate particle incipient motion analyses) that may be part of the ISF assessment

3.2 Study Area and Reach Boundaries

The geographic scope of the study area includes the state-designated “scenic” section of the Illinois River, including Barren Fork and Flint Creeks, which are also designated as Scenic (Figure 3-1). The Illinois River study area extends from the Arkansas state boundary downstream to the confluence with Barren Fork Creek. The 2-mi section of the Illinois River from Barren Fork Creek to Tenkiller Ferry Reservoir, and the 9-mi section below Tenkiller Dam to the Arkansas River confluence are not part the study area. Flint Creek is included upstream to the Arkansas state line. The Barren Fork Creek study area (scenic reach) extends from its confluence with the Illinois River upstream to the Highway 59 Bridge, which is approximately 7 mi from the Arkansas border. The upper Illinois River and these sections of the two tributaries were designated as scenic rivers per the OSRA of 1970 (82.0 Sections 1451-1471).

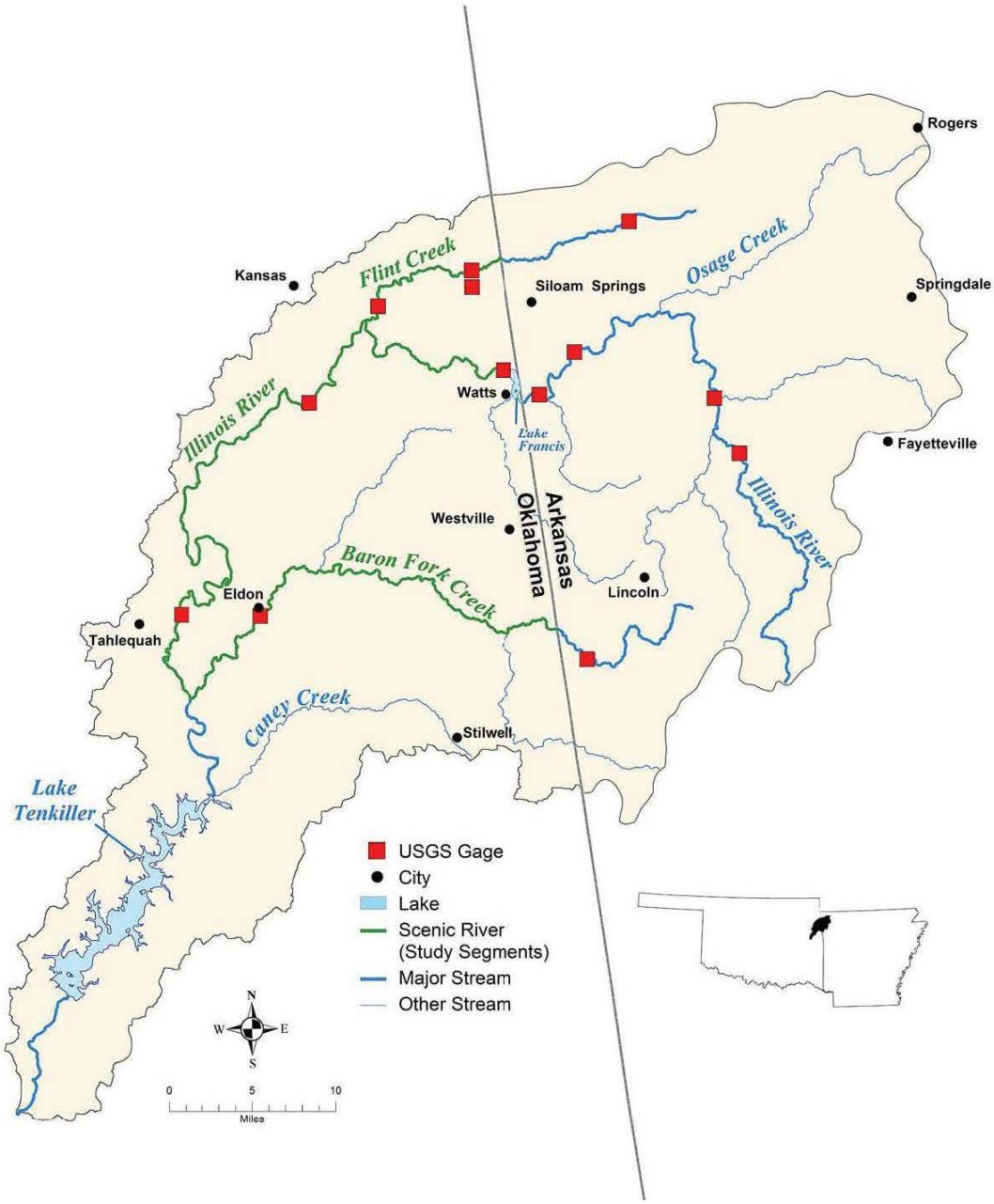


Figure 3-1. Illinois River Study Area

The gradient of the 63 mile study area along the Illinois River is consistent at 4.5 feet per mile (ft/mi). Barren Fork Creek has a gradient of approximately 8 ft/mi. The gradient in the lower 10 mi of Flint Creek is constant at about 10 ft/mi but increases to 16 ft/mi in the upper 4 mi of stream nearest the Arkansas border.

Man-made features and structures that significantly affect flows, such as diversion dams, storage dams, and return flow points, can also constitute reach boundaries, and operation of these facilities is frequently the focus of an ISF study. No major flow-modification structures occur in the Illinois River study area. The reservoir behind Frances Dam, which spans the Illinois River near Watts, Oklahoma, by the Arkansas border, provides no active water storage, although the town of Siloam Springs in northwestern Arkansas withdraws some water from the reservoir for municipal supply.

The Illinois River study area was divided into two reaches based on these considerations:

1. Lower reach from the confluence with Barren Fork Creek upstream to the confluence with Flint Creek
2. Upper reach from the Flint Creek confluence upstream to the Oklahoma-Arkansas state boundary near Watts

The lower reach of the Illinois River is 48 mile long, which is longer than a typical single reach for a PHABSIM application. Prior to field data collection, it was decided to focus the study on a 21 mile section in the lower reach because this area best represents the entire reach, and includes the Illinois River section most used for recreational boating.

The study area for Flint Creek was limited to the lower 2 miles of the stream. The intent of this study is to recommend flows that could potentially be used as guidelines in protecting the stream resources; therefore, it makes sense that those flows be quantified toward the lower end of the reaches assuming that is where flow compliance would be measured.

3.3 Methods

3.3.1 Habitat Mapping

Habitat mapping provides an overall instream mesohabitat (such as pools, runs, glides, and riffles) representation of each stream reach in the study area. Results of habitat mapping aids in transect selection were used for habitat weighting in reaches where fish habitat modeling was completed. The following habitat types and definitions were used for mapping in the study area:

- **Pool** – Scour areas within the stream channel with column velocities usually less than 1 foot per second (fps). Pools also generally lack surface agitation and commonly contain eddies or other slow water areas along one or both banks.
- **Run** – Swift flow areas with little surface agitation and no major flow obstructions. Runs may occur at heads or tails of pools. Between hydraulic controls, they may appear as flooded riffles and might contain some waves. Mean column velocities generally exceed 1 fps.
- **Glide** – Generally wide uniform channels with no flow obstructions, no surface agitation, and low velocities. Glides may occur at tails of pools. Substrate usually consists of cobble, gravel, and sand. Glides and runs are often combined as their differences are largely a function of streamflow.
- **Riffle** – Shallow areas with swiftly flowing, turbulent water often with some partially exposed substrate with a gradient less than 4 percent. Riffles are usually dominated by cobble or gravel substrate.

Mapping was conducted by canoe in the Illinois River and on foot in Flint Creek. Habitat mapping for Barren Fork Creek was previously completed by Fisher and Remshardt (2000) and is incorporated into this study. Individual mesohabitat types were identified and habitat boundaries were delineated by breaks in stream channel slope, depth, or hydraulic controls. Boundaries were marked using handheld global positioning system (GPS) units. In long habitat units, additional GPS coordinates were taken into account for bends in the river. The minimum demarcated length of a habitat unit was generally limited to the width of the wetted stream channel unless they were of significance or rare, such as riffles. Habitat units with characteristics of more than one habitat type were identified with a sub-type (such as run/glide and run/riffle); however, only the primary type was used in calculating habitat type totals and percentages. Split channels and secondary flow channels were identified, although high flow channels were often not recognizable from the main channel because debris or vegetation obstructed the view.

Final habitat unit lengths were calculated and recorded in a spreadsheet, with a formula applied to the lengths that determines the distance between two GPS coordinates.

3.3.2 Study Site and Transect Selection/Placement

The primary goal of the study site and transect selection was to locate habitats units (pool, riffle, run) that are representative of those occurring throughout the study reach. The number of one-dimensional (1D) transects needed to adequately model hydraulics and produce a habitat index is dependent on habitat complexity, number of habitat types present, and general preferences of the aquatic species and life stages under study. Payne, et al. (2004) determined that 18 to 20 transects will produce a robust habitat index function that differs little from results based on 40 to 70 transects, assuming all strata (habitat types) are sampled in relative proportion to the total, and the extent of hydraulic characteristics are included. Habitat index functions for this study were developed using generic criteria for a range of velocities and depths (shallow/fast, shallow/slow, deep/fast, and deep/slow) to include all potential aquatic microhabitat uses. As few as 10 transects can provide suitable results in less complex and uniform stream channels, though at a minimum two transects should represent each mesohabitat type, particularly those occurring infrequently. With these guidelines, each study reach was represented by 15 to 20 transects.

For this study, the lowest available habitat type by percentage was used to locate study sites. Access and logistical needs associated with collecting data at the sites were also considered. The number of transects established at a single site was dependent on the distribution of types in the immediate vicinity upstream and downstream of the selector habitat unit. Identifying and establishing a single site per study reach is not necessary and, in fact, not commonly done. Each study site consisted of all mesohabitat types where the transects were clustered. At least two of each major mesohabitat type were included in a reach. In some cases, particularly for pools, two or three transects were placed within a single habitat unit.

3.3.3 Data Collection

3.3.3.1 Calibration Flows

The flows at which field data were collected were based on predetermined target flows for calibrating the PHABSIM hydraulic models and identified considering water availability, physical safety, and preferred flow range for habitat analysis. The target high flows indicated in Table 3-1 correspond to the approximate mean annual flow for the lower section of each stream reach. This range should provide ample coverage of the flows that might be considered for fish habitat protection. The results of the PHABSIM model for the Barren Fork Creek (Fisher and Remshardt, 2000) showed that maximum microhabitat occurred at flows (50 to 100 cfs) considerably less than mean annual flow (330 cfs). These results suggest that the velocity calibration flows can be considerably less than those indicated in Table 3-1. This finding provided some flexibility in scheduling field work in the uncontrolled Illinois River.

Table 3-1. Target Calibration Flows by Reach for the Illinois River Instream Flow Study

River Reach	Target Calibration Flow (cfs)		
Lower Illinois	220	450	**900**
Upper Illinois	150	300	**600**
Flint Creek	25	50	**100**

Bold numbers indicate velocity data acquisition flow.
Calibration flows for Barren Fork Creek were derived by Fisher and Remshardt (2000)

3.3.3.2 Field Techniques

Field data collection and recording followed the guidelines established in the Instream Flow Group (IFG) field techniques manuals (Trihey and Wegner, 1981; Milhous, et al., 1984; Bovee, 1997). The following additional quality control checks were included:

- Rebar or spikes were placed on each bank of each transect to serve as reference elevation points and working pins for measuring distances across transects.
- An independent benchmark was established for each transect or set of transects. This benchmark was an immovable tree, boulder, or other naturally occurring object that would not be subject to tampering, vandalism, or movement. Upon establishment of pin elevations, a level loop was shot to check the auto-level for measurement accuracy and verify measured elevations. Allowable error tolerances on level loops were set at 0.02 foot. This tolerance is also applicable unless extenuating circumstances (such as pins under sloped banks or shots through dense foliage) explain discrepancies and the accompanying pin elevation is free of excessive error.
- Temporary staff gages were established and continually monitored throughout the course of collecting data on each transect. If significant changes occurred, water surface elevations were remeasured following collection of transect water velocity measurements.
- A minimum of two water surface elevations, one on each bank, were measured across each transect at each flow. The more complex and uneven the water surface transect is, the greater the number of measurements required. For example, a riffle transect may require more frequent water surface measurements, while pool and glide transects may require only two.
- All pin elevations and water surface elevations were calculated during field measurement and compared to previous measurements, if any. Stage change patterns were compared between transects and determined, if reasonable. If discrepancies were discovered, potential sources of error were explored and noted.
- Photographs were taken of all transects from downstream, across, and upstream at the measured flows. Photographs were taken from the same location at each flow level when possible. These photographs provided a record of the streamflow conditions (including velocity and depth), water surface levels, and channel configurations that may require confirmation during hydraulic model calibration.

3.3.3.3 Velocity Measurements

Most velocity measurements in the Illinois River were collected using a Teledyne RD Instruments Rio Grande Acoustic Doppler Current Profiler (ADCP). The ADCP gathers both depth and velocity information at very small steps, laterally and vertically, across each transect. The ADCP unit was operated by boat with the unit encased in an Ocean Sciences Trimaran Riverboat, and attached to the side of the vessel, see Figure 3-2. When operated from shore, the trimaran was hauled back and forth across the channel with ropes and kept on line with tension. The operator views real-time data through a wired or radio modem connection between the ADCP and a computer. Because the ADCP can only accurately measure to a depth of approximately 1 foot, edge cell measurements were obtained by wading to complete the velocity patterns in shallow areas for each transect.

For those stations or transects requiring a handheld meter, the standard method for determining mean column velocity will be a single measurement at 0.6 of the water depth in depths less than 2.5 feet, and a 0.2 and 0.8 measurement for depths between 2.5 feet and 4.0 feet. Electromagnetic Marsh-McBirney flowmeters attached to 4-foot wading rods were used for locations not suited for the ADCP.

Figure 3-2. Acoustic Doppler Current Profiler (ADCP) in use on the Illinois River

3.3.3.4 Transect Substrate and Cover Coding

During field data collection, the low flow, bottom substrate, and cover (if present) were identified and recorded across each transect. Stations (offset) were noted where substrate composition changed. In areas too deep for wading, a GPS unit was used to delineate changes in substrate composition. Distances between the coordinates were later calculated to locate the correct stationing. Substrate composition was noted by percentage of substrate categories at each location. These descriptive substrate/cover categories were converted to numerical codes for modeling purposes as was used by Fisher and Remshardt (2000) on the Barren Fork Creek study (Table 3-2).

Table 3-2. Categories of Substrate and Cover and their Codes Used in the Barren Fork Creek Instream Flow Simulation

Category	Code
Substrate	
Detritus	1
Vegetation flocculation	2
Clay (0.0005-0.004 mm)	3
Silt (0.004-0.0625 mm)	4
Sand (0.0625-2 mm)	5
Small gravel (2-8 mm)	6
Medium gravel (8-16 mm)	7
Large gravel (16-64 mm)	8
Small cobble (64-128 mm)	9
Large cobble (128-256 mm)	10
Boulder (>256 mm)	11
Bedrock (slab)	12
Bedrock (fractured)	13

Table 3-2. Categories of Substrate and Cover and their Codes Used in the Barren Fork Creek Instream Flow Simulation

Category	Code
Cover	
None	0
Undercut bank	1
Bedrock (fractured)	2
Log	3
Tree root wad	4
Aquatic vegetation	5
Boulder	6

Source: Fisher and Remshardt, 2000.

3.3.4 Hydraulic Simulation

3.3.4.1 Software

PHABSIM was originally developed and maintained by the U.S. Fish and Wildlife Service Instream Flow Group (now USGS, Aquatic Systems and Technology Application Group, Fort Collins Science Center). PHABSIM calculates a habitat index in part based on simulation of river depths and velocities from 1D hydraulic models that represent the river by cross-sections.

For 1D applications in this study, the hydraulic models and habitat index simulations were derived from the System for Environmental Flow Assessment (SEFA) computer program. SEFA was developed jointly by originators of the primary models used in ISF studies, Bob Milhous (PHABSIM), Tom Payne (RHABSIM), and Ian Jowett (RHYHABSIM), and merges and expands the capabilities of these software programs. Primary upgrades include the addition of a second velocity calibration algorithm, sediment transport, and reach temperature and dissolved oxygen models.

The ADCP uses its proprietary software (WinRiver by RD Instruments) for data acquisition and playback. Because the ADCP collects water velocities throughout the water column at relatively short intervals, the output was synthesized and condensed into a form usable by PHABSIM software. For this task, an ADCP conversion program allowed the user to interactively view bottom profiles and velocity patterns and establish stationing, which can then be directly entered into the hydraulic programs.

3.3.4.2 Stage-Discharge Calibration

Unforeseen circumstances (extreme flooding) allowed collection of only two stage-discharge pairs on transects in the lower Illinois River and Flint Creek. One set of points included velocity data acquisition so that modeling could be performed. In most PHABSIM models, stage-discharge relationships for each transect are developed using empirical log/log formula (IFG-4), or a hydraulic channel conveyance method. Under both methods each transect is treated independently to develop rating curves. The IFG-4 method generally requires a minimum of three sets of stage-discharge measurements and an estimate of stage-at-zero-flow (SZF) for each transect. The stage-discharge relationship quality is evaluated by examining the mean error and slope output from the model; however, with only two data points mean error could not be calculated.

Channel conveyance only requires a single stage-discharge pair and uses channel shape, depth, and the Manning's equation to determine a stage-discharge relationship (Bovee and Milhous, 1978); however, it is generally validated by additional stage-discharge measurements. In situations where irregular channel features occur on a cross section, such as bars or terraces, hydraulic channel conveyance is often better

at predicting higher stages than IFG-4. Conveyance is most often used on riffle or run transects, and is generally not applicable for transects with backwater effects from downstream controls, such as pools. The method can also be used as a test to verify IFG-4 relationships.

3.3.4.3 Velocity Calibration

A 1D model represents a stream by means of vertical slices (transects) across the channel. Depths are simulated with the rise and fall of a single, level (in most cases) water surface. For simulating water velocities, the "one-flow" option was used. This technique uses a single set of measured velocities to predict individual cell velocities over a range of flows. Simulated velocities are based on measured data and a relationship between a fixed roughness coefficient (Manning's n) and depth. In some cases, roughness was modified for individual cells if substantial velocity errors were noted at simulation flows. Velocity adjustment factors (VAFs) were examined to detect significant deviations and determine if velocities remained consistent with stage and total discharge.

3.3.5 Target Species and Habitat Suitability Criteria

An important component of an ISF study is the selection of target species, and its corresponding HSC that typically describes the relative suitability of water depth, water velocity, stream substrate, and cover types for the fish species and life stages of interest in the study area.

Historically, PHABSIM has been used to describe fish habitat-flow relationships for specific target species, often those considered as important game species or designated species of concern. Including these species in an ISF study also helps with the public acceptance of the study. In the Illinois River system, the smallmouth bass is the most sought-after and harvested game fish, has been the focus of numerous PHABSIM studies throughout the country, and was included in the Barren Fork Creek ISF study (Fisher and Remshardt, 2000). Review of the HSC developed for smallmouth bass in Barren Fork Creek indicates that those criteria would be well suited for application to the Illinois River and Flint Creek PHABSIM. The streams are in the same river basin, share similar geomorphic characteristics (gradient, substrate) and hydrologic patterns, and support a similar fish community.

The Illinois River system supports more than 72 species of fish, and each species and its life stage has a wide range of habitat needs. Defined microhabitat criteria (depth, velocity, and substrate) suitable for PHABSIM and ultimately for IFIM analysis are not available for most of these species. Therefore, to facilitate this many species in a habitat analysis, the species are categorized into habitat-use guilds, or assemblages (groups of fish that occupy similar habitats) (Leonard and Orth, 1988). This approach was also used in the Barren Fork Creek ISF study where HSC were developed from fish-use data collected in that stream (Fisher and Remshardt, 2000). Data analysis identified three habitat-use assemblages defined as shallow-fast (riffles), intermediate, and deep-slow (pools). These categories and their associated attributes (depth, velocity) are comparable to those developed in other stream systems (Leonard and Orth, 1988; Bain and Knight, 1996).

Assignment of most of the Illinois basin fish species to the three habitat assemblages is presented in Table 3-3. These assignments are based on those provided in Fisher and Remshardt (2000) for fish species identified in Barren Fork Creek. The deep-slow (pool) assemblage represents about half of the species, and include most of the sunfish and sucker species. The two most commonly observed species in the basin, cardinal shiner and central stoneroller (see Table 2-8), were placed in the intermediate assemblage. The shallow-fast (riffle) assemblage includes most of the darter species, which are also commonly observed throughout the basin.

Table 3-3. Common Names of Fish Species Found in the Illinois River Basin Associated with Key Habitat-Use Assemblages.

Habitat-Use-Assemblage		
Shallow - Fast	**Intermediate**	**Deep - Slow**
Stippled darter	Stoneroller	Black redhorse
Orangethroat darter	Northern hogsucker	Golden redhorse
Redfin darter	Bigeye chub	Shorthead redhorse
Banded darter	Redspot chub	White sucker
Blackstripe topminnow	Creek chub	Spotted sucker
Blackspotted topminnow	Rosyface shiner	Black bullhead
Banded sculpin	Cardinal shiner	Yellow bullhead
Slender madtom	Ozark minnow	Channel catfish
	Greenside darter	Brook silversides
		Green sunfish
		Warmouth sunfish
		Redear sunfish
		Largemouth bass
		Smallmouth bass
		Rock bass
		Bluegill sunfish
		Longear sunfish
		White crappie
		Logperch
		Gizzard shad

Source: Fisher and Remshardt, 2000.

The Barren Fork Creek HSC used in this study are presented in Tables 3-4 and 3-5 and on Figures 3-3 through 3-7. Habitat quality is classified as optimal, usable, and suitable. The optimal range contained the central 50 percent of the observations and is given a normalized suitability index of 1.0 in following the formula:

$$NSI=2(1-P)$$

where:

NSI = the normalized suitability index
P = the proportion of the population under the curve (50, 75, and 95 percent ranges)

Optimal habitat encompasses the central 50 percent (NSI = 1.0), usable habitat encompasses the broader central 75 percent (NSI = 0.5) of the observations, and the broadest range of habitat suitability contains the observations within the 95 percent (NSI = 0.1) range (Bovee, 1986).

Table 3-4. Habitat Suitability Criteria for Juvenile and Adult Smallmouth Bass

	Habitat Variable	
Habitat Quality Category	**Juvenile**	**Adult**
	Depth (cm)	
Optimal	35–115	55–155
Usable	15–135	25–180
Suitable	5–150	5–200
	Velocity (cm/s)	
Optimal	25–80	10–30
Usable	10–95	5–35

Table 3-4. Habitat Suitability Criteria for Juvenile and Adult Smallmouth Bass

	Habitat Variable	
Habitat Quality Category	**Juvenile**	**Adult**
Suitable	0–105	0–40
	Substrate (code)	
Optimal	7	8
Usable	7,8	6,8,11
Suitable	4,6–9	4,6–12
	Cover (code)	
Optimal	1	4
Usable	1,4,5	1,4,6
Suitable	0,1,3–6	0,1,3,4,6

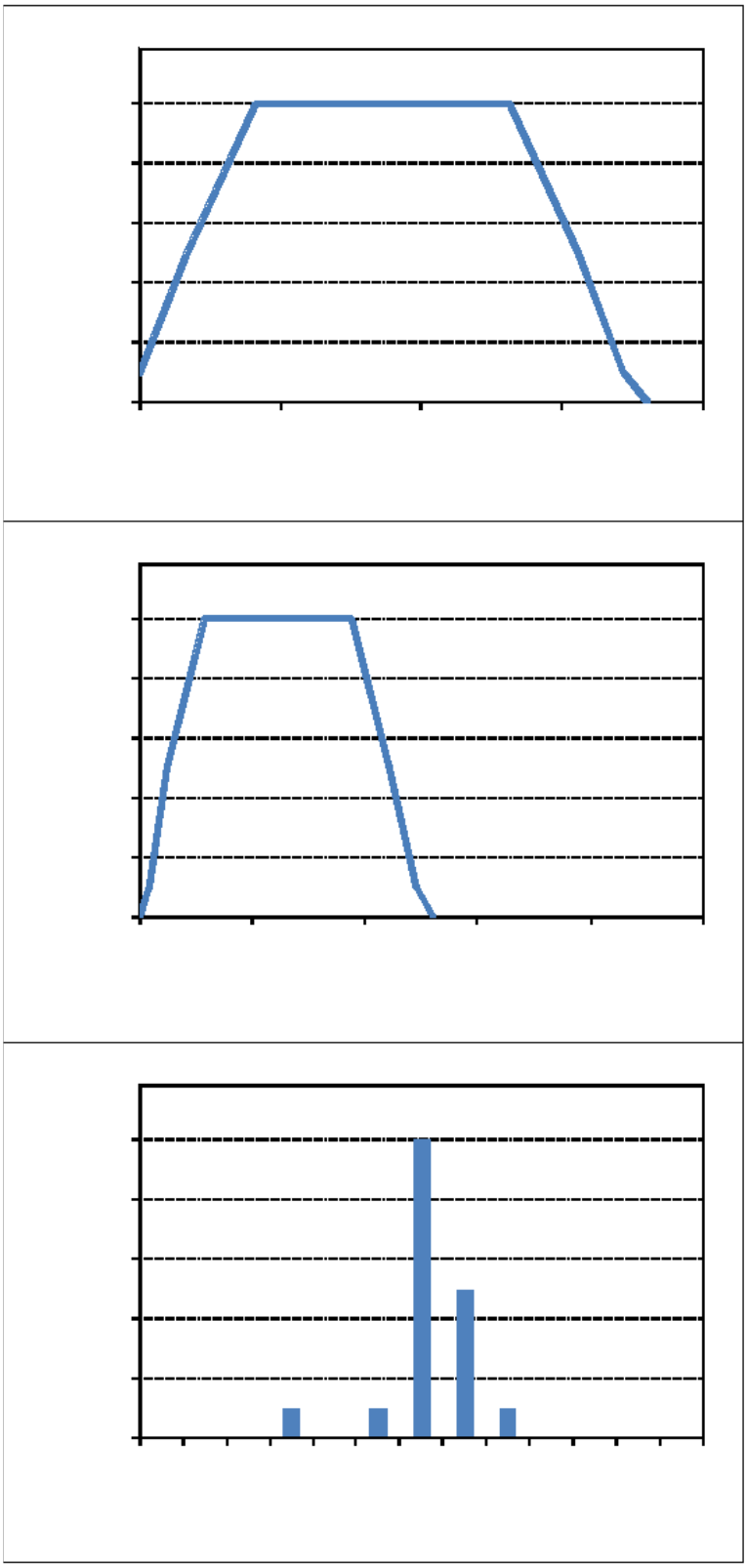
Source: Fisher and Remshardt 2000.

cm = centimeters
cm/s = centimeters per second

Table 3-5. Habitat Suitability Criteria for Shallow-fast, Intermediate, and Deep-slow Habitat-use Assemblages

Habitat Quality Category	Habitat variable		
	Shallow-fast	**Intermediate**	**Deep-slow**
	Depth (cm)		
Optimal	10–25	25–60	55–110
Usable	10–45	15–80	40–145
Suitable	5–60	5–115	25–200
	Velocity (cm/s)		
Optimal	10–45	5–25	0–5
Usable	5–55	5–40	0–10
Suitable	0–85	0–80	0–25
	Substrate (code)		
Optimal	1, 2, 5, 10, 13–15	1, 2, 5, 10, 13–15	1, 2, 5, 10, 13–15
Usable	1, 2, 4–15	1, 2, 4–15	1, 2, 4–15
Suitable	1, 2, 4–15	1, 2, 4–15	1, 2, 4–15
	Cover (code)		
Optimal	0–3	0–3	0–4
Usable	0–3	0–4	0–6
Suitable	0–5	0–6	0–6

Source: Fisher and Remshardt, 2000.

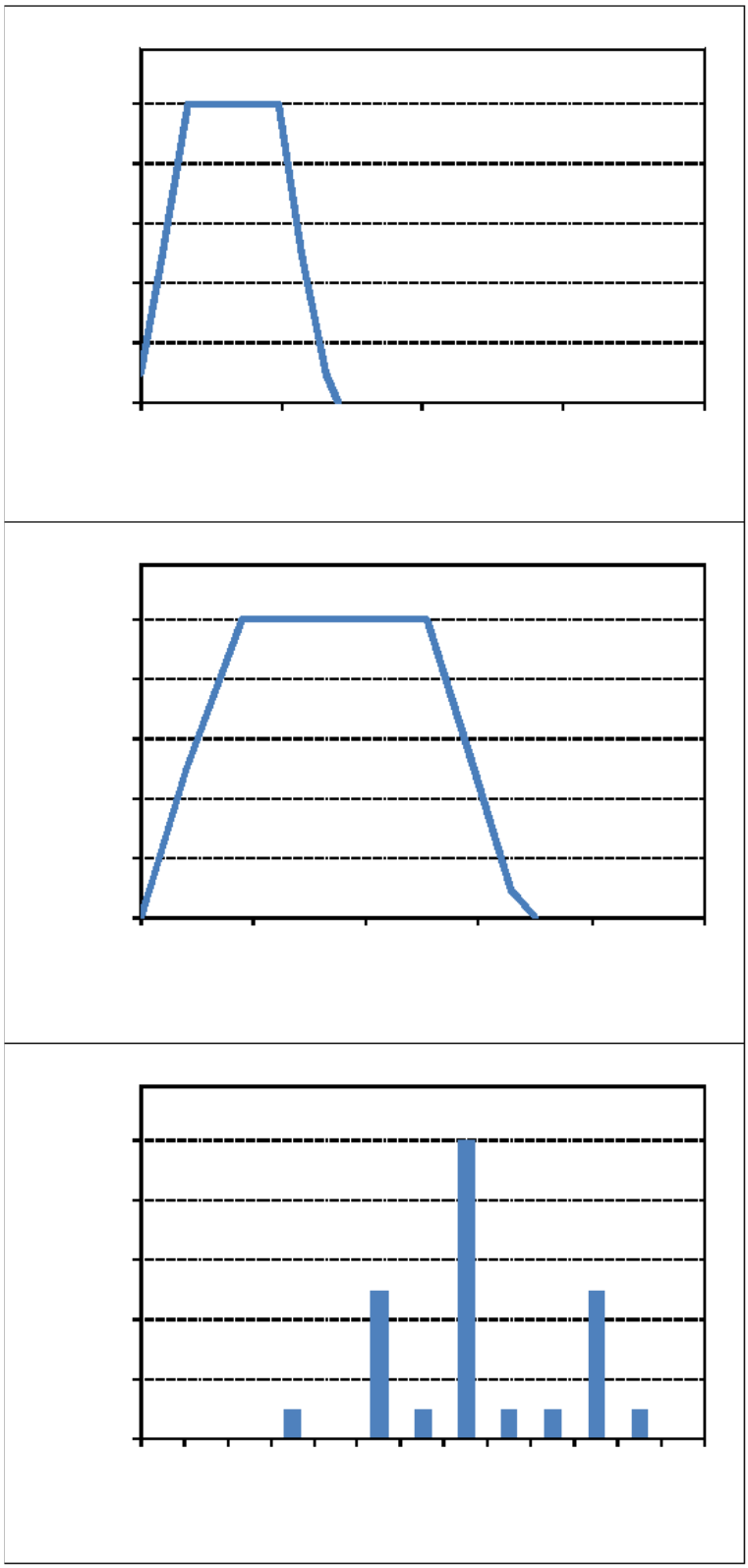


Velocity (ft/s)	SI
0.00	0.10
0.33	0.50
0.82	1.00
2.62	1.00
3.12	0.50
3.44	0.10
3.60	0.00

Depth (ft)	SI
0.00	0.00
0.16	0.10
0.49	0.50
1.15	1.00
3.77	1.00
4.43	0.50
4.92	0.10
5.20	0.00

Substrate Code	SI
1	0.00
2	0.00
3	0.00
4	0.10
5	0.00
6	0.10
7	1.00
8	0.50
9	0.10
10	0.00
11	0.00
12	0.00
13	0.00

Figure 3-3. Smallmouth Bass Juvenile HSC for Velocity, Depth, and Substrate from Fisher and Remshardt

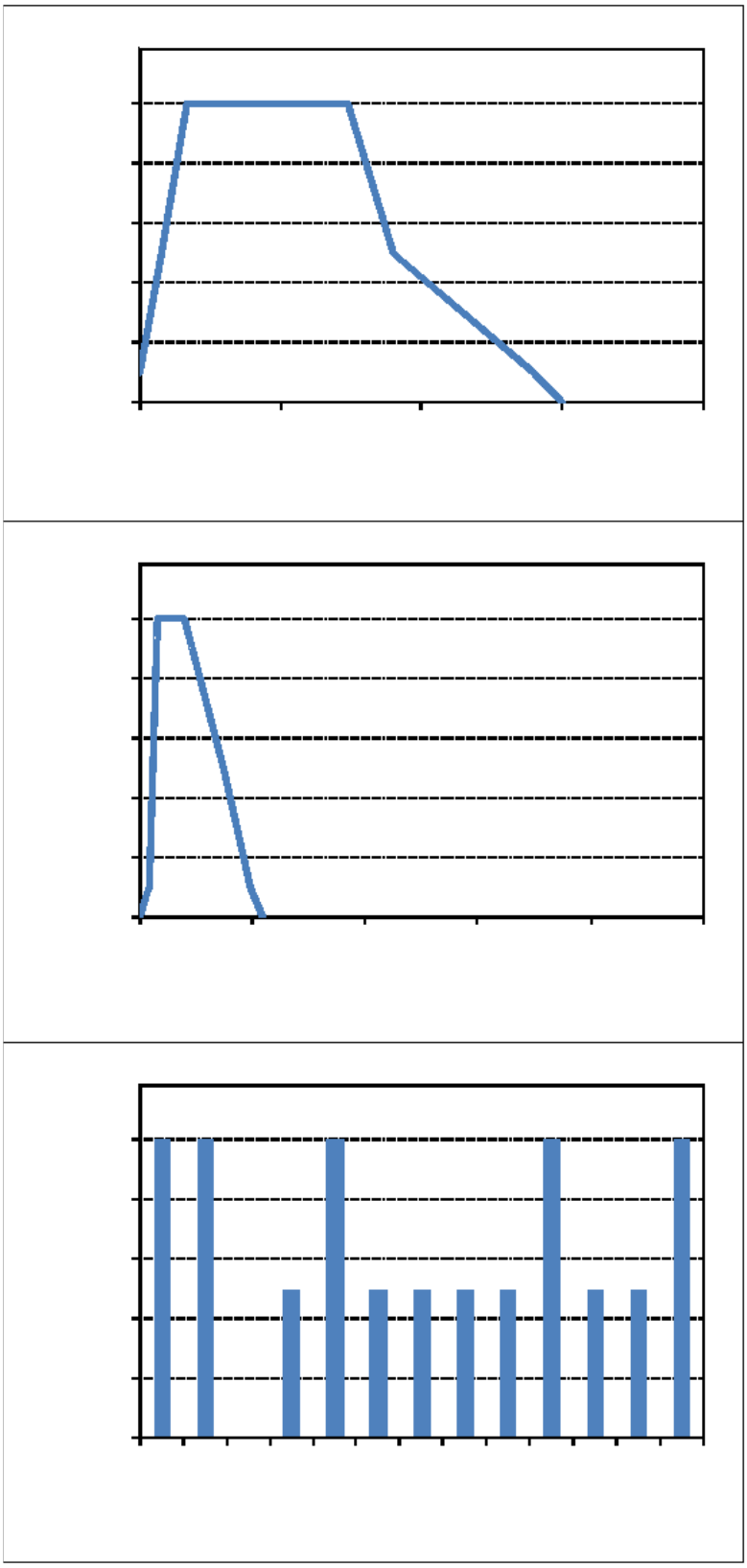


Velocity (ft/s)	SI
0.00	0.10
0.16	0.50
0.33	1.00
0.98	1.00
1.15	0.50
1.31	0.10
1.40	0.00

Depth (ft)	SI
0.00	0.00
0.16	0.10
0.82	0.50
1.80	1.00
5.09	1.00
5.91	0.50
6.56	0.10
7.00	0.00

Substrate Code	SI
1	0.00
2	0.00
3	0.00
4	0.10
5	0.00
6	0.50
7	0.10
8	1.00
9	0.10
10	0.10
11	0.50
12	0.10
13	0.00

Figure 3-4. Smallmouth Bass Adult HSC for Velocity, Depth, and Substrate from Fisher and Remshardt

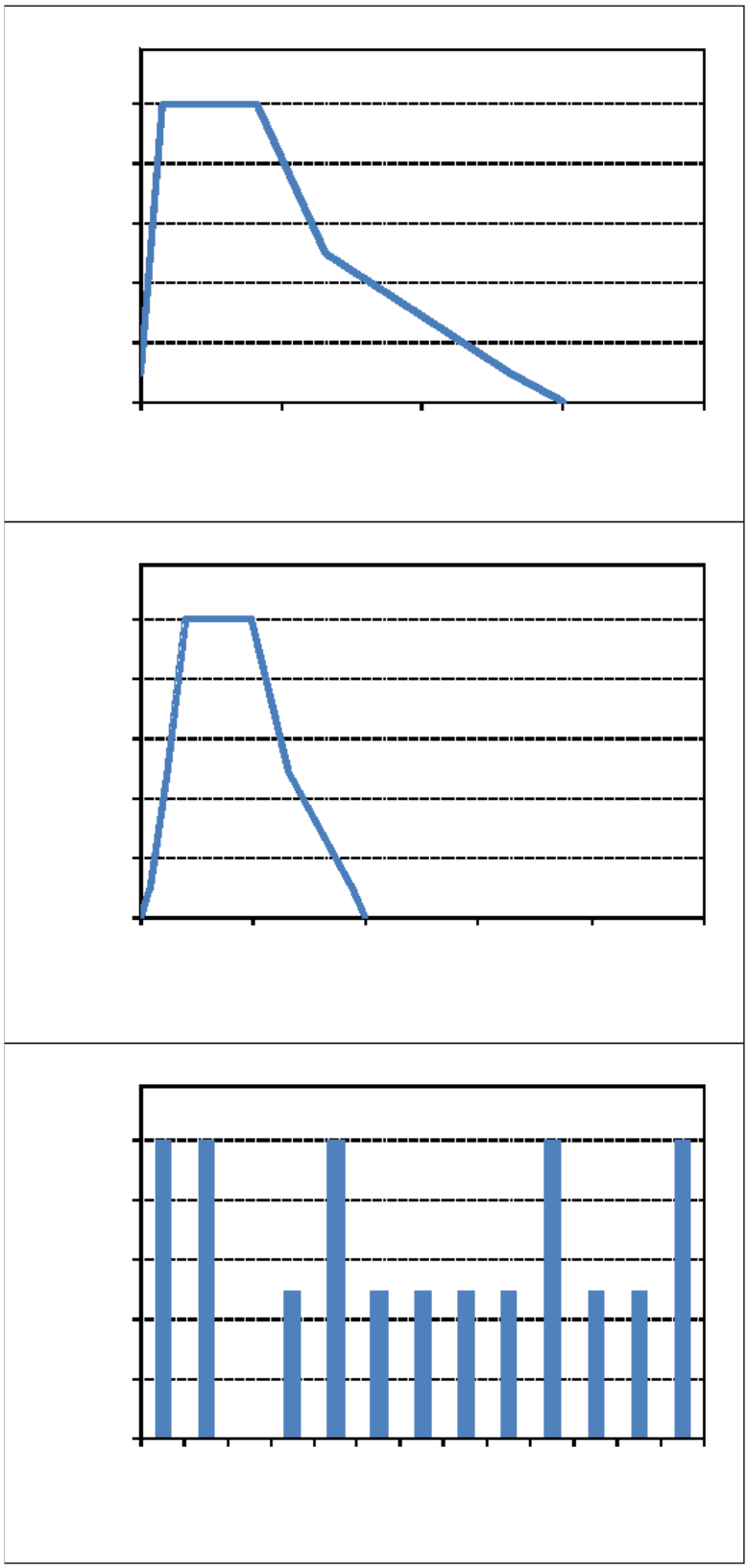


Velocity (ft/s)	SI
0.00	0.10
0.16	0.50
0.33	1.00
1.48	1.00
1.80	0.50
2.79	0.10
3.00	0.00

Depth (ft)	SI
0.00	0.00
0.16	0.10
0.33	1.00
0.82	1.00
1.48	0.50
1.97	0.10
2.20	0.00

Substrate Code	SI
1	1.00
2	1.00
3	0.00
4	0.50
5	1.00
6	0.50
7	0.50
8	0.50
9	0.50
10	1.00
11	0.50
12	0.50
13	1.00

Figure 3-5. Shallow-fast Fish Assemblage HSC for Velocity, Depth, and Substrate from Fisher and Remshardt

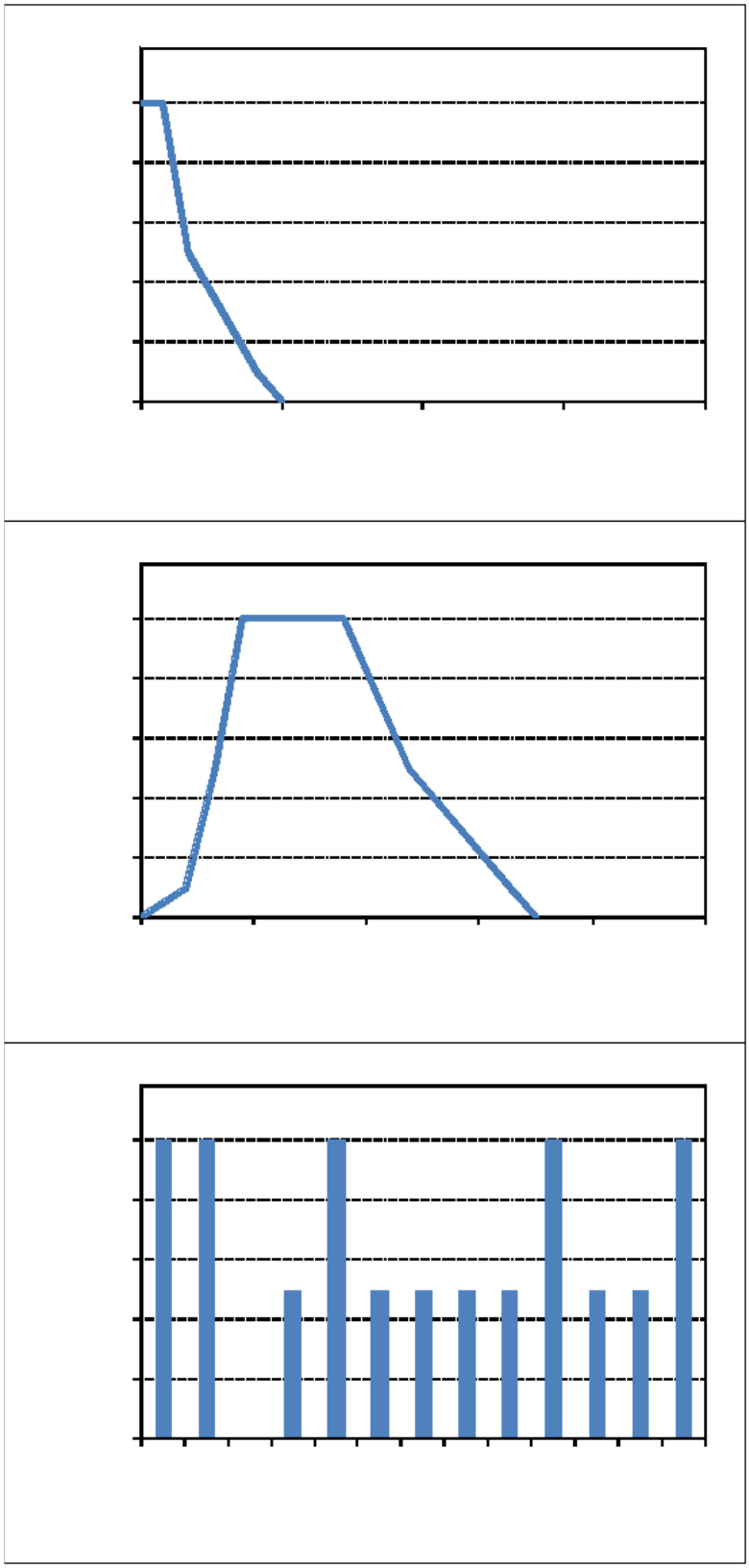


Velocity (ft/s)	SI
0.00	0.10
0.16	1.00
0.82	1.00
1.31	0.50
2.62	0.10
3.00	0.00

Depth (ft)	SI
0.00	0.00
0.16	0.10
0.49	0.50
0.82	1.00
1.97	1.00
2.62	0.50
3.77	0.10
4.00	0.00

Substrate Code	SI
1	1.00
2	1.00
3	0.00
4	0.50
5	1.00
6	0.50
7	0.50
8	0.50
9	0.50
10	1.00
11	0.50
12	0.50
13	1.00

Figure 3-6. Intermediate Fish Assemblage HSC for Velocity, Depth, and Substrate from Fisher and Remshardt



Velocity (ft/s)	SI
0.00	1.00
0.16	1.00
0.33	0.50
0.82	0.10
1.00	0.00

Depth (ft)	SI
0.00	0.00
0.82	0.10
1.31	0.50
1.80	1.00
3.61	1.00
4.76	0.50
6.56	0.10
7.00	0.00

Substrate Code	SI
1	1.00
2	1.00
3	0.00
4	0.50
5	1.00
6	0.50
7	0.50
8	0.50
9	0.50
10	1.00
11	0.50
12	0.50
13	1.00

Figure 3-7. Deep-slow Fish Assemblage HSC for Velocity, Depth, and Substrate from Fisher and Remshardt

3.3.6 Physical Habitat Simulation

Once the hydraulic data are calibrated through standard methods, AWS by discharge is generated. The range of flows included in the habitat simulations was determined by the calibration flows obtained in the field and by the suitability of the hydraulic data for extrapolation. The hydraulic and HSC data were used to generate AWS relationships for smallmouth bass juvenile and adult and species guilds in the Illinois River and Flint Creek. AWS relationships for smallmouth bass on Barren Fork Creek were previously generated by Fisher and Remshardt (2000). A cell's suitability is calculated by multiplying the individual variable suitabilities (depth, velocity, and substrate/cover) at the center of each cell. The suitability of all the cells within each transect are added together to calculate the habitat for each transect. Reach habitat is computed by applying weighting factors to each transect and summing the result.

Confidence limits can be calculated for AWS predictions using bootstrapping with random selection within each habitat type. Confidence limits indicate the range that can be placed on an AWS value at a particular flow, assuming that cross sections have been randomly selected within each stratum. The cross-section weights (as determined by habitat mapping) are used to determine the cross-section combinations that are randomly selected. For example, if there are run, riffle, and pool cross sections, AWS will be calculated for randomly selected cross sections of each habitat type. It is assumed that the cross-section weights for each habitat type are different. If they are the same, it will be assumed that they represent the same habitat type.

These statistical confidence limits reflect the variability in cross-section properties and do not address all uncertainties in instream habitat modeling. Results are presented by displaying error bars on AWS values graphically.

3.4 Results

3.4.1 Habitat Mapping

Habitat mapping was conducted under flow conditions that allowed visual habitat type distinction (Table 3-6). Habitat mapping summaries are presented for the lower Illinois River (Table 3-7), upper Illinois River (Table 3-8), and Flint Creek (Table 3-9).

Table 3-6. Habitat Mapping Date and River Flow in Three River Reaches used for the Illinois River Instream Flow Study

River Reach	Date	Flow (cfs)
Lower Illinois River	September 29-30, 2015	280-289
Upper Illinois River	October 5, 2015	193
Flint Creek	September 28, 2015	44

Habitat mapping for Barren Fork Creek was conducted by Fisher and Remshardt (2000)

Mapping along the lower Illinois River was conducted upstream of U.S. Highway 62 near Tahlequah, OK and was more than 12 miles upstream of the approximate backwater effects of Tenkiller Reservoir. Within the lower Illinois River, pools were the overall dominant habitat type accounting for more than 50 percent, followed by run (23 percent), glide (12 percent), and riffle (8 percent). A similar mesohabitat distribution was found in the upper Illinois River, though pool accounted for a larger percentage and run slightly less. Mapping on Flint Creek was conducted in the lower 1.6 miles, upstream of the confluence with the Illinois River. Pool was again the dominant habitat type (35 percent) followed by riffle (25 percent) with relatively equal amounts for run and glide. The lower 0.3 mi, composed of heavily braided channels through large gravel bars, accounted for 40 percent of all riffle habitat in Flint Creek.

Table 3-7. Habitat Mapping Summary for the Lower Illinois River

Habitat Type	Count	Length (ft.)	% Length
Pool	79	62,016	56
Glide	31	13,907	12
Run	59	26,089	23
Riffle	38	9,464	8
Total	**207**	**111,477**	**100**

Table 3-8. Habitat Mapping Summary for the Upper Illinois River

Habitat Type	Count	Length (ft.)	% Length
Pool	33	24,609	62
Glide	10	3,793	10
Run	24	7,063	18
Riffle	16	4,004	10
Total	**83**	**39,470**	**100**

Table 3-9. Habitat Mapping Summary for Flint Creek

Habitat Type	Count	Length (ft.)	% Length
Pool	14	2,994	35
Glide	7	1,709	20
Run	11	1,736	20
Riffle	15	2,108	25
Total	**47**	**8,548**	**100**

3.4.2 Study Site and Transect Selection/Placement

Prior to study site selection, the lower Illinois River was split into two segments, each of which was proposed to include 10 transects, to allow for study site separation and incorporate any potential habitat variability. Riffle habitat was used as a selector for locating study sites in the lower Illinois River for the following reasons:

1. Riffle habitat was the least available habitat type by percentage.
2. Of the 38 riffles identified, 11 were considered suitable for modeling using transects. Those not judged suitable for modeling were either in braided channels, along cut banks, or transverse to the channel.

When the first suitable riffle was located, a study site was established. A transect was placed across that riffle and other transects were established in the immediate vicinity to represent other habitat types. This process continued until the predetermined number of transects were established (Table 3-10). Because only three riffles were needed, the fourth study site (Transects 15–20) was selected based on a

combination of access and availability of the remaining habitat types. Four study sites with 4 to 6 transects each were established (Figures 3-8 and 3-9). The same process was used on the upper Illinois River where 16 transects were placed to represent that reach (Table 3-11 and Figure 3-10).

Glide habitat was used as a selector for Flint Creek because glide and run were the least available habitat type, and there were only seven habitat units identified during mapping. A total of 15 transects were established in Flint Creek (Table 3-12 and Figure 3-11).

Table 3-10. Number of Transects by Habitat Type and Percent Representation Based on Habitat Mapping Results for the Lower Illinois River

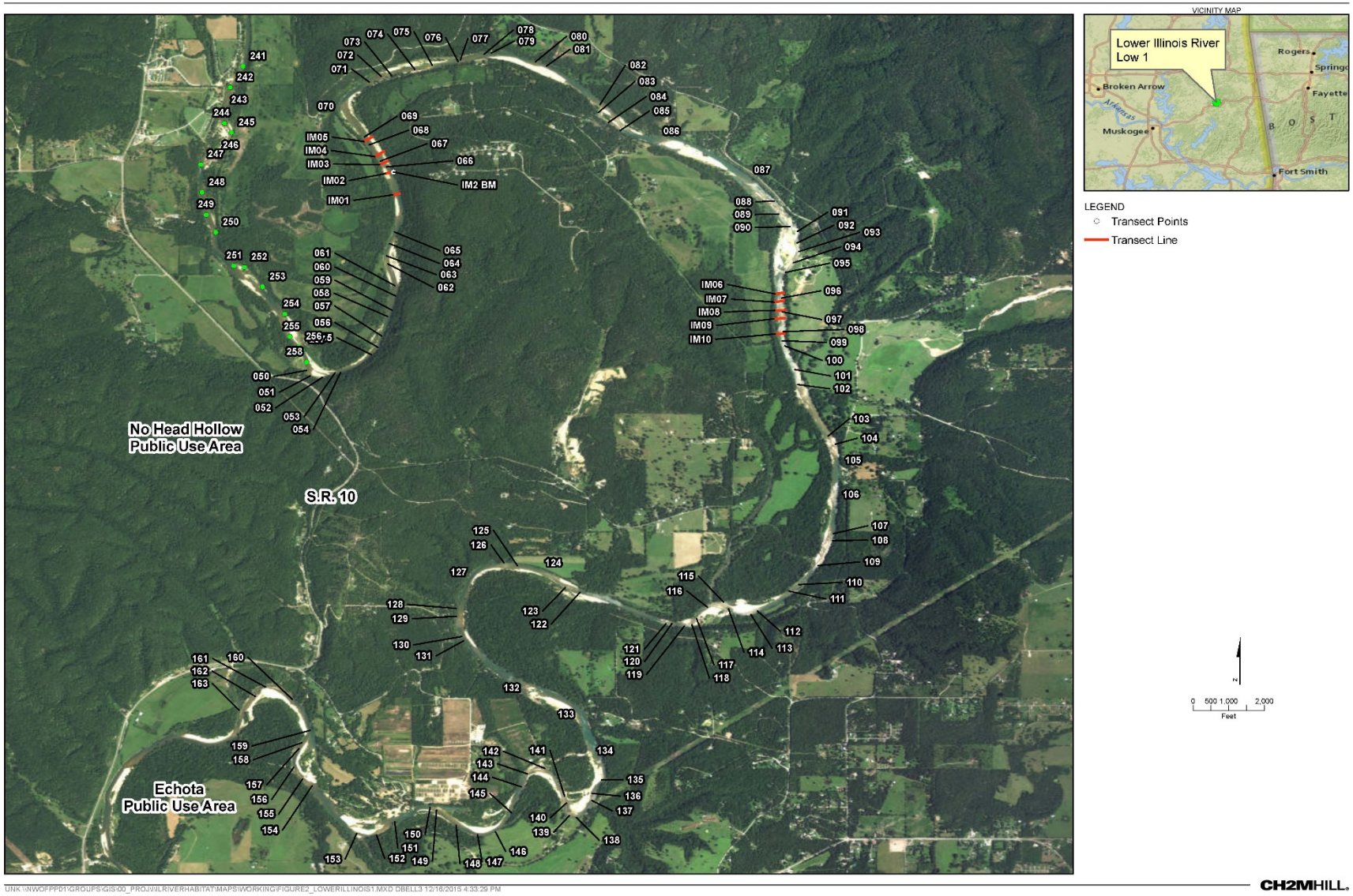
Habitat Type	No. of Transects	Percent/Transect
Pool	9	6.2%
Glide	3	4.2%
Run	5	4.7%
Riffle	3	2.8%
Total	**20**	

Table 3-11. Number of Transects by Habitat Type and Percent Representation Based on Habitat Mapping Results for the Upper Illinois River

Habitat Type	No. of Transects	Percent/Transect
Pool	8	7.8%
Glide	2	4.8%
Run	4	4.5%
Riffle	2	5.1%
Total	**16**	

Table 3-12. Number of Transects by Habitat Type and Percent Representation Based on Habitat Mapping Results for Flint Creek

Habitat Type	No. of Transects	Percent/Transect
Pool	4	8.8%
Glide	3	6.7%
Run	4	5.1%
Riffle	4	6.2%
Total	**15**	



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CH2MHILL.

Figure 3-8. Location of Transects 1-10 in the Lower Illinois River between No Head Hollow and Echota

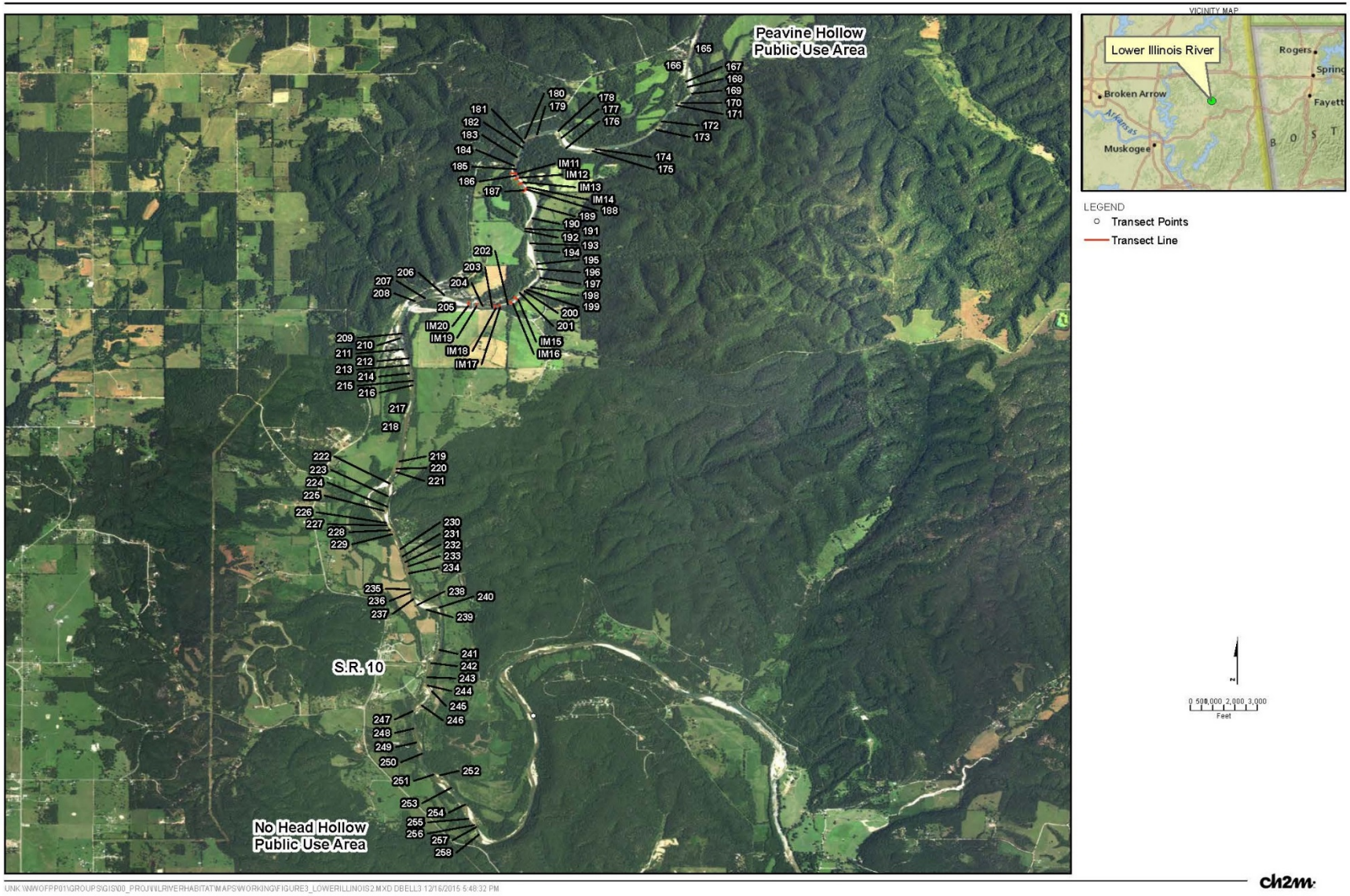


Figure 3-9. Location of Transects 11-20 in the Lower Illinois River between Peavine and No Head Hollow

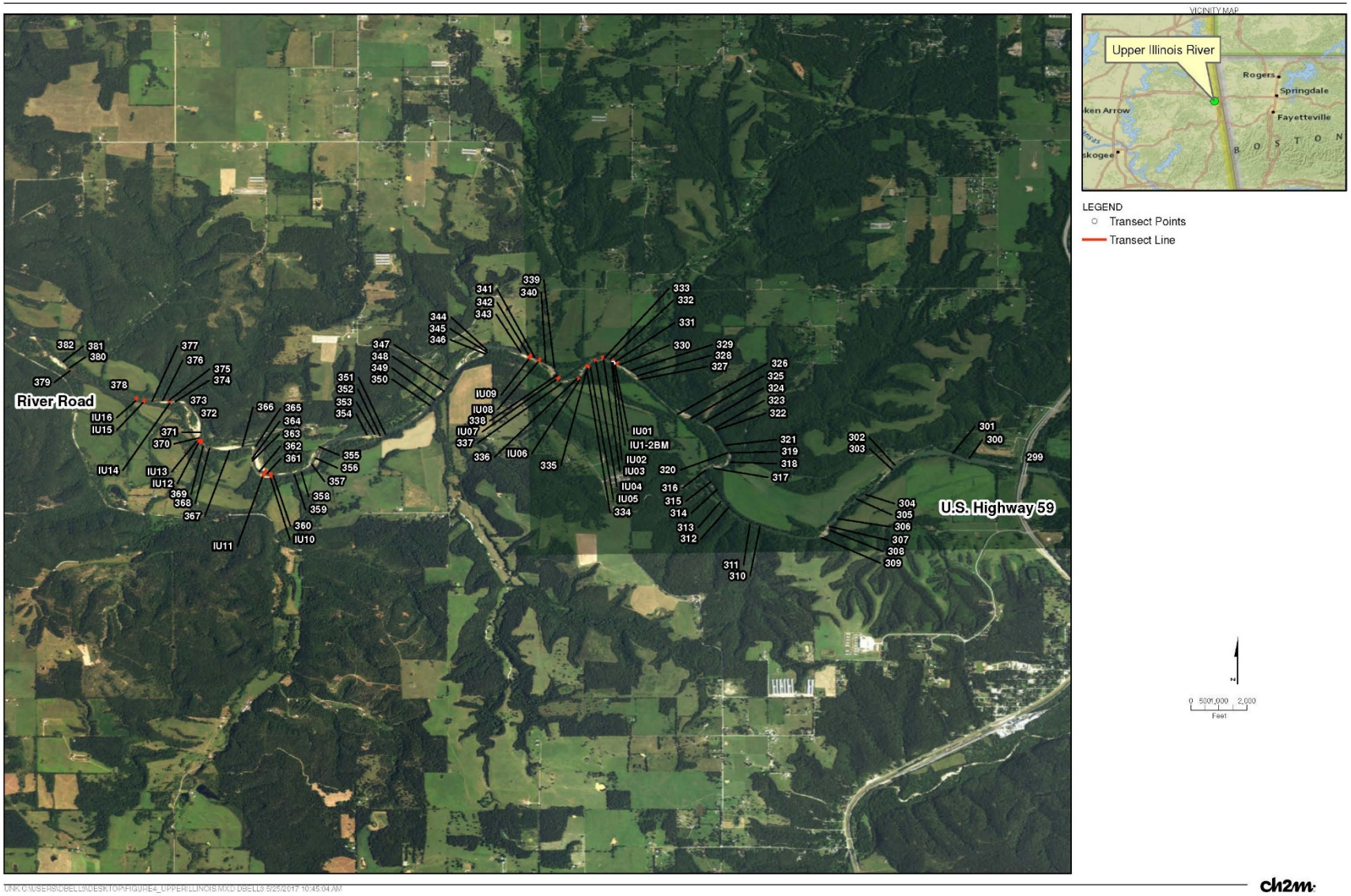


Figure 3-10. Location of Transects 1-16 in the Upper Illinois River between U.S. Highway 59 and low head dam near River Road

Figure 3-11. Location of Transects 1-15 in Flint Creek

3.4.3 Data Collection

3.4.3.1 Measured Flows

Both low and high flows were measured on the lower Illinois River transects and Flint Creek. However, unforeseen and unprecedented flooding occurred in the basin in late December 2015, precluding any data collection along the upper Illinois River. Therefore no hydraulic modeling or PHABSIM simulations were conducted for the upper Illinois River.

Measured high calibration flows in the lower Illinois River and Flint Creek were within 5 percent of target flows (Table 3-13). Normally two additional measurements of water surface elevation for each transect and a single discharge measurement (per transect cluster) would be made at the remaining flow levels.

Table 3-13. Measured Calibration Flows by Reach for the Illinois River Instream Flow Study

	Measured Flow (cfs) [a]		
River Reach	**Low**	**Middle**	**High**
Lower Illinois	272-282	NM	906-941
Upper Illinois	197	NM	NM
Flint Creek	NM	43	106

[a] High velocity acquisition flow
NM = not measured

Substrate coding was completed at low flow in the lower and upper Illinois River and at middle flow in Flint Creek. Bottom profiling (measuring elevations of out-of-water stations) was accomplished on all but four transects in Flint Creek. Time did not permit out-of-water elevation profiling beyond the high flow water line on the lower or upper Illinois River.

Complete sets of high flow velocities and depths were obtained on 18 of 20 transects in the lower Illinois River (Table 3-14) and 14 of 15 transects in Flint Creek (Table 3-15), using a combination of ADCP and wading measurements. In the lower Illinois River, equipment issues prevented measurement of two transects. In Flint Creek, one pool transect measurement was not completed because of channel changes caused by woody debris and bank collapse between middle and high flow.

Table 3-14. Measured High Flow and Wetted Width of Transects in the Lower Illinois River

Transect	Measured Flow (cfs)	Width (feet)
T1 - Pool	906.1	194.3
T2 - Pool	921.6	142.7
T3 - Riffle	961.6	198.0
T4 - Run	894.8	187.2
T5 - Pool	912.8	136.7
T6 - Pool	853.1	203.0
T7 - Pool	894.8	222.8
T8 - Glide	907.1	230.5
T9 - Riffle	NM	NM

Table 3-14. Measured High Flow and Wetted Width of Transects in the Lower Illinois River

Transect	Measured Flow (cfs)	Width (feet)
T10 - Run	NM	NM
T11 - Glide	960.6	163.5
T12 - Pool	967.8	134.2
T13 - Pool	955.7	158.7
T14 - Riffle	935.7	204.9
T15 - Run	937.8	106.3
T16 - Run	924.3	103.3
T17 - Run	941.6	141.4
T18 - Glide	910.2	154.4
T19 - Pool	939.8	135.2
T20 - Pool	902.2	164.2

Table 3-15. Measured High Flow and Wetted Width of Transects in Flint Creek

Transect	Measured Flow (cfs)	Width (feet)
F1 –Run	104.6	54.6
F2 - Run	104.1	42.0
F3 - Riffle	107.1	40.1
F4 - Riffle	114.0	62.5
F5 - Pool	NM	NM
F6 - Pool	105.2	70.7
F7 - Glide	99.9	58.9
F8 - Riffle	110.3	32.0
F9 - Glide	103.1	66.0
F10 - Pool	108.9	45.6
F11 - Run	105.9	47.7
F12 - Pool	113.1	41.8
F13 - Glide	103.6	60.0
F14 - Run	101.0	44.9
F15 - Riffle	101.8	52.1

3.4.4 Hydraulic Model Simulation

3.4.4.1 Stage-Discharge Calibration

Rating curves were developed for the lower Illinois River and Flint Creek using the two measured calibration flows. When using a 2-point rating curve with a SZF estimate, interpolation between the points and extrapolation down from the lowest measured flow is considered acceptable; however, extrapolation above the highest flow can be uncertain. Because both the log/log and channel conveyance methods produced very similar results, the final rating curves are considered suitable for modeling. As shown in the habitat modeling portion of the report, the highest habitat index values also tend to occur within the interpolation and low end extrapolation range of the curves.

One riffle transect in the lower Illinois River was calibrated using the channel conveyance method with a single stage-discharge pair because an adequate relationship could not be obtained using the lowest measured calibration flow. The resulting hydraulic rating curve was considered adequate, based on the comparison of rating curve slope to other transects.

3.4.4.2 Velocity Calibration

Velocity calibration involves examination of velocity simulation profiles and VAFs to detect significant deviations and determine if velocities remain consistent with stage and total discharge. Edge cells near the banks of a transect, even in riffles and runs, often have very low measured velocities (sometimes negative) caused by shallow depths and flow obstruction by substrate. Velocity adjustments were made to some of these points if simulation of higher flows showed unusual patterns. An example of this is shown on Figure 3-12, which shows an unadjusted velocity pattern with low negative velocities predicted across a shallow bar at high simulation flows. The adjusted pattern is more realistic and allows velocities to increase across the same bar as flows increase (Figure 3-13).

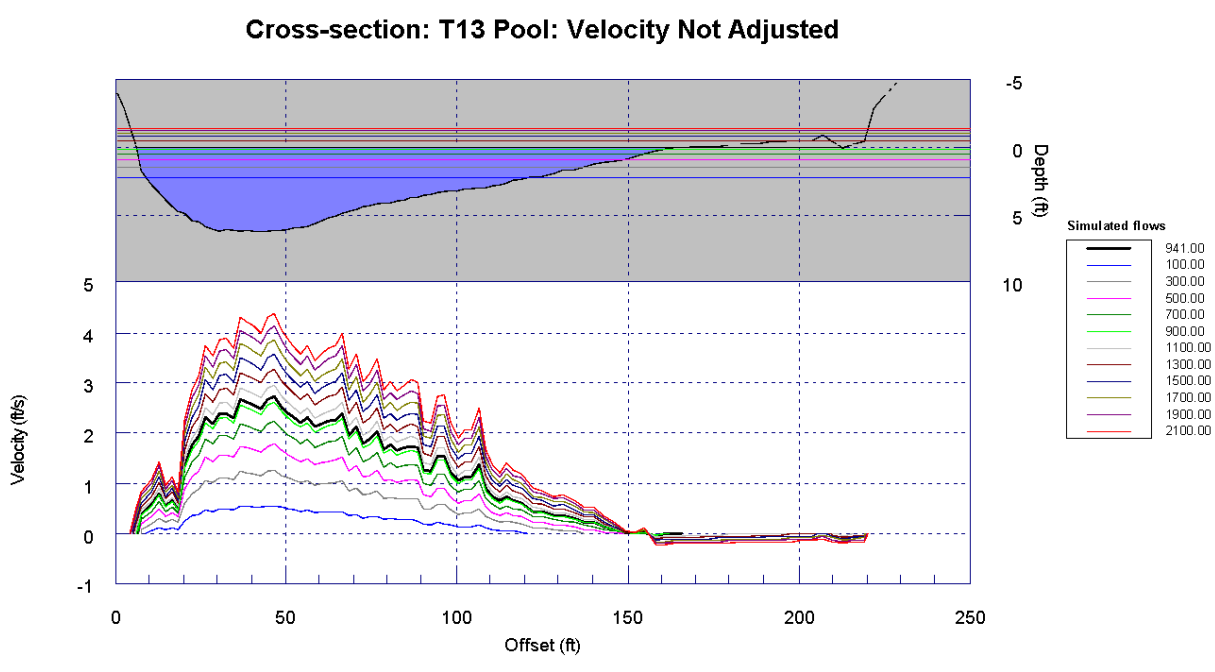


Figure 3-12. Velocity Simulation over a Range of Flows without Adjustment

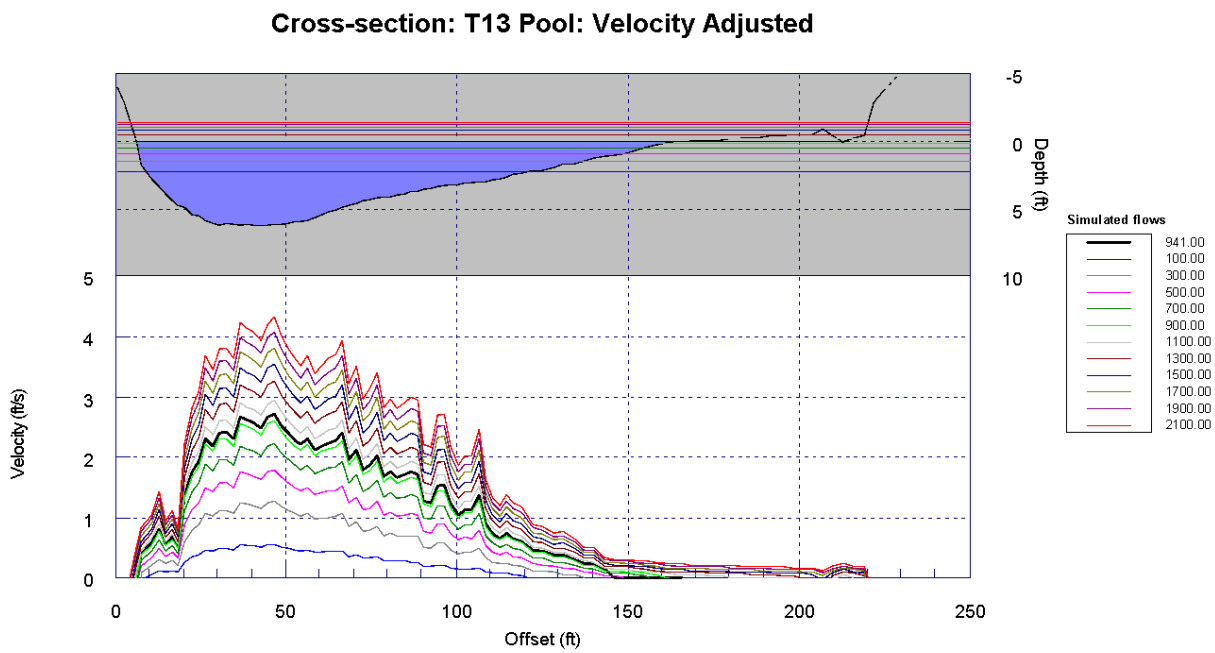


Figure 3-13. Velocity Simulation over a Range of Flows with Adjustment

3.4.5 Physical Habitat Simulation

3.4.5.1 Lower Illinois River

All the satisfactorily calibrated hydraulic transects were weighted according to the percentage of each major habitat type modeled in the study reach (Table 3-16).

Table 3-16. Final Number of Transects and Weight per Transect Used in Habitat Calculations in the Lower Illinois River

Habitat Type	No. of Transects	Weight/Transect
Pool	9	6.2%
Glide	3	4.2%
Run	4	5.8%
Riffle	2	4.3%
Total	**18**	

Habitat simulation for smallmouth bass juvenile and adult in the lower Illinois River was run based on AWS calculated, using a combination of velocity x depth and velocity x depth x substrate (Figure 3-14). As shown, the addition of substrate does not change the shape or peak of the AWS curves but only reduces the values. Even more reduction would occur if cover were added to the calculation (not shown on Figure 3-14) because the vast majority of points on transects had no cover, and a suitability of 0.1 would be applied to the AWS calculation. This is a common result when additional criteria are included in the calculations and most suitability values are less than 1.0. All subsequent analyses include the substrate component in calculating AWS habitat.

Normalized AWS provides an alternative perspective and allows for examination of habitat retention over a range of flows (Figure 3-15). With respect to smallmouth bass juvenile, 90 percent of the microhabitat is retained between flows of 250 to 900 cfs. Smallmouth bass adults maintain 90 percent of habitat at flows between 100 and 350 cfs. The intersection of these two normalized curves at 300 cfs represents the flow that optimizes habitat between the two life stages (Leonard and Orth, 1988).

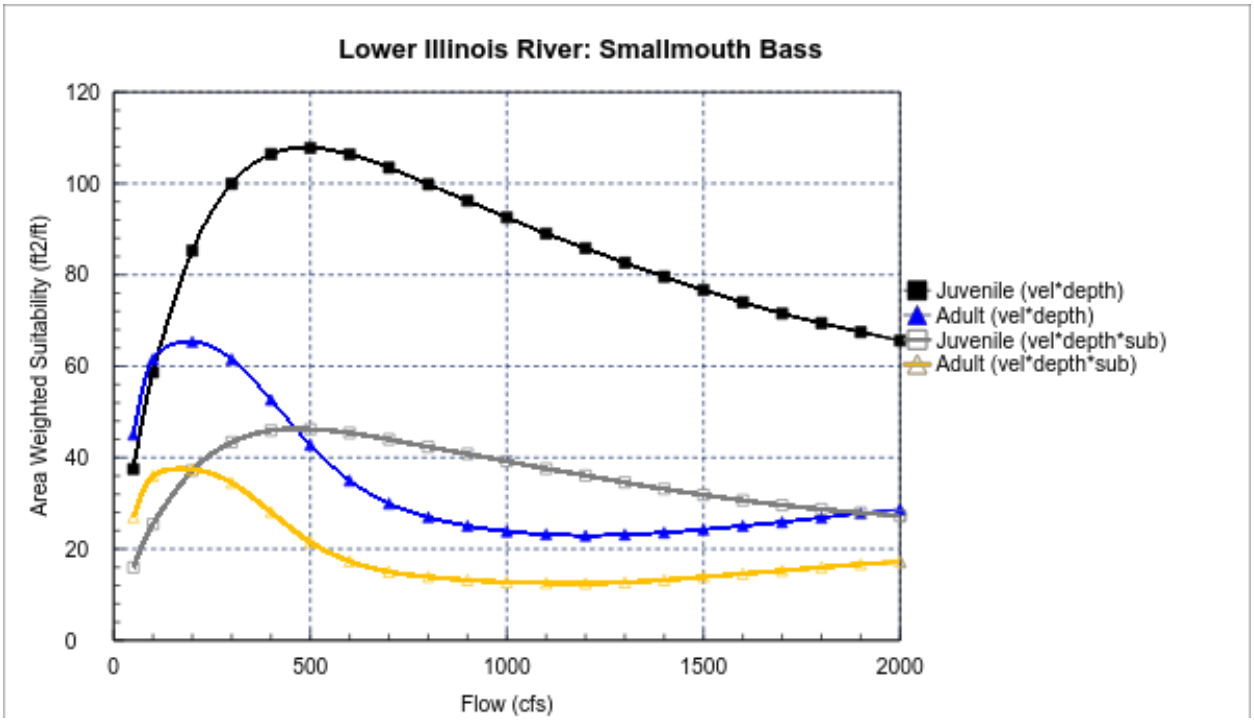


Figure 3-14. Smallmouth Bass Juvenile and Adult AWS versus Flow in the Lower Illinois River Using Velocity and Depth Suitability only with Addition of Substrate

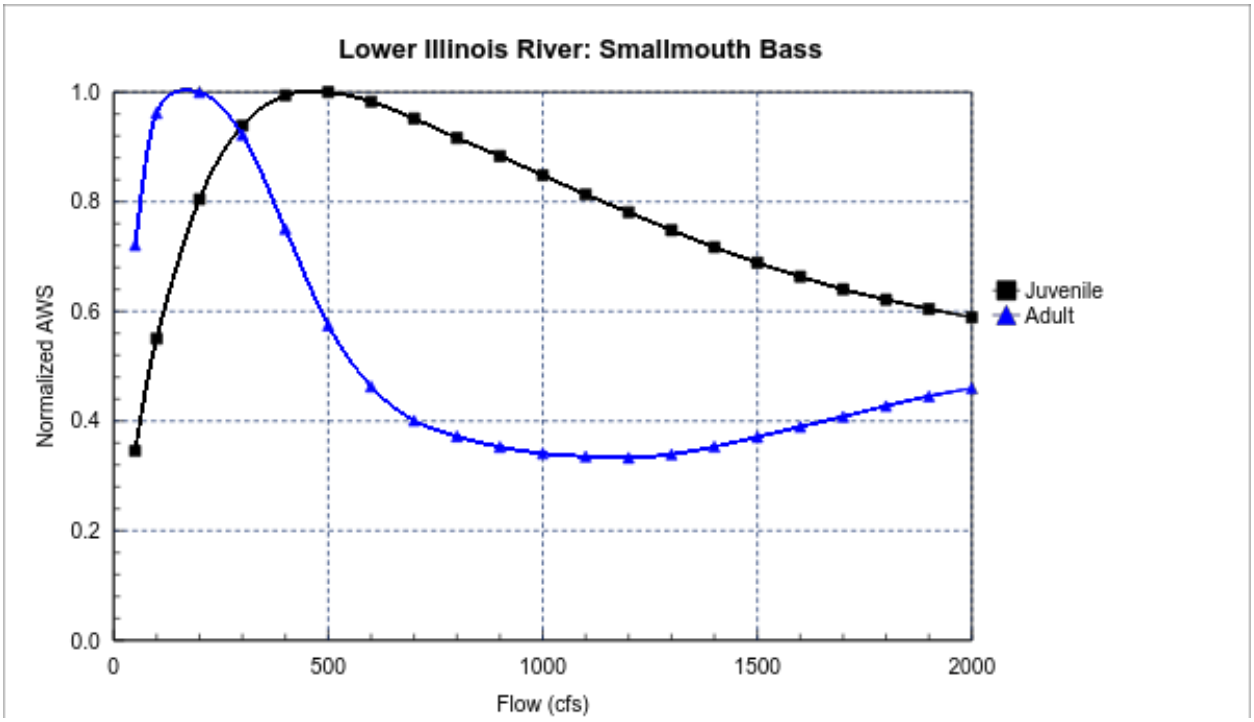


Figure 3-15. Normalized AWS versus Flow for Smallmouth Bass in the Lower Illinois River

3.4.5.2 Mesohabitat Consideration

The three habitat assembly categories (guilds) used in this study represent those species that, as a group, prefer either shallow-fast, intermediate, or deep-slow depth and velocity condition. The microhabitat (AWS) results depicted on Figure 3-16 represent how these habitat conditions respond to flow regardless of where in the stream they occur.

Some species within these categories may show strong fidelity to the specific mesohabitat (pool, riffle, run) where they reside; therefore, even when suitable depth and velocity conditions temporarily occur at certain flows at a location outside of their mesohabitat, they may not seek out and use these locations. To analyze this potential habitat (AWS) versus flow curves for mesohabitats were developed by applying the specific assemblage criteria to the transect types that correspond to these mesohabitats.

Specifically, shallow-fast criteria were applied only to riffles, deep-slow criteria only to pools, and intermediate criteria only to glides and runs. The results shown on Figures 3-17 to 3-19 are similar to those obtained using all habitat types with respect to curved shape. Though this may seem unusual, it is not necessarily an unexpected result. For example, because shallow-fast habitat is found primarily in riffles, the shallow-fast criteria show the most response in riffles. The addition of pools does little to change the curve since a very small component of pools is shallow-fast habitat. For pools, deep-slow habitat is available at lower flows but declines rapidly as flows increase, the result of increasing velocities overriding suitable depth.

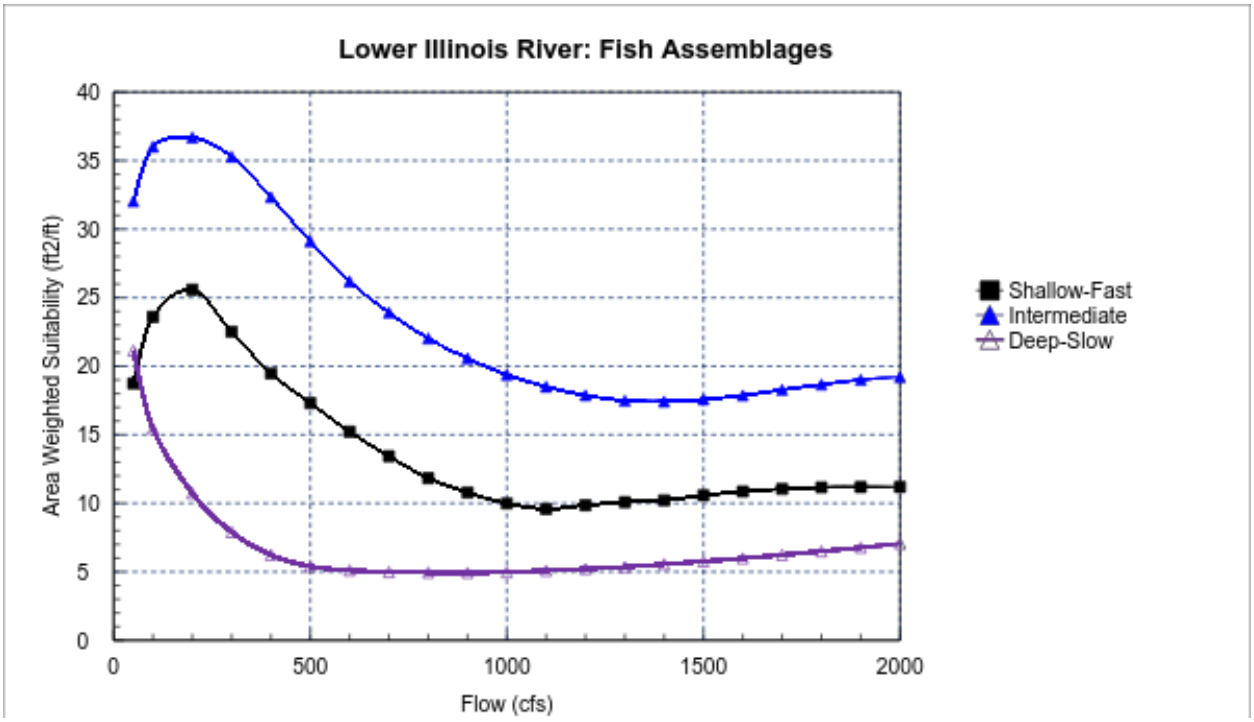


Figure 3-16. Fish Assemblage AWS versus Flow in the Lower Illinois River

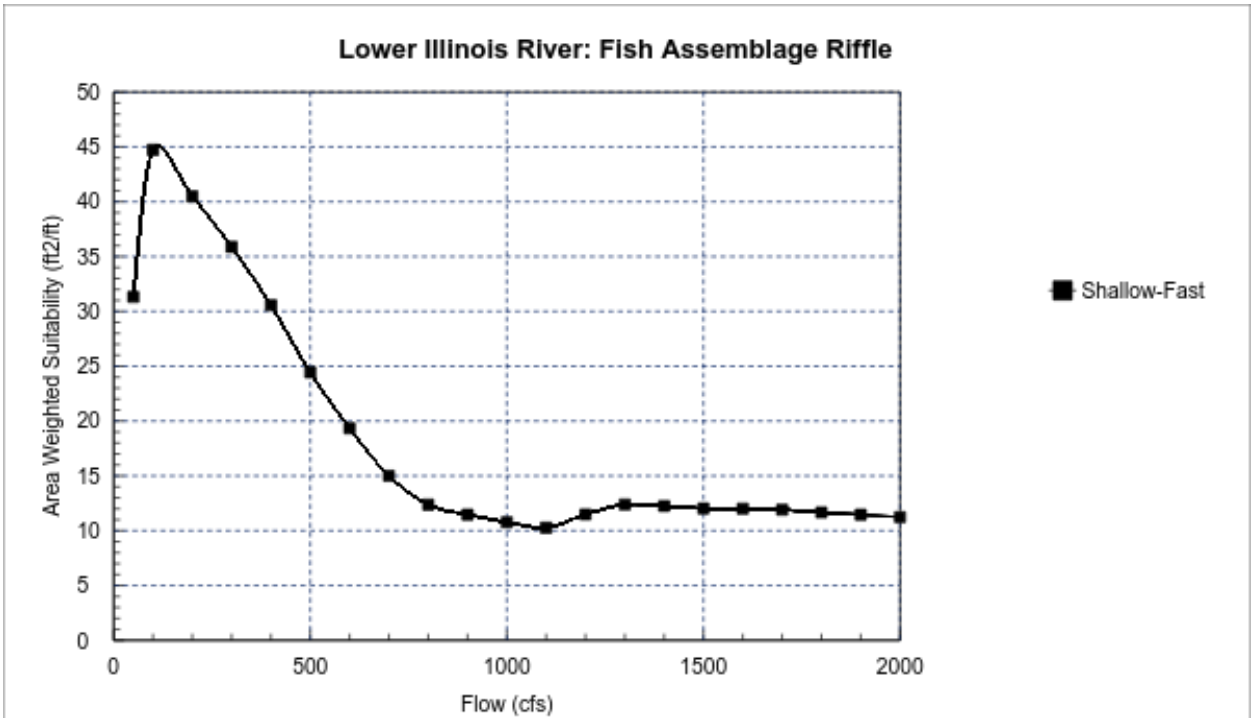


Figure 3-17. Shallow-fast Fish Assemblage Criteria Applied to Riffle Habitat in the Lower Illinois River

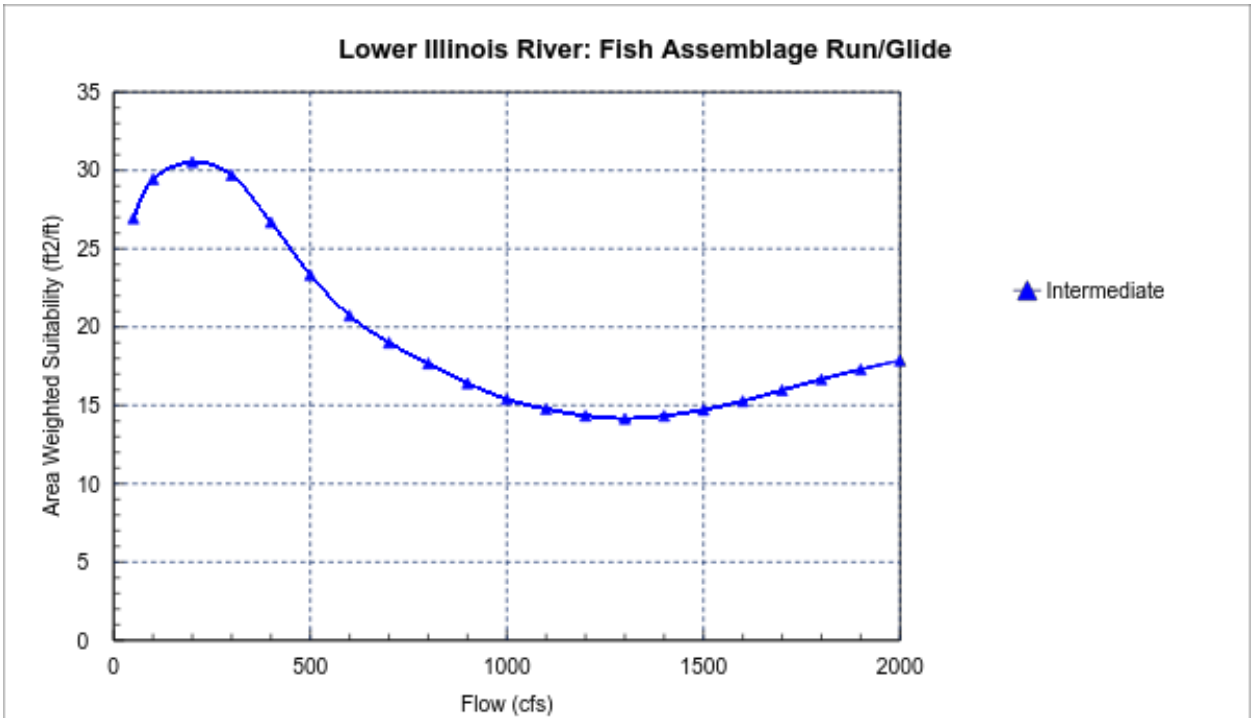


Figure 3-18. Intermediate Fish Assemblage Criteria applied to Riffle Habitat in the Lower Illinois River

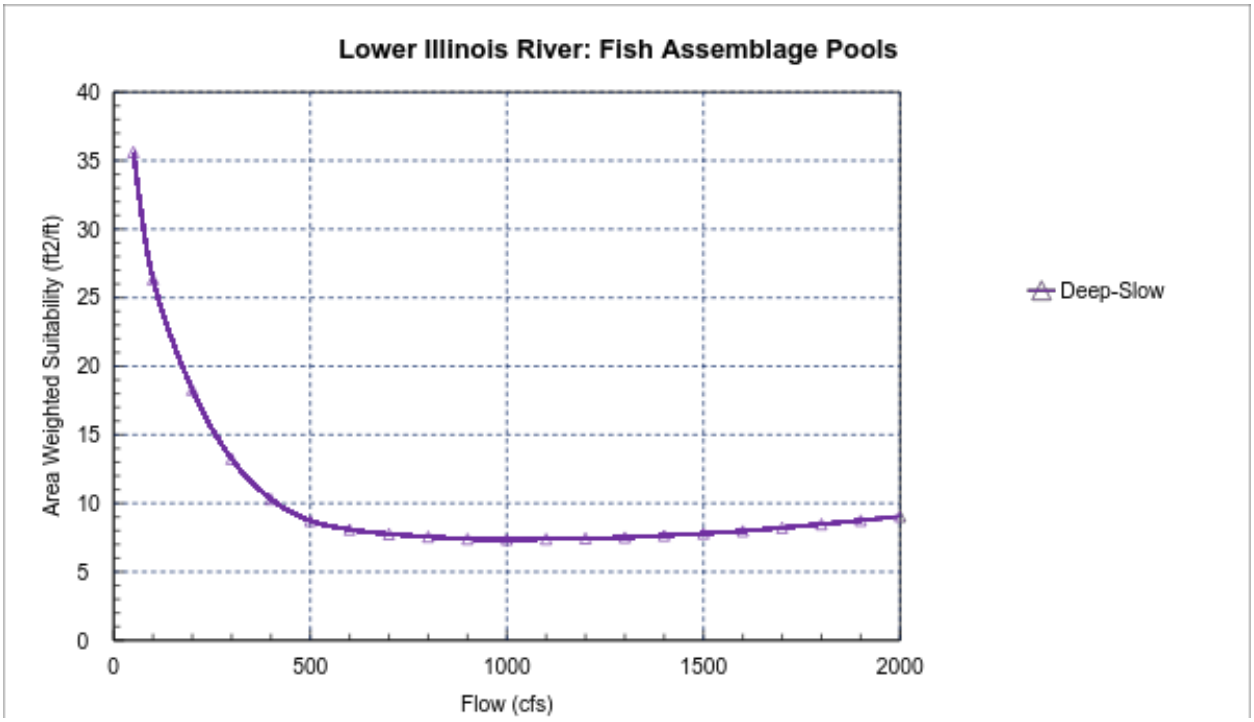


Figure 3-19. Deep-slow Fish Assemblage Criteria Applied to Riffle Habitat in the Lower Illinois River

3.4.5.3 Flint Creek

One pool transect was removed from the analysis in Flint Creek, resulting in pool habitat being weighted slightly higher than other habitat types (Table 3-17).

Table 3-17. Final Number of Transects and Weight per Transect Used in Habitat Calculations in Flint Creek

Habitat Type	No. of Transects	Weight/Transect
Pool	3	11.7%
Glide	3	6.7%
Run	4	5.1%
Riffle	4	6.2%
Total	**14**	

Similar to the lower Illinois River, smallmouth bass adults show a higher suitability at lower flows than juveniles (Figure 3-20). Smallmouth bass juvenile AWS at 60 cfs is nearly identical to that at 250 cfs. Adult smallmouth bass shows the highest suitable habitat range between 20 and 70 cfs. Fish assemblage AWS curves are also similar to those for the lower Illinois River with higher habitat values at lower flows (Figure 3-21).

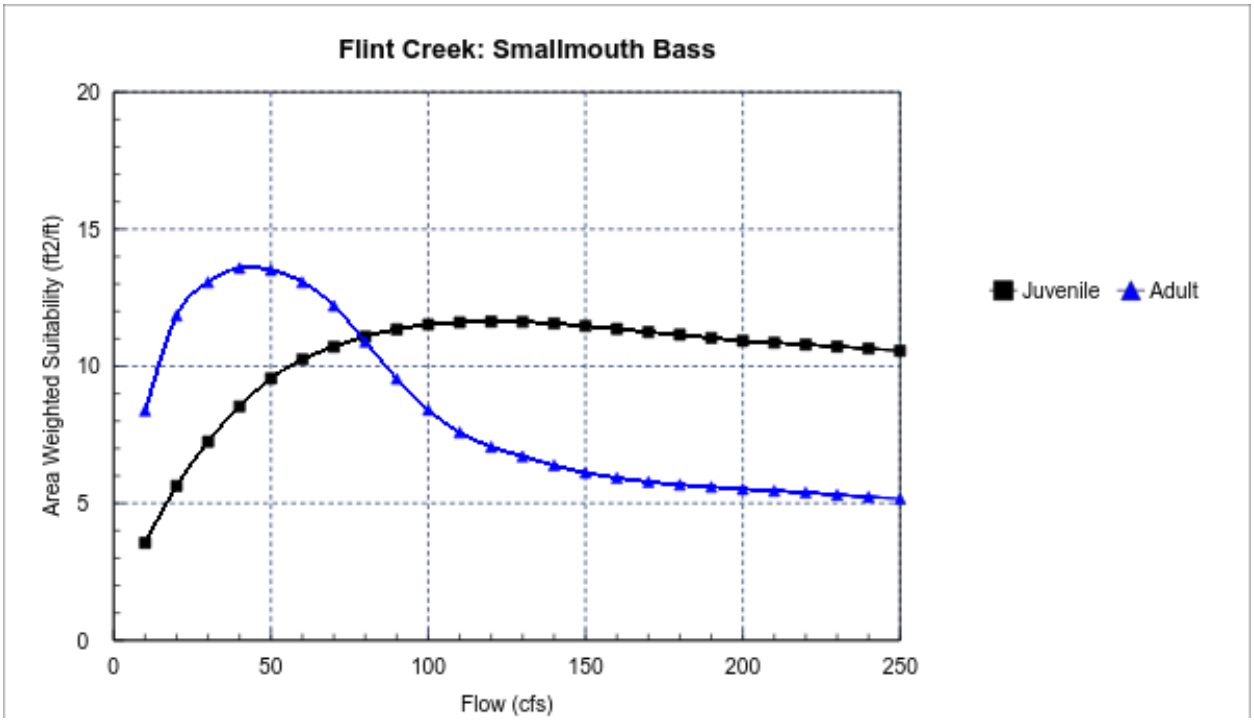


Figure 3-20. Smallmouth Bass Juvenile and Adult AWS versus Flow in Flint Creek

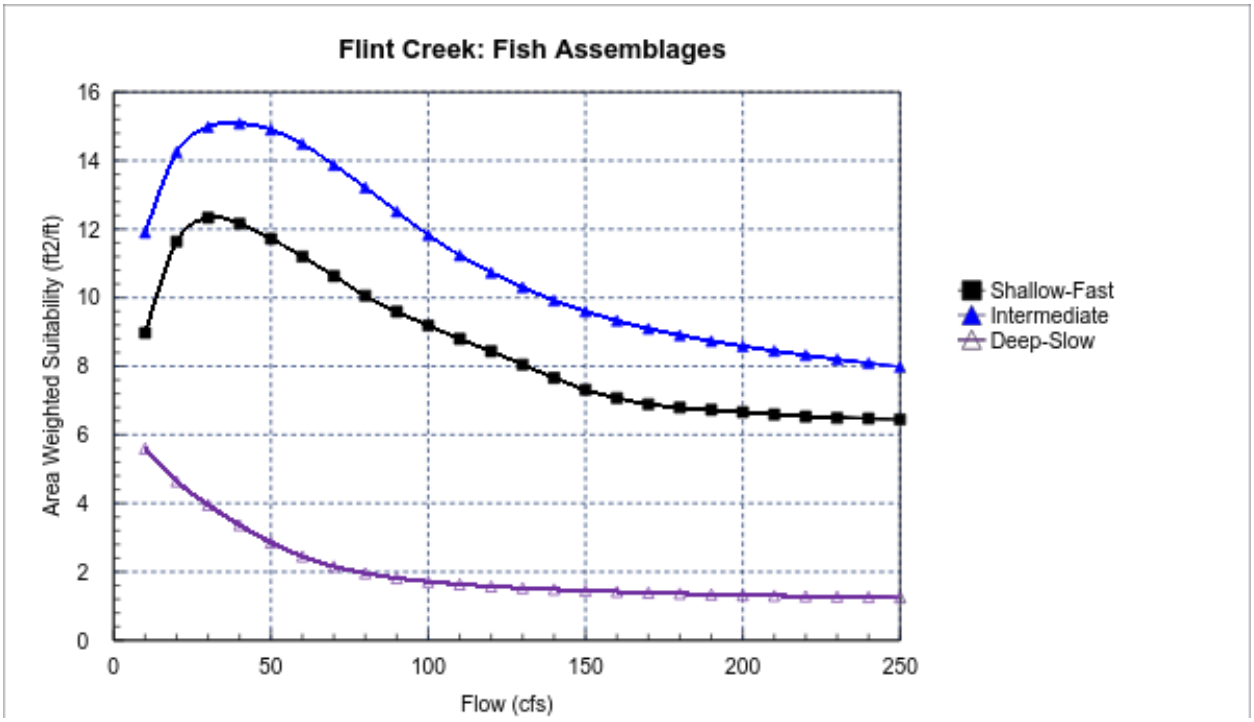


Figure 3-21. Fish Assemblage AWS versus Flow in Flint Creek

3.4.5.4 Barren Fork Creek

Habitat modeling results for Barren Fork Creek were obtained from Fisher and Remshardt (2000). The results are comparable to those for the lower Illinois River and Flint Creek because the same habitat criteria were used for all three streams. The habitat index (weighted usable area or WUA) shown for Barren Fork Creek represents the same values as the AWS used for the lower Illinois River and Flint Creek results. AWS is simply a more contemporarily used term for the same habitat index.

Similar to Flint Creek and the lower Illinois River, juvenile smallmouth bass show a higher habitat suitability at slightly higher flows compared to adults (Figure 3-22 (Fisher and Remshardt, 2000)). Good habitat conditions for juvenile smallmouth bass range from 50 to 150 cfs, peaking at 75 cfs. For adult smallmouth bass good habitat conditions range from 40 to 100 cfs, peaking at 50 cfs.

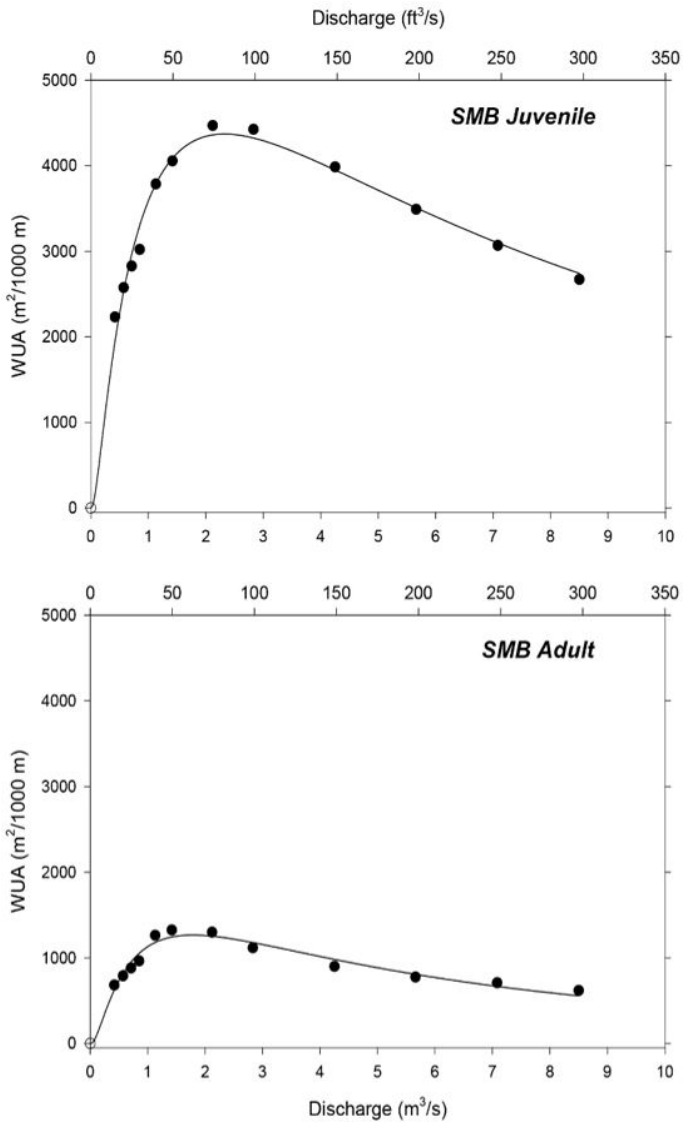


Figure 3-22. Relationship between Weighted Usable Area and Discharge for Juvenile and Adult Smallmouth Bass in Barren Fork Creek, Oklahoma

For the three fish assemblages in Barren Fork Creek, habitat peaks at 50 cfs for the shallow-fast and intermediate assemblages (Figure 3-23) (Fisher and Remshardt, 2000). For the deep-slow assemblage, habitat peaks at 20 cfs.

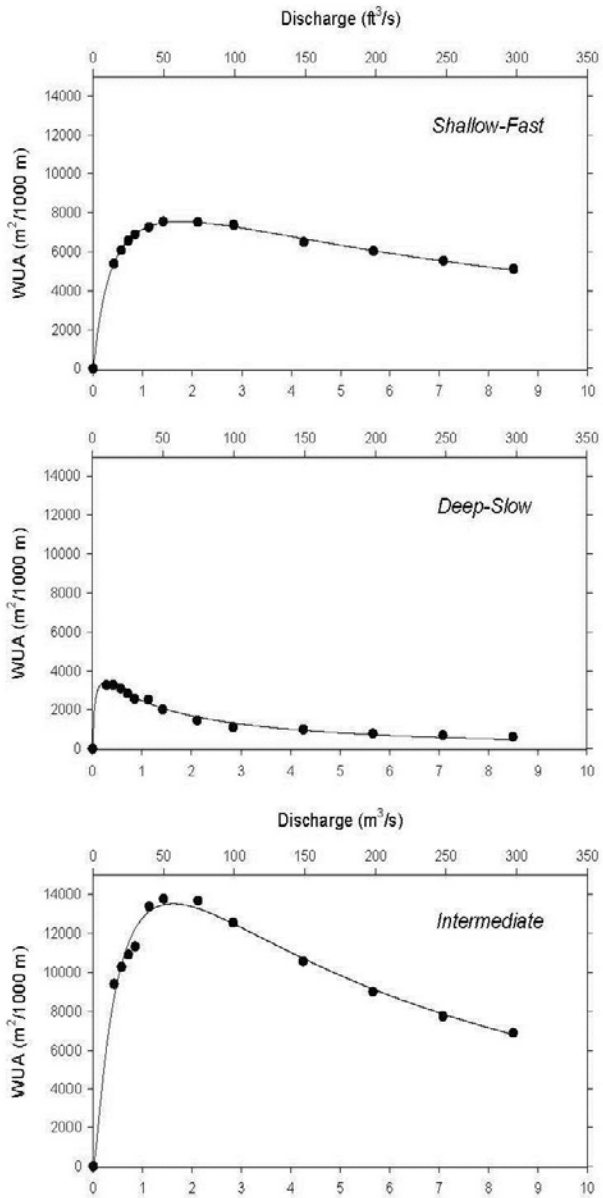
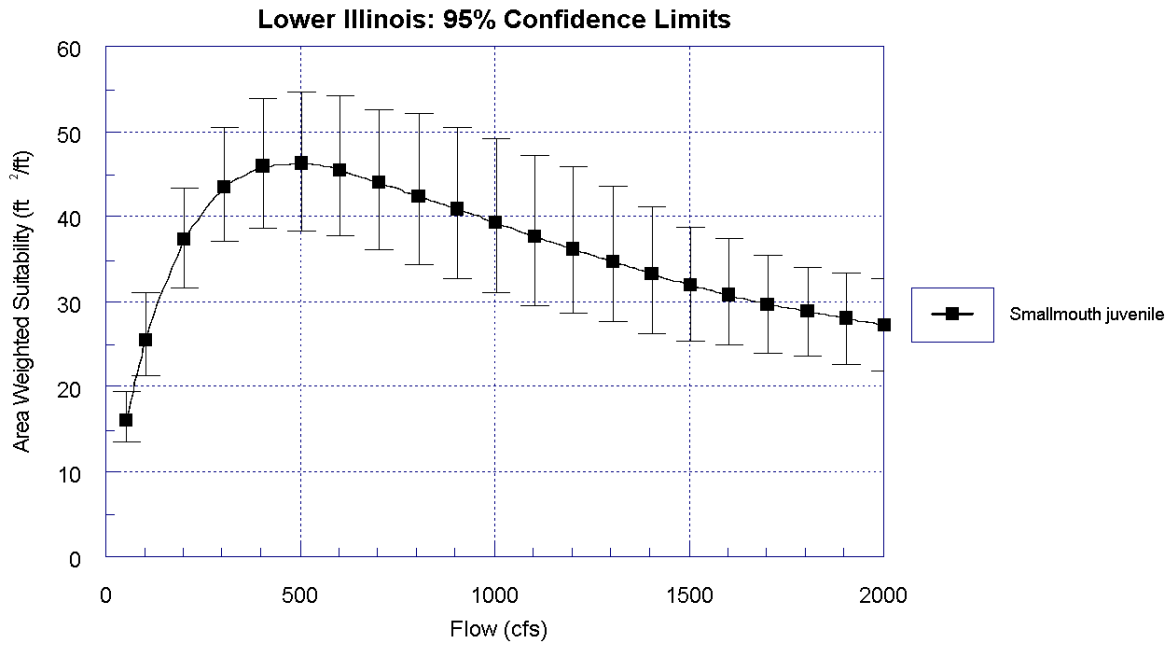


Figure 3-23. Relationship between Weighted Usable Area and Discharge for Shallow-fast, Intermediate, and Deep-slow Habitat-Use Fish Assemblages in Barren Fork, Oklahoma

3.4.5.5 Sensitivity Analysis

There is always uncertainty in flow-habitat relationships because of sample size (transects) or the suitability criteria applied. Using a bootstrap method with replacement by habitat type, confidence intervals (CI) were applied to AWS values for juvenile and adult smallmouth bass in the lower Illinois River (Figure 3-24) and Flint Creek (Figure 3-25). In the lower Illinois River, CI tended to be greater at lower flows for adult smallmouth bass but relatively constant at all flows for juvenile smallmouth bass. Similarly, in Flint Creek CI were greater at lower flows, but the opposite trend was observed for juvenile smallmouth bass. The juvenile smallmouth bass showed narrower CI in AWS compared to adult smallmouth bass at a similar flow in both streams, which is probable because there is less overall defined habitat for adult smallmouth bass compared to juvenile smallmouth bass, based on the criteria used to define habitat.

A further analysis was conducted for the lower Illinois River to determine the effect that sampling different habitat units and types may have on results. There were a total of 9 pool, 4 run, 3 glide, and 2 riffle transects in the lower Illinois River. Three sets of 9 transects containing 5 pools, 2 runs, 1 glide, and 1 riffle were randomly selected. One stipulation established with regard to the sample was that each habitat unit must be used at least once. Results for smallmouth bass are similar for all groups of randomly selected transects (Figures 3-26 to 3-28). Fish assemblage results show a small difference for the Group 1 transects (Figures 3-29 to 3-31); however, the highest habitat values still occur over the same range of flows as the other two groups. These results demonstrate the robustness of the modeling and emphasizes the importance of having an adequate sample size to reduce results uncertainty.



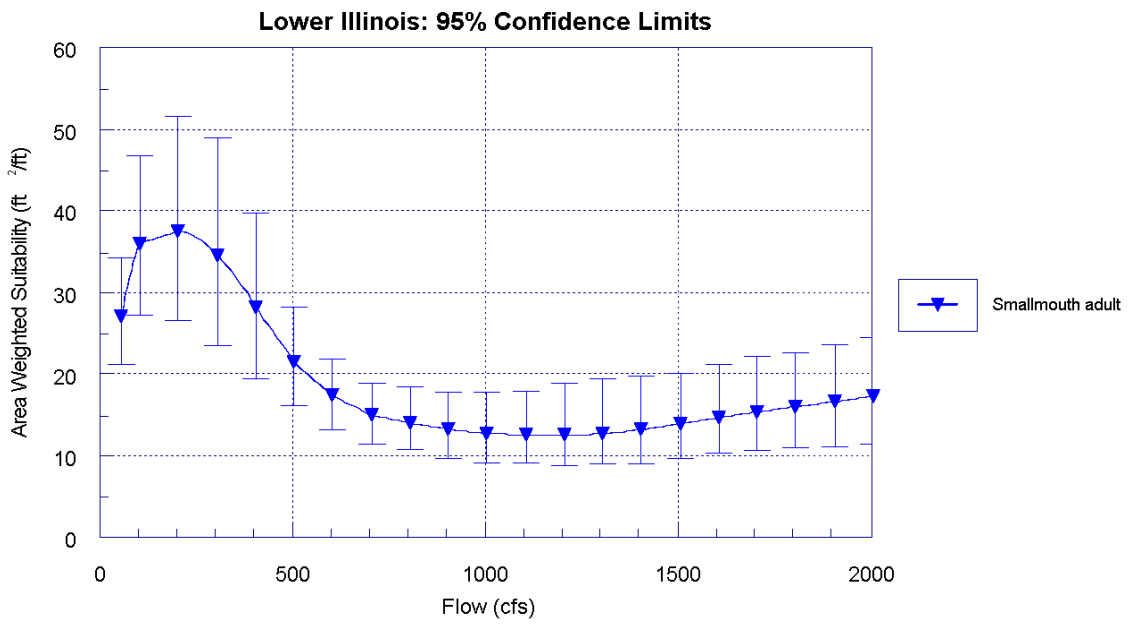
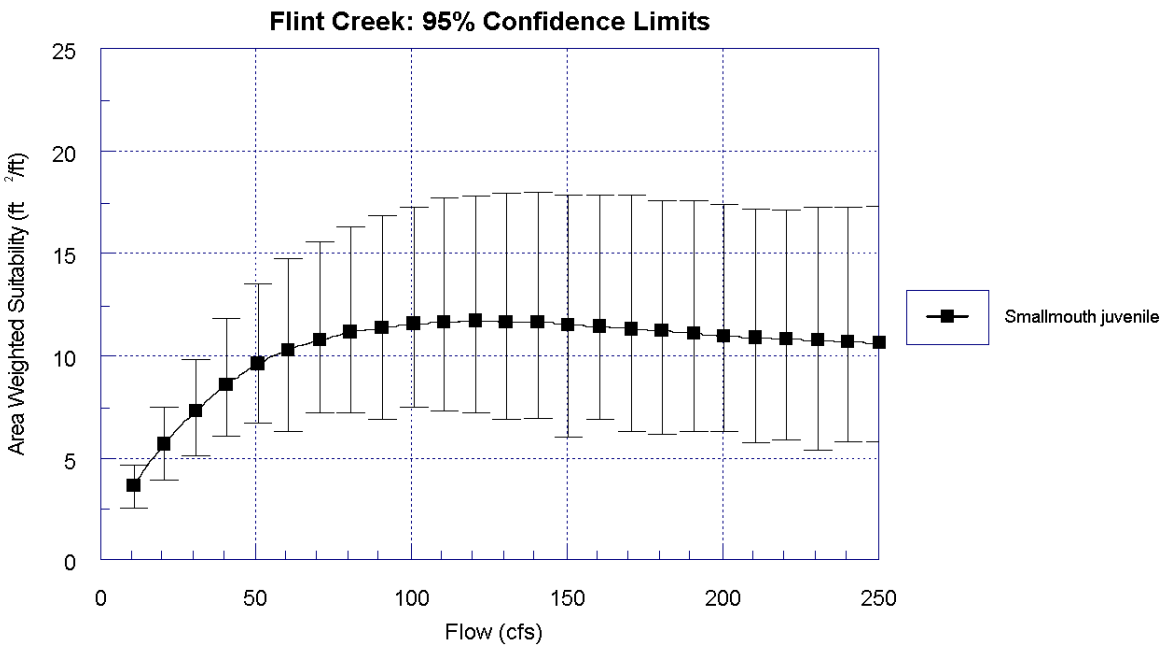


Figure 3-24. Confidence Limits around Smallmouth Bass Juvenile and Adult AWS Values versus Flow in the Lower Illinois River



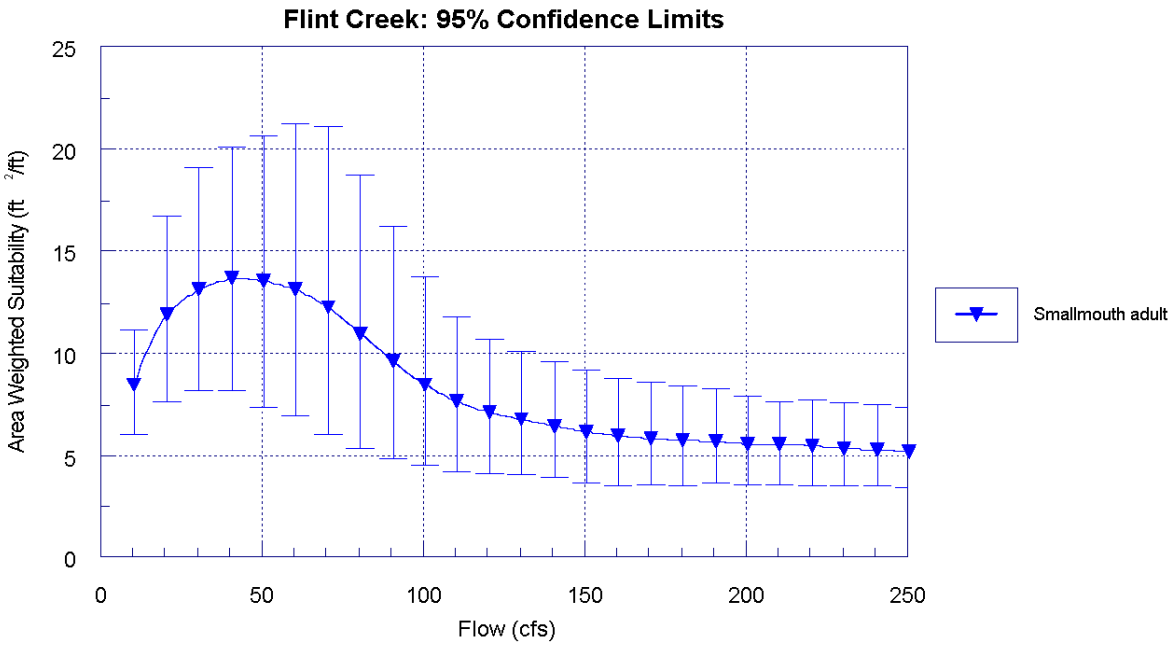


Figure 3-25. Confidence Limits around Smallmouth Bass Juvenile and Adult AWS Values versus Flow in Flint Creek

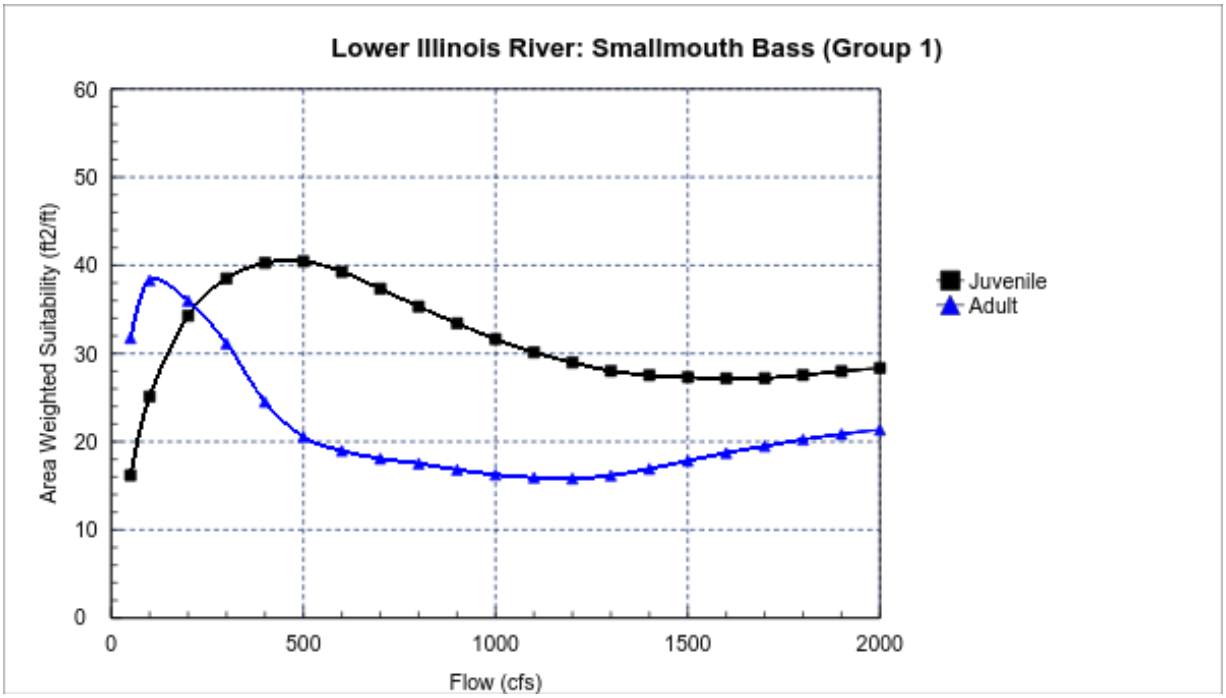


Figure 3-26. Smallmouth Bass Juvenile and Adult AWS versus Flow in the Lower Illinois River (Group 1) based on Nine Randomly Selected Transects

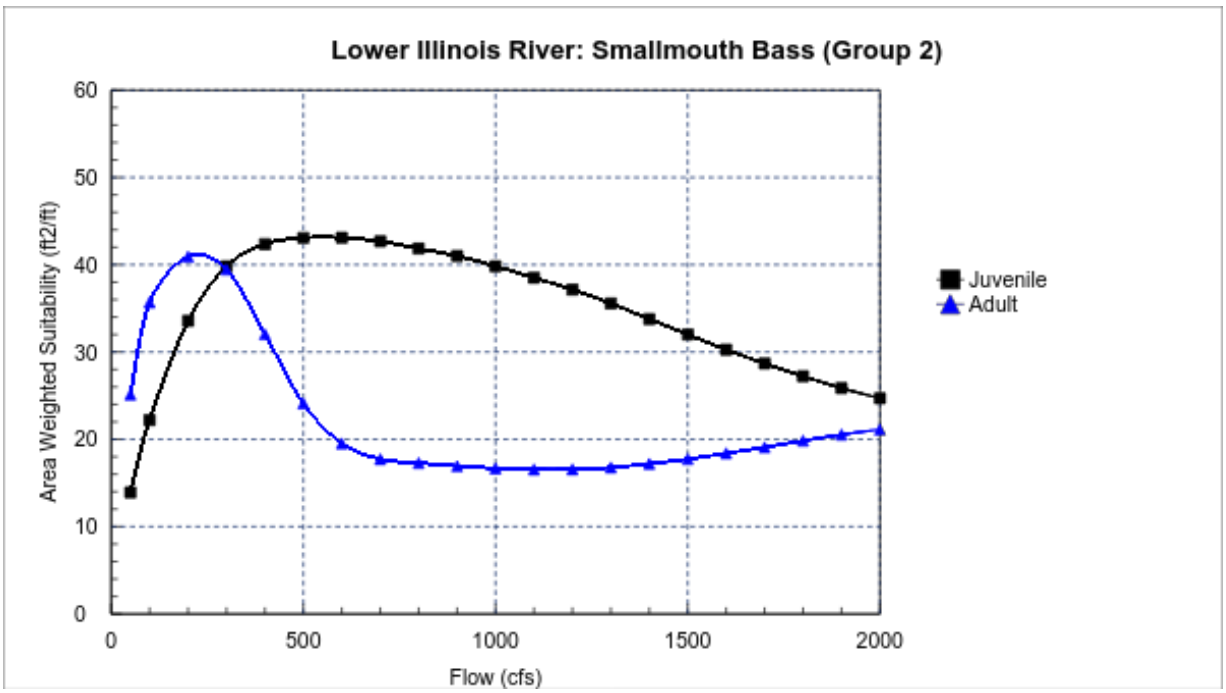


Figure 3-27. Smallmouth Bass Juvenile and Adult AWS versus Flow in the Lower Illinois River (Group 2) based on Nine Randomly Selected Transects

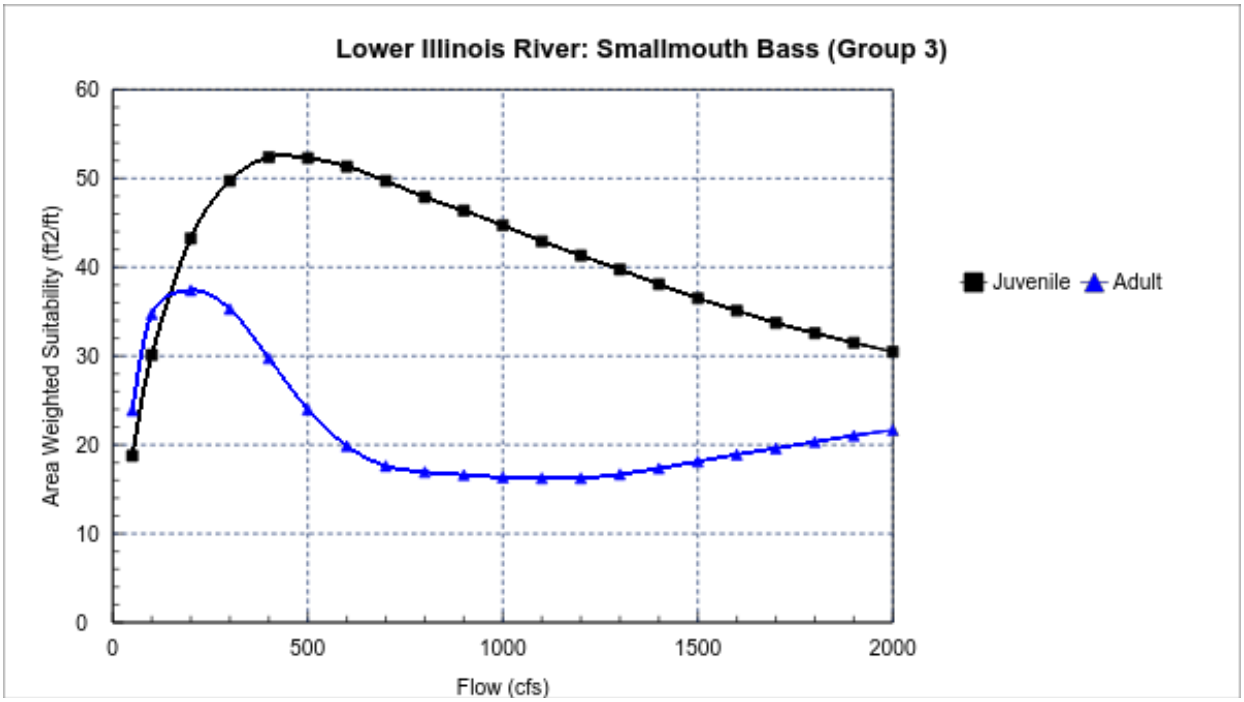


Figure 3-28. Smallmouth Bass Juvenile and Adult AWS versus Flow in the Lower Illinois River (Group 3) based on Nine Randomly Selected Transects

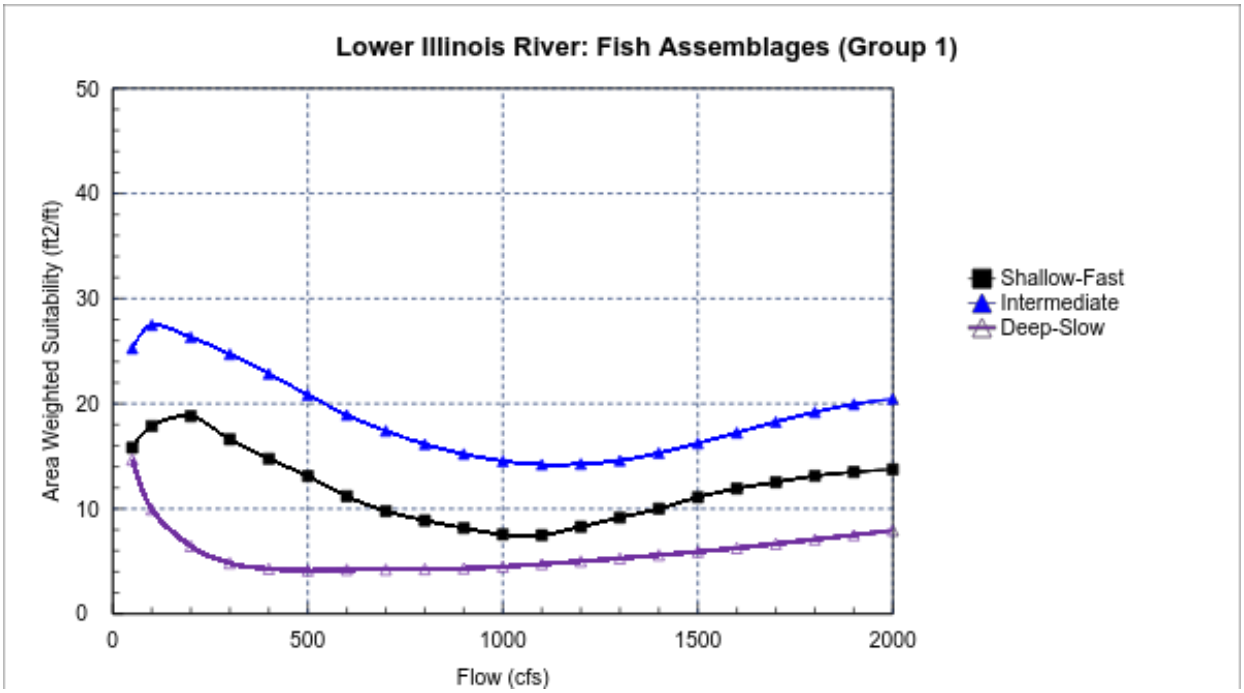


Figure 3-29. Fish Assemblages AWS versus flow in the Lower Illinois River (Group 1) based on Nine Randomly Selected Transects

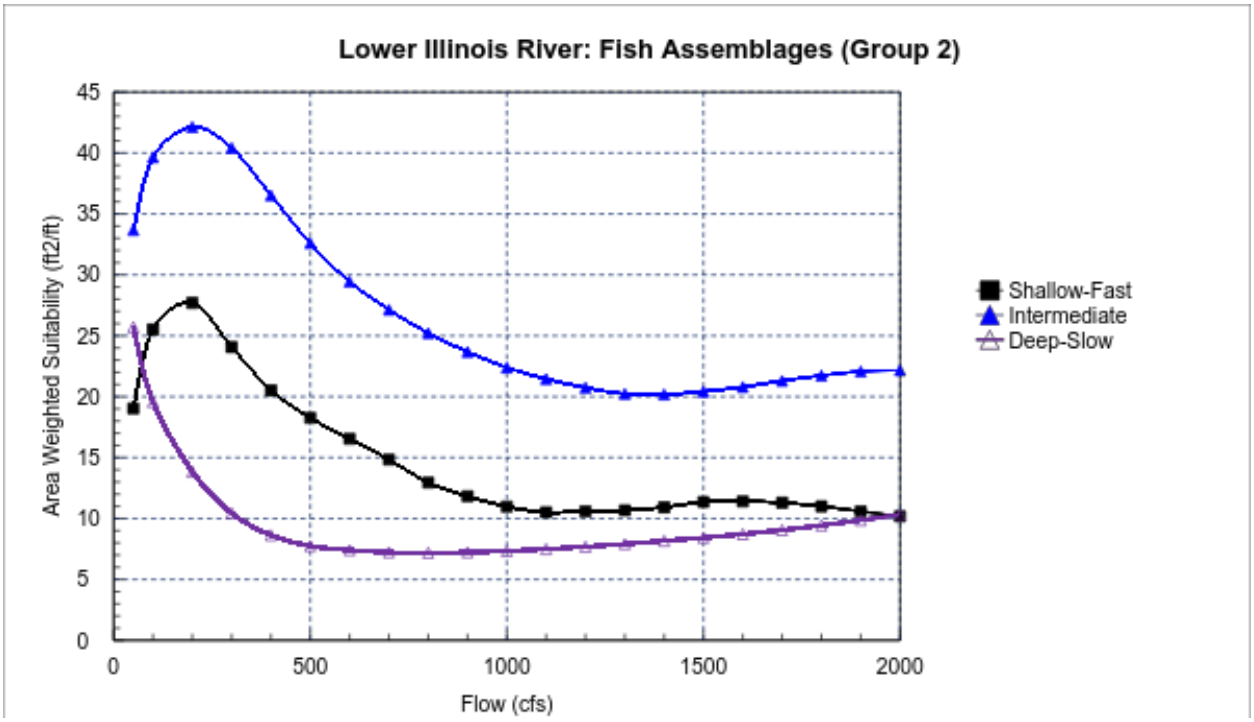


Figure 3-30. Fish Assemblages AWS versus Flow in the Lower Illinois River (Group 2) based on Nine Randomly Selected Transects

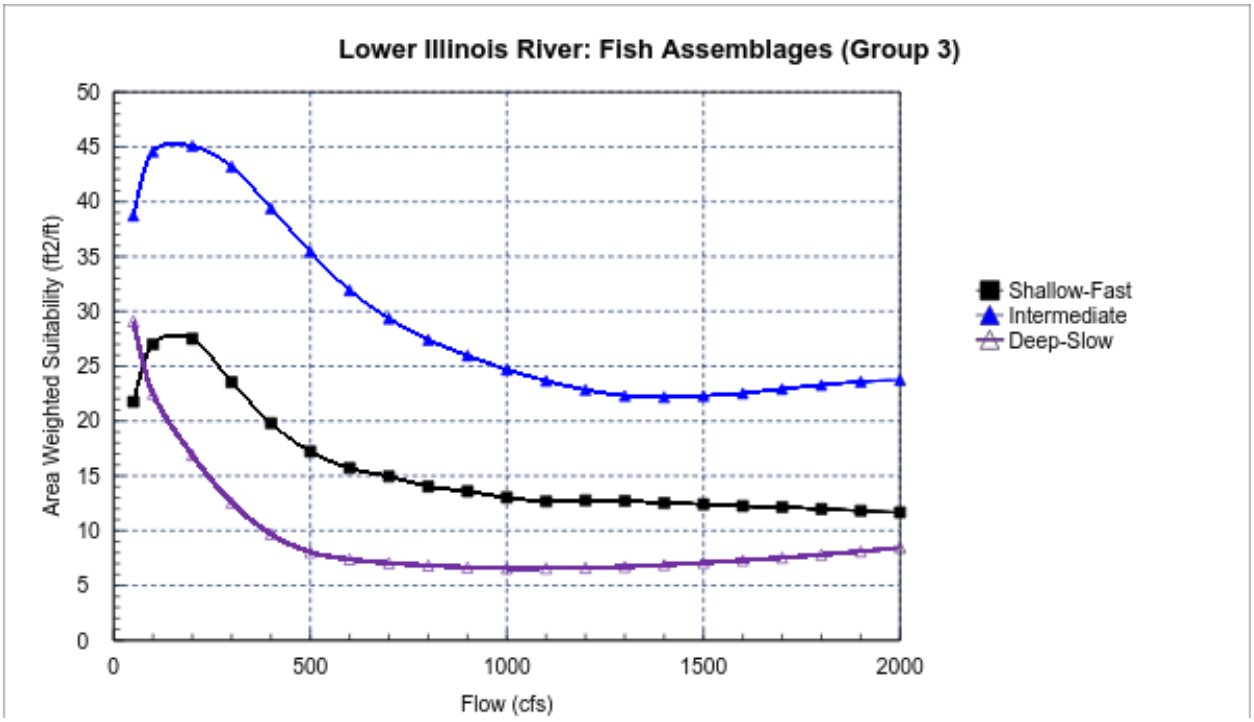


Figure 3-31. Fish Assemblages AWS versus Flow in the Lower Illinois River (Group 3) based on Nine Randomly Selected Transects

The results of the PHABSIM modeling also were compared to the results of a wetted perimeter analysis for riffles in the lower Illinois River and Flint Creek study sites as a way to validate the PHABSIM against a common simple ISF method. The wetted perimeter method is a flow-based approach that considers aquatic productivity in shallow-fast waters (riffles) of a stream (Nelson, 1983, Gipple and Stewardson,

1998). The wetted perimeter is the distance across the bottom of the stream channel that is in contact with water. A graph of the wetted perimeter versus discharge generally identifies a turning or breakpoint of the curve. Incremental flows above the breakpoint produce smaller increases in wetted streambed compared to flows below the breakpoint. This breakpoint is often used to identify an ISF value for protection of aquatic communities, especially fish. Results of that analysis for the lower Illinois River and Flint Creek are presented on Figures 3-32 and 3-33.

For the lower Illinois River, the wetted perimeter-discharge curve identifies a distinct breakpoint at 200 cfs. This is the same flow that also provides maximum habitat for the shallow-fast and intermediate fish assemblages as determined in the PHABSIM analysis. For Flint Creek, the wetted perimeter curve indicates a breakpoint at approximately 20 cfs, but it is not very distinct. This flow is within the range providing good habitat conditions for most species in Flint Creek but less than the flows (30-40 cfs) providing maximum habitat.

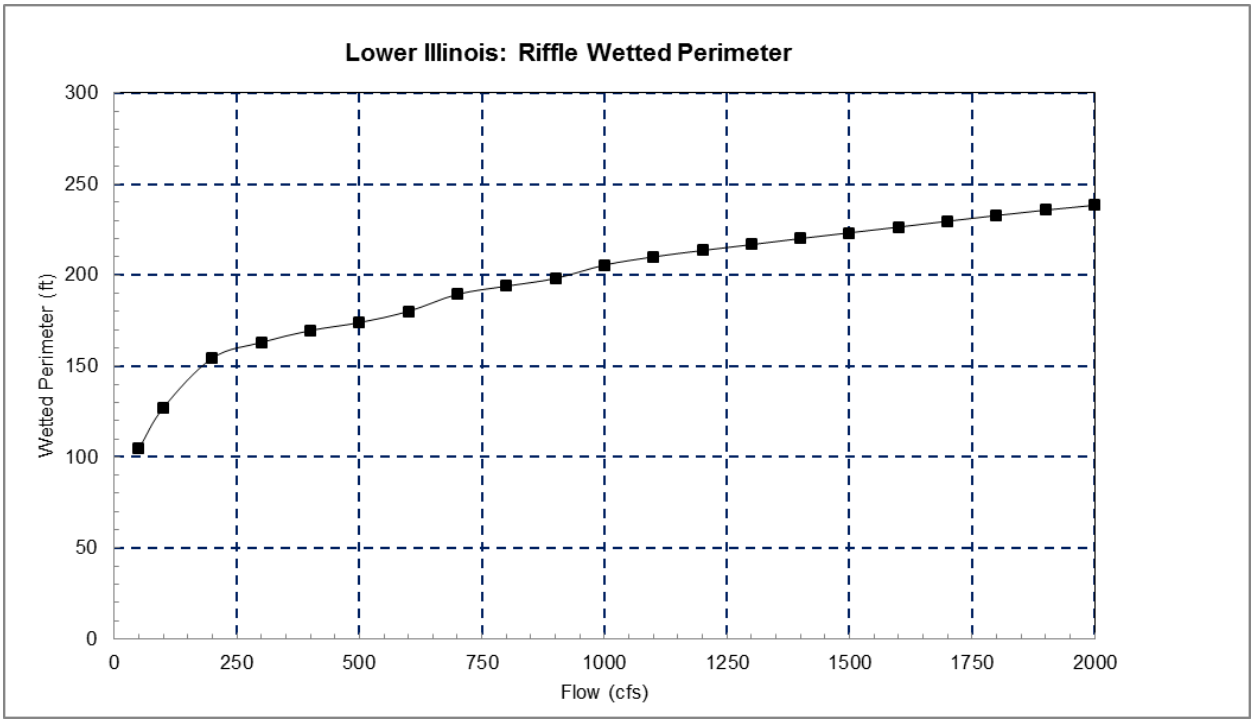


Figure 3-32. Wetted Perimeter versus Discharge Relationship for Riffle Transects on the Lower Illinois River Study Site

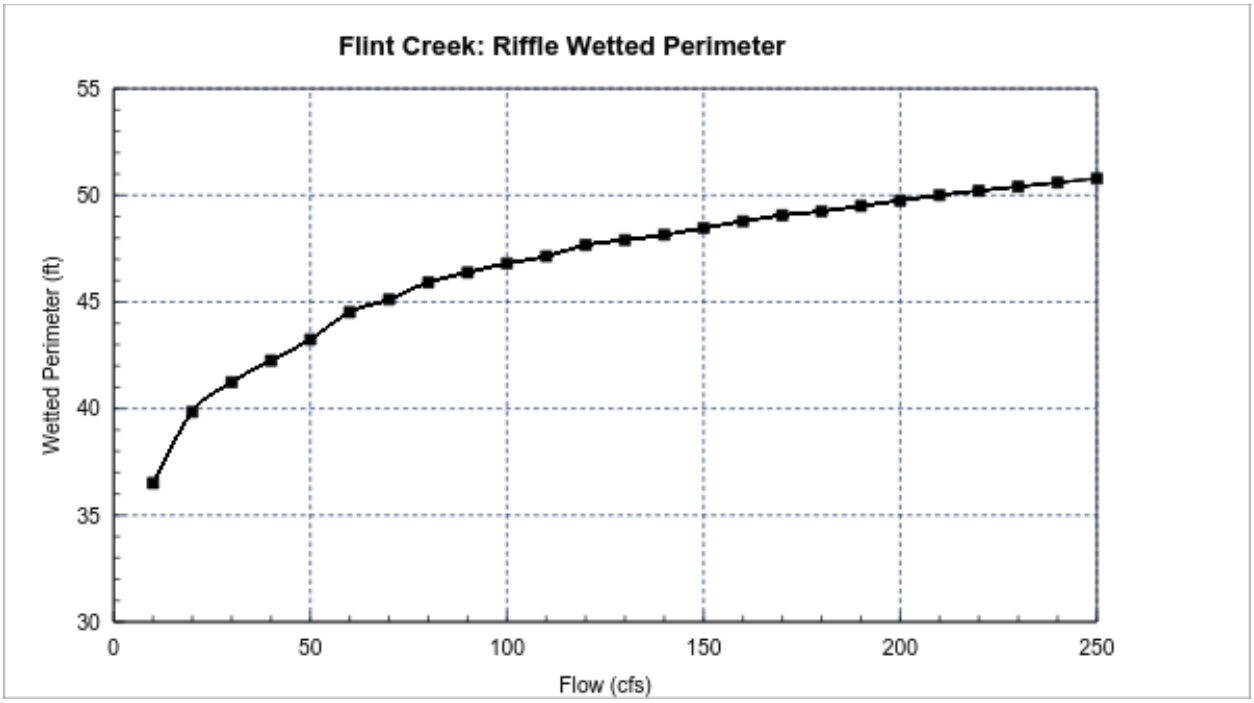


Figure 3-33. Wetted Perimeter versus Discharge Relationship for Riffle Transects in the Flint Creek Study Site

SECTION 4

Discussion

This section provides an interpretation of fish habitat modeling results, a discussion of ecological flow needs, and an assessment of decision making considerations and next steps.

Technical direction for the project was provided by the Technical Study Workgroup (TSWG) through a series of three workshops during the winter of 2015 through the spring and summer of 2016. The TSWG was composed of participants from six resource agencies who reviewed the methodology, work plan, preliminary findings, and technical reports. The Illinois River Instream Flow Analysis Study Plan for Field Data Collection and Habitat Modeling ("Final Study Plan") is included in Appendix B of this report. TSWG comments and input were incorporated in the Final Study Plan design and reports. The TSWG meeting agendas, meeting summaries, and presentations are included in the Appendix C. In addition to input from the TSWG, stakeholders within the watershed provided information and input throughout the study period at three public meetings held within the study area watershed in Tahlequah. Approximately 150 members of the public attended the meetings. The public provided valuable information on the current and potential future watershed related resources. The relevant feedback and information from the public meetings were incorporated in this final report. The public meeting agendas, meeting summaries, and presentations are included in Appendix D. In addition to the TSWG technical review and collaboration, the ISF AG reviewed and commented on the Illinois River Instream Flow Assessment Report. The consolidated comments and prepared comment responses are included in Appendix E.

4.1 Interpretation of Fish Habitat Modeling Results

The habitat flow curves (AWS) presented in the PHABSIM modeling portion of this report are simply relationships between fish rearing habitat and streamflow; they do not provide specific flows values that can be simply converted to numerical ISF prescriptions. To make reasonable ISF recommendations for fish habitat, the study results must be interpreted as to their biological meaning to the fish community as a whole.

The AWS curves were developed only for fish rearing habitat. As such, they do not address spawning, food production, competition, predation, and other important biological factors that can be affected by streamflow conditions. Also, AWS curves depict habitat conditions as related to flow under the existing channel condition. They do not address the flows that actually create the physical habitat in the first place. The need for these ecological process flows are discussed later.

Much of the PHABSIM modeling was done for smallmouth bass because it is the most sought-after game fish in the basin. But one should not interpret this as meaning that smallmouth bass is the most important fish species relative to others. In fact, there are more than 60 other species that make up the fish community of the Illinois River basin. Results of the habitat use assemblages (guilds) provide a much more comprehensive assessment of the relationship between streamflow and habitat for the fish community as a whole.

Of the various mesohabitat types, riffles are often considered most important because they provide conditions conducive to the production of algae and macroinvertebrates in addition to being preferred habitat for many fish species. Algae and macroinvertebrates are the primary source of food for most riverine fish species. So while low flows may provide good conditions for pool dwelling species, such as suckers and sunfishes, these fish largely rely on the algae and macroinvertebrates produced in the riffles for food. Also, many of the pool-classified species spawn in gravel areas, which are more commonly associated with riffles. Because of these factors, habitat conditions for the shallow-fast fish assemblage,

which represents those fish species preferring riffles, should be given particular attention when considering ISF prescriptions.

The results of the PHABSIM modeling suggests that relatively low flows favor suckers and sunfishes (deep-slow guild) in the Illinois River compared to other species. While this pattern may be true when considering only microhabitat conditions, one must be careful in how to interpret these results. One must take into account the fact that pools make up by far the most predominant mesohabitat type in the Illinois River, accounting for 58 percent of the total (see Tables 3-6 and 3-7 of Results Section 3.4). Therefore, it is unlikely that the amount of pool habitat at any flow is a population-limiting factor to the species preferring pools. It is more likely that food, spawning habitat, or behavioral interactions with other species limit these pool-preference species. This provides a good example of the need to look at the entire fish community and the nonhabitat biological factors affecting the community when interpreting PHABSIM results.

In general, the results of the fish habitat modeling suggest that flows between 100 cfs and 300 cfs provide good rearing habitat conditions for most fish species in the Illinois River. For the shallow-fast and intermediate fish assemblages as well as smallmouth bass adults, maximum habitat occurs at 200 cfs. Habitat values drop precipitously at flows below 100 cfs for these assemblages. Juvenile smallmouth bass show a preference for higher flows (maximum at 400 to 500 cfs) but with 80 percent of the maximum habitat still available at 200 cfs.

For Flint Creek, suitable habitat conditions occur when flows range from 10 cfs to 60 cfs with maximum habitat for the shallow-fast and intermediate fish assemblages occurring at 30 cfs and 40 cfs, respectively. Adult smallmouth bass habitat is maximized at 40 cfs.

Habitat modeling results for Barren Fork Creek were obtained from Fisher and Remshadt (2000). The habitat criteria used in the modeling were the same as those used for the Illinois River and Flint Creek. Results indicate that suitable habitat conditions occur from about 40 cfs to 100 cfs for most species. Maximum habitat for the shallow-fast and intermediate fish assemblages as well as smallmouth bass adults occurs at 50 cfs.

As stated in Section 1, the purpose of this Report is to summarize the methods and results of an ISF pilot study, which modeled the availability of suitable mesohabitat for key fish species at different life cycles under different flows. The ISF AG is ultimately responsible for evaluating these modeling results while considering other stakeholder needs as well as water use policy before making final ISF recommendations.

4.2 Need for Ecological Flows

ISF prescriptions that include the various natural components of the hydrograph are most desired when the goal is to provide long-term protection of the ecological processes that maintain the stream's natural environmental values. Although many components of the natural hydrograph can be defined, for practical purposes they are often categorized as baseflows, channel maintenance flows, and overbank flows. For each of these flow components, consideration should be given to their magnitude, duration, frequency, seasonal timing, and rate of change (Annear, et al., 2004). These three flow components are defined below:

- **Baseflows** represent the normal flows between significant precipitation events. For setting of ISF management prescriptions, emphasis is typically placed on the summer or fall base-flow period. Most ISF setting methods focus on the baseflow needs.
- **Channel Maintenance Flows** are those moderate-to-high flows that occur about once every year or two. They correspond to bankfull conditions. They serve to create and maintain important habitat conditions and connectivity along the stream corridor.

- **Overbank Flows** are the infrequent flood events that produce water levels that exceed those of the river bank. These flood flows help maintain riparian areas, transport sediment and nutrients onto the floodplain, recharge floodplain aquifers, and provide lateral connectivity to off-channel water bodies. Floods typically occur in defined seasons.

Discussion of these three ISF components as they relate to the Illinois River basin and results of this study is presented below.

Baseflows. Establishing baseflow prescriptions for the Illinois River, and Barren Fork Creek and Flint Creeks, is perhaps the most important need among the various flow components. Establishment of such flows would represent a minimum flow management prescription for use by the OWRB in assessing future out-of-stream water right applications. Having adequate baseflow protection during the summer and fall months is especially important because (1) fish populations tend to be limited by conditions during the warm low-flow period, (2) recreational use of streams (e.g., fishing, boating) is greatest during this period, and 3) demands for out-of-stream water use such as irrigation are highest during the summer low flow season.

In the process of establishing ISF management prescriptions, especially for unregulated streams, it is important to consider the availability of water for meeting resource value goals associated with ISF. Flow prescriptions that frequently exceed the availability of water in the stream tend to be difficult to justify to the public, particularly in a stream with conflicting water uses. For the Illinois River, the typical late summer baseflows (median) are in the 200 – 300 cfs range (Table 4-1). The results of this study indicate these baseflows also correspond to good habitat conditions for the native fish community. Similarly, for Flint and Barren Fork Creeks, the flows that provide good habitat conditions for the fish community correspond closely to the median baseflows during the summer and fall. Habitat availability at these baseflows are what fish populations tend to track over time.

Table 4-1. Median Streamflows (cfs) in the Illinois River (Tahlequah gage), Flint Creek (Kansas gage), and Barren Fork Creek (Eldon gage) during the Low-flow Season July - November

Stream	Month					Average Median Flow
	July	August	September	October	November	
Illinois River	297	217	200	225	308	249
Flint Creek	40	31	29	31	49	36
Barren Fork Creek	69	45	40	50	83	57

Channel maintenance flows. Channel maintenance or channel forming flows are those high flows that erode banks, move large quantities of substrate, shift gravel bars, and scour vegetation. When such flows occur in unconfined reaches, which typifies much of the Illinois River, secondary side channels are formed. At multi-channel sites, riffles often occur at the upstream end and pools at the downstream end or to one side of the riffle. Backwaters are formed at the downstream end of many side channels when inflow ceases at the upstream end as runoff subsides. It is common for eddies to form at the interface of the backwater mouth and the main channel. All of these channel features can be seen on the available aerial photographs of the Illinois River corridor (see Appendix A). These features provide the complexity and diversity of habitats preferred by the fish community as well as other water dependent wildlife.

In an unregulated stream, the channel maintenance flows typically correspond to the bankfull flow. A commonly accepted and universally applicable definition of bankfull is provided by Dunne and Leopold (1978): "The bankfull stage corresponds to the discharge at which channel maintenance is the most effective, that is, the discharge at which moving sediment, forming or removing bars, forming or changing bends and meanders, and generally doing work results in the average morphologic

characteristics of channels." It is this discharge, along with the range of flows that make up an annual hydrograph, which governs the shape and size of the active channel. Bankfull discharge is associated with a momentary maximum flow that has an average recurrence interval of 1.5 years as determined using a flood frequency analysis (Dunne and Leopold, 1978). Although greater erosion and enlargement of steep incised channels may occur during more extreme fluvial events, it is the modest flow regimes that transport the greatest quantity of sediment material over time, due to the higher frequency of occurrence for such events (Wolman and Miller, 1960).

The 1.5-year recurrence flows for the three study streams (four sites) are as follows:

- Illinois River at Tahlequah – 14,112 cfs
- Illinois River at Watts – 13,912 cfs
- Barren Fork Creek at Eldon – 11,099 cfs
- Flint Creek near Kansas – 2,520 cfs

In terms of maintenance of the channel itself, it may be inconsequential which month the high flow event occurs. However, there are other ecological functions associated with these high flow events that do depend on their season of occurrence. These may include fish spawning and migration, seed and plant germination in riparian areas, and wildlife life history needs. Annual peak flow events that exceed the 1.5-year recurrence probability (14,112 cfs) in the Illinois River at Tahlequah can occur in any month (see Table 2-4). However, most occur in the winter and spring months (December to June). The least likely months for these events to occur are August and September.

Overbank flows. It is important that natural streams have access to their floodplains. As floodwater spreads over a floodplain, velocities and thus erosive force are reduced. As the water overflows onto the floodplain, water velocities tend to drop thus attenuating downstream flooding. If flood flows are contained within a stream channel, water velocities remain high and cause channel degradation in the forms of incision or excess lateral migration (bank erosion).

Higher flood events also are important from an ecological process standpoint (floodplain maintenance), but recommending or prescribing the maintenance of flow levels/events that are above the bankfull level is problematic in a regulatory sense if there is considerable human encroachment onto the floodplain (roads, homes, businesses, farms). For the Illinois River, Flint Creek, and Barren Fork Creek, a quantified prescription for a flood flow may not be necessary because of the presumed protection of these natural flood events embodied in the language of the OSRA. Furthermore, the need to protect floodplain maintenance flows would only be an issue if a major flood control dam were to be proposed in the basin, and that appears to be unlikely in the foreseeable future.

4.3 Key Findings of the PHABSIM

The results from this PHABSIM assessment are intended to provide technical information on relationships between fish habitat and flow, ecological processes and flow, and recreational use and flow. The following are the key findings of the PHABSIM phase of the Illinois River Pilot Study:

1. The Illinois River, Flint Creek, and Barren Fork Creek in the study area are largely unregulated streams, and diversions of water for out-of-stream use represent a small proportion of the total available water (Approximately 1.3 percent of the surface water availability in the river in Oklahoma. See water usage section of the main report)
2. Fish microhabitat modeling results indicate that the following flow ranges provide suitable fish rearing habitat conditions for the respective fish communities: Illinois River 100–300 cubic feet per second (cfs), Flint Creek 10–60 cfs, and Barren Fork Creek 40–100 cfs. These flow ranges correspond closely with the existing base flows, based on monthly medians, during the July through November low flow period.

3. The Illinois River supports an extensive network of secondary channels, which in turn support many important ecological functions. Maintaining the high-flow regime, especially the bankfull flows, is critical for protecting these ecological values.
4. Recreational use of the Illinois River is a major activity. The minimum streamflows needed for recreational floating on the river (as determined by the Oklahoma Scenic Rivers Commission) correspond closely to those flows needed to protect the fish rearing habitat.

TSWG Input: The data and information from this report was reviewed by the TSWG membership. Their review comments may be found in Appendix E of this report. In addition, several TSWG members met on July 18, 2016. Using data from this study, the group came to consensus on a set of recommended flow ranges and implementation measures for future consideration in the IFIM process. These recommendations can be found in their submitted meeting notes included in Appendix E: July 18, 2016 "Flow Meeting Follow-up"). Further, on July 15, 2016, The Nature Conservancy submitted an extensive comment letter, presumably with concurrence from other TSWG members. Some of the comments have been addressed in this final report version or in the response matrix found in Appendix E. The letter also includes additional site-specific data and suggested this study consider approaches other than IFIM and PHABSIM. Their substantial and in-depth analysis should not be ignored but cannot be readily fit into this study. However, this information may be a valuable reference for discussion in Phase IV, Alternatives Analysis meetings with stakeholders. Respectively, the suggestion to consider approaches other than IFIM and the PHABSIM model are perfect examples of what should be reviewed in Phase VI, Process Evaluation.

4.4 Next Steps

The first three phases of the IFIM process for this pilot study are finished. To complete the process and support the development of an ISF program, the final three phases of the traditional IFIM process should now be considered. These phases include **Alternatives Analysis** (Phase IV), **Issue Resolution** (Phase V), and **Process Evaluation** (Phase VI).

Phase IV: **Alternatives Analysis** is important to the IFIM process because the IFIM process generally does not result in a single "best" flow value. Rather, the IFIM generates WUA estimates over a range of flows (or for alternative flow time-series) for each target species. The WUA estimates form the basis of negotiations among interested parties, including the stakeholders identified in Phase I, on the recommended flows that best balance the needs of the aquatic resources and other uses in the river system. Typically, establishment of ISF or flow-regime alternatives for a particular stream reach are formulated by any interested parties (resource agencies and stakeholders) after reviewing both the institutional analysis and the results of the technical studies from previous study phases. Alternatives are compared to an agreed-upon baseline condition to facilitate understanding of potential impacts and to begin negotiating and creating new alternatives that may be more compatible with the multiple objectives of the parties.

Each alternative would be evaluated by the following criteria:

- Effectiveness—Are the objectives of each party sustainable? Is no net loss of habitat or biological function possible on a sustainable basis? What are the habitat costs and benefits of each alternative?
- Physical Feasibility—Are prior water rights and existing water uses maintained? Are reservoir purposes maintained? Is enough water available for instream resource values and potential future out-of-stream uses?
- Risk—How often does an alternative lead to a failure of the biological system? Is the failure reversible? Can contingency plans be developed?

- Economics—What are the costs and benefits of each alternative? Are existing water rights affected? Are values associated with reasonable future water uses accounted for?

Phase V: **Issue Resolution:** Stakeholders deliberate ISF criteria or standards that meet the overall watershed goals. This is called the **Issue Resolution**. The stakeholders must integrate their knowledge and understanding of the technical and social issues to reach an ultimate resolution. This process implies that the solution will entail some kind of a balance among conflicting environmental and social values.

The PHABSIM modeling generates WUA habitat estimates over a range of flows (or for alternative flow time-series) for each target species or recreational requirement, or both. The maximum WUA values typically will occur at different flows and differing times of the year for the various target species, life stages, or other uses. In addition, the current and future needs for water for developmental purposes must be considered in the resolution process. Thus, selection of flow regimes suitable for protecting the aquatic community while recognizing the need to accommodate other beneficial uses of the water often requires balancing, tradeoffs, and seasonal variation that are the subject of negotiations and management decisions.

Phase VI: **Process Evaluation**: Because the primary purpose of this pilot study was to define a conceptual framework and study process to be used for considering ISF needs for water resource planning purposes, it was important that the process itself be evaluated by the participating stakeholders. This will be accomplished with a questionnaire of the stakeholders that will solicit opinions as to strengths and weaknesses of the steps used in the pilot study and suggestions for improvement for future application to other watersheds. This phase may include workshops and other activities as identified in the stakeholder process.

Ultimately, this pilot study and the technical studies on the Illinois River will provide a significant data set for determining the ISF recommendations in this pilot watershed. In addition, a considerable amount of progress was made within the ISF AG and the TSWG on the resource management needs that will need to be considered in any final recommended ISF program. Implementation of the additional steps outlined above will help to clarify the remaining information gaps, support further negotiations with resource agencies and stakeholders, and allow the OWRB to identify the most appropriate recommendations for ISF that balances the environmental, social, and economic needs.

SECTION 5

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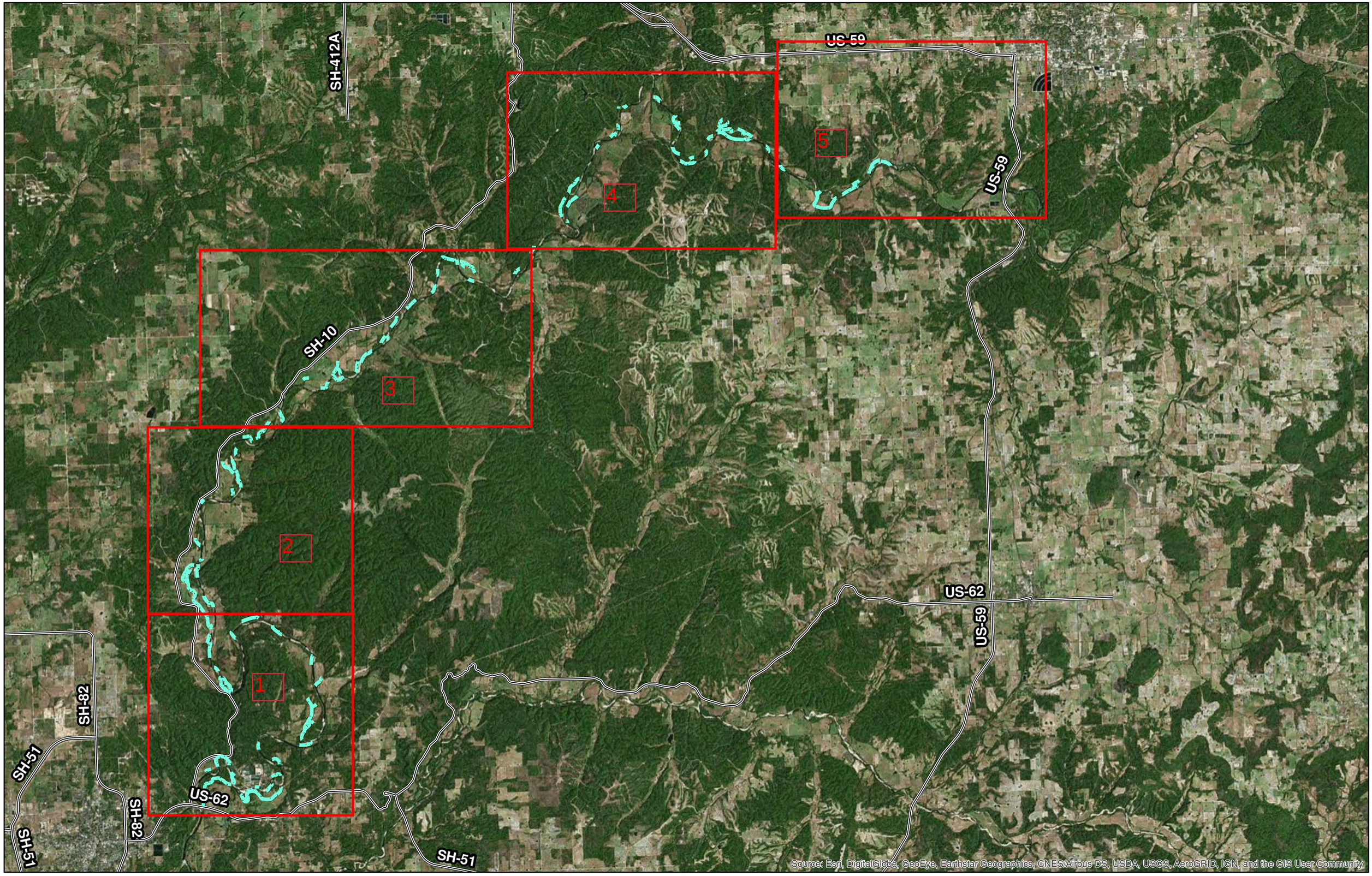
Appendix A
Aerial Maps of the Illinois River Corridor between Tahlequah and Watts, Oklahoma, with Secondary Channels Highlighted

Maps are ordered from downstream to upstream.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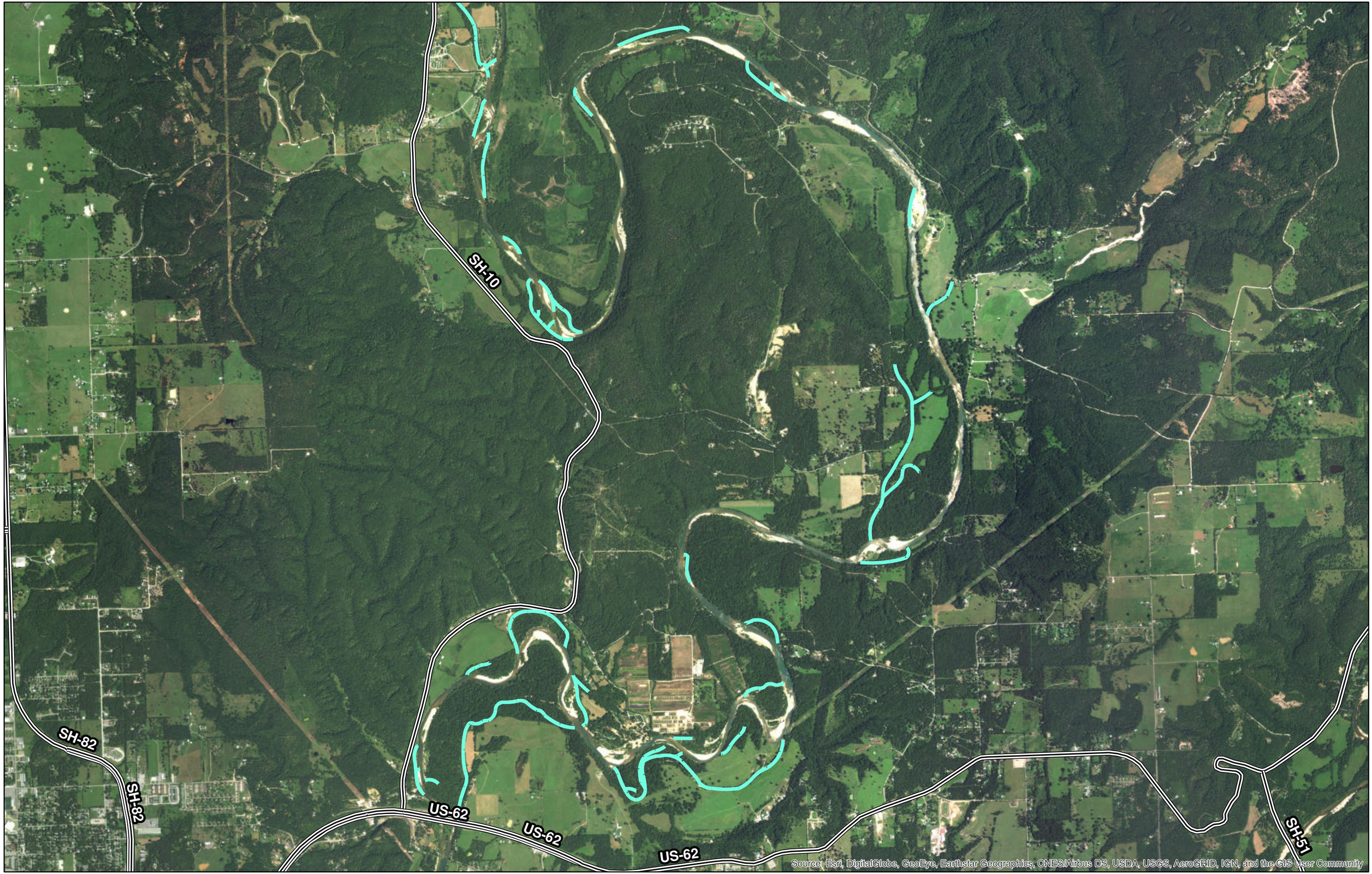
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community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Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

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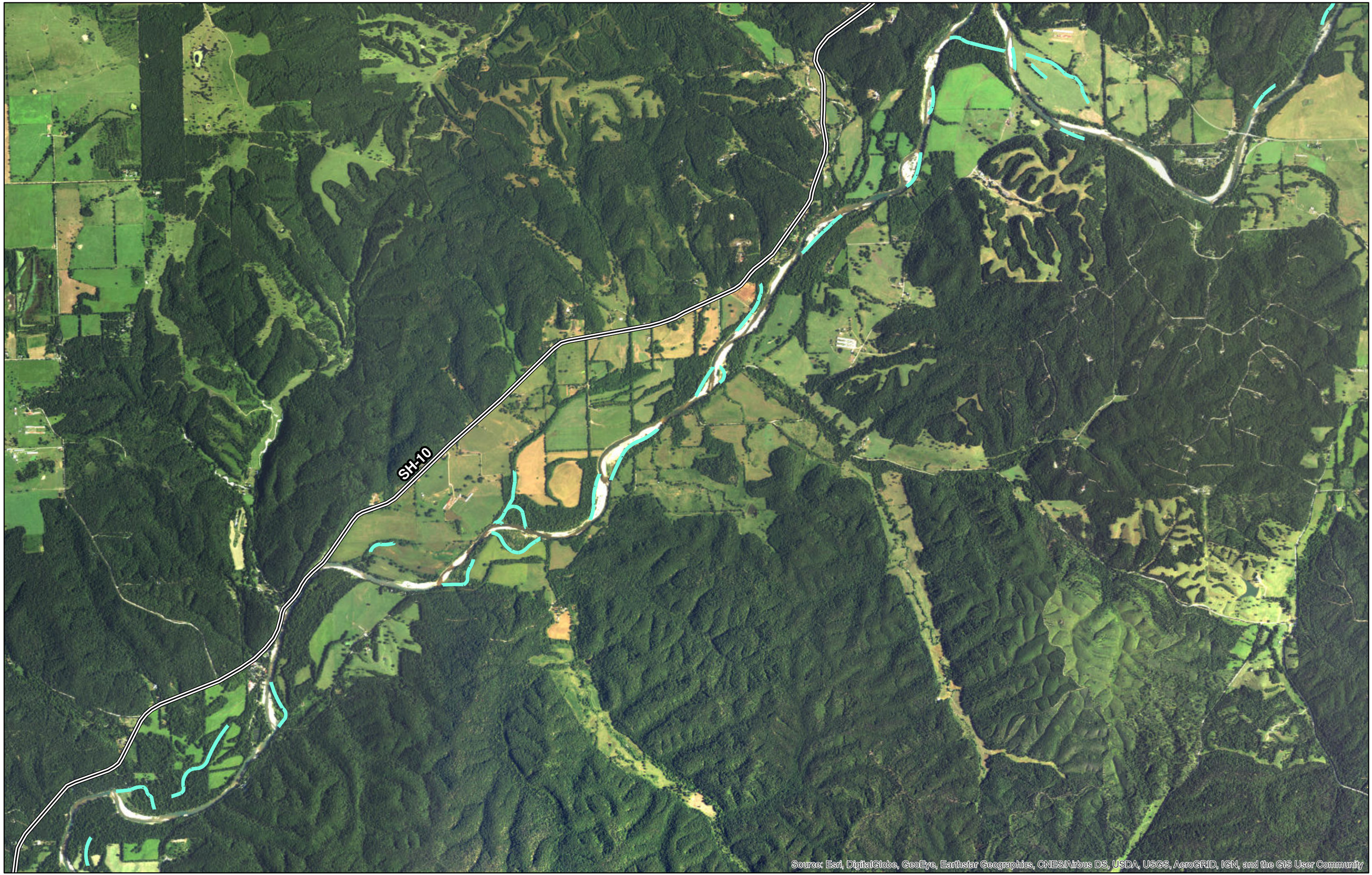
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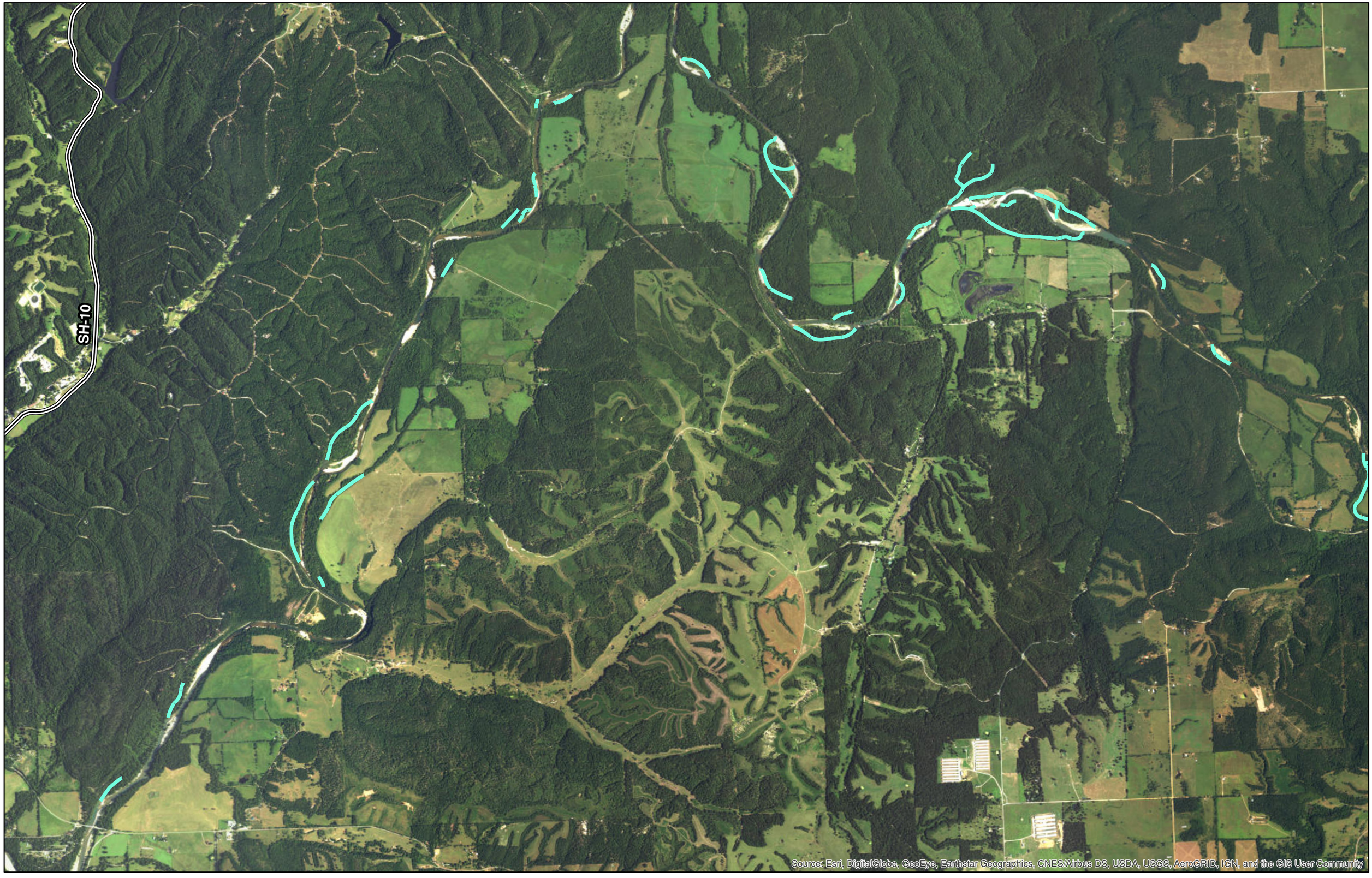
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Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Appendix B
Illinois River Instream Flow Analysis Study Plan for Field Data Collection and Habitat Modeling (Final Study Plan)

Oklahoma Instream Flow Pilot Study Approach

PREPARED FOR: Oklahoma Water Resources Board and US Army Corps Engineers, Tulsa District

PREPARED BY: CH2MHILL

DATE: Revised May 30, 2014

Introduction

As part of the 2012 Oklahoma Comprehensive Water Plan (OCWP), the Oklahoma Water Resources Board (OWRB) convened an Instream Flow Advisory Group to discuss benefits and issues with a potential future Oklahoma instream flow program. This effort culminated in a report titled *Instream Flow Issues and Recommendations* (February 2011). The report outlined the issues associated with an instream flow program and recommended the following steps:

1. Address the legal and policy questions.
2. Study other mechanisms for protecting instream flows.
3. Develop a draft methodology for instream flow studies in Oklahoma.
4. Conduct a study on the economics of instream flows in Oklahoma.
5. Perform an instream flow pilot study in a scenic river.
6. Preserve the Instream Flow Advisory Group.

Furthermore, the *2012 OCWP Executive Report* identified eight priority recommendations including the following recommendation regarding Instream/Environmental Flows:

> The process developed by the OCWP Instream Flow Workgroup should be implemented and followed to ascertain the suitability and structure of an instream flow program for Oklahoma, with such process commencing in 2012 and concluding by 2015, as outlined by the Workgroup.

Consistent with these recommendations, the Instream Flow Advisory Group reconvened in 2013 to further define whether and how an instream flow (ISF) program might be implemented in Oklahoma. The ongoing Advisory Group has continued the dialogue about ISFs in Oklahoma per the recommendations in the 2011 report and the steps listed above. As part of the effort to address the institutional arrangements that govern what can or should be done with an ISF program in Oklahoma (Recommendations 1 and 2), a background report—*Instream Flow Advisory Group Support* (CH2M HILL and Carollo 2013)—investigated and summarized relevant Oklahoma water laws, existing programs and state and federal laws that may provide some level of ISFs and affect development of an ISF program in Oklahoma. The background report provided an initial overview on the ISF legal and policy framework, other states' ISF programs, and mechanisms for protecting ISFs to support the initial discussions with the Instream Flow Advisory Group.

Background

To more fully understand the issues raised by the Advisory Group, the OWRB conducted a questionnaire/survey with open-ended questions in February 2013. Fifty-nine percent of the respondents replied to the questionnaire. In addition, the issues were the subject of significant dialogue by the entire group at each of the Advisory Group meetings.

The issues identified by the Advisory Group were summarized in May 2013. The detailed input was compiled as received and distributed to the Advisory Group. A synopsis of these issues is posted to OWRB's ISF webpage (http://www.owrb.ok.gov/supply/ocwp/instreamflow.php). It is recognized that the list does not represent consensus on the issues, but indicates the types of questions and concerns raised by members of the group. This preliminary input from the Advisory Group was used to guide the facilitated discussions during subsequent ISF Advisory Group workshops.

The prevailing theme of the Advisory Group responses concerned the institutional issues and potential economic impacts surrounding an ISF program, e.g., water law and permitting, and protecting existing and future consumptive water rights. The complexity of addressing the ISF program legal and policy issues in the abstract creates an immense challenge for the meaningful analysis of the voiced concerns. To make sound policy recommendations, the Group acknowledged that the basis, specifics and consequences of an ISF program must be known and understood.

The measures recommended in the ISF Advisory Group survey included the use of a pilot study to "measure, refine and adjust an ISF program process before finalizing or implementing any program," and one respondent noted that "scenic rivers are a logical starting point, especially considering that there is already precedence for regulations of flows." The recommendations provide a good starting point from which to address the institutional issues surrounding an ISF program with a reference to a specific instance.

Input received via the facilitated Instream Flow Advisory Group meetings and workshops was analyzed to further develop recommendations regarding an ISF program process. Four workshops were conducted (March 1, May 16, and October 7, 2013, and January 16, 2014). The detailed workshop agendas, summaries and presentations are found on OWRB's ISF website (http://www.owrb.ok.gov/supply/ocwp/instreamflow.php). The workshops were held to solicit the Advisory Group's expertise, to advance the dialogue on the ISF program in Oklahoma and to deepen their understanding of the different elements of existing ISF programs through technical presentations.

Most of the ISF Advisory Group workshop dialogue and subsequent output from workshops centered on legal and policy questions as well as effects on water users and economics, reflecting the comments received from the questionnaire. At the October 7, 2013 facilitated workshop discussion, Advisory Group Chair J.D. Strong suggested that one way to advance the ISF perspectives and dialogue would be to develop or consider an ISF study process similar to the Instream Flow Incremental Methodology (IFIM) process, rather than developing a specific ISF minimal flow. The IFIM is the most widely used method for assessing ISF needs. He suggested developing a process for a pilot study that incorporates a systematic way to address outstanding concerns/issues, including potential economic benefits and impacts associated with establishing ISF goals or requirements in Oklahoma. That is, the results of the pilot study would provide tangible information that the Advisory Group could use as a basis for its recommendations. It was agreed that OWRB and consultants would develop a suggested piloting approach/process plan for review by the Advisory Group before the January 2014 Instream Flow Advisory Group meeting.

The process would be geared toward assessing the list of issues and concerns identified in previous meetings by the Instream Flow Advisory Group. This would address Recommendation No. 5 from the February 2011 report: perform an ISF pilot study in a state-designated scenic river. The January 16, 2014 ISF Advisory Group meeting was utilized to discuss and refine the ISF pilot study approach.

The Advisory Group identified the upper Illinois River above Tenkiller Reservoir including Barren Fork and Flint Creeks as the best scenic-designated watershed to test the proposed ISF evaluation process. The Illinois was chosen because it has some discharges and has a broad existing dataset that should help reduce study costs. The group discussed the merits of conducting the pilot in a watershed that is more heavily used by consumptive users, or conducting pilot studies in more than one watershed. The group ultimately determined that an upper Illinois River study as the first watershed to be analyzed would be the best approach for initial testing of the proposed process.

Recognizing that the issues identified in Recommendations 1, 2, and 4 from the February 2011 report are abstract and statewide, the pilot study would focus on both policy and technical questions on a single stream/watershed so as to:

(1) better understand the benefits, costs, impacts, and other implications of a possible ISF program,

(2) identify additional questions and concerns,

(3) test and refine the process to better address the questions and issues raised by the ISF Advisory Group, and

(4) identify specific technical components of the approach that can be applied to ISF assessments in other watersheds.

The primary goal of the pilot study is to gain a better understanding of the implications of a process to assess ISF benefits and issues consistent with the overall goal of managing water resources in Oklahoma for multiple uses. This includes consideration of ISF needs, recreational uses of water, and consumptive uses of water in the watershed (e.g., public water supply, crop irrigation, power generation and industrial uses), drawing on significant involvement of stakeholders from all water interest groups in the watershed throughout the process.

Study Purpose and Expected Outcomes

The purpose of a pilot study is to help define a study process that could be used for development of ISF recommendations for water resource planning purposes in other watersheds, if the state should move forward with an ISF program. The Illinois River system upstream of Tenkiller Reservoir is the suggested study area for piloting the IFIM process. This stream reach is mostly unregulated, i.e., it contains no major storage reservoirs or large diversions. However, the effects that streamflow alternatives might have on the downstream operational purposes of Tenkiller Reservoir would need to be assessed. Primary out-of-stream (consumptive) water uses include those for domestic and agriculture purposes. Instream water flow supports one of the state's most popular destinations for sport fishing, recreational boating, and scenic beauty. Also, this reach of the river and two of its tributaries, Barren Fork and Flint Creeks, are state-designated scenic rivers. An ISF study focused on fish has already been conducted on the Barren Fork.[1]

While the overall goal is to establish an ISF study process for potential application in other Oklahoma watersheds, it is important to recognize that each watershed will differ in terms of water supply, water use, future demand, and priorities. Flow recommendations and criteria that may be developed for the scenic – designated Illinois River would not be extrapolated to other stream systems. Again, the emphasis of this study is the process itself, not the specific flow recommendations that may be developed for the Illinois River system. Thus, the watershed-specific results of the pilot would only apply to the upper Illinois River watershed, but the same process (modified based on lessons learned in the pilot) could be applied to other watersheds in Oklahoma with different watershed-specific conditions and goals, and different watershed-specific findings. The pilot study should help identify concerns and needs associated with applying the approach elsewhere in the state.

The study approach outlined below would take approximately two years to complete. The initial information reviews, stakeholder outreach, and study planning would require 6 to 12 months. Implementing the field studies, which would include all field work and modeling, would require 6 months or more. Field work would occur primarily in the summer low flow period with additional measurements (flow related) during the spring and/or fall. Once the study results are completed, the analysis of alternatives and

[1] W. L. Fisher and W. J. Remshardt. 2000. Instream Flow Assessment of Baron Fork Creek, Oklahoma. Final Report, Oklahoma Water Resources Board, Oklahoma City, OK.

resolution of issues could be accomplished in about 6 months assuming that the parties to the study process are committed to its timely completion.

Proposed Study Approach

The proposed approach to the pilot study is modeled after the USGS IFIM process. Details of the methodology are available at the USGS website (http://www.fort.usgs.gov/products/software/ifim/). The IFIM is a decision-support process that provides a comprehensive technical framework for addressing streamflow needs for fish and other aquatic resources while incorporating consideration of the institutional environment (i.e., recreational interests and consumptive water uses such as public water supply, crop irrigation, power generation and industrial uses). It is the most commonly used methodology that includes institutional and stakeholder components. It employs a phased approach, putting the institutional tasks first, in accordance with the recommendations in the OCWP. The methodology typically is used for specific water project proposals (for example, a water diversion). However, the same steps can be applied to a stream- or basin-wide study considering future water use patterns. The methodology includes both an institutional analysis as well as the technical studies needed to identify and assess ISF alternatives. It includes deliberate engagement of all uses and users of water in the watershed in the decision-making process.

The proposed study would be completed by experts with experience in IFIM elements, with guidance provided by ISF Advisory Group. State and federal agency expertise would be drawn upon as well.

The IFIM process is implemented in five sequential phases:

1. Issue Identification
2. Study Planning
3. Study Implementation
4. Alternatives Analysis
5. Issue Resolution
6. Process Evaluation

The result is not based strictly on a calculated flow rate or flow regime for the watershed. Rather, it is the product of significant deliberation and input by all parties with water interests in the watershed. The intent of the pilot is to consider all water users and uses without bias, but with opportunities for each interest group to engage in the process. The process helps inform decision-making to reflect the competing needs of various water users and uses, and culminates in negotiations between various interests.

The steps above differ slightly from the published IFIM process in two regards. First, Phase 1 is defined as “Issues Identification” rather than “Problem Identification” because the study is not focused on a specific problem or proposed water development. This is not to say that some of the water issues in the Illinois River system are not viewed as problems by some stakeholders; however, the primary focus of the study is to evaluate the “process” of evaluating issues associated with ISFs. Second, we have added a sixth phase, which will evaluate the overall process itself in line with the overall goal of the study.

At this early stage, OWRB proposes to undertake only the first two phases because the last three cannot be clearly scoped until the earlier phases are completed, which could take 6 to 12 months.

Phase 1. Issue Identification and Stakeholder Involvement

Phase 1 has two components: (1) address legal and policy questions; and (2) initial physical analysis. Phase 1 will result in a better understanding of the issues and objectives of the interested parties. Understanding the different objectives will set the stage for multi-objective planning. Collaboration at an early stage of the study will provide the foundation for a successful process.

The following tasks are to be completed for the legal/policy analysis:

- Identify stakeholders and affected parties from both within the watershed and from elsewhere where there is interest in the Illinois River (e.g., regional tourism).
- Conduct outreach to affected parties (stakeholder meetings).
- Identify and document concerns and issues of affected parties and provide responses to those issues.
- Outline a preliminary decision process to be used to recommend ISF criteria.

This first component of Phase 1 would address the following legal and policy issues in the context of the Illinois River study as those have been identified by the Instream Flow Advisory Group in the 2011 OWRB *Instream Flow Issues and Recommendations* report:

- Consideration of relevant legal, policy, and regulatory factors in the Illinois River study area
- Potential effect on current and future water right holders for municipal, industrial, agricultural, and other out-of-stream uses in the Illinois River study area
- Process for implementing flow recommendations in the Illinois River study area

While these issues were initially identified from an abstract, statewide perspective, the pilot study would address them in context specific to the Illinois River study area.

The Advisory Group also raised concerns about the economics of implementing an ISF program in Oklahoma both in terms of study costs and economic benefits/costs on developmental (out-of-stream water uses) and nondevelopmental (ISF-related) resources. These economic issues would be analyzed in specific context of the Illinois River study area.

The second component of Phase 1 includes the review and summary of information on the physical environment that would be subject to the ISF assessment:

- Summarize existing information on fish and other aquatic resources of concern.
- Determine the aquatic resource management goals for the streams or watershed.
- Summarize hydrologic information, including existing conditions and simulated natural (unimpaired) flows.
- Summarize all existing water rights by quantity and use categories.
- Summarize water quality information for the study streams.
- Describe landscape features and land use activities that affect hydrology, water quality, and stream sediment dynamics.

The final product of the review of existing information will be an identification of data gaps that can be addressed in the study planning and implementation phases discussed below.

Phase 2. Study Planning

The emphasis of Phase 2 is to identify the information needed to address the concerns of each interest group. Proper planning will lead to the identification of:

- The temporal and spatial scale of the evaluations
- Important variables for which information is needed
- How information will be obtained if it is not available
- A schedule of when data must be collected in the field
- Coordination of data collection needed for model input, calibration, and testing
- Estimates of labor, equipment, travel, and other costs required to complete the studies by the agreed study deadline

The study tasks expected for Phase 3 of the overall Illinois River study include those associated with understanding the physical (including hydrologic), biological, and chemical processes that contribute to the stream ecosystem. These may include the following:

- Reanalysis of the hydrological data summarized in Phase 1, to potentially include use of Indicators of Hydrologic Alteration (IHA) or similar software
- Collection of fish and potentially other aquatic organisms if existing data are not sufficient to describe existing conditions
- Characterization of stream channels, including sediment and habitat typing
- Modeling of water temperature and perhaps other chemical constituents
- Development of physical habitat simulation models for representative stream reaches
- Development of habitat suitability criteria for key fish species and habitat guilds for inclusion in the physical habitat simulation models

Phase 2 includes only the study planning effort for the above processes. It should also identify the links among these processes in light of the natural, historical, existing, and anticipated future land use and water allocation practices in the Illinois River basin.

Phase 3. Study Implementation

The technical studies identified during Phase 2 will be implemented in accordance with the schedules and budgets also identified in Phase 2. IFIM study implementation usually can be broken down into four fundamental steps:

1. Data collection/supplementation
2. Model calibration
3. Predictive simulation
4. Synthesis and integration of results

These steps assume that most of the studies, such as fish habitat, hydraulics, hydrology, sediment movement, and water temperature, will involve simulation modeling to some degree.

The general sequence of data collection activities can include the following:

1. Identify aquatic mesohabitats (riffle, runs, pools) within each key physiographic region.
2. Select transects in each mesohabitat and physiographic region.
3. Select IFIM-focus species of fish and macroinvertebrates, and compile habitat suitability criteria (HSC) for specific resident species and life stages of interest, as well as for recreation (e.g., canoeing/kayaking).
4. Collect field hydraulic and habitat data at selected transects at specific target flows.
5. Implement the Physical Habitat Simulation Model, which integrates stream hydraulic and physical characteristics with microhabitat requirements of key species and life stages. The output “Weighted Usable Area” (WUA) is a surrogate index for what is judged to be suitable habitat for each species under a range of flows.

Phase 4. Alternatives Analysis

The final two phases of the traditional IFIM process involve alternatives analysis (Phase 4) and issues resolution (Phase 5). The alternatives analysis is important to the IFIM process because the IFIM process

generally does not result in a single "best" flow value. Rather, the IFIM generates WUA estimates over a range of flows (or for alternative flow time-series) for each target species. The WUA estimates form the basis of negotiations among interested parties, including the stakeholders identified in Phase 1.

Establishment of ISF or flow-regime alternatives for a particular stream reach can be formulated by any interested party after reviewing both the institutional analysis and the results of the technical studies from previous study phases. Alternatives are compared to an agreed-upon baseline condition to facilitate understanding of potential impacts and to begin negotiating and creating new alternatives that may be more compatible with the multiple objectives of the parties.

Each alternative will be evaluated by the following criteria and questions:

- Effectiveness—Are the objectives of each party sustainable? Is no net loss of habitat or biological function possible on a sustainable basis? What are the habitat costs and benefits of each alternative?
- Physical Feasibility—Are prior water rights and existing water uses maintained? Are reservoir purposes maintained? Is enough water available for instream resource values and potential future out-of-stream uses?
- Risk—How often does an alternative lead to a failure of the biological system? Is the failure reversible? Can contingency plans be developed?
- Economics—What are the costs and benefits of each alternative? Are existing water rights affected? Are values associated with reasonable future water uses accounted for?

Phase 5. Issue Resolution

After several alternative flow regimes have been thoroughly evaluated by the teams that are party to the ISF resolution process (defined in Phase 1), the teams deliberate ISF criteria or standards that meet the overall watershed goals established in Phase 1. The teams must integrate their knowledge and understanding of the technical and social issues to reach an ultimate resolution. This process implies that the solution will entail some kind of a balance among conflicting social values.

The IFIM process rarely results in a single "best" flow value. Rather, the IFIM generates WUA habitat estimates over a range of flows (or for alternative flow time-series) for each target species and/or recreational requirement. It is important to understand that the maximum WUA values typically will occur at different flows and differing times of the year for the various target species, life stages, or other uses. In addition, the current and future needs for water for developmental purposes must be considered in the resolution process. Thus, selection of flow regimes suitable for protecting the aquatic community while recognizing the need to accommodate other beneficial uses of the water often requires balancing, tradeoffs, and seasonal variation that are the subject of negotiations and management decisions.

Phase 6. Process Evaluation

Because the primary purpose of this pilot study is to define a conceptual framework and study process to be used for considering ISF needs for water resource planning purposes, it is important that the process itself be evaluated by the participating stakeholders. This will be accomplished with a questionnaire of the stakeholders that will solicit opinions as to strengths and weaknesses of the steps used in the pilot study and suggestions for improvement for future application to other watersheds. This phase may include workshops and other activities as identified in the stakeholder process.

Appendix C
Technical Study Workgroup Meeting Agendas, Meeting Summaries, and Presentations

AGENDA

Illinois River Instream Flow Pilot Study Public/Stakeholder Meeting

Municipal Armory, Tahlequah, OK

January 22, 2015, 6:30 pm

I. **Welcome and Introductions (6:30 – 6:40) – J. D. Strong**

II. **Instream flows and the Ok. Comprehensive Water Plan (6:40 – 6:50) – John Rehring**

III. **History and background of Instream Flows in OK (6:50 – 7:10) – Derek Smithee**

IV. **Review of the Illinois River Instream flow pilot study (7:10 – 7:30)– Forrest Olson**

V. **Public comment and group facilitation (7:30 – 8:45) – Rehring**

VI. **Next steps (8:45 – 9:00) – All**

Notes:

Appendix D
Public Meeting Agendas, Meeting Summaries and Presentations

INPUT FROM ILLINOIS RIVER INSTREAM FLOW

PILOT STUDY PUBLIC/STAKEHOLDER MEETING

Armory Municipal Center — Tahlequah, OK

January 22, 2015

The Oklahoma Water Resources Board (OWRB), working in partnership with the US Army Corps of Engineers under their Planning Assistance to States program, held the first of a series of public meetings to share information and obtain feedback on an Instream Flow Pilot Study being conducted on the Upper Illinois River (including Barren Fork and Flint Creeks) above Lake Tenkiller in northeastern Oklahoma. The pilot study is based on the recommendations of a 25-member Instream Flow Advisory Group and the 2012 Oklahoma Comprehensive Water Plan (OCWP). The OCWP set forth a process to "ascertain the suitability and structure of an instream flow program for Oklahoma." This pilot study is a key element of that process, as it will be used to assess the potential benefits and challenges that would be associated with an instream flow program, if Oklahoma were to implement such a program. As the pilot study progresses, the OWRB and technical workgroup will host future stakeholder forums and provide updates.

An extensive overview of initiatives leading to the pilot study as well as presentation materials discussed at the meeting is posted to the OWRB Instream Flow Advisory Group webpage: http://www.owrb.ok.gov/ISF. Information presented below summarizes the feedback received at the meeting, but is not indicative of meeting attendees' consensus, nor does it represent any form of endorsement by the OWRB or its technical or facilitation partners.

The meeting included presentations by J.D. Strong (Executive Director, OWRB, and Chair of the Instream Flow Advisory Group), John Rehring (Carollo Engineers), and Forrest Olson (CH2MHILL). The presentation materials are attached to this summary and also posted to the Instream Flow Advisory Group webpage. A summary of comments provided by meeting participants is presented below.

TAHLEQUAH ARMORY MUNICIPAL CENTER – 6:30 pm, January 22, 2015

- Quantify non-fish recreational needs (boating/rafting).
- Assess public water use and efficiencies.
- Consider hydrogeology and stream/groundwater interaction.
- Include assessment of wetlands, oxbows, etc.
- Assessment should address not just minimum flows—flow patterns.

- Address variabilities beyond study period data.
- Consider water quality as well as quantity (especially metals).
- Is there a maximum flow we want to stay under? Discharges upstream change the river.
- Cherokee Nation involvement encouraged.
- Will (or how will) Arkansas/Oklahoma litigation outcomes affect this study?
- How will the study/data collection affect river users and neighbors?
- Include critical low-flow summer months in study data.
- Consider implications relative to Lake Tenkiller water use allocations.
- Consider what happens if instream flow recommended values conflict with interstate stream compact requirements.
- Process should apply to diverse types of watersheds.
- Please post slides to Instream Flow website (complete).
- Consider erosion in pilot study.
- River is getting wider and shallower; changing flow dynamics.
- Trout Unlimited study looked at over 18,000 man-days of recreation in the study area; recreation groups are willing to conduct additional surveys.
- Oklahoma Department of Wildlife Conservation has conducted small–mouth bass studies.
- Plant gathering is another use and other cultural resources and uses.
- Dive shops may have information on Lake Tenkiller water quality trends.
- Quantify actual use by consumptive users, including impacts to groundwater and impacts to individual wells.
- Recreation can impact landowners along the river.
- Should there be a system for prioritizing uses?
- Other watersheds will have much higher public and industrial uses than the upper Illinois River—consider how that works with this method.
- Forms/mailings could be used to solicit more input and data.
- Recreation opportunities such as hunting, camping, and birding are also linked to the river and its flow.
- Add Oklahoma Department of Tourism to workgroup to help provide data.
- Will the ongoing Red River Basin study look at instream flows?
- Some development has been talked about on both sides of Arkansas/Oklahoma border.

Illinois River Instream Flow Pilot Study
Public/Stakeholder Meeting

January 22, 2015

Municipal Armory

Tahlequah, Oklahoma

US Army Corps of Engineers

State of Oklahoma
OWRB
Water Resources Board
the water agency

Agenda for Tonight's Discussion

Welcome and Introductions
J.D. Strong, Executive Director, OWRB

Instream flows and the OK Comprehensive Water Plan
John Rehring, Carollo Engineers

History and background of Instream Flows in Oklahoma
Derek Smithee, Water Quality Programs Division Chief, OWRB

Review of the Illinois River Instream flow pilot study
Forrest Olson, CH2M Hill

Public comment

Next steps

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Housekeeping items

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Keeping in Touch

www.owrb.ok.gov/ISF

Provide E-mail address on Sign-in Sheet

Derek.Smithee@owrb.ok.gov

Derek Smithee

(405) 530-8800

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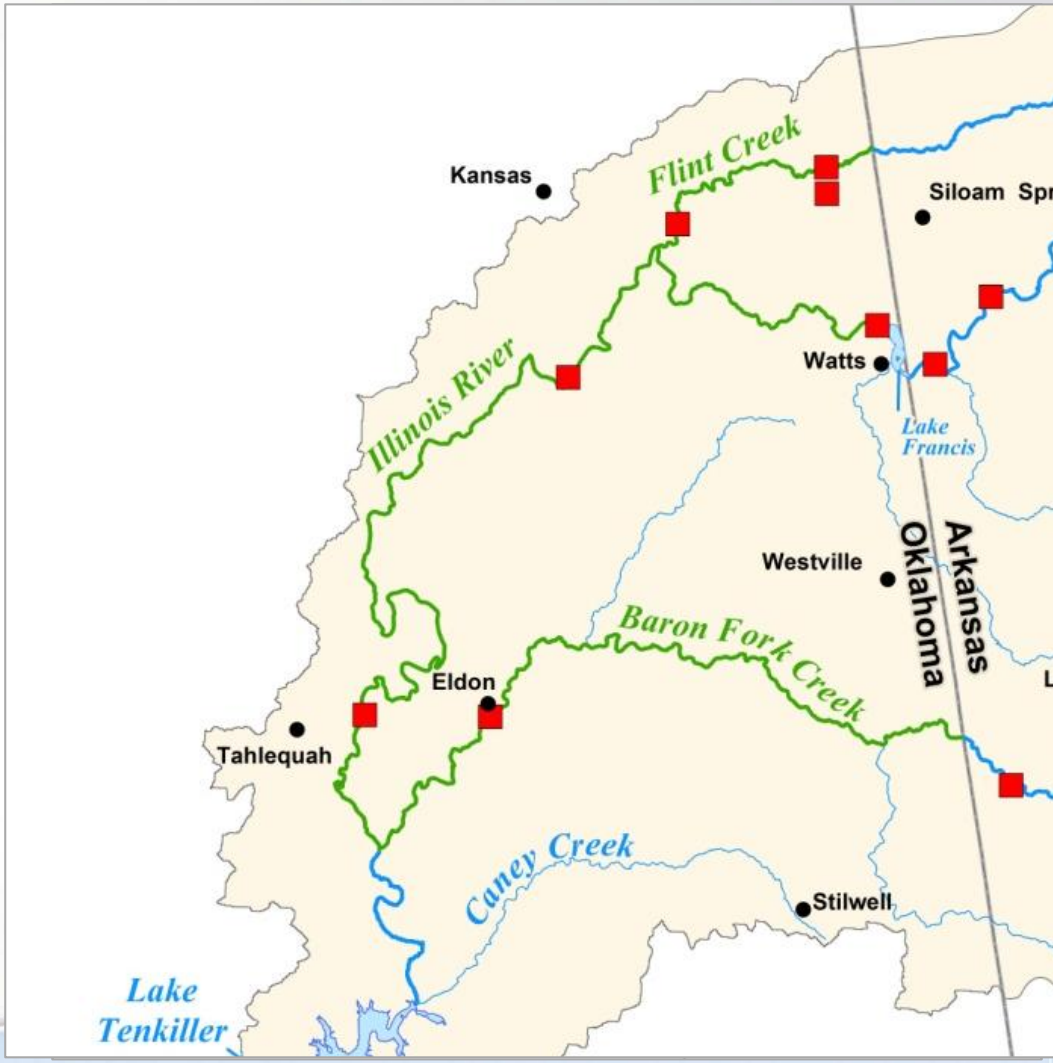
Focus of Tonight's Discussion

- **Instream (or environmental) flows** are those necessary to provide for a **healthy ecosystem** and support **water-related recreation** (such as fishing, hunting, swimming, and boating) as well as **tourism**.



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Illinois River Instream Flow Pilot Study Public/Stakeholder Meeting

1. Instream Flows and the Oklahoma Comprehensive Water Plan
2. History and Background of Instream Flows in Oklahoma
3. Review of the Illinois River Instream Flow Pilot Study
4. Public Comment

US Army Corps of Engineers

State of Oklahoma OWRB Water Resources Board the water agency

Instream Flows and the Oklahoma Comprehensive Water Plan

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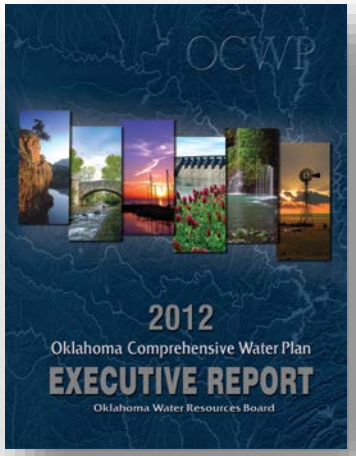
2012 Oklahoma Comprehensive Water Plan

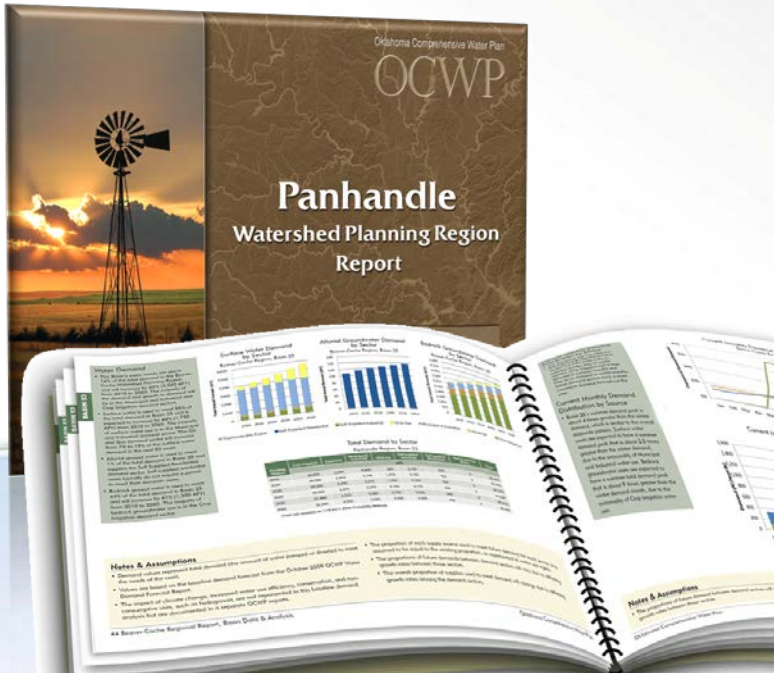


Executive Report:

- Synthesis of technical studies and results
- Water policy recommendations

13 Watershed Planning Region Reports:

- Results of OCWP technical analyses
- Options to address local water shortages



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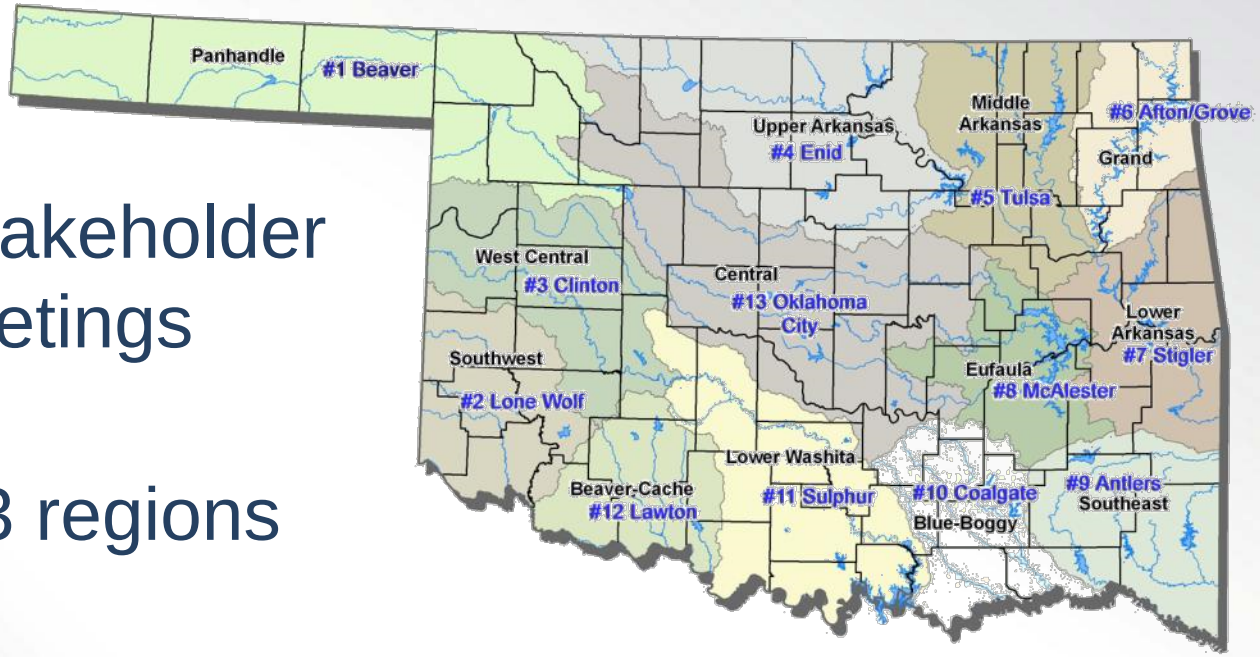
OCWP Public/Stakeholder Participation



- Hundreds of stakeholder and citizen meetings
- 82 basins in 13 regions
- Public input and priorities shaped the OCWP priority recommendations

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OCWP "Big 8" Priority Recommendations

- Infrastructure Financing
- Conservation, Reuse, Recycling
- Monitoring
- Supply Reliability
- Instream Flows
- Excess/Surplus
- State/Tribal Resolution
- Regional Planning

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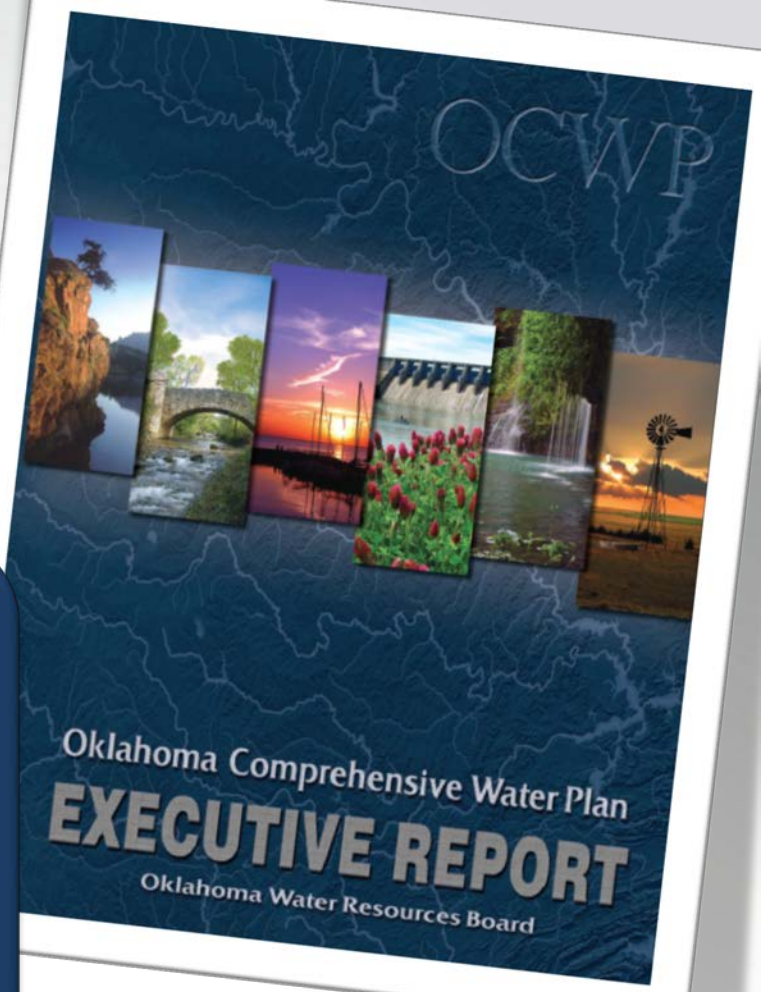
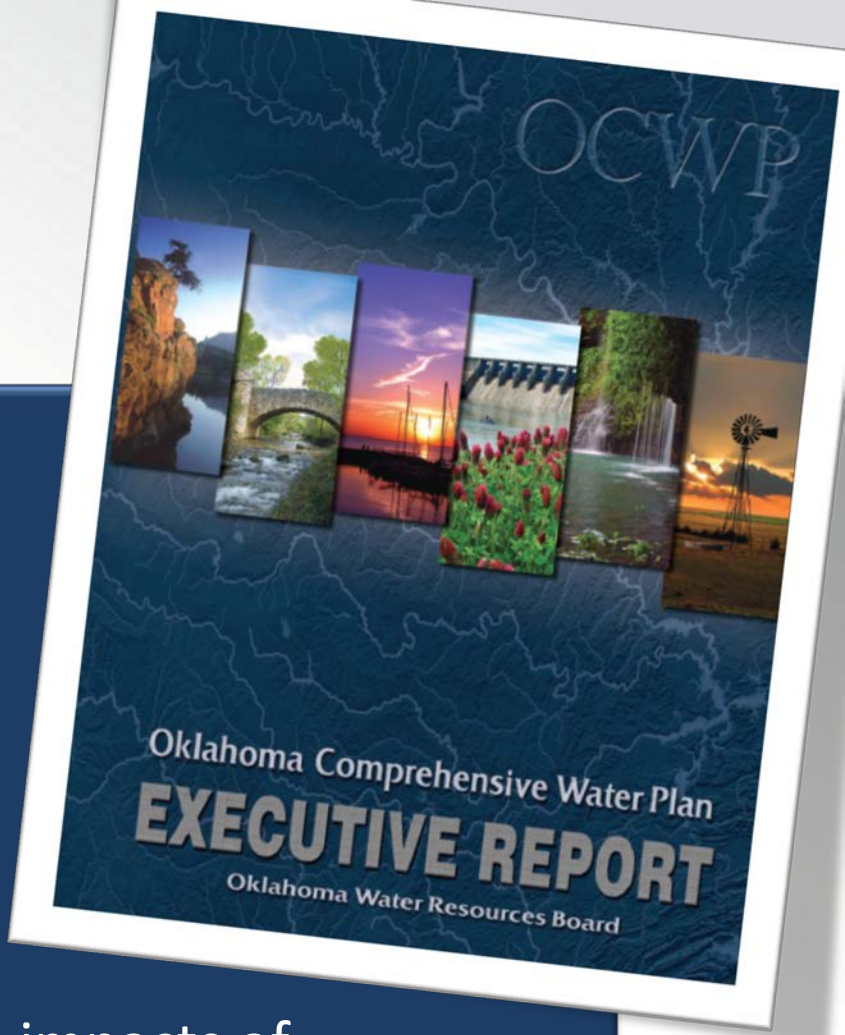
Oklahoma Comprehensive Water Plan

OCWP



"The process developed by the OCWP Instream Flow Workgroup should be implemented and followed to ascertain the suitability and structure of an instream flow program for Oklahoma..."

ISF Advisory Group:
Process for Assessing Instream Flow



1. Address the legal and policy questions.
2. Study other mechanisms for protecting instream flows.
3. Develop a draft methodology for instream flow studies in Oklahoma.
4. Conduct a study on the economic impacts of instream flows in Oklahoma.
5. Perform an instream flow pilot study in a scenic river.
6. Preserve the Instream Flow Workgroup.

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J.D. Strong (Chair)
- OWRB

Tom Creider
- Oklahoma State Parks

Mark Derichsweiler
- ODEQ

Tom Elkins
- Cherokee Nation

Mike Fuhr
- The Nature Conservancy

James Gammill
- Oklahoma Rural Water Association

Bud Ground
- Public Service Company of Oklahoma

Charlette Hearne
- ORWP

Arnella Karges
- State Chamber of Oklahoma

Michael Kelsey
- Okla. Cattlemen's Association

Mike Mathis
- Continental Resources

Diane Pedicord
- Okla. Municipal League

Marla Peek
- Oklahoma Farm Bureau

Tyler Powell
- Office of the Sec. of Energy & Environment

Marsha Slaughter
- OKC Water Utilities Trust

Kevin Stubbs
- US Fish & Wildlife Service

Jeff Tompkins
- Bureau of Reclamation

Brooks Tramell
- Okla. Conser-vation Comm.

Brian Woodard
- OK Independent Petroleum Assoc.

Support
- OWRB Staff
- CH2M Hill
- Carollo Engineers

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ISF Advisory Group:
Process for Assessing Instream Flow

J.D. Strong (Chair) • OWRB	**Tom Creider** • Oklahoma State Parks	**Mark Derichsweiler** • ODEQ	**Tom Elkins** • Cherokee Nation
Mike Fuhr • The Nature Conservancy	**James Gammill** • Oklahoma Rural Water Association	**Bud Ground** • Public Service Company of Oklahoma	**Charlette Hearne** • ORWP
Arnella Karges • State Chamber of Oklahoma	**Michael Kelsey** • Okla. Cattlemen's Association	**Mike Mathis** • Continental Resources	**Diane Pedicord** • Okla. Municipal League
Marla Peek • Oklahoma Farm Bureau	**Tyler Powell** • Office of the Sec. of Energy & Environment	**Marsha Slaughter** • OKC Water Utilities Trust	**Kevin Stubbs** • US Fish & Wildlife Service
Jeff Tompkins • Bureau of Reclamation	**Brooks Tramell** • Okla. Conser-vation Comm.	**Brian Woodard** • OK Independent Petroleum Assoc.	**Support** • OWRB Staff • CH2M Hill • Carollo Engineers

- ✓ Address the legal and policy questions.
- ✓ Study other mechanisms for protecting instream flows.
- ? Develop a draft methodology for instream flow studies in Oklahoma.
- ? Conduct a study on the economic impacts of instream flows in Oklahoma.
- 5. Perform an instream flow pilot study in a scenic river.
- ✓ Preserve the Instream Flow Workgroup.

Illinois River Instream Flow Pilot Study

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Illinois River Instream Flow Pilot Study Public/Stakeholder Meeting

1. Instream Flows and the Oklahoma Comprehensive Water Plan
2. History and Background of Instream Flows in Oklahoma
3. Review of the Illinois River Instream Flow Pilot Study
4. Public Comment

US Army Corps of Engineers

State of Oklahoma OWRB Water Resources Board the water agency

Public Comment

- How do we use and enjoy the Upper Illinois River?
- Will that change over time? How and why?
- What should the instream flow pilot study evaluate?
- Who else should be involved?

Keeping in Touch

www.owrb.ok.gov/ISF

Provide E-mail address on Sign-in Sheet

Derek.Smithee@owrb.ok.gov

WRITTEN FEEDBACK

Derek Smithee

(405) 530-8800

Illinois River Instream Flow Pilot Study
Public/Stakeholder Meeting

January 22, 2015

Municipal Armory

Tahlequah, Oklahoma

US Army Corps of Engineers

State of Oklahoma
OWRB
Water Resources Board
the water agency

Instream Flow Assessment of the Scenic Illinois River A Pilot Study

Presented to
Public Stakeholder Meeting in Tahlequah, OK

Presented by
Forrest Olson, CH2M HILL

January 22, 2015

US Army Corps of Engineers

WRB

CH2MHILL®

What is an instream flow?

- The amount of water flowing in a stream at all times necessary to sustain instream resource values at an acceptable level.

What are instream resources?

- Fisheries, wildlife, water quality, recreation, aesthetics, and the ecological processes that support these resources.

OWRB working definition of instream flow: “flows necessary to provide for a healthy ecosystem and support water-related recreation (such as fishing, hunting, swimming and boating) as well as tourism.”

What is an instream flow method(ology)?

- A means of determining (quantifying) sufficient (adequate, acceptable, desired, suitable, preferred, minimal, optimal) instream flows.
  - **Method** infers a technique or simple formula.
  - **Methodology** infers a process or decision-support system.

Primary Study Goals:

- Develop seasonal instream flow recommendations for the Illinois River including Barren Fork and Flint creeks.
- Gain a better understanding of the implications of a process to deal with instream flow issues consistent with the overall goal of managing water resources in Oklahoma for multiple uses. The study would help define a conceptual framework and study process that could be used statewide.

*Note: This study is **not** being done in response to a proposed water development project.*

The pilot study would focus on policy and technical questions on a single stream/watershed so as to:

1. Better understand implications of a possible statewide instream flow program
2. Identify additional questions and concerns
3. Identify specific technical components and metrics that can be applied to instream flow assessments in other watersheds
4. Help determine costs associated with various ISF study components

Why Study a Scenic River?

1. Stream flows are less altered
2. Unique state law emphasizing protection of flows
3. Already have a precedent for regulation of flows
4. Significant flow-based recreation and ecological value
5. Extensive data and modeling already exist
6. Recommended by the Instream Flow Advisory Group

Study Area

Rogers
Springdale
Fayetteville
Kansas
Siloam Springs
Flint Creek
Osage Creek
Watts
Lake Francis
Illinois River
Illinois River
Westville
Arkansas
Oklahoma
Baron Fork Creek
Lincoln
Eldon
Tahlequah
Caney Creek
Stilwell
Lake Tenkiller
USGS Gage
City
Lake
Scenic River
Major Stream
Other Stream
N
W
E
S
0
5
10
Miles

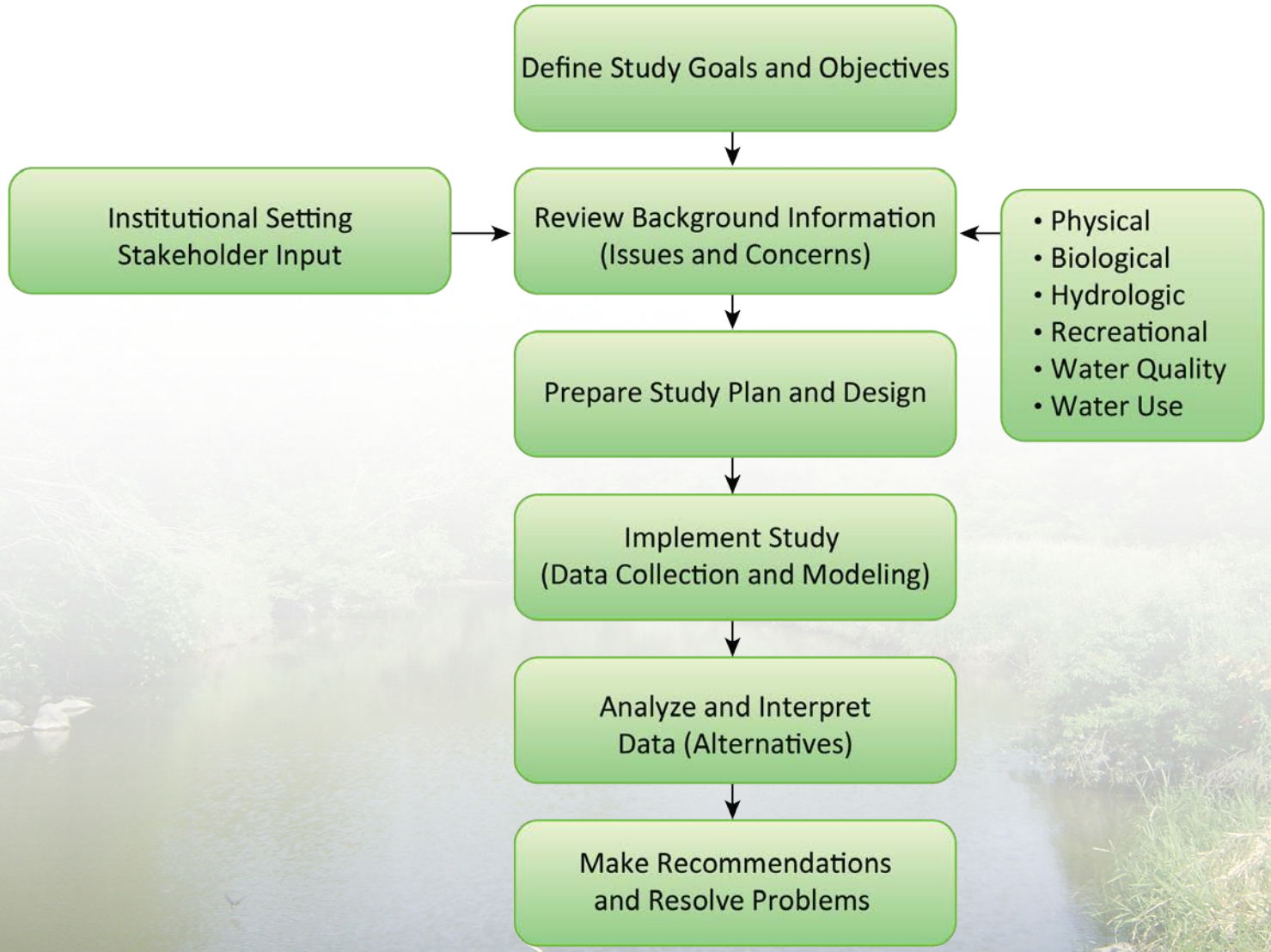
Study Approach:

The study approach is modeled after the Instream Flow Incremental Methodology (IFIM)

Five sequential phases:

1. Problem Identification/ Information evaluation
2. Study planning
3. Study Implementation
4. Alternatives analysis/ Data interpretation and integration
5. Problem resolution/ Flow recommendations

Steps in Illinois River Instream Flow Assessment



Technical Study Work Group

- OK Water Resource Board
- US Corps of Engineers
- CH2M HILL
- OK Department of Wildlife Conservation
- OK Conservation Commission
- OK Scenic Rivers Commission
- US Geological Survey / OSU
- US Fish and Wildlife Service
- The Nature Conservancy

Institutional and Stakeholder Input

- Identify stakeholders and interested parties
- Conduct outreach to interested parties (stakeholder meetings)
- Identify and document concerns and issues of affected parties

Previously Identified Institutional Issues

- Legal considerations
- Potential effects on current and future water right holders
- Process for implementing flow recommendations
- Need for statutory changes
- Need for a formal instream flow program

Existing Information Review

- Identify any aquatic resource and river management goals
- Describe landscape features and land use activities that affect hydrology, water quality, and sediment dynamics
- Summarize information on fish and other aquatic resources of concern
- Summarize and characterize hydrologic data including flow magnitude, timing, duration, frequency, and variability.
- Summarize water quality information for study streams
- Characterize recreational use of the river (primarily fishing and boating)
- Summarize existing water rights and use

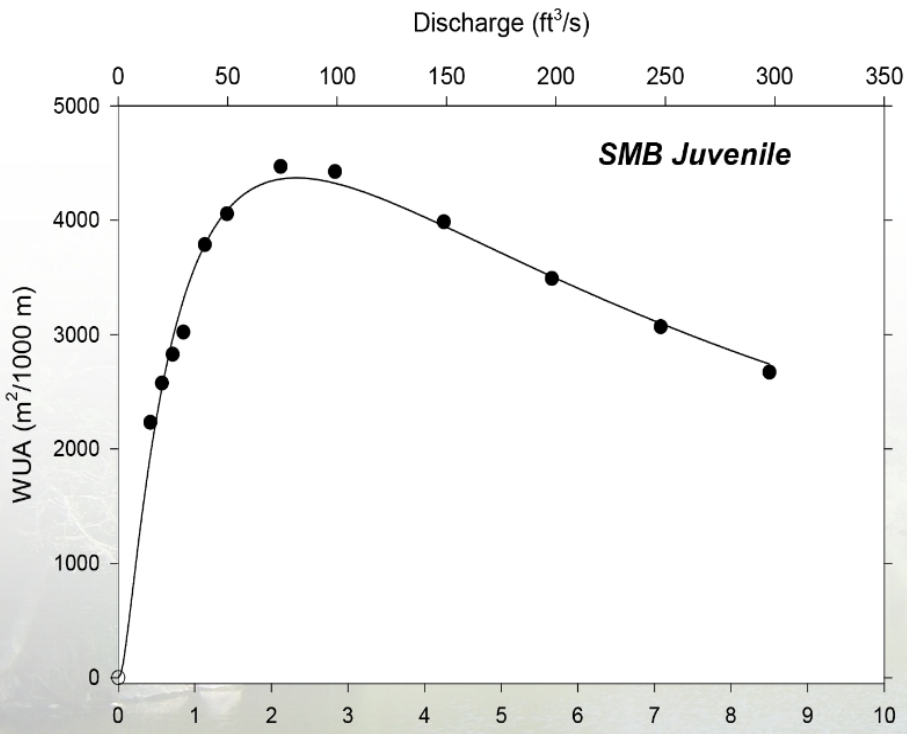
Study Planning

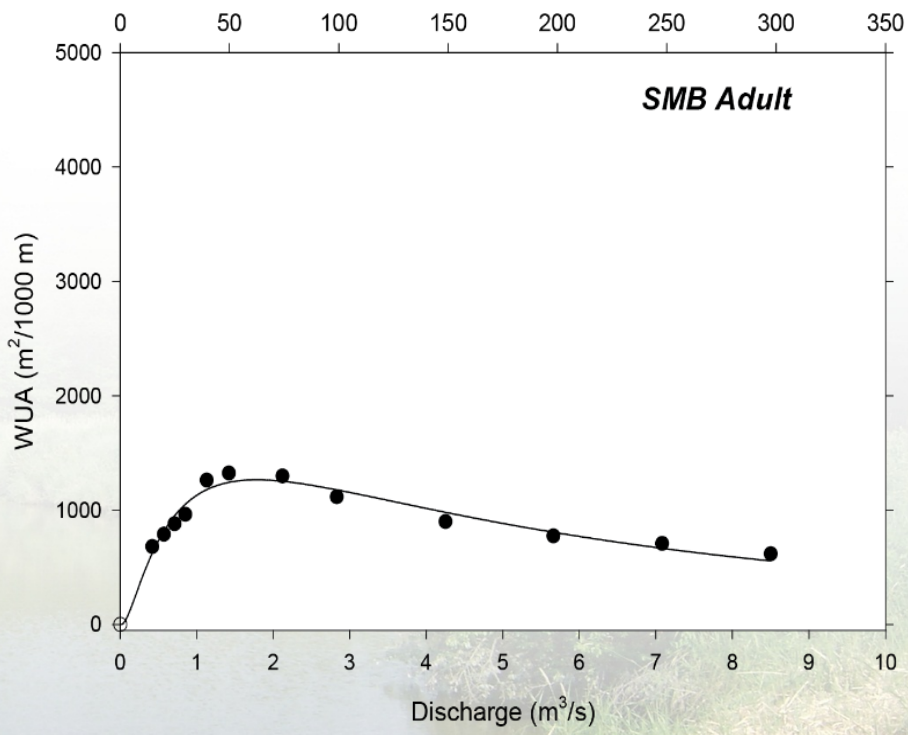
- The temporal and spatial scale of the evaluations
- Important variables for which information is needed
- How information will be obtained if it is not available
- A schedule of when data must be collected in the field
- Coordination of data collection needed for model input, calibration, and testing
- Estimates of labor, equipment, travel, and other costs required to complete the studies by the agreed study deadline

Study Implementation

- Data Collection
- Model calibration
- Predictive simulation
- Synthesis and integration of results

Physical Habitat Simulation Model (PHABSIM) is the primary technical tool of IFIM





Next Steps.

- Summarize Stakeholder Comments (January-February)
- Refine Goals and Objectives (January-February)
- Develop Detailed Study Plan (February-March)
- Complete Background Information Review (April +)
- Begin Data Collection (May-June)

- Estimated Study Completion - December 31, 2015

Questions

AGENDA

Illinois River Instream Flow Pilot Study Public/Stakeholder Meeting

Municipal Armory, Tahlequah, OK

January 21, 2016, 6:30 pm

I. **Welcome and Introductions (6:30 – 6:40) – Derek Smithee, Division Chief, OWRB**

II. **Recap of January 2015 Public/Stakeholder Meeting (6:40– 6:50) – John Rehring, Carollo Engineers**

III. **Technical Presentation: "Updates on the Illinois River Instream Flow Pilot Study and Next Steps" (6:50 –7:30) – Forrest Olson, CH2M**

IV. **Q&A (7:30-7:45)**

V. **Next Steps (7:45- 8:00)**

INPUT FROM ILLINOIS RIVER INSTREAM FLOW

PILOT STUDY PUBLIC/STAKEHOLDER MEETING

Armory Municipal Center — Tahlequah, OK

January 21, 2016

The Oklahoma Water Resources Board (OWRB), working in partnership with the US Army Corps of Engineers under their Planning Assistance to States program, held the second of a series of public meetings to present updates and gather information from the stakeholders on the Illinois River Instream Flow (ISF) Pilot Study. This was a follow-up to the meeting held in Tahlequah on January 21, 2015, as part of a series of public meetings to share information and obtain feedback on an ISF Pilot Study being conducted on the Upper Illinois River (including Barron Fork and Flint Creeks) above Lake Tenkiller in eastern Oklahoma. The meeting was attended by approximately 31local residents and other key stakeholders.

The ISF Pilot Study was initiated in early spring of 2015. The pilot study is based on the recommendations of a statewide 25-member Instream Flow Advisory Group and the 2012 Oklahoma Comprehensive Water Plan (OCWP). The OCWP set forth a process to "ascertain the suitability and structure of an instream flow program for Oklahoma." This pilot study is a key element of that process, as it will be used to assess the potential benefits and challenges that would be associated with an instream flow program, if Oklahoma were to implement such a program. The technical study team continues the data collection and modeling. As the technical study progresses, the OWRB and technical study experts will host a final stakeholder forum to provide the results of the technical phase of the study.

The focus of the meeting was to present the status and preliminary findings of the ongoing ISF Pilot Study. The pilot study presentations given during the meeting and the meeting agenda can be found on the OWRB Instream Flow Advisory Group webpage: http://www.owrb.ok.gov/ISF. Information presented below summarizes the feedback received at the meeting and the responses provided by the study team.

PRESENTATIONS

Derek Smithee Presentation

Derek Smithee, Chief of the OWRB Water Quality Division, welcomed everyone, provided housekeeping notes, reviewed the meeting agenda and introduced the project team. He revisited the goals for the Instream Flow Pilot Study and the key components of the current phase of the project.

Key Issues

- The Advisory Group identified the upper Illinois River above Tenkiller Reservoir including Barren Fork and Flint Creeks for the ISF Pilot Study consistent with the Oklahoma Comprehensive Water Plan recommendation.
- The Instream Flow Pilot Study was intended to answer some previously unanswered questions, such as economics, policy and legal issues associated with an instream flow program.
- Any policy recommendations must be rooted in science.

John Rehring Presentation

John Rehring, Carollo Engineers, stated four goals for the meeting: 1- Recap feedback from 2015 public meeting; 2- Learn about Illinois River resource values; 3- Learn about 2015 Instream Flow fieldwork, and 4- Ask questions and look ahead to next steps. Mr. Rehring discussed the comments and recommendations received during the 2015 public stakeholder meeting. Mr. Rehring encouraged public to participate in tonight's meeting.

Key Issues

- 2015 public meeting feedback was assessed and when practicable, incorporated to the Baseline Data Report.
- Public participation is a key in the study process: ask questions about the technical study and how it fits the overall pilot study, provide feedback on types of uses on the Upper Illinois River and tributaries above Lake Tenkiller. The comments can be provided to OWRB after the public meeting and information will be available to the public on OWRB's website.
- Future work will include re-engagement of the Instream Flow Advisory Group to assess study results; initiate policy dialogue to determine how the identified instream flow needs fit into upper Illinois River flow management, and assess applicability of the process to other streams in Oklahoma (recognizing that the flow values and results will differ between watersheds due to region-specific hydrologies and local priorities for water management).

Forrest Olson Presentation

Forrest Olson, CH2M, Principal Investigator of the ISF Pilot Technical Study, provided updates on the ongoing technical studies, data collection and modeling using the Physical Habitat Simulation Model (PHABSIM).
Mr. Olson discussed the project goals: the study would help define a conceptual framework and study process, and also develop a seasonal instream flow recommendations for the Illinois River including Barren Fork and Flint creeks. Mr. Olson discussed the overall hydrology and water uses in the study area: the types of flows and the frequency, the main water uses, groundwater and surface water interactions, and upstream flow augmentation in Arkansas. In addition, Mr. Olson provided information on the fisheries and recreational uses in the study area and the type of flow needs to support these. The model overview included a description of how depth and velocity data were measured and modeled. Mr. Olson explained the selection of the study sites for different reaches and data collection methods in different sites. He explained how the results would be utilized to model relationships between fish habitat and streamflow.

Key Issues

- Main consumptive water use: mostly public supply for Tahlequah area and some irrigation
- Flow augmentation from Arkansas (Fayetteville area)
- Bank-full flows: 1.5-or 2-year recurrence flow: 10,000 –20,000 cfs for Illinois River at Tahlequah.
- Importance of secondary channels for fish, wildlife, and water quality and the importance of higher flows to maintain these channels
- 2015 floods: Affected data collection such that fish habitat model extrapolation limited to < 1,000 cfs for Illinois River, <150 cfs for Flint Creek. Upper Illinois River site above Flint Creek: insufficient data; site washed out.
- The current study will focus on modeling of fish habitat-flow relationships; the model does not provide answers. The results must be interpreted and then included with consideration of other important resource values.
- Final public/stakeholder meeting to present results of the technical studies.

LARGE GROUP DISCUSSION

A summary of comments and questions provided by meeting participants is presented below. Comment responses were provided during the meeting and also presented below.

- When will the economic evaluation be performed?
    - Moderator response: That will be addressed with the policy assessment after the technical study has been completed.
- Why is upper Illinois River being studied and not the lower Illinois River that has regulated flows?
    - Moderator response: Consistent with Oklahoma Comprehensive Water Plan recommendations to conduct an Instream Flow Pilot Study in a Scenic River, the statewide Instream Flow Advisory Group explored how to further define whether and how an instream flow (ISF) program might be implemented in Oklahoma. To make sound policy recommendations, the Group acknowledged that the basis, specifics and consequences of an ISF program must be known and understood. The Advisory Group identified the upper Illinois River above Tenkiller Reservoir including Barren Fork and Flint Creeks as the best scenic-designated watershed to test the proposed ISF evaluation process. The Illinois was chosen because it has some discharges and has a broad existing dataset that should help reduce study costs. The group ultimately determined that an upper Illinois River study as the first watershed to be analyzed would be the best approach for initial testing of the proposed process.
- Has the study assessed flow vs. water temperature impacts and the relationship to dissolved oxygen (D.O.)?
    - Technical Study Team Lead response: Previous temperature modeling studies by OSU looked at temperature correlations with low flows in Flint and Barren Fork creeks and the Illinois River. These study results will be discussed in our technical report. Dissolved oxygen was not modeled but typically follows temperature (inversely).

- What if Arkansas Wastewater Treatment Plants (WWTP) located upstream of Illinois River start reusing their effluent? Will it affect flows and the study results?
    - Technical Study Lead response: The study team is not aware of effluent flow diversions from Arkansas and has not addressed those. However, if the Fayetteville area WWTPs stopped discharging their effluent and instead reused it, the flow/habitat relationship would be unchanged but there could be impacts on Illinois River stream flows, especially noticeable in the summer. Currently these discharges (from all Arkansas WWTPs) contribute about 30 cfs to the downstream flow of the Illinois River. The study team will look into this issue further.
- Does reuse/water for 2060 goals conflict with ISF goals?
    - OWRB response: No. Beneficially reusing water helps offset the need to make other fresh water uses and diversions, which can maintain instream flows.
- Who makes recommendations?
    - OWRB response: The technical study results will be taken back to the ISF Advisory Group for further direction on how to move forward with policy decisions.
    - Technical Study Lead response: The OWRB has ultimate authority for the state's water allocations, but their decisions are informed by recommendations and input from other agencies, groups, and interested stakeholders following completion of the technical study.
- How do we address extreme flow values? Drought contingencies; flow ranges vs. "min." flow value.
    - Technical Study Lead response: Instream flow standards are intended to protect or support conditions for those resources dependent on appropriate flow conditions (e.g. fish, recreation). Flows that provide these conditions vary over time – by season and by year-type. Instream flow standards are often conditioned to reflect the realities of extreme conditions such as droughts.
- Impacts of high precipitation in 2015?
    - Technical Study Lead response: The December 2015 floods altered the study sites and thereby limited the field data collection to only two flows rather than the desired three flows at the lower Illinois and Flint Creek sites. This means that the fish habitat model extrapolation will be limited to < 1,000 cfs for Illinois River, <150 cfs for Flint Creek – about half of what was targeted. The Upper Illinois River site above Flint Creek was washed out before adequate data could be collected for modeling that site.
- What is the peer review process?
    - Technical Study Lead response: All the study documents to date have been prepared in collaboration with the Technical Study Workgroup (TSWG). This includes the Study Plan and the Background Data Report. In addition, the key partner agencies have been indispensable in preparing and developing data for the reports and reviewing them. The TSWG will continue review of technical documents and will make recommendations on the flows after the PHABSIM modeling has been completed.

- Any forecasted shift in recreation use?
    - OWRB response: Maybe Ed Fite who is the Technical Study Workgroup member, could answer this question.
    - Ed Fite, The Oklahoma Scenic River Commission Chairman (TSWG member) response: There are more kayaks, less canoes, and about the same amount of rafts. Kayakers like faster water but can handle shallower water.
- This demonstrates how ISF needs change over time, but climate change will affect it too.
    - Technical Study Lead response: Future climate predictions prepared by OU were reviewed as part of the Baseline Data Report. The prediction is that average annual precipitation will increase in northeastern Oklahoma in the future (to year 2099). They were not able to predict changes in storm intensity or frequency.

END

Illinois River Instream Flow Pilot Study
Public/Stakeholder Meeting

January 21, 2016

Municipal Armory

Tahlequah, Oklahoma

US Army Corps of Engineers

State of Oklahoma
OWRB
Water Resources Board
the water agency

Agenda for Tonight's Discussion

Welcome and Introductions

Derek Smithee, Division Chief, OWRB

Recap of January 2015 Public/Stakeholder Meeting

John Rehring, Carollo Engineers

Technical Presentation: "Updates on the Illinois River Instream Flow Pilot Study and Next Steps"

Forrest Olson, CH2M

Public comment / Questions and Answers

Next steps

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OCWP "Big 8" Priority Recommendations

- Infrastructure Financing
- Conservation, Reuse, Recycling
- Monitoring
- Supply Reliability
- Instream Flows
- Excess/Surplus
- State/Tribal Resolution
- Regional Planning

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ISF Advisory Group:
Process for Assessing Instream Flow

- Address the legal and policy questions.
- Study other mechanisms for protecting instream flows.
- Develop a draft methodology for instream flow studies in Oklahoma.
- Conduct a study on the economic impacts of instream flows in Oklahoma.
- 5. Perform an instream flow pilot study in a scenic river.
- Preserve the Instream Flow Workgroup.

Illinois River Instream Flow Pilot Study

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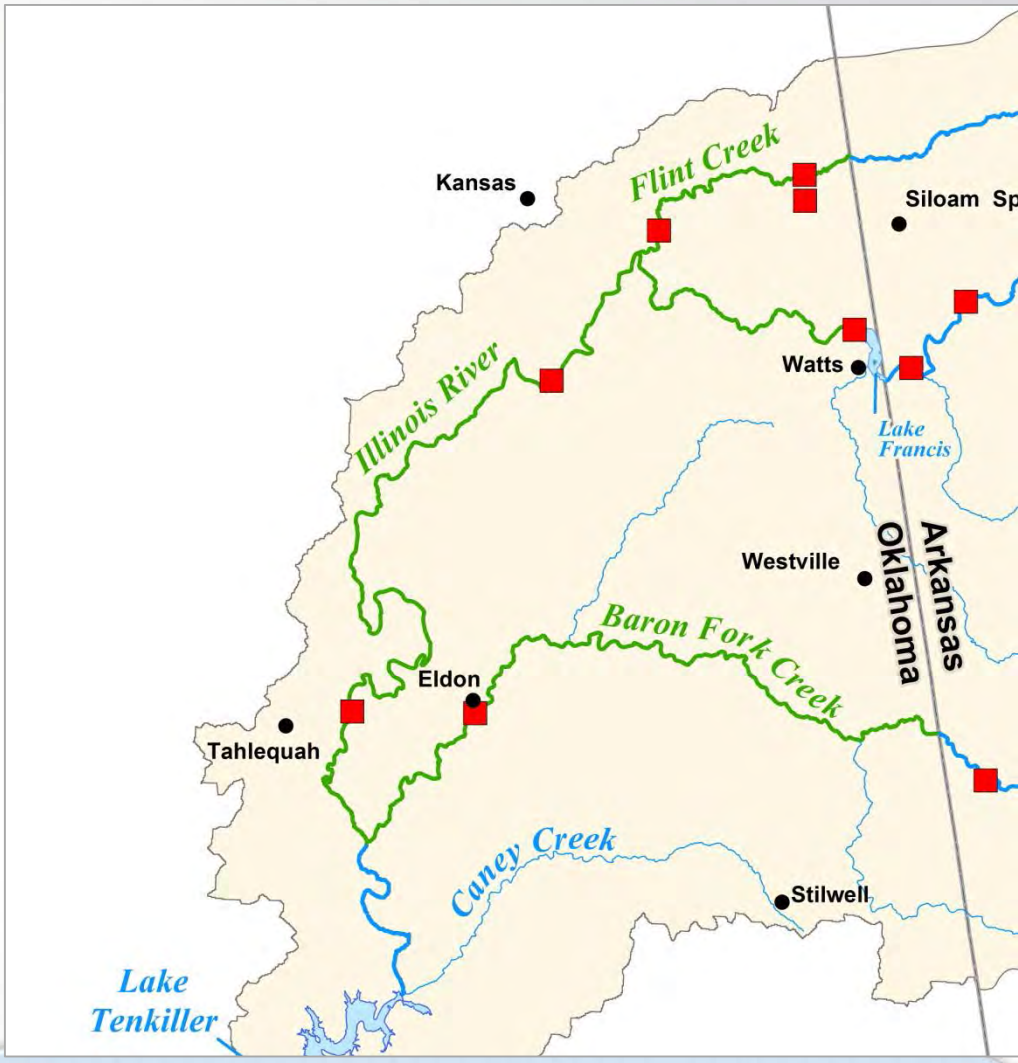
Focus of Tonight's Discussion

- **Instream (or environmental) flows** are those necessary to provide for a **healthy ecosystem** and support **water-related recreation** (such as fishing, hunting, swimming, and boating) as well as **tourism**.



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Goals for Tonight's Meeting

Recap feedback from 2015 public meeting

Learn about Illinois River resource values

Learn about 2015 Instream Flow fieldwork

Ask questions and look ahead to next steps

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Keeping in Touch

www.owrb.ok.gov/ISF

Provide E-mail address on Sign-in Sheet

Derek.Smithee@owrb.ok.gov

Derek Smithee

(405) 530-8800

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Examples of feedback shared at the first ISF Pilot Study stakeholder meeting (1/22/15)

Suggested Considerations

- Instream Recreation (boating, rafting)
- Related Recreation (hunting, camping, birding)
- Wetlands and Oxbows
- Stream/groundwater interactions
- Flow patterns
- Variability beyond historical data
- Potential maximum flows
- Cherokee Nation involvement
- Summer critical low-flows
- Changing erosion and channel dynamics
- Impact of recreation on landowners
- Tenkiller allocation impacts
- Interstate Compact conflicts

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Public Comment

- Questions about the field work?
- Questions about the technical studies and how that fits into the overall Instream Flow Pilot Study?
- Discussion of other river/stream uses on the Upper Illinois River and tributaries above Tenkiller
- Any other Instream flow questions?

Keeping in Touch

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Illinois River Instream Flow Pilot Study
Public/Stakeholder Meeting

January 21, 2015

Municipal Armory

Tahlequah, Oklahoma

US Army Corps of Engineers

State of Oklahoma
OWRB
Water Resources Board
the water agency

Instream Flow Assessment of the Illinois River, OK

Study Update and Next Steps

Presented to
Public Stakeholder Meeting in Tahlequah, OK

Presented by
Forrest Olson, CH2M HILL

January 21, 2016

US Army Corps of Engineers

WRB

ch2m

What is an instream flow?

OWRB working definition of instream flow:

"Flows necessary to provide for a healthy ecosystem and support water-related recreation (such as fishing, hunting, swimming and boating) as well as tourism."

What are instream resources?

- Fisheries, wildlife, water quality, recreation, aesthetics, and the ecological processes that support these resources.

Primary Study Goals:

- Gain a better understanding of the implications of a process to deal with instream flow issues consistent with the overall goal of managing water resources in Oklahoma for multiple uses. The study would help define a conceptual framework and study process that could be used statewide.

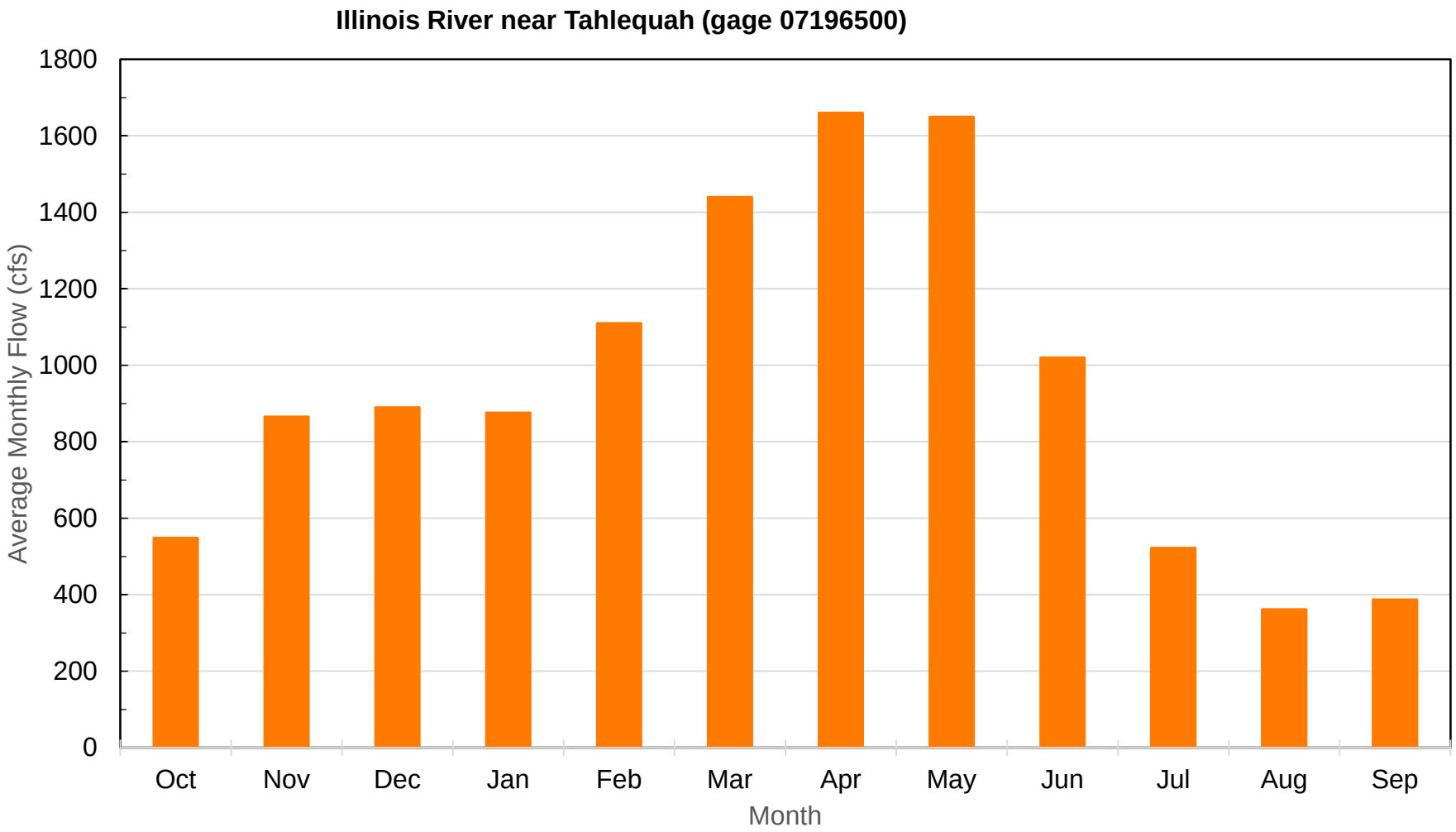
- Develop seasonal instream flow recommendations for the Illinois River including Barren Fork and Flint creeks.

*Note: This study is **not** being done in response to a proposed water development project.*

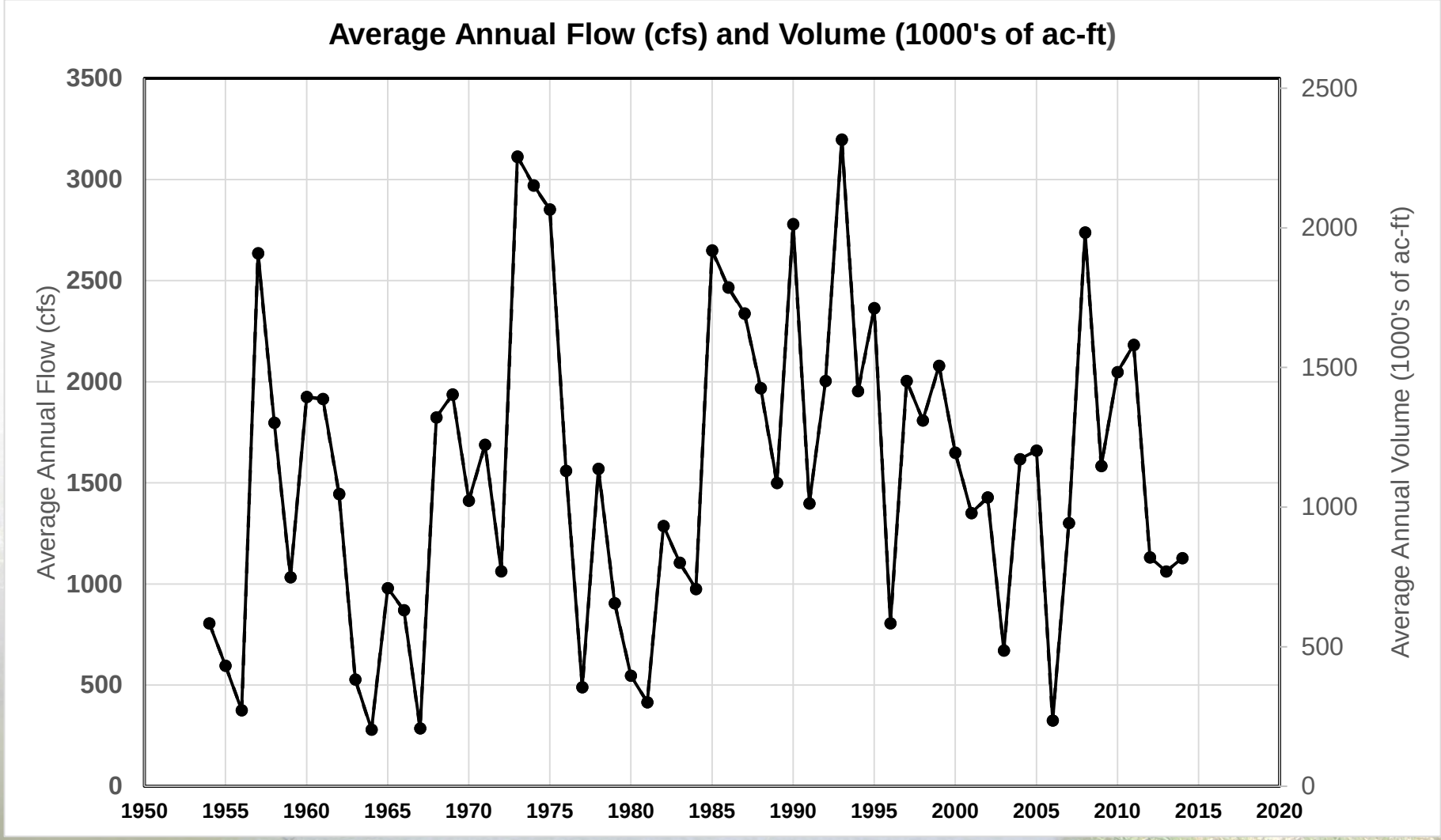
Study Area

Rogers
Kansas
Flint Creek
Siloam Springs
Osage Creek
Springdale
Watts
Illinois River
Lake Francis
Fayetteville
Illinois River
Westville
Arkansas
Oklahoma
Baron Fork Creek
Lincoln
Eldon
Tahlequah
Caney Creek
Stilwell
Lake Tenkiller
USGS Gage
City
Lake
Scenic River
Major Stream
Other Stream
N
W
E
S
0
5
10
Miles

Illinois River Average Monthly Flows



Average Annual Flows for the Illinois River near Gore



Illinois River December 27, 2015

Peak Flow Recurrence Intervals

Peak Flow Return Period (Year)	Probability (%)	Flow (cfs)		
		Illinois River near Tahlequah	Illinois River near Watts	Barren Fork at Eldon
2	50	19,535	18,868	16,250
5	20	38,289	33,947	29,836
10	10	53,919	45,185	37,328
25	4	77,173	60,390	44,675
50	2	96,925	72,233	48,789
100	1	118,643	84,362	51,962

Average Annual Surface Water Usage (acre-feet) in the Upper Illinois River Basin (OK) above and including Barren Fork

Water Use	Total
Irrigation	1,301.4
Agriculture	0
Public Supply	10,751.4
Rec, Fish, & Wildlife	0
Commercial	0
Industrial	0
Mining	0
Other	35.1
Total	**12,087.9**

Groundwater Usage

Deep Bedrock Aquifer	3,900 acre-feet (water right)	Little effect on streamflows
Shallow Alluvial Aquifer	1,050 acre feet (est. usage)	Direct but delayed effect on stream

Alluvial Groundwater use is equivalent to 1.5 cfs, which is 0.11 % of basin yield

Water Use Summary:

1. Surface water use in Oklahoma portion of Illinois River above Barren Fork is only 1.3 % of the average annual basin yield
2. Most water use is for public supply – mostly Tahlequah
3. Basin water use in Arkansas is similar to Oklahoma in quantity and use category
4. White River water for Fayetteville area municipal use augments flows in Illinois River
5. Flow augmentation from White River may totally offset other surface water withdrawals in both states on annual average basis
6. Ground water use has minimal effect on streamflows

Water Quality

- Basin’s major water quality concern is nutrient loading, primarily phosphorus
- Phosphorus affects the Illinois River and Lake Tenkiller
- Phosphorus loading is trending downward in Illinois River and Barren Fork Creek, not in Flint Creek

Fisheries

1. Highly diverse fish community of >72 species
2. Most fish species are native to the basin
3. Smallmouth bass is the most sought-after game fish
4. The Neosho smallmouth bass and sunfish are of high conservation value
5. No fish species are listed as federal or state threatened or endangered

Recreational Use

- Annual visitation ~400,000 to Scenic section
- Approximately 25 Commercial Floatation Device Operators
- Annual floaters (canoe, raft, kayak) ~100,000
- Annual recreational economic value (above Tenkiller) ~ $12 million
- Fishing is a popular activity, primarily for bass and sunfish. No estimates of angler use or catch for Illinois River (some for Barren Fk)

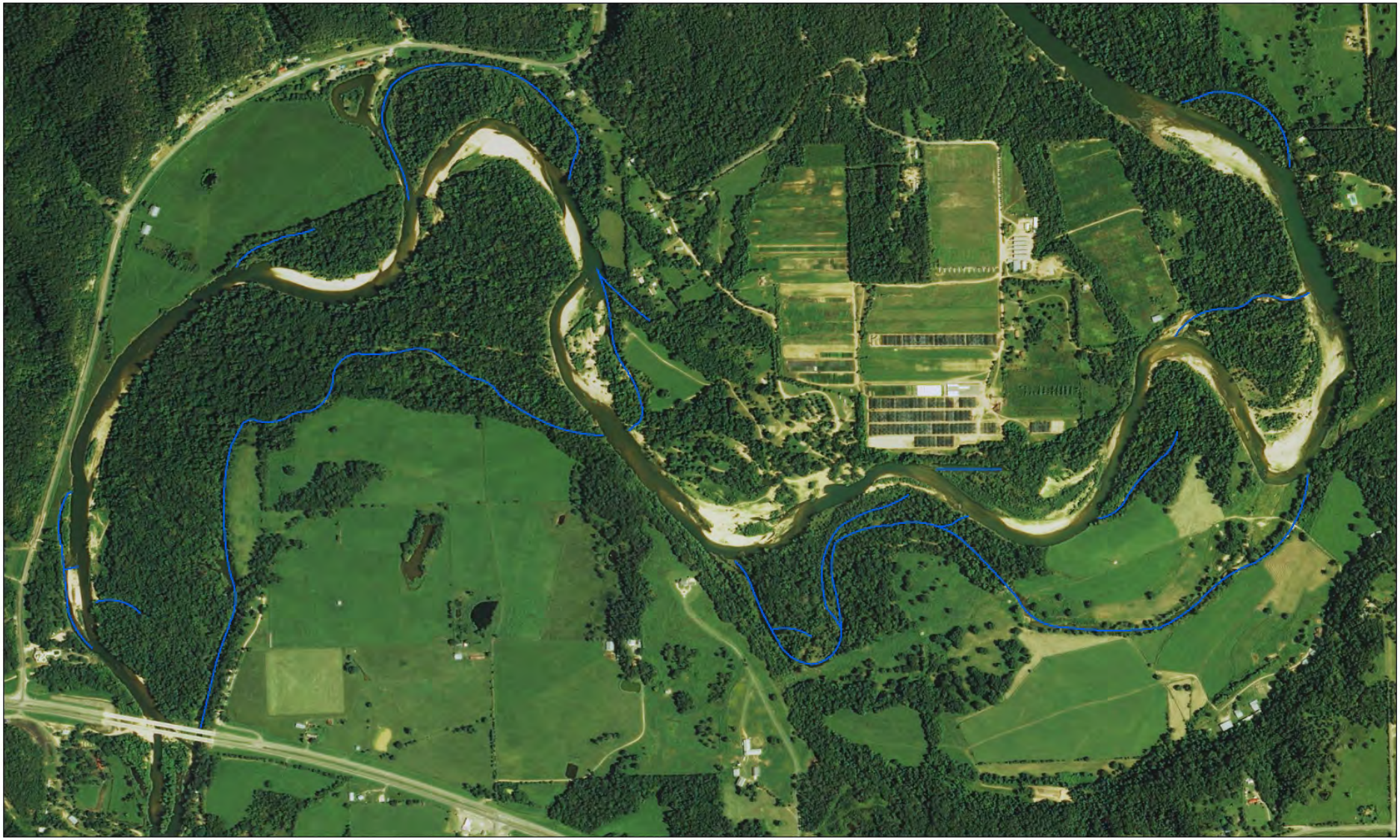
Illinois River Monthly Float Users, Average Annual for 2003-2008

Month	Commercial	Private	Total
January	1	35	36
February	2	34	36
March	110	19	129
April	348	81	429
May	9,938	411	10,349
June	22,734	681	23,415
July	37,441	1,094	38,535
August	24,540	804	25,344
September	8,657	400	9,057
October	878	93	971
November	76	24	100
December	6	48	54
Total	**104,731**	**3,724**	**108,455**

Flow Ranges for Recreational Floating (Tahlequah Gage) (source: OSRC)

Preferred range	400 – 1,200 cfs
Minimum for canoeing & kayaking	150 cfs
Minimum for rafting	250 cfs
Maximum for general safety	1,200 cfs
Maximum for experienced boaters	4,000 cfs

Secondary Channels



Ratio of secondary channel length to the main channel length in the Illinois River between Watts and Tahlequah, Oklahoma.

River Reach	Watts to Flint Creek	Flint Creek to Peavine	Peavine to Tahlequah	Total
River Reach Length (mi)	13.3	16.3	22.9	53
Secondary Channel Length (mi)	5.3	6.3	18.3	30.5
Ratio of 2ndary channel to main channel length	**44.4 %**	**38.7%**	**80.0%**	**57.5%**

Importance of Secondary Channels

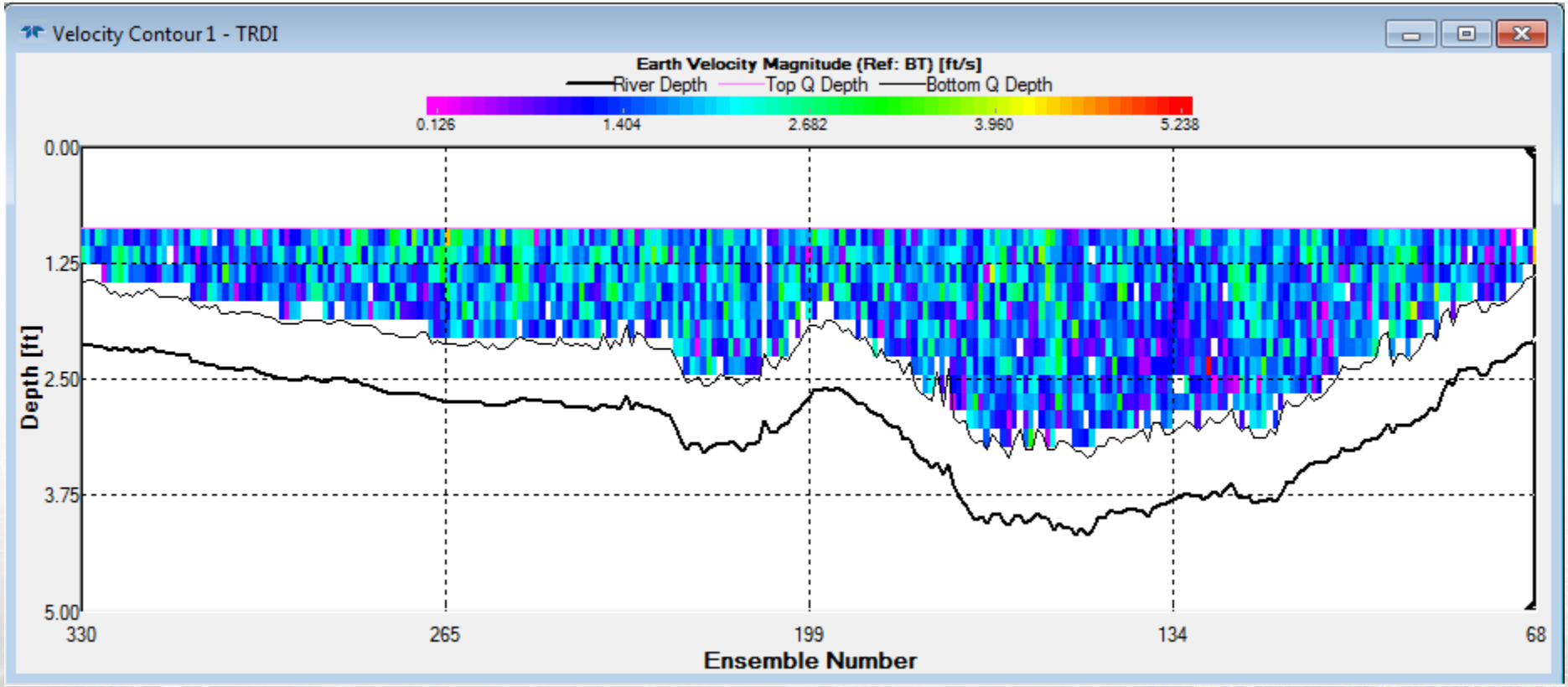
- Rearing and refuge habitat for fish
- Support of many wildlife species that don’t tend to use the main channel
- Water quality (clarity and temperature)
- Floodwater relief
- Help govern the size and shape of the main channel

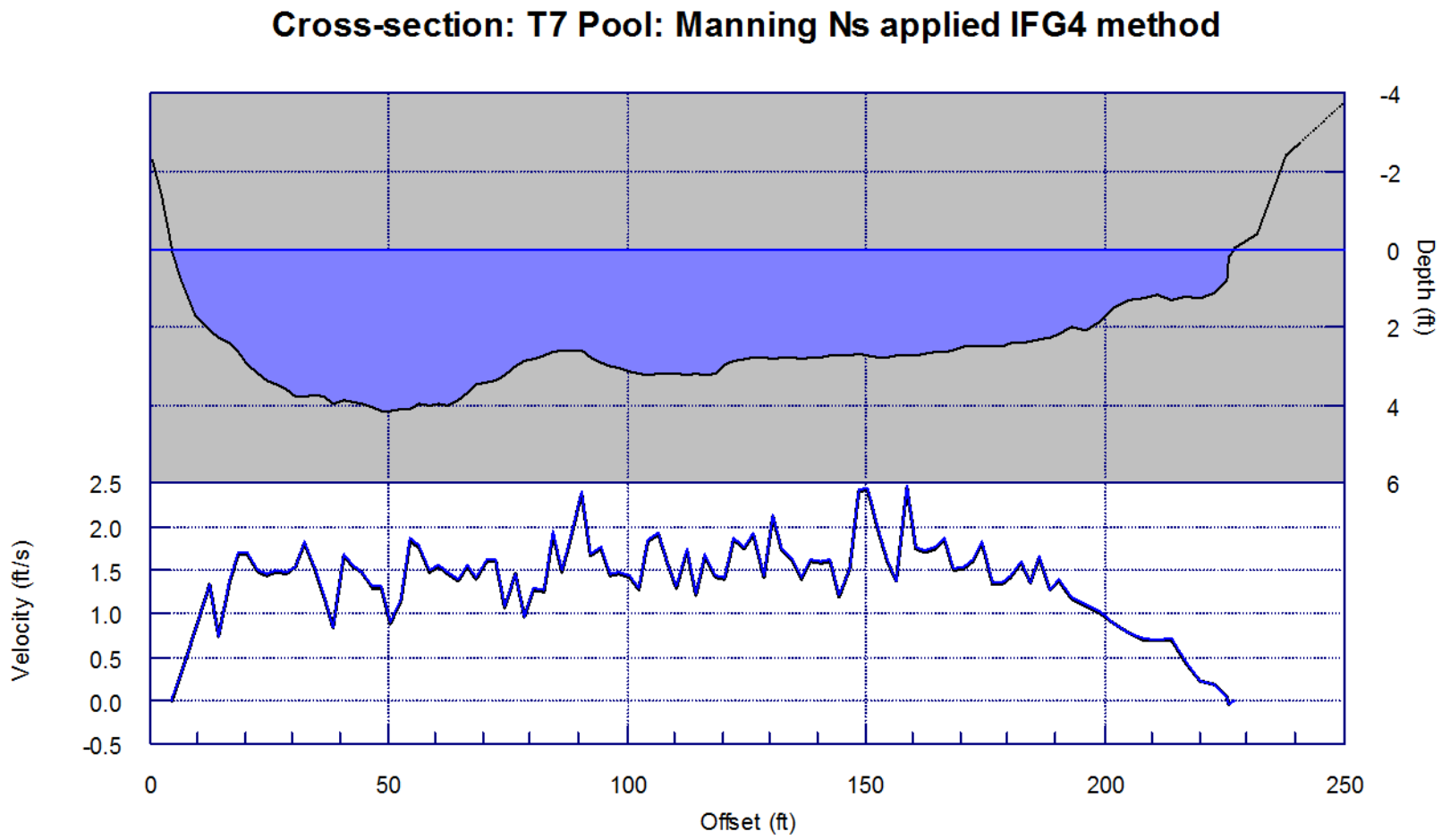
How to Protect Secondary Channels:

- Preserve bank-full/channel maintenance flows (frequency and magnitude)
- Typically equates to the 1.5- or 2-year recurrence flow
- Approximately 15,000 – 20,000 cfs for Illinois River at Tahlequah

Fish Habitat Modeling

- Simple explanation of model
- Study sites (map with transects)
- Photos
- Example results (Barren Fork)


Velocity Contour 1 - TRDI
Earth Velocity Magnitude (Ref: BT) [ft/s]
River Depth
Top Q Depth
Bottom Q Depth
0.126
1.404
2.682
3.960
5.238
0.00
1.25
2.50
3.75
5.00
Depth [ft]
330
265
199
134
68
Ensemble Number


Cross-section: T7 Pool: Manning Ns applied IFG4 method
Depth (ft)
-4
-2
0
2
4
6
Velocity (ft/s)
2.5
2.0
1.5
1.0
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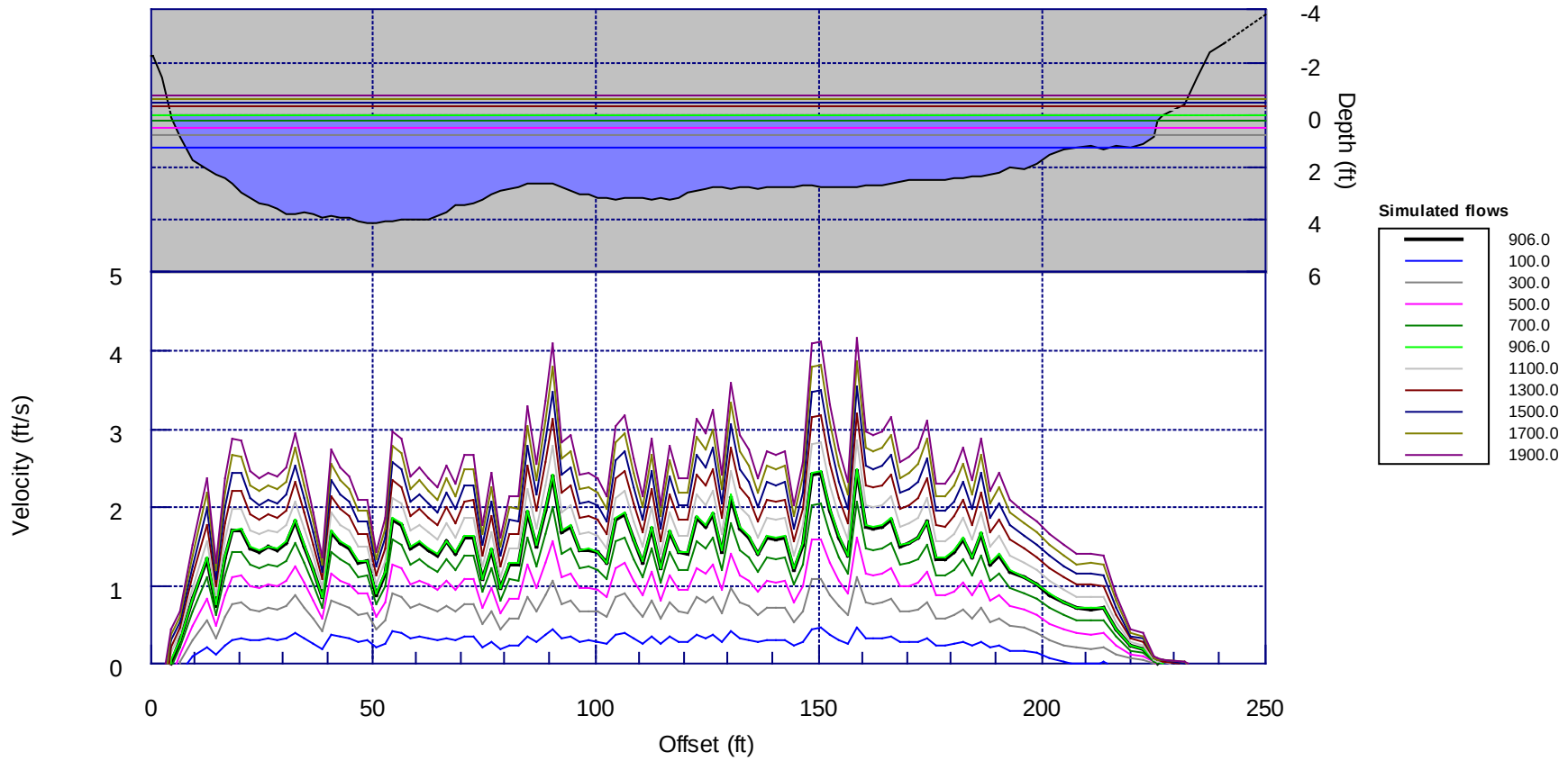
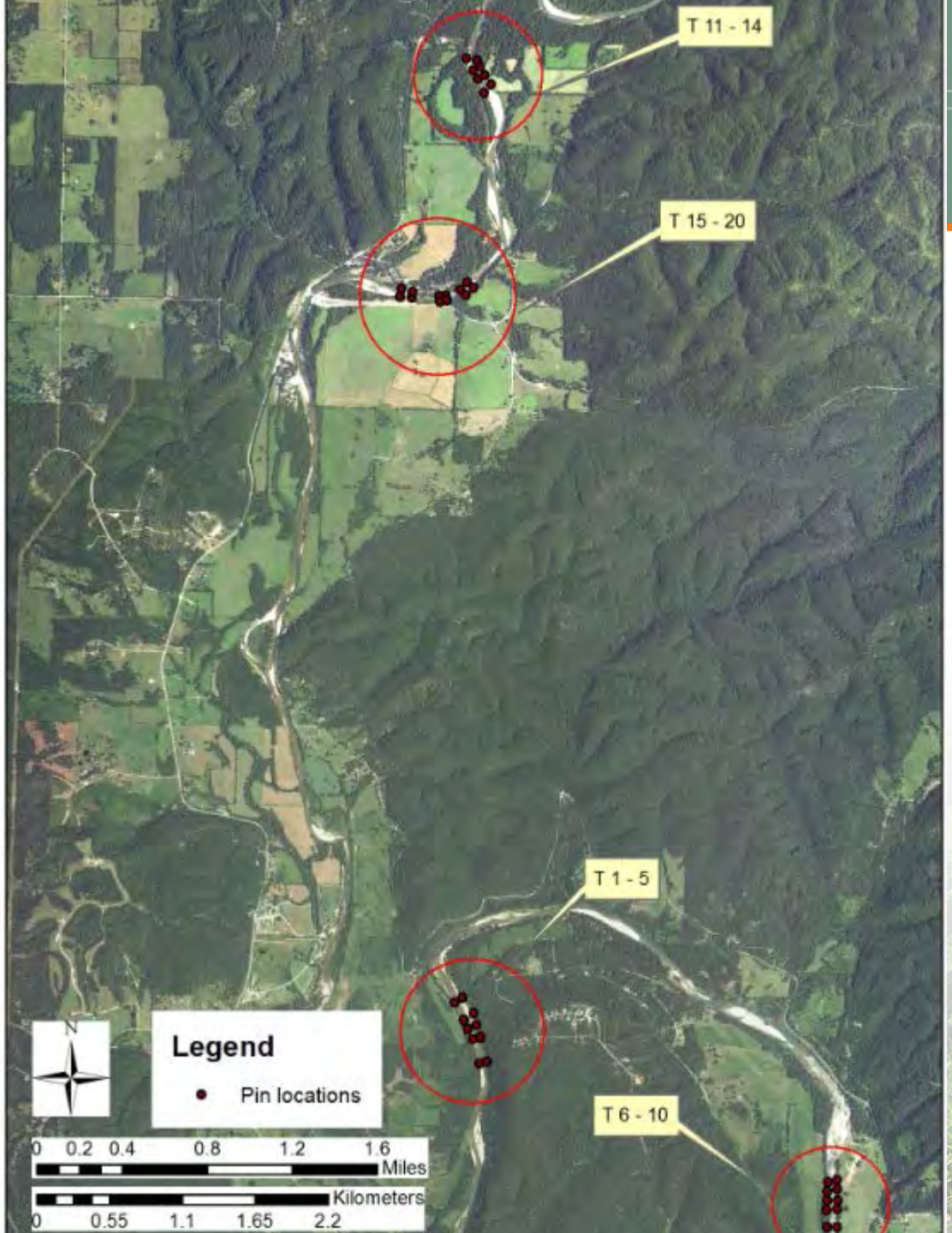
-0.5
0
50
100
150
200
250
Offset (ft)

Cross-section: T7 Pool: Manning Ns applied IFG4 method




T 11 - 14
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N
Legend
Pin locations
0 0.2 0.4 0.8 1.2 1.6
Miles
Kilometers
0 0.55 1.1 1.65 2.2

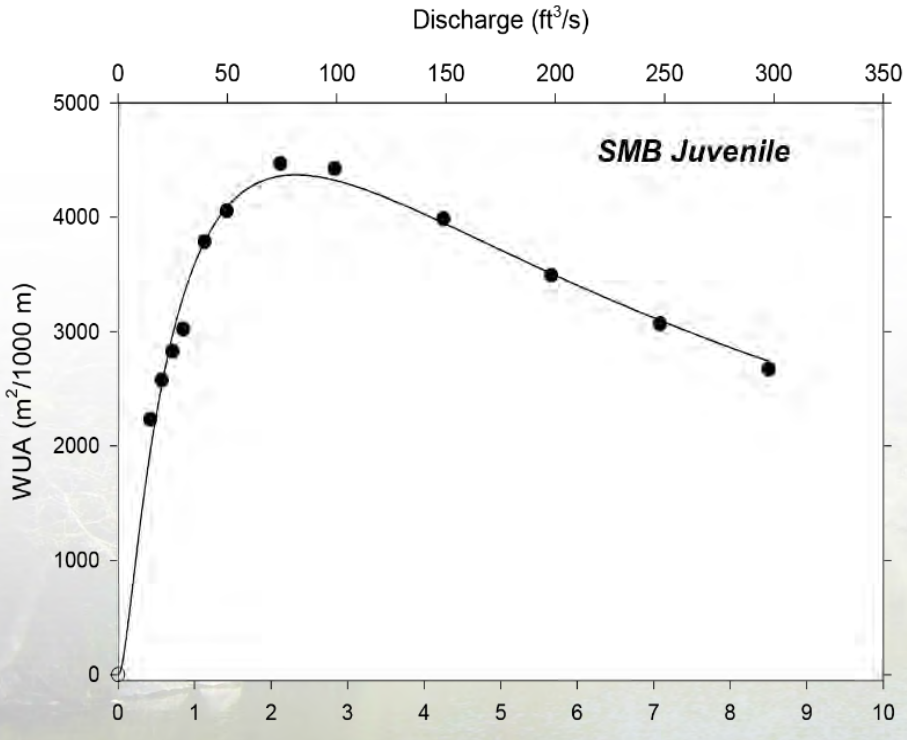
Lower Flint Creek

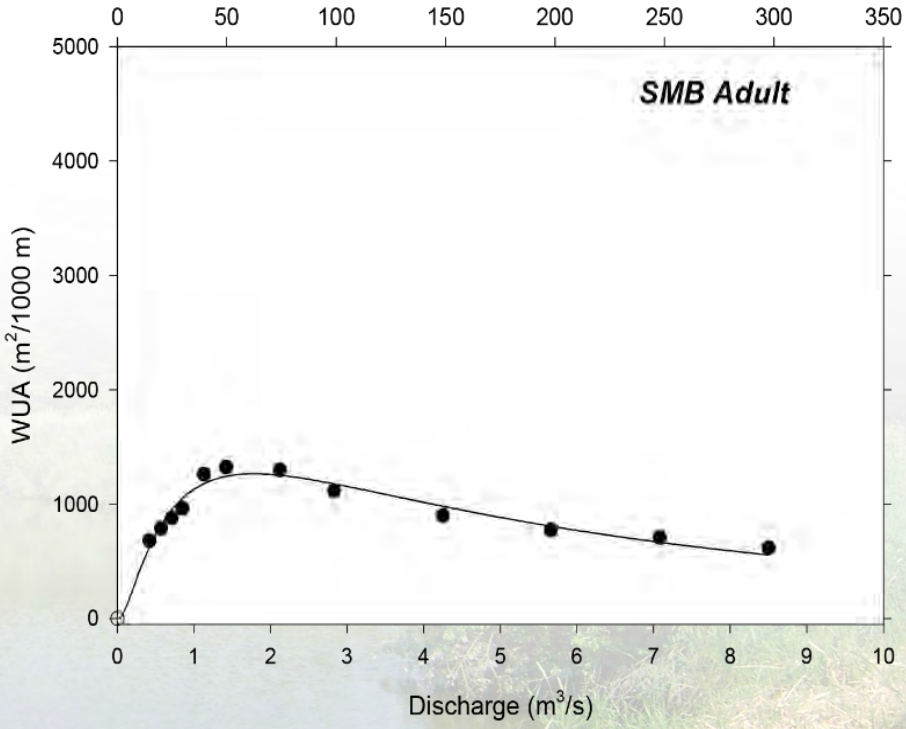
Flint Creek Study Transect

Lower Illinois River

Upper Illinois River Bedrock Pool Transect

Example (Barren Fork) of Fish Habitat Modeling Results





Implication of recent flood on study

- Fish habitat model extrapolation limited to < 1,000 cfs for Illinois River, <150 cfs for Flint Creek
- Upper Illinois River site above Flint Creek – insufficient data; site washed out.

Next Steps.

- Finish habitat modeling
- Complete Technical Report (late spring 2016)
- Final public/stakeholder meeting to present results of the technical studies

Future Work.

- Results will be provided to the Instream Flow Advisory Group
- Begin policy dialogue to determine how these flows fit into upper Illinois River water quantity management
- Assess applicability to other streams in Oklahoma

AGENDA

Illinois River Instream Flow Pilot Study Public/Stakeholder Meeting

Municipal Armory, Tahlequah, OK

June 16, 2016, 6:30 pm

I. **Welcome and Introductions (6:30 – 6:40) – Derek Smithee, Division Chief, OWRB**

II. **Recap of January 2016 Public/Stakeholder Meeting (6:40– 6:50) – John Rehring, Carollo Engineers**

III. **Technical Presentation: "Instream Flow Assessment Technical Study Findings" (6:50 –7:30) – Forrest Olson, CH2M**

IV. **Q&A (7:30-7:45)**

V. **Next Steps (7:45- 8:00)**

INPUT FROM ILLINOIS RIVER INSTREAM FLOW

PILOT STUDY PUBLIC/STAKEHOLDER MEETING

Armory Municipal Center — Tahlequah, OK

January 21, 2016

The Oklahoma Water Resources Board (OWRB), working in partnership with the US Army Corps of Engineers under their Planning Assistance to States program, held the second of a series of public meetings to present updates and gather information from the stakeholders on the Illinois River Instream Flow (ISF) Pilot Study. This was a follow-up to the meeting held in Tahlequah on January 21, 2015, as part of a series of public meetings to share information and obtain feedback on an ISF Pilot Study being conducted on the Upper Illinois River (including Barren Fork and Flint Creeks) above Lake Tenkiller in eastern Oklahoma. The meeting was attended by approximately 31local residents and other key stakeholders.

The ISF Pilot Study was initiated in early spring of 2015. The pilot study is based on the recommendations of a statewide 25-member Instream Flow Advisory Group and the 2012 Oklahoma Comprehensive Water Plan (OCWP). The OCWP set forth a process to "ascertain the suitability and structure of an instream flow program for Oklahoma." This pilot study is a key element of that process, as it will be used to assess the potential benefits and challenges that would be associated with an instream flow program, if Oklahoma were to implement such a program. The technical study team continues the data collection and modeling. As the technical study progresses, the OWRB and technical study experts will host a final stakeholder forum to provide the results of the technical phase of the study.

The focus of the meeting was to present the status and preliminary findings of the ongoing ISF Pilot Study. The pilot study presentations given during the meeting and the meeting agenda can be found on the OWRB Instream Flow Advisory Group webpage: http://www.owrb.ok.gov/ISF. Information presented below summarizes the feedback received at the meeting and the responses provided by the study team.

PRESENTATIONS

Derek Smithee Presentation

Derek Smithee, Chief of the OWRB Water Quality Division, welcomed everyone, provided housekeeping notes, reviewed the meeting agenda and introduced the project team. He revisited the goals for the Instream Flow Pilot Study and the key components of the current phase of the project.

Key Issues

- The Advisory Group identified the upper Illinois River above Tenkiller Reservoir including Barren Fork and Flint Creeks for the ISF Pilot Study consistent with the Oklahoma Comprehensive Water Plan recommendation.
- The Instream Flow Pilot Study was intended to answer some previously unanswered questions, such as economics, policy and legal issues associated with an instream flow program.
- Any policy recommendations must be rooted in science.

John Rehring Presentation

John Rehring, Carollo Engineers, stated four goals for the meeting: 1- Recap feedback from 2015 public meeting; 2- Learn about Illinois River resource values; 3- Learn about 2015 Instream Flow fieldwork, and 4- Ask questions and look ahead to next steps. Mr. Rehring discussed the comments and recommendations received during the 2015 public stakeholder meeting. Mr. Rehring encouraged public to participate in tonight's meeting.

Key Issues

- 2015 public meeting feedback was assessed and when practicable, incorporated to the Baseline Data Report.
- Public participation is a key in the study process: ask questions about the technical study and how it fits the overall pilot study, provide feedback on types of uses on the Upper Illinois River and tributaries above Lake Tenkiller. The comments can be provided to OWRB after the public meeting and information will be available to the public on OWRB's website.
- Future work will include re-engagement of the Instream Flow Advisory Group to assess study results; initiate policy dialogue to determine how the identified instream flow needs fit into upper Illinois River flow management, and assess applicability of the process to other streams in Oklahoma (recognizing that the flow values and results will differ between watersheds due to region-specific hydrologies and local priorities for water management).

Forrest Olson Presentation

Forrest Olson, CH2M, Principal Investigator of the ISF Pilot Technical Study, provided updates on the ongoing technical studies, data collection and modeling using the Physical Habitat Simulation Model (PHABSIM).
Mr. Olson discussed the project goals: the study would help define a conceptual framework and study process, and also develop a seasonal instream flow recommendations for the Illinois River including Barren Fork and Flint creeks. Mr. Olson discussed the overall hydrology and water uses in the study area: the types of flows and the frequency, the main water uses, groundwater and surface water interactions, and upstream flow augmentation in Arkansas. In addition, Mr. Olson provided information on the fisheries and recreational uses in the study area and the type of flow needs to support these. The model overview included a description of how depth and velocity data were measured and modeled. Mr. Olson explained the selection of the study sites for different reaches and data collection methods in different sites. He explained how the results would be utilized to model relationships between fish habitat and streamflow.

Key Issues

- Main consumptive water use: mostly public supply for Tahlequah area and some irrigation
- Flow augmentation from Arkansas (Fayetteville area)
- Bankfull flows: 1.5-or 2-year recurrence flow: 10,000 –20,000 cfs for Illinois River at Tahlequah.
- Importance of secondary channels for fish, wildlife, and water quality and the importance of higher flows to maintain these channels
- 2015 floods: Affected data collection such that fish habitat model extrapolation limited to < 1,000 cfs for Illinois River, <150 cfs for Flint Creek. Upper Illinois River site above Flint Creek: insufficient data; site washed out.
- The current study will focus on modeling of fish habitat-flow relationships; the model does not provide answers. The results must be interpreted and then included with consideration of other important resource values.
- Final public/stakeholder meeting to present results of the technical studies.

LARGE GROUP DISCUSSION

A summary of comments and questions provided by meeting participants is presented below. Comment responses were provided during the meeting and also presented below.

- When will the economic evaluation be performed?
    - Moderator response: That will be addressed with the policy assessment after the technical study has been completed.
- Why is upper Illinois River being studied and not the lower Illinois River that has regulated flows?
    - Moderator response: Consistent with Oklahoma Comprehensive Water Plan recommendations to conduct an Instream Flow Pilot Study in a Scenic River, the statewide Instream Flow Advisory Group explored how to further define whether and how an instream flow (ISF) program might be implemented in Oklahoma. To make sound policy recommendations, the Group acknowledged that the basis, specifics and consequences of an ISF program must be known and understood. The Advisory Group identified the upper Illinois River above Tenkiller Reservoir including Barren Fork and Flint Creeks as the best scenic-designated watershed to test the proposed ISF evaluation process. The Illinois was chosen because it has some discharges and has a broad existing dataset that should help reduce study costs. The group ultimately determined that an upper Illinois River study as the first watershed to be analyzed would be the best approach for initial testing of the proposed process.
- Has the study assessed flow vs. water temperature impacts and the relationship to dissolved oxygen (D.O.)?
    - Technical Study Team Lead response: Previous temperature modeling studies by OSU looked at temperature correlations with low flows in Flint and Barren Fork creeks and the Illinois River. These study results will be discussed in our technical report. Dissolved oxygen was not modeled but typically follows temperature (inversely).

- What if Arkansas Wastewater Treatment Plants (WWTP) located upstream of Illinois River start reusing their effluent? Will it affect flows and the study results?
    - Technical Study Lead response: The study team is not aware of effluent flow diversions from Arkansas and has not addressed those. However, if the Fayetteville area WWTPs stopped discharging their effluent and instead reused it, the flow/habitat relationship would be unchanged but there could be impacts on Illinois River stream flows, especially noticeable in the summer. Currently these discharges (from all Arkansas WWTPs) contribute about 30 cfs to the downstream flow of the Illinois River. The study team will look into this issue further.
- Does reuse/water for 2060 goals conflict with ISF goals?
    - OWRB response: No. Beneficially reusing water helps offset the need to make other fresh water uses and diversions, which can maintain instream flows.
- Who makes recommendations?
    - OWRB response: The technical study results will be taken back to the ISF Advisory Group for further direction on how to move forward with policy decisions.
    - Technical Study Lead response: The OWRB has ultimate authority for the state's water allocations, but their decisions are informed by recommendations and input from other agencies, groups, and interested stakeholders following completion of the technical study.
- How do we address extreme flow values? Drought contingencies; flow ranges vs. "min." flow value.
    - Technical Study Lead response: Instream flow standards are intended to protect or support conditions for those resources dependent on appropriate flow conditions (e.g. fish, recreation). Flows that provide these conditions vary over time – by season and by year-type. Instream flow standards are often conditioned to reflect the realities of extreme conditions such as droughts.
- Impacts of high precipitation in 2015?
    - Technical Study Lead response: The December 2015 floods altered the study sites and thereby limited the field data collection to only two flows rather than the desired three flows at the lower Illinois and Flint Creek sites. This means that the fish habitat model extrapolation will be limited to < 1,000 cfs for Illinois River, <150 cfs for Flint Creek – about half of what was targeted. The Upper Illinois River site above Flint Creek was washed out before adequate data could be collected for modeling that site.
- What is the peer review process?
    - Technical Study Lead response: All the study documents to date have been prepared in collaboration with the Technical Study Workgroup (TSWG). This includes the Study Plan and the Background Data Report. In addition, the key partner agencies have been indispensable in preparing and developing data for the reports and reviewing them. The TSWG will continue review of technical documents and will make recommendations on the flows after the PHABSIM modeling has been completed.

- Any forecasted shift in recreation use?
    - OWRB response: Maybe Ed Fite who is the Technical Study Workgroup member, could answer this question.
    - Ed Fite, The Oklahoma Scenic River Commission Chairman (TSWG member) response: There are more kayaks, less canoes, and about the same amount of rafts. Kayakers like faster water but can handle shallower water.
- This demonstrates how ISF needs change over time, but climate change will affect it too.
    - Technical Study Lead response: Future climate predictions prepared by OU were reviewed as part of the Baseline Data Report. The prediction is that average annual precipitation will increase in northeastern Oklahoma in the future (to year 2099). They were not able to predict changes in storm intensity or frequency.

END

Illinois River Instream Flow Pilot Study
Public/Stakeholder Meeting

June 16, 2016

Municipal Armory

Tahlequah, Oklahoma

US Army Corps of Engineers

State of Oklahoma
OWRB
Water Resources Board
the water agency

Agenda for Tonight's Discussion

Welcome and Introductions

Derek Smithee, Division Chief, OWRB

Recap of January 2016 Public/Stakeholder Meeting

John Rehring, Carollo Engineers

Technical Presentation:
Instream Flow Assessment Technical Study Findings

Forrest Olson, CH2M

Public Comment / Questions and Answers

Next Steps

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Housekeeping

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Keeping in Touch

www.owrb.ok.gov/ISF

Provide E-mail address on Sign-in Sheet

Derek.Smithee@owrb.ok.gov

Derek Smithee

(405) 530-8800

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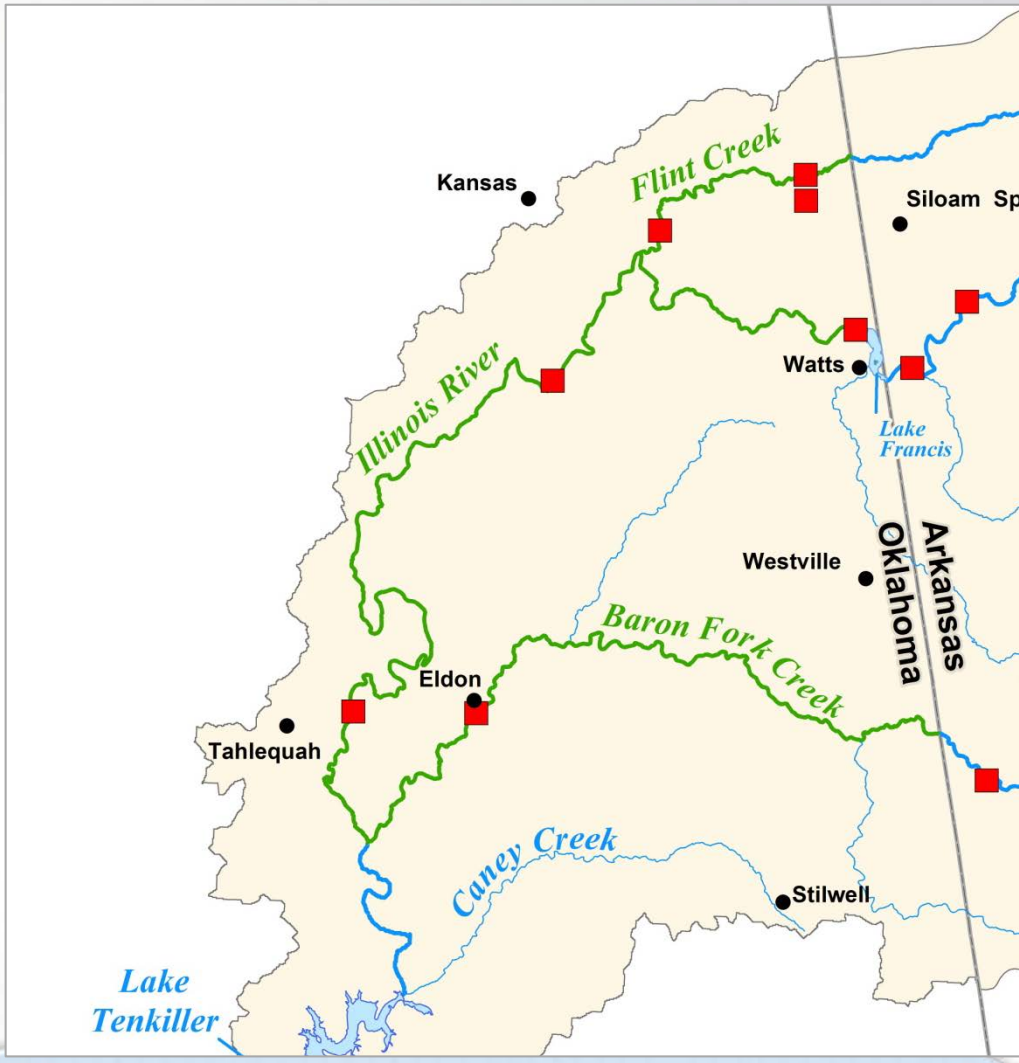
Focus of Tonight's Discussion

- **Instream (or environmental) flows** are those necessary to provide for a **healthy ecosystem** and support **water-related recreation** (such as fishing, hunting, swimming, and boating) as well as **tourism**.



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Instream Flow Advisory Group

J.D. Strong (Chair)
- OWRB

Shannon Brewer
- USGS

Tom Creider
- Oklahoma State Parks

Mark Derichsweiler
- Sierra Club

Tom Elkins
- Cherokee Nation

A.J. Ferate
- OIPA

Mike Fuhr
- The Nature Conservancy

James Gammill
- Oklahoma Rural Water Association

Bud Ground
- Environmental Federation of Oklahoma

Charlette Hearne
- ORWP

Michael Kelsey
- Okla. Cattlemen's Association

Mike Jackson
- Okla. Chamber of Commerce

Joe Long
- ODEQ

Mike Mathis
- Continental Resources

Sue Ann Nicely
- Okla. Municipal League

Marla Peek
- Oklahoma Farm Bureau

Tyler Powell
- Office of the Sec. of Energy & Environment

Jim Reese
- Okla. Dept. of Ag, Food & Forestry

Marsha Slaughter
- OKC Water Utilities Trust

Kevin Stubbs
- US Fish & Wildlife Service

Jeff Tompkins
- Bureau of Reclamation

Brooks Tramell
- Okla. Conser-vation Comm.

Support
- OWRB Staff
- CH2M
- Carollo

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ISF Advisory Group:
Process for Assessing Instream Flow

J.D. Strong (Chair) • OWRB	**Shannon Brewer** • USGS	**Tom Creider** • Oklahoma State Parks	**Mark Derichsweiler** • Sierra Club	**Tom Elkins** • Cherokee Nation
A.J. Ferate • OIPA	**Mike Fuhr** • The Nature Conservancy	**James Gammill** • Oklahoma Rural Water Association	**Bud Ground** • Environmental Federation of Oklahoma	**Charlette Hearne** • ORWP
Michael Kelsey • Okla. Cattlemen's Association	**Mike Jackson** • Okla. Chamber of Commerce	**Joe Long** • ODEQ	**Mike Mathis** • Continental Resources	**Sue Ann Nicely** • Okla. Municipal League
Marla Peek • Oklahoma Farm Bureau	**Tyler Powell** • Office of the Sec. of Energy & Environment	**Jim Reese** • Okla. Dept. of Ag, Food & Forestry	**Marsha Slaughter** • OKC Water Utilities Trust	**Kevin Stubbs** • US Fish & Wildlife Service
	Jeff Tompkins • Bureau of Reclamation	**Brooks Tramell** • Okla. Conser-vation Comm.	**Support** • OWRB Staff • CH2M • Carollo	

- ✓ Address the legal and policy questions.
- ✓ Study other mechanisms for protecting instream flows.
- ? Develop a draft methodology for instream flow studies in Oklahoma.
- ? Conduct a study on the economic impacts of instream flows in Oklahoma.
- 5. Perform an instream flow pilot study in a scenic river.
- ✓ Preserve the Instream Flow Workgroup.

Upper Illinois River Instream Flow Pilot Study

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ISF Advisory Group: Overall goals for the Upper Illinois River Instream Flow Pilot Study

- Better understand the benefits and implications of a possible ISF program
- Identify additional questions and concerns
- Test and refine the IFIM process to address questions and issues raised by the ISF Advisory Group
- Identify specific technical components of the approach that could be applied to ISF assessments in other watersheds

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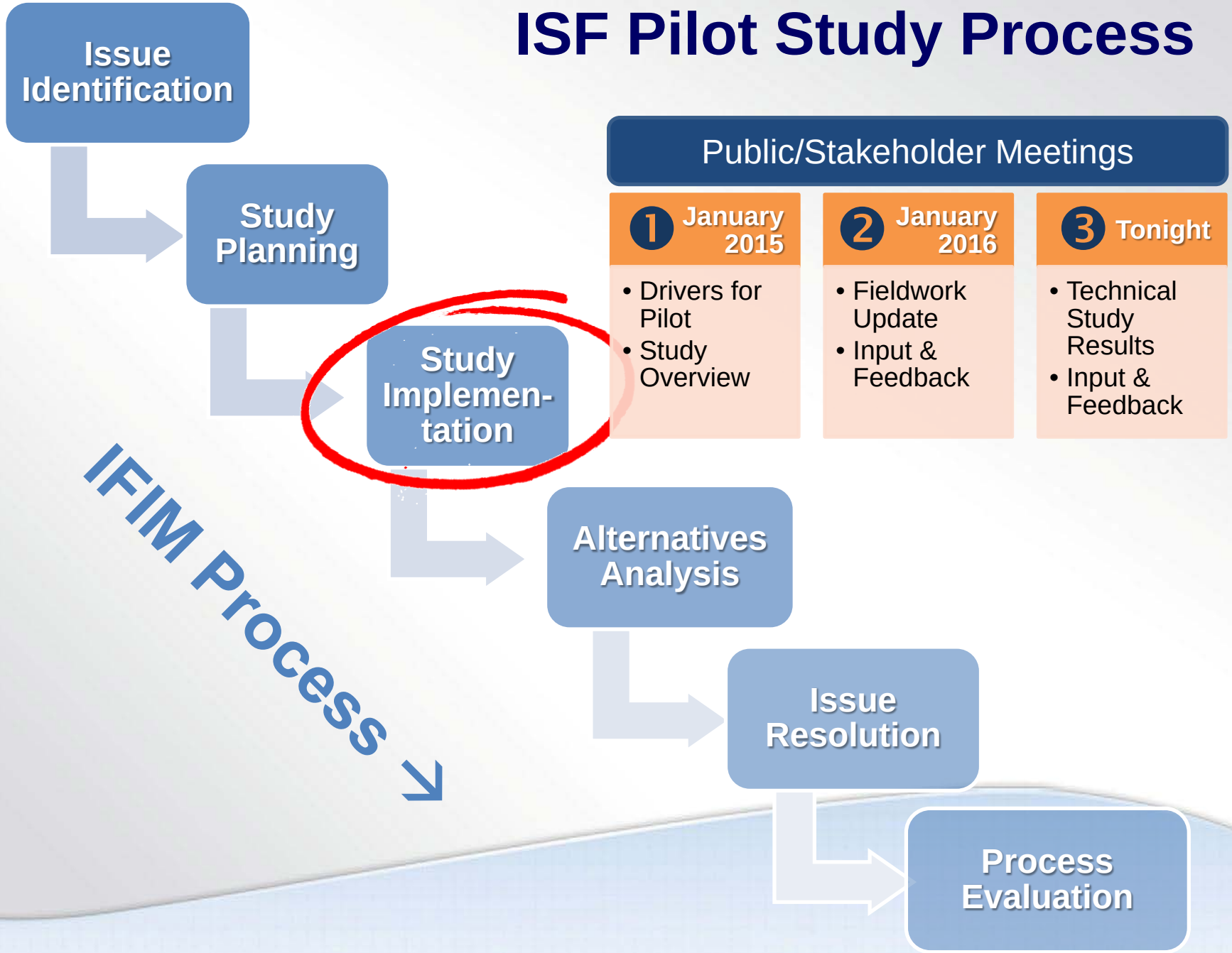
ISF Pilot Study Process



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Feedback shared at ISF Pilot Study Public/Stakeholder Meeting #2

Public/Stakeholder Meetings

1 January 2015	2 January 2016	3 Tonight
• Drivers for Pilot • Study Overview	• Fieldwork Update • Input & Feedback	• Technical Study Results • Input & Feedback

Suggested Considerations

- Economic evaluation should accompany policy dialogue
- Flow vs. water temperature and dissolved oxygen
- Potential flow impact of future water reuse in Arkansas
- Consider flow patterns, not just extremes
- Consider shifts in types of recreational boating
- Climate change considerations

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Illinois River Instream Flow Pilot Study
Public/Stakeholder Meeting

June 16, 2016

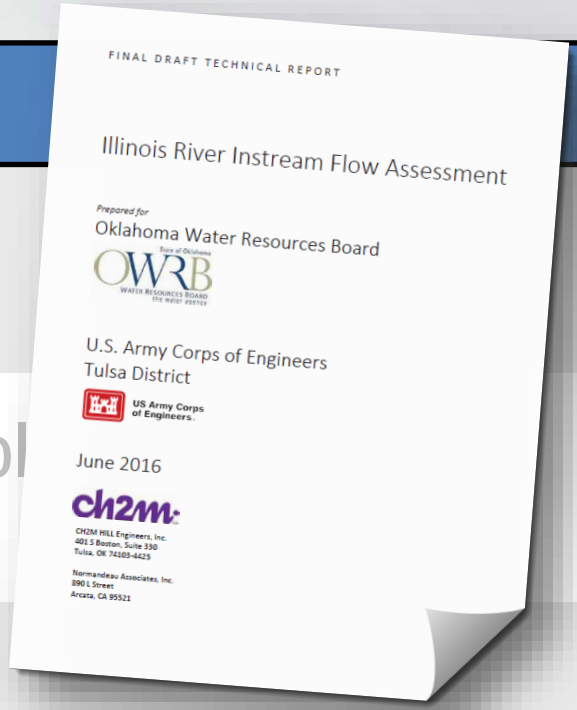
Municipal Armory

Tahlequah, Oklahoma

US Army Corps of Engineers

State of Oklahoma
OWRB
Water Resources Board
the water agency

Agenda for Tonight's Discussion


FINAL DRAFT TECHNICAL REPORT

Illinois River Instream Flow Assessment

Prepared for
Oklahoma Water Resources Board

U.S. Army Corps of Engineers
Tulsa District

June 2016

CH2M HILL Engineers, Inc.
401 S Boston, Suite 330
Tulsa, OK 74103-4425

Normandeau Associates, Inc.
890 L Street
Arcata, CA 95521

Welcome and Introductions

Derek Smithee, Division Chief, OWRB

Recap of January 2016 Public/Stakehol

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Forrest Olson, CH2M

Public Comment / Questions and Answers

Next Steps

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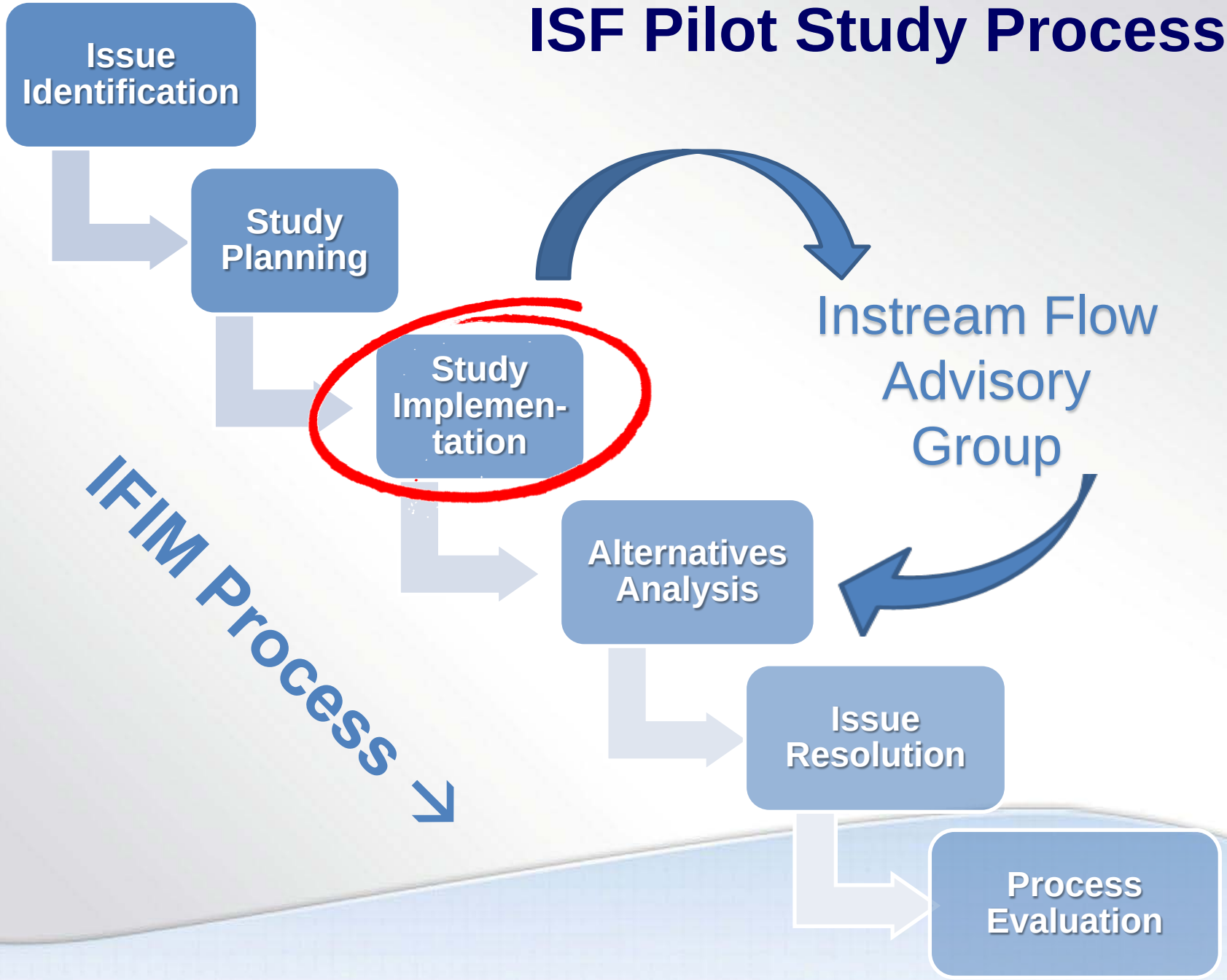
ISF Pilot Study Process



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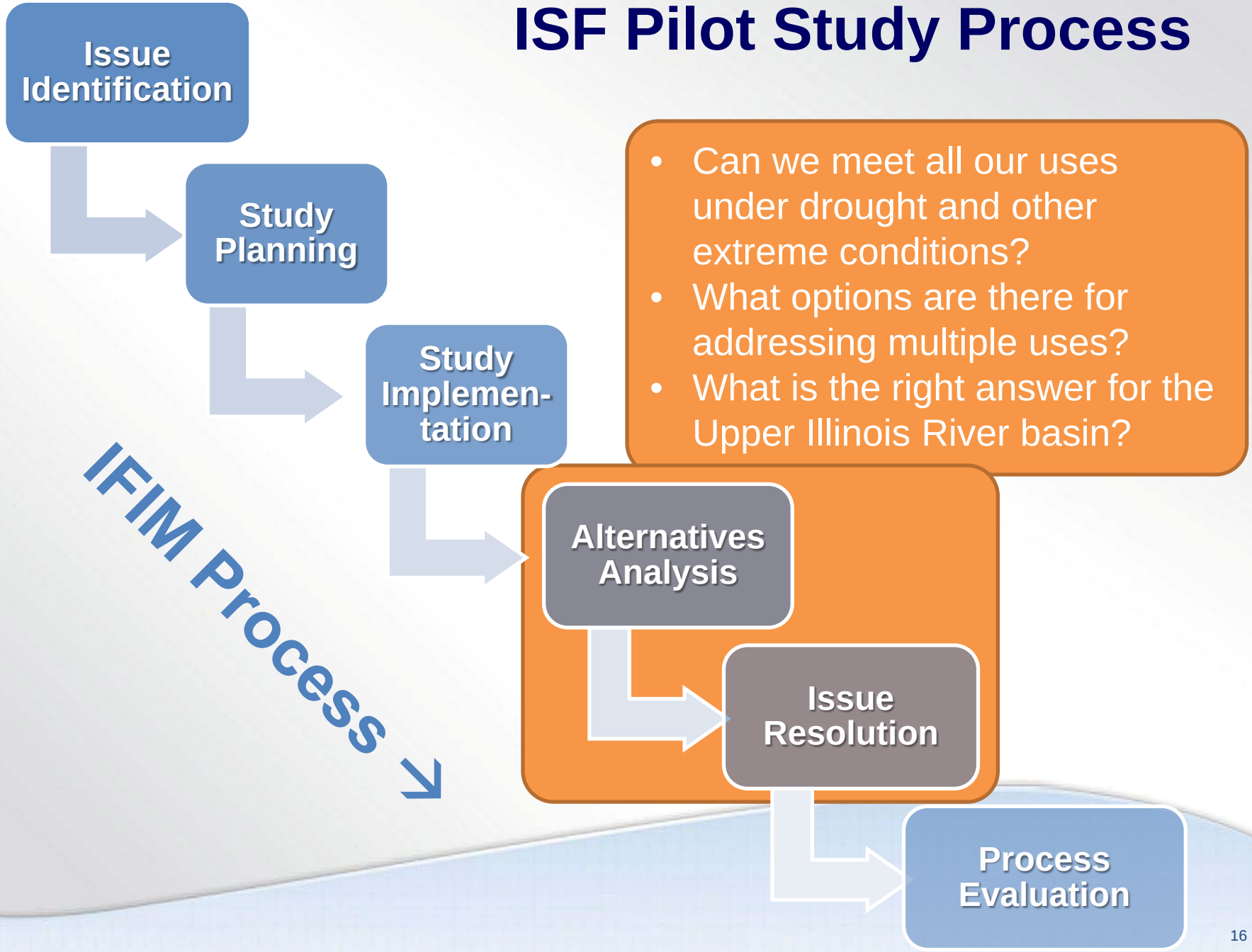
ISF Pilot Study Process



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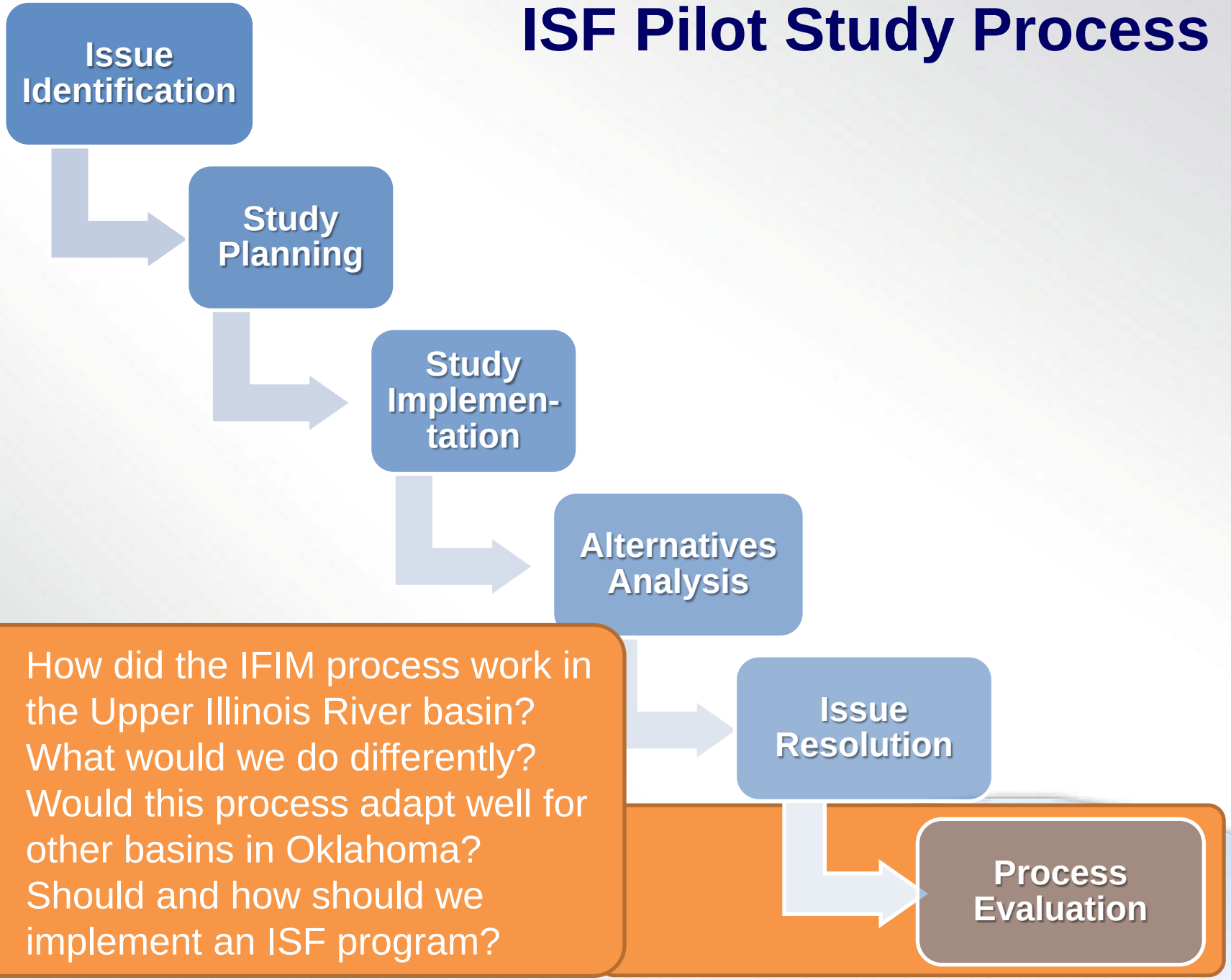
ISF Pilot Study Process



- How did the IFIM process work in the Upper Illinois River basin?
- What would we do differently?
- Would this process adapt well for other basins in Oklahoma?
- Should and how should we implement an ISF program?

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Public Comment

- Questions about the technical studies and how they support the overall Instream Flow Pilot Study?
- Input on the Pilot Study process?
- Other Instream Flow questions?

Keeping in Touch

www.owrb.ok.gov/ISF

Provide E-mail address on Sign-in Sheet

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Derek Smithee

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Illinois River Instream Flow Pilot Study
Public/Stakeholder Meeting

June 16, 2016

Municipal Armory

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Instream Flow Assessment of the Illinois River, OK

Summary of Technical Studies

Presented at
Public Stakeholder Meeting in Tahlequah, OK

Presented by
Forrest Olson, CH2M HILL

June 16, 2016

US Army Corps of Engineers

WRB

ch2m

What is an instream flow?

OWRB working definition of instream flow:

"Flows necessary to provide for a healthy ecosystem and support water-related recreation (such as fishing, hunting, swimming and boating) as well as tourism."

What are instream resources?

- Fisheries, wildlife, water quality, recreation, aesthetics, and the ecological processes that support these resources.

Technical Study Goal:

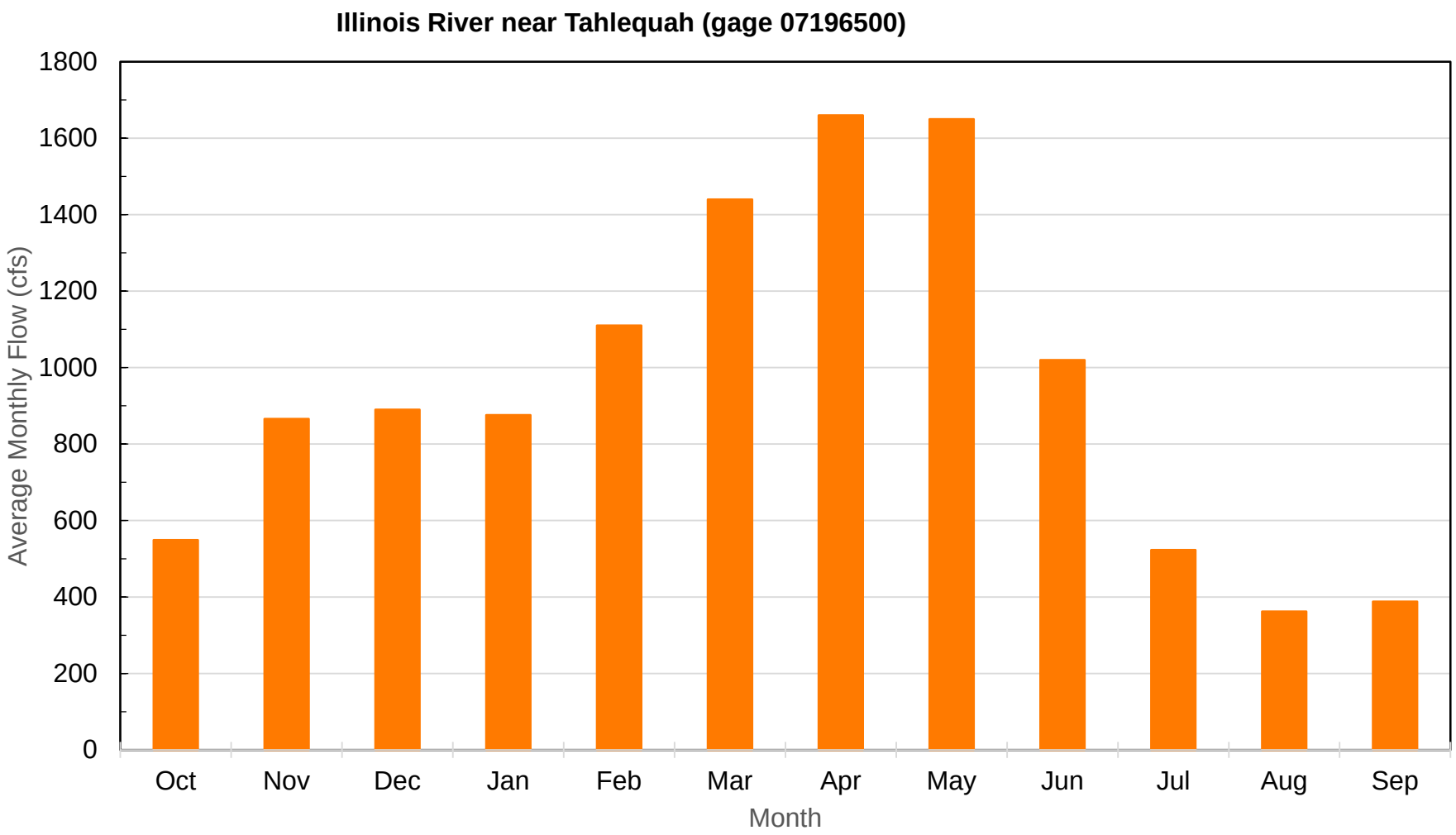
- Summarize technical resource information for use in supporting the decision making process in developing seasonal instream flow management prescriptions for the Illinois River including Barren Fork and Flint creeks.

*Note: This study is **not** being done in response to a proposed water development project.*

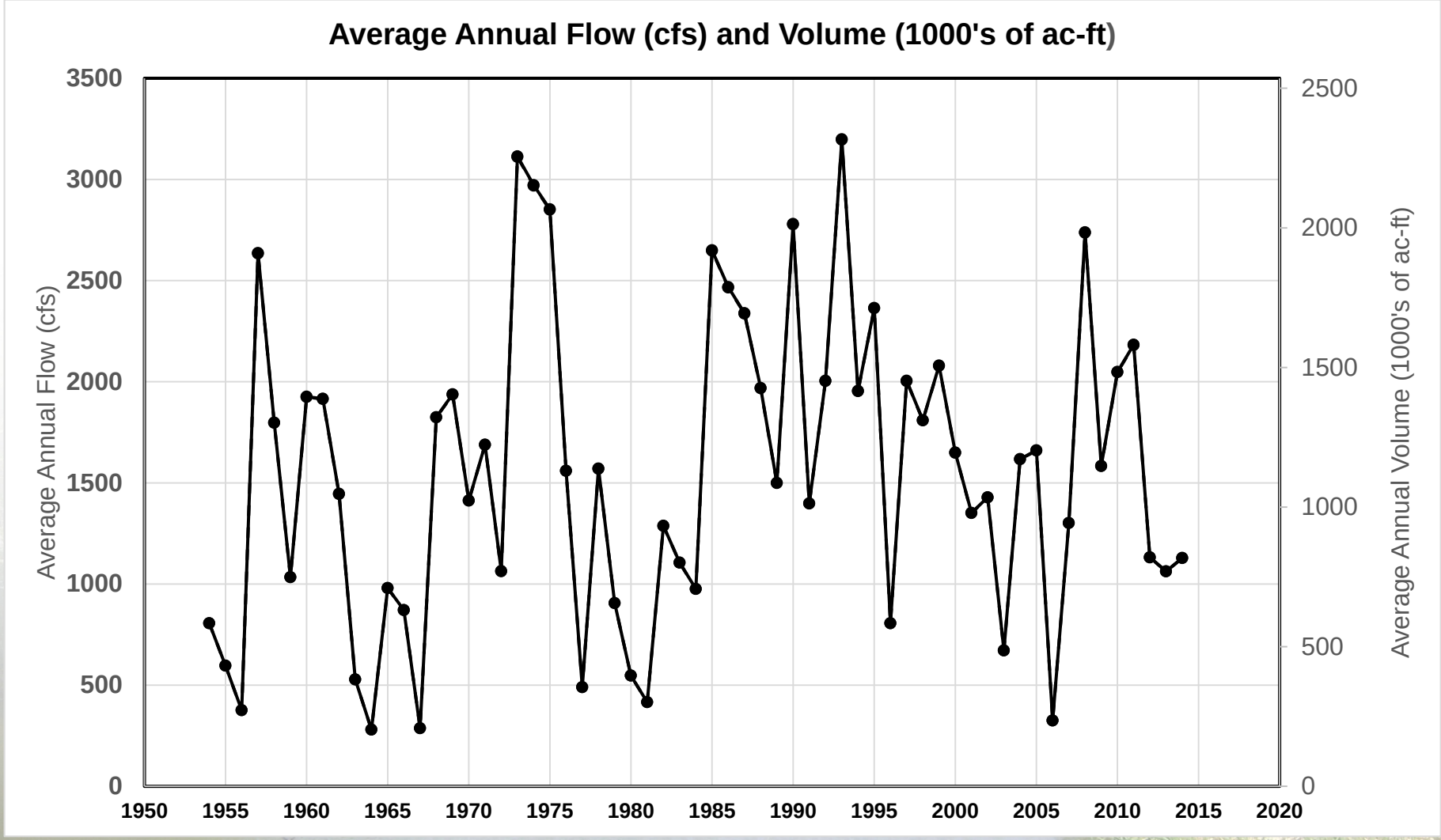
Study Area

Rogers
Springdale
Fayetteville
Kansas
Siloam Springs
Flint Creek
Osage Creek
Watts
Lake Francis
Illinois River
Illinois River
Westville
Arkansas
Oklahoma
Baron Fork Creek
Lincoln
Eldon
Tahlequah
Caney Creek
Stilwell
Lake Tenkiller
USGS Gage
City
Lake
Scenic River
Major Stream
Other Stream
N
W
E
S
0
5
10
Miles

Illinois River Average Monthly Flows



Average Annual Flows for the Illinois River near Gore



Illinois River December 27, 2015

Peak Flow Recurrence Intervals

Peak Flow Return Period (Year)	Probability (%)	Flow (cfs)		
		Illinois River near Tahlequah	Illinois River near Watts	Barren Fork at Eldon
2	50	19,535	18,868	16,250
5	20	38,289	33,947	29,836
10	10	53,919	45,185	37,328
25	4	77,173	60,390	44,675
50	2	96,925	72,233	48,789
100	1	118,643	84,362	51,962

Average Annual Surface Water Usage (acre-feet) in the Upper Illinois River Basin (OK) above and including Barren Fork

Water Use	Total	Percent of Total
Irrigation	1,301.4	10.8
Agriculture	0	0.0
Public Supply	10,751.4	88.9
Rec, Fish, & Wildlife	0	0
Commercial	0	0
Industrial	0	0
Mining	0	0
Other	35.1	0.3
Total	**12,087.9**	**100.0**

Groundwater Usage

Deep Bedrock Aquifer	3,900 acre-feet (water right)	Little effect on streamflows
Shallow Alluvial Aquifer	1,050 acre feet (est. usage)	Direct but delayed effect on stream

Alluvial Groundwater use is equivalent to 1.5 cfs, which is 0.11 % of basin yield

Water Use Summary:

1. Surface water use in Oklahoma portion of Illinois River above Barren Fork is only 1.3 % of the average annual basin yield
2. Most water use is for public supply – mostly Tahlequah
3. Basin water use in Arkansas is similar to Oklahoma in quantity and use category
4. White River water for Fayetteville area municipal use augments flows in Illinois River
5. Flow augmentation from White River may totally offset other surface water withdrawals in both states on annual average basis
6. Ground water use has minimal effect on streamflows

Water Quality

- Basin’s major water quality concern is nutrient loading, primarily phosphorus
- Phosphorus affects the Illinois River and Lake Tenkiller
- Phosphorus loading is trending downward in Illinois River and Barren Fork Creek, not in Flint Creek
- Phosphorus concentrations are related to streamflow, but indirect common effect of runoff
- Little evidence of contaminant concerns such as heavy metals or organics

Fisheries

1. Highly diverse fish community of >72 species
2. Nearly all fish species (except carp) are native to the basin
3. Smallmouth bass are the most sought-after game fish
4. The smallmouth bass are of the Neosho subspecies thus of high conservation value
5. No fish species are listed as federal or state threatened or endangered

Recreational Use

- Annual visitation ~400,000 to Scenic section
- Approximately 15 Commercial Floatation Device Operators
- Annual floaters (canoe, raft, kayak) ~150,000
- Annual recreational economic value (above Tenkiller) ~ $12 million
- Fishing is a popular activity, primarily for bass. No estimates of angler use or catch for Illinois River (some for Barren Fk)

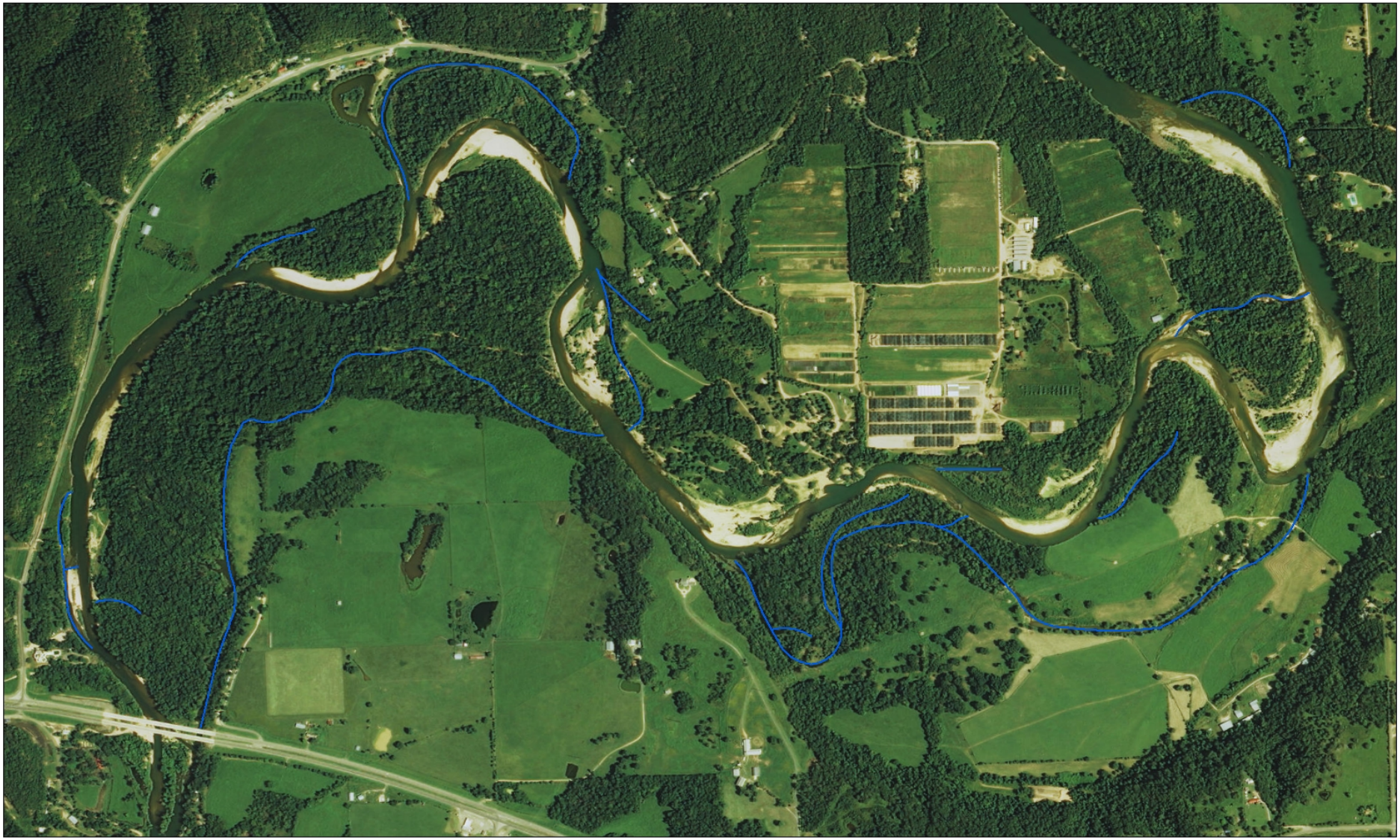
Illinois River Monthly Float Users, Average Annual for 2003-2008

Month	Commercial	Private	Total
January	1	35	36
February	2	34	36
March	110	19	129
April	348	81	429
May	9,938	411	10,349
June	22,734	681	23,415
July	37,441	1,094	38,535
August	24,540	804	25,344
September	8,657	400	9,057
October	878	93	971
November	76	24	100
December	6	48	54
Total	**104,731**	**3,724**	**108,455**

Flow Ranges for Recreational Floating (Tahlequah Gage) (source: OSRC)

Preferred range	400 – 1,200 cfs
Minimum for canoeing & kayaking	150 cfs
Minimum for rafting	250 cfs
Maximum for general safety	1,200 cfs
Maximum for experienced boaters	4,000 cfs

Riparian Corridor Secondary Channels



Ratio of secondary channel length to the main channel length in the Illinois River between Watts and Tahlequah, Oklahoma.

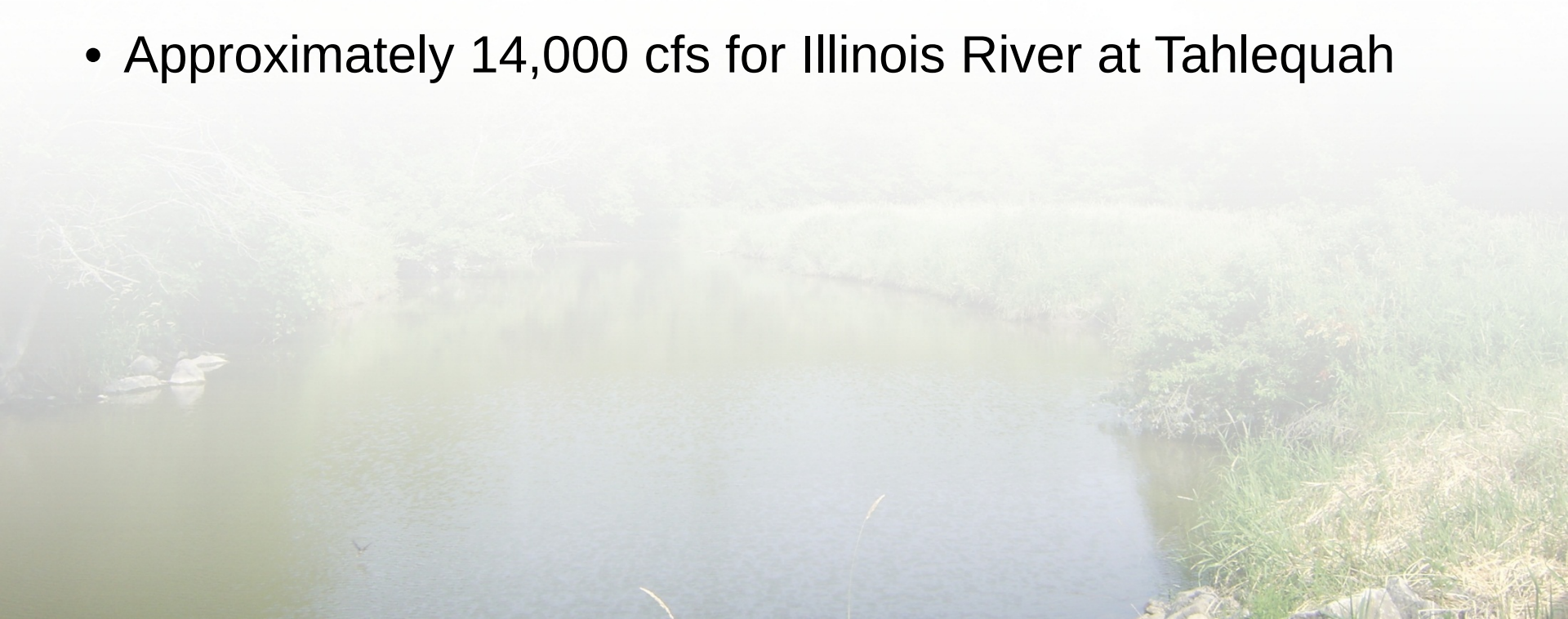
River Reach	Watts to Flint Creek	Flint Creek to Peavine	Peavine to Tahlequah	Total
River Reach Length (mi)	13.3	16.3	22.9	53
Secondary Channel Length (mi)	7.1	7.0	17.3	31.4
Ratio of 2ndary channel to main channel length	**53.1 %**	**42.9%**	**75.6%**	**59.2%**

Importance of Secondary Channels

- Rearing and refuge habitat for fish
- Support of many wildlife species that don’t tend to use the main channel
- Water quality (clarity and temperature)
- Floodwater relief
- Help govern the size and shape of the main channel

How to Protect Secondary Channels:

- Preserve bank-full/channel maintenance flows (frequency and magnitude)
- Typically equates to the 1.5-year recurrence flow
- Approximately 14,000 cfs for Illinois River at Tahlequah



Fish Habitat Modeling

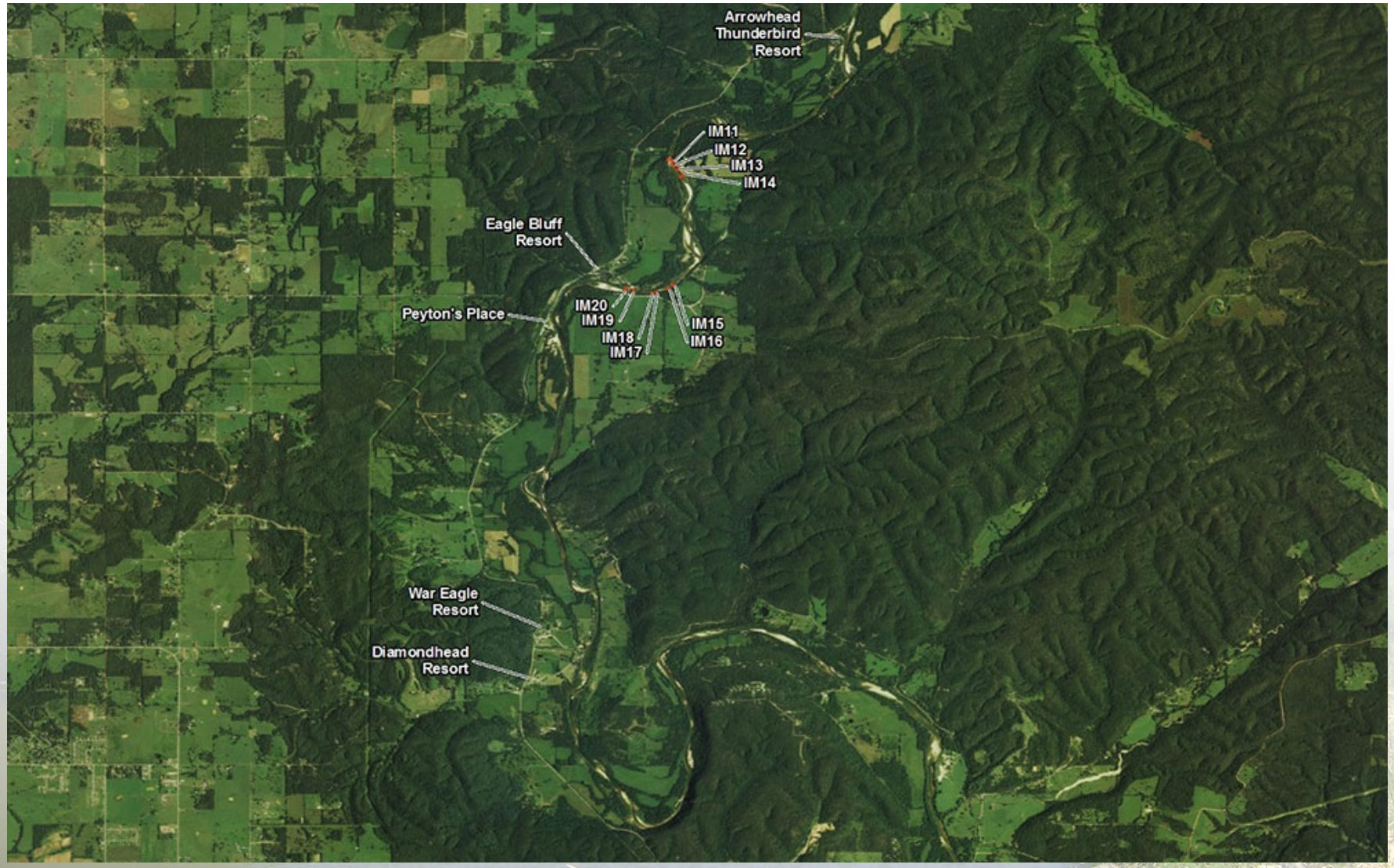
- Simple explanation of model
- Study sites (map with transects)
- Photos
- Results

Habitat-Type Survey Results (% by type)

Habitat Type	Illinois River	Flint Creek	Barren Fork Cr
Pool	57	35	42
Glide	12	20	0
Run	22	20	36
Riffle	9	25	22
Gradient ft/mi	**4.5**	**10**	**8**

Illinois River Habitat Study Transects

Illinois River Habitat Study Transects

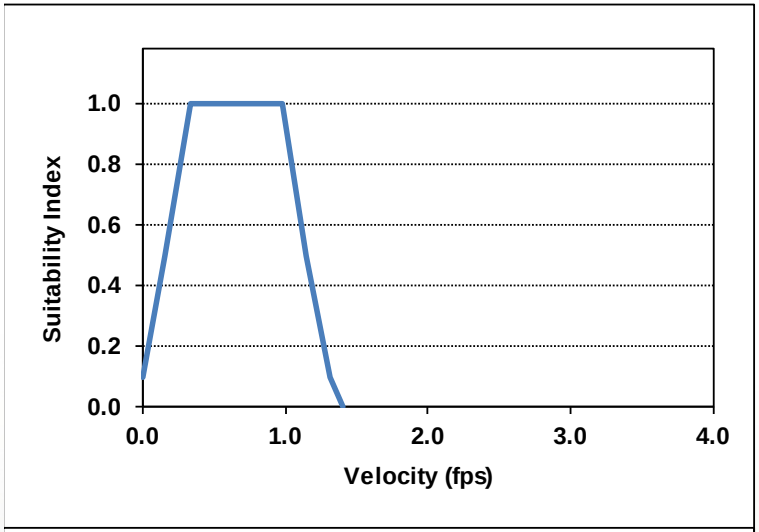


Flint Creek Habitat Study Transects

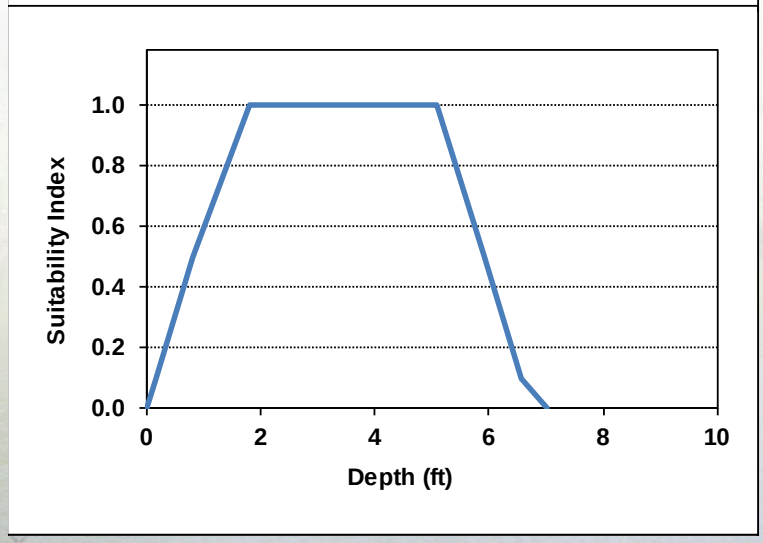
Fish Habitat Modeling

- Integrates a hydraulic model (that predicts water depths and velocities) with fish habitat criteria (expressed as preferred depth and velocity).
- Each measurement point (500-1,000) in the study site is evaluated separately as to its suitability for fish at a range of stream flows.
- The model then adds all the points (cells) together to get a total habitat vs flow relationship.

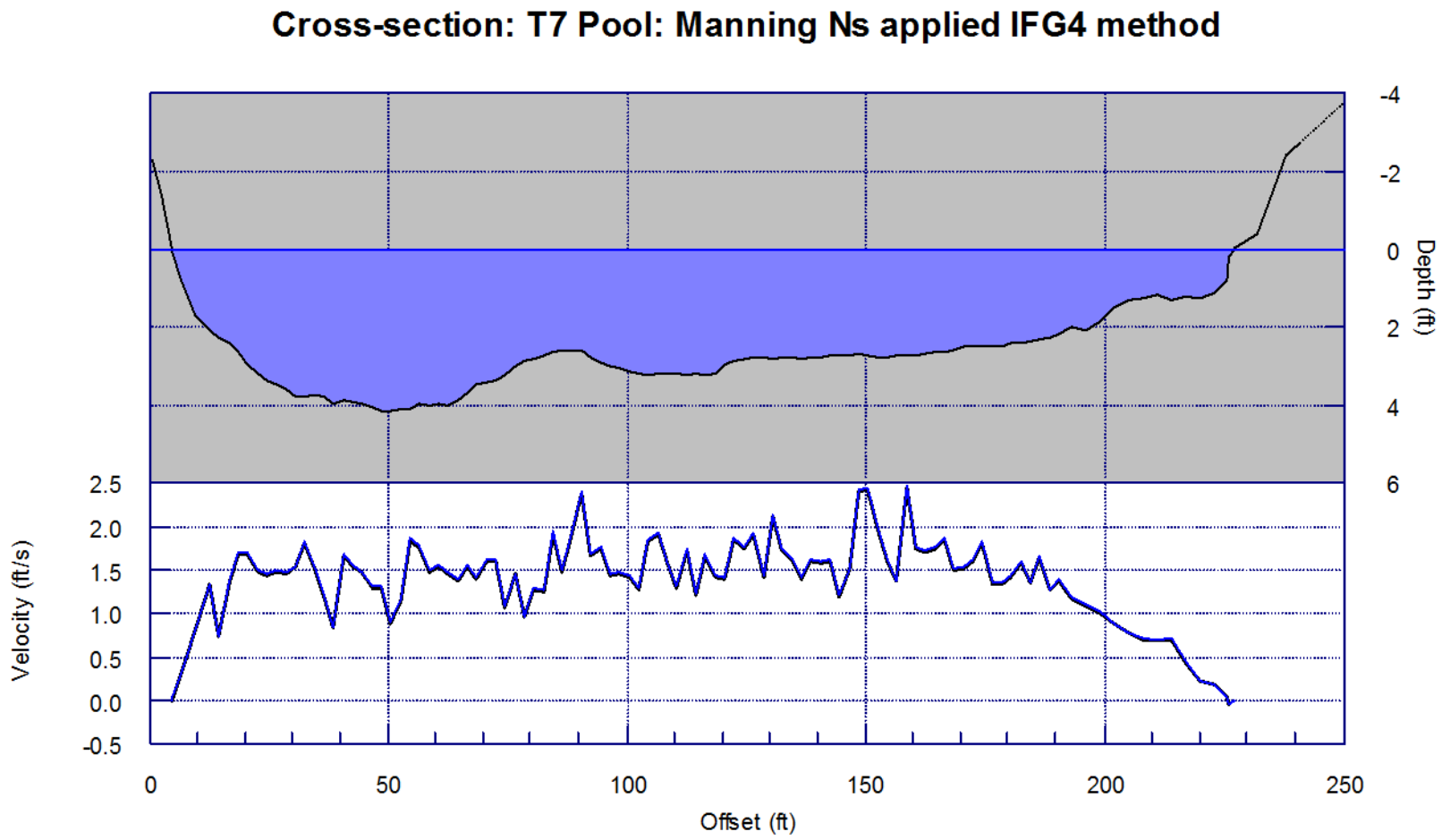
Smallmouth Bass Adult Habitat Criteria



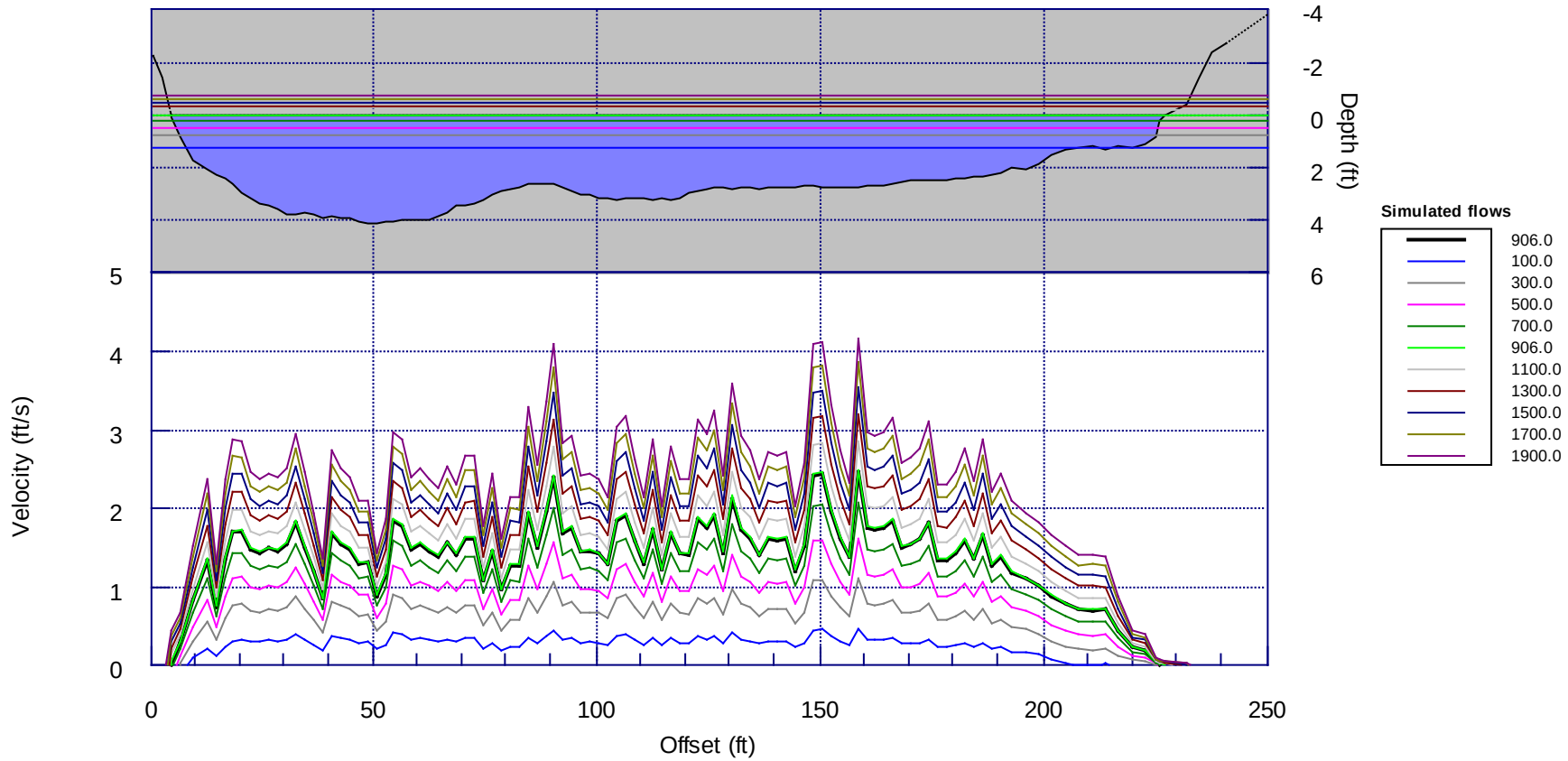
Velocity (ft/s)	SI
0.00	0.10
0.16	0.50
0.33	1.00
0.98	1.00
1.15	0.50
1.31	0.10
1.40	0.00



Depth (ft)	SI
0.00	0.00
0.16	0.10
0.82	0.50
1.80	1.00
5.09	1.00
5.91	0.50
6.56	0.10
7.00	0.00

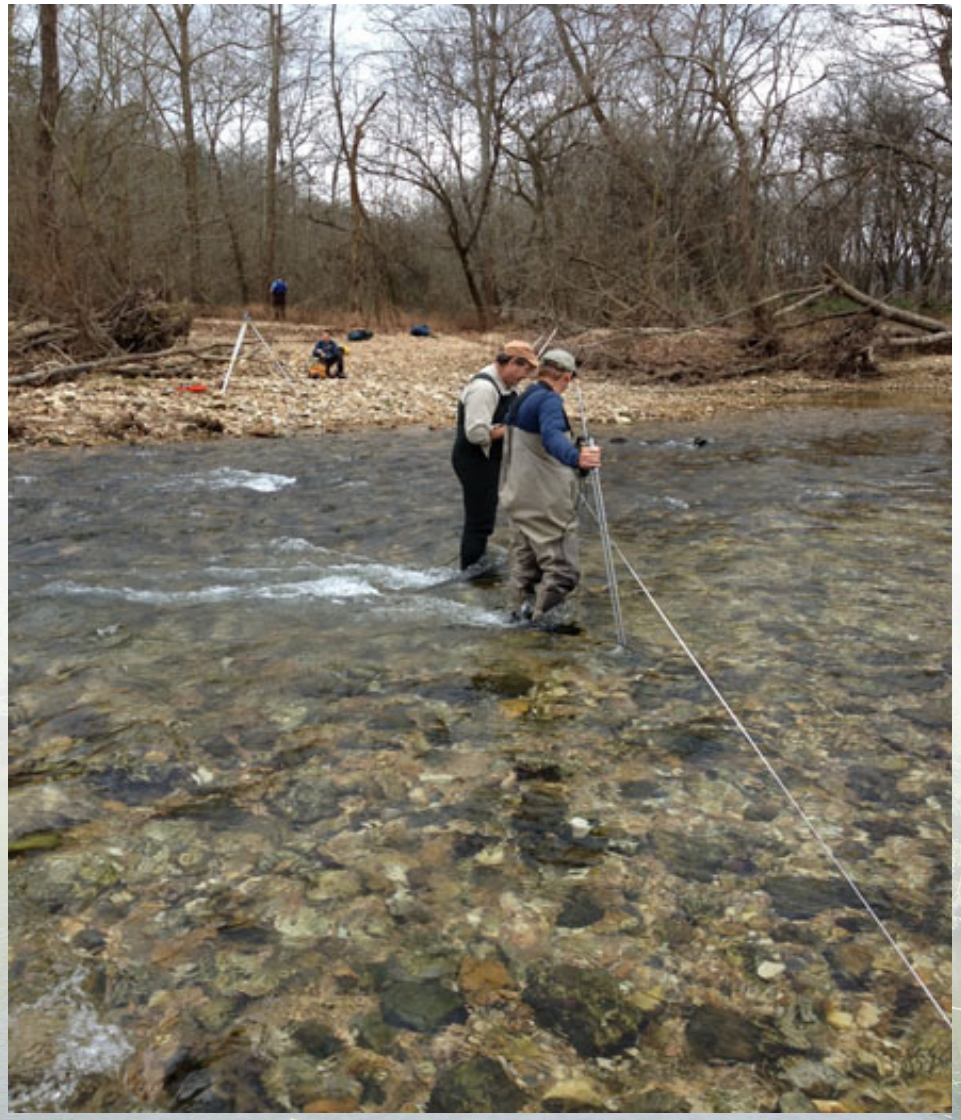

Cross-section: T7 Pool: Manning Ns applied IFG4 method
Depth (ft)
-4
-2
0
2
4
6
Velocity (ft/s)
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
0
50
100
150
200
250
Offset (ft)

Cross-section: T7 Pool: Manning Ns applied IFG4 method



Lower Flint Creek

Flint Creek Study Transect



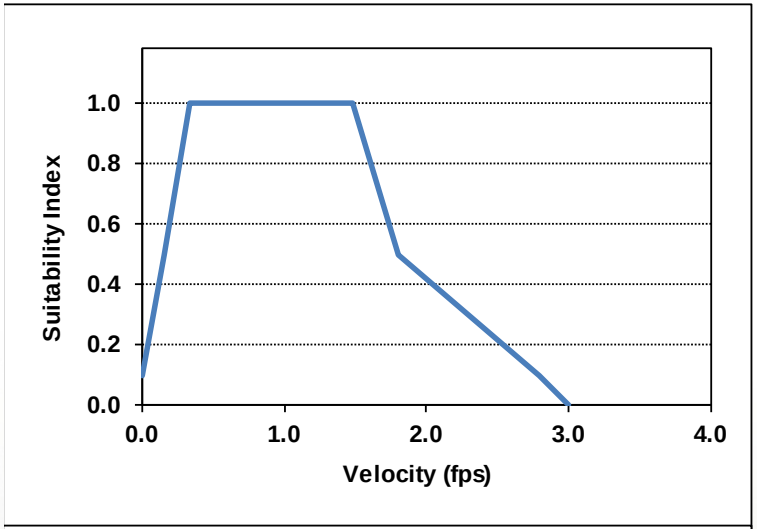
Lower Illinois River

Upper Illinois River Bedrock Pool Transect

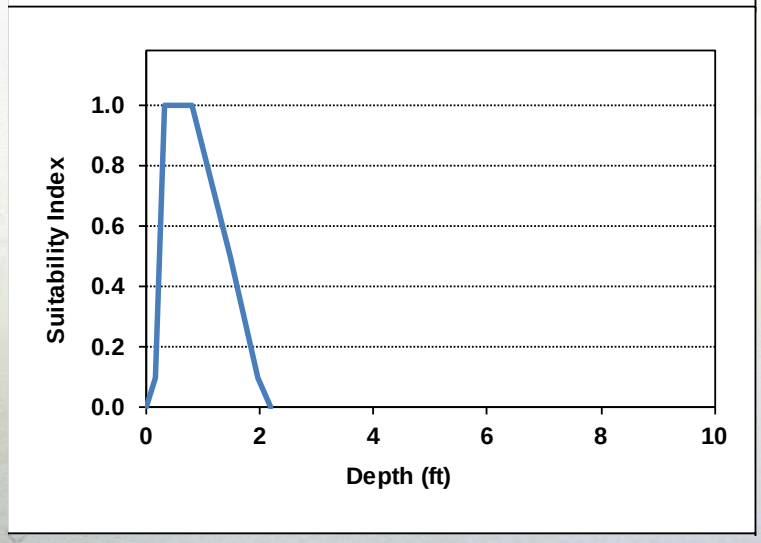
Fish Assemblages

Shallow Fast	Intermediate	Deep Slow
Darters (4)	Stoneroller (1)	Suckers (5)
Topminnow (2)	Chubs (3)	Sunfish (9)
Madtom (1)	Shiners (2)	Bullhead (3)

Shallow-Fast Habitat Criteria



Velocity (ft/s)	SI
0.00	0.10
0.16	0.50
0.33	1.00
1.48	1.00
1.80	0.50
2.79	0.10
3.00	0.00

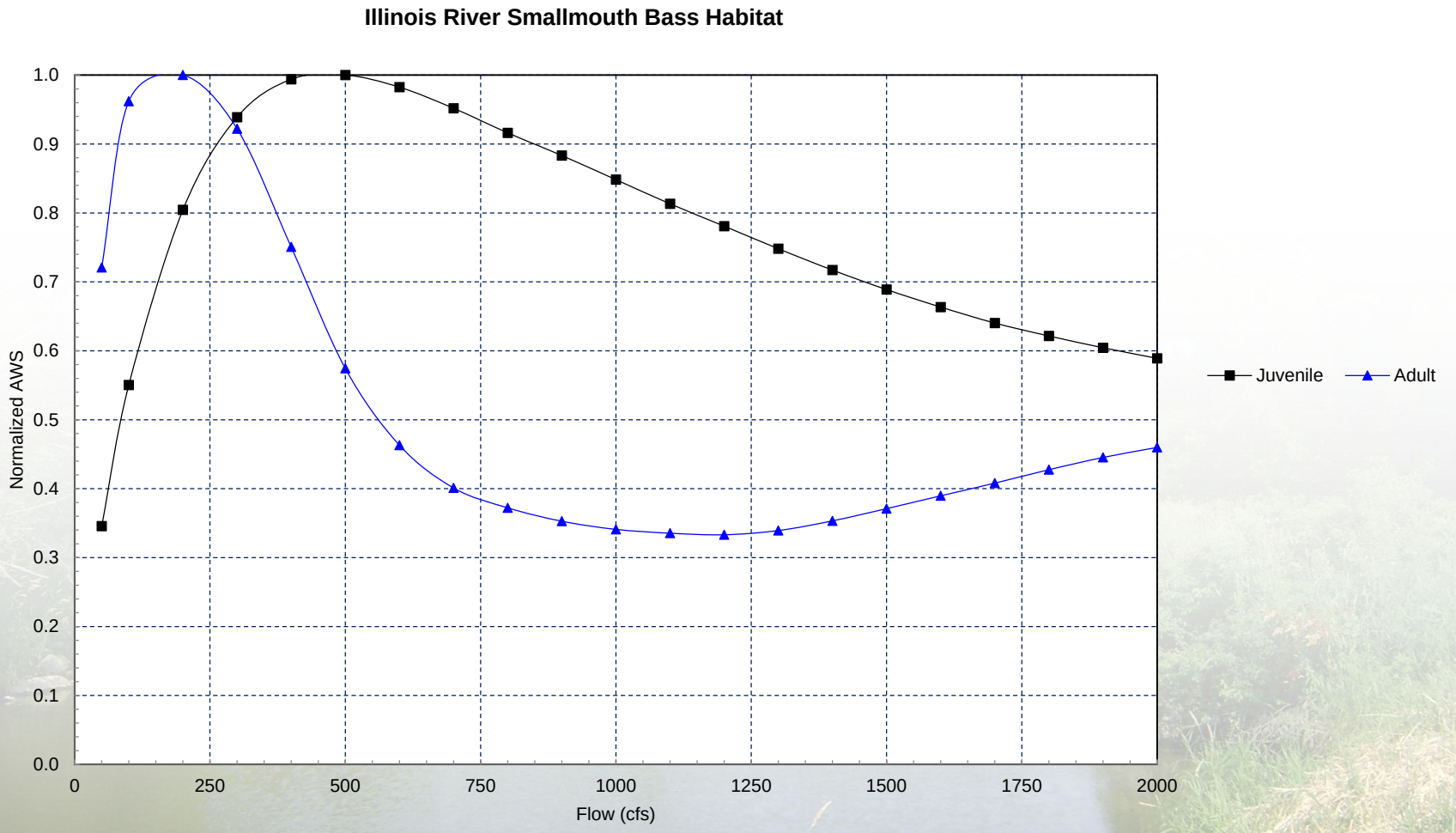


Depth (ft)	SI
0.00	0.00
0.16	0.10
0.33	1.00
0.82	1.00
1.48	0.50
1.97	0.10
2.20	0.00

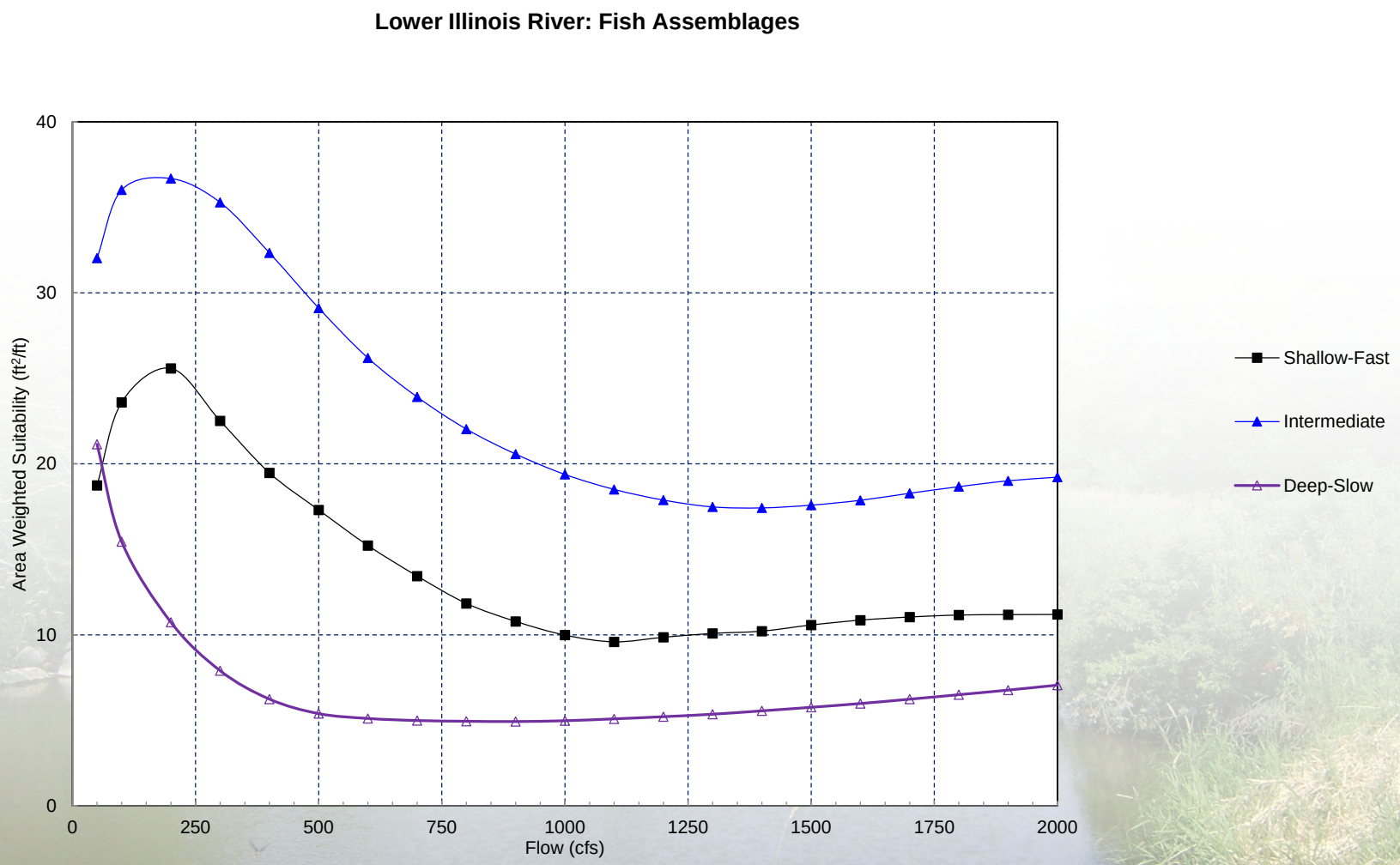
Median Stream Flows

Stream	Month					Average Median Flow
	July	August	September	October	November	
Illinois River	297	217	200	225	308	**249**
Flint Creek	40	31	29	31	49	**36**
Barren Fork Cr.	69	45	40	50	83	**57**

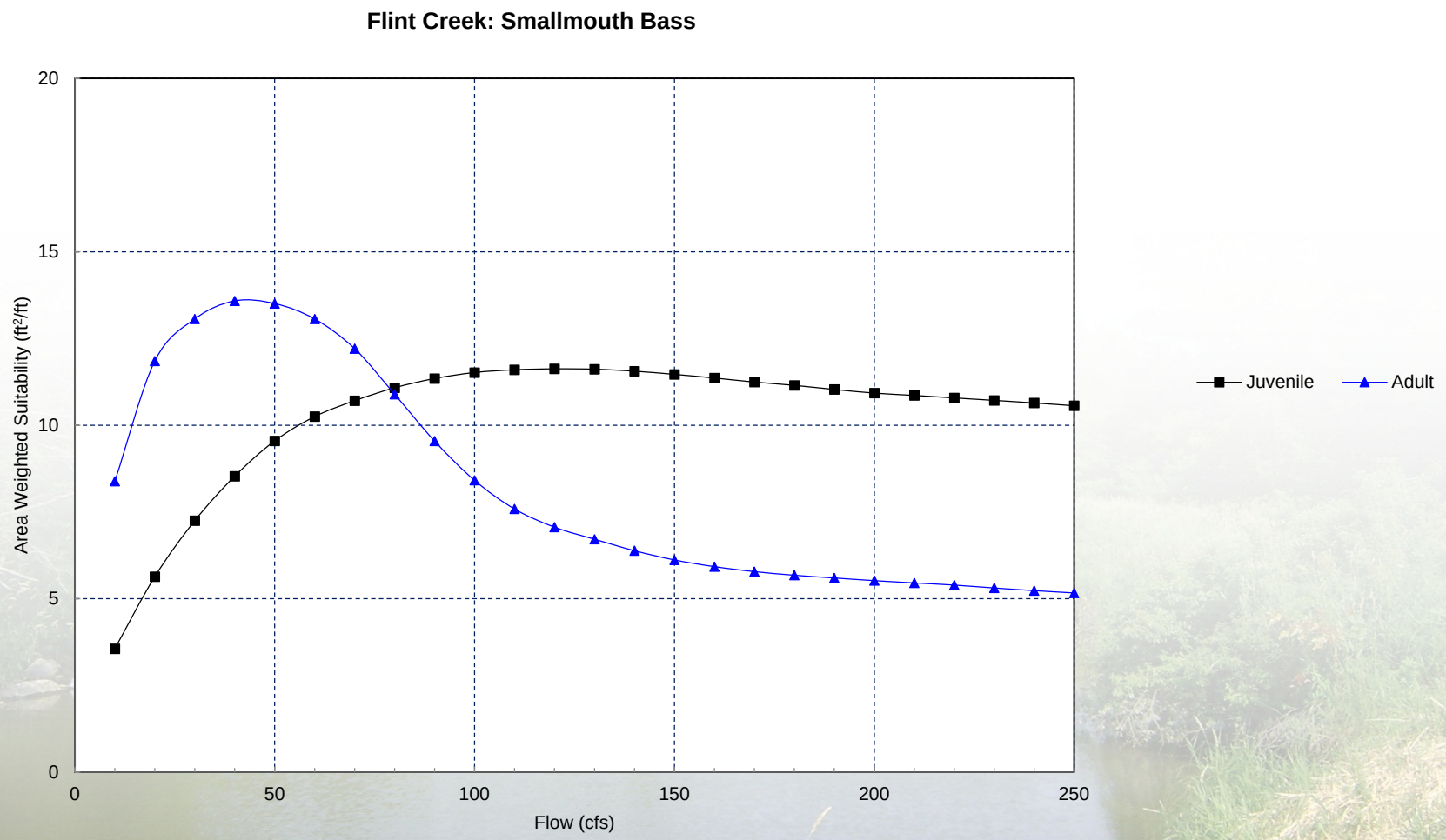
Illinois River Smallmouth Bass Habitat



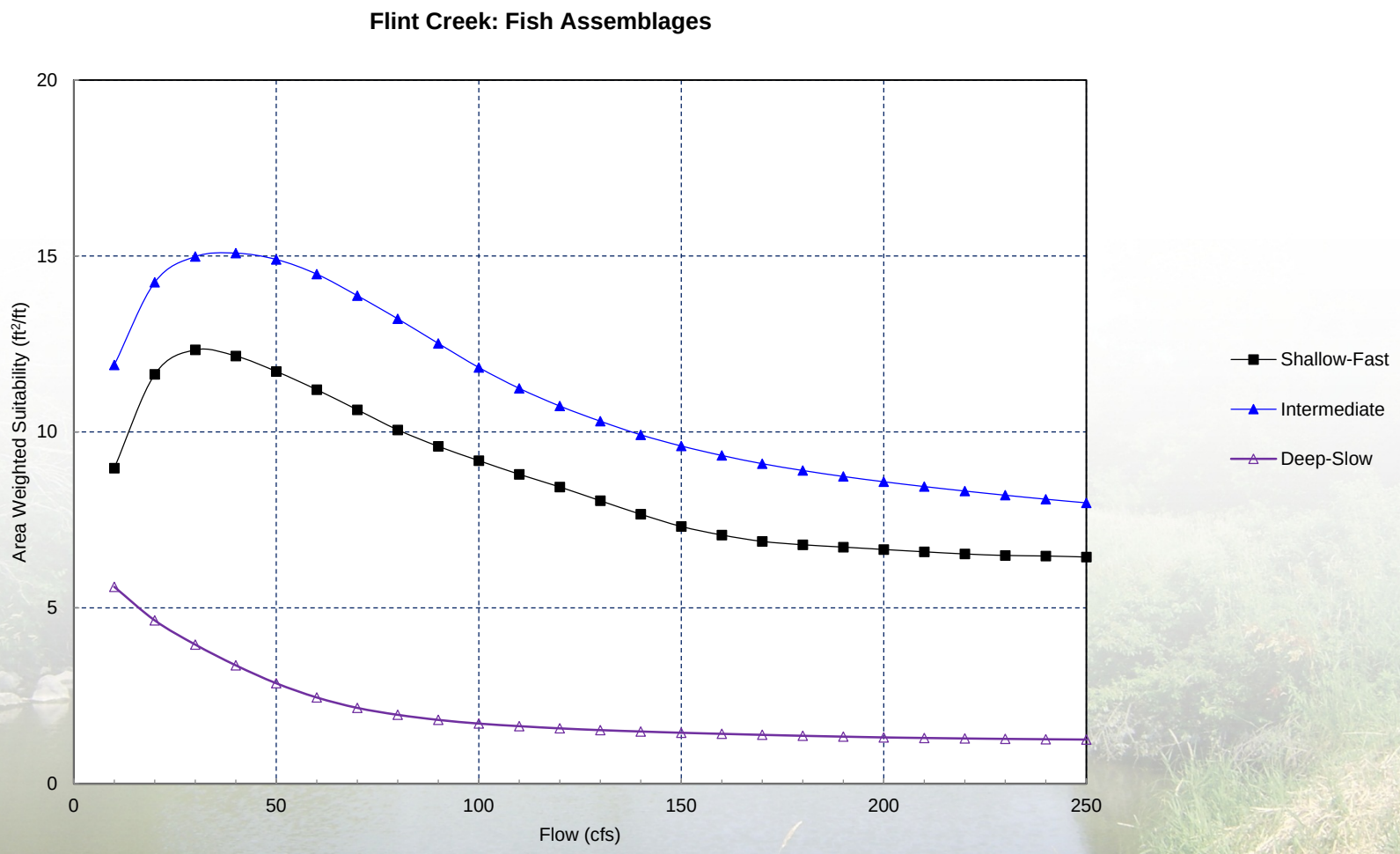
Illinois River Fish Assemblage Habitat



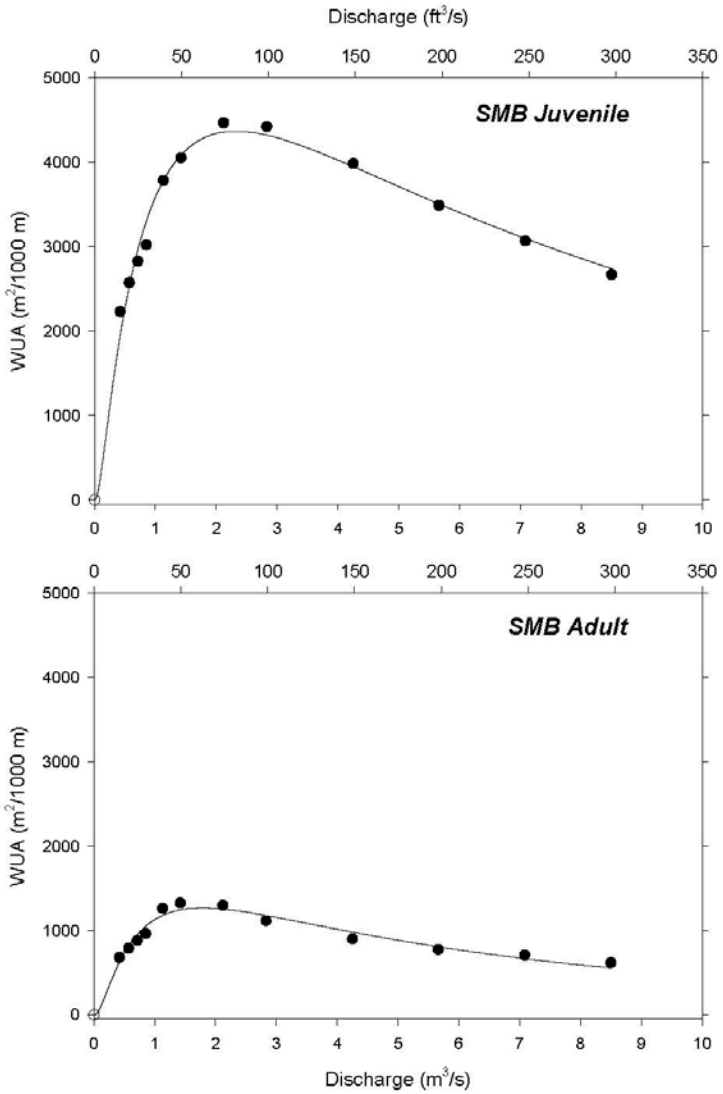
Flint Creek Smallmouth Bass Habitat



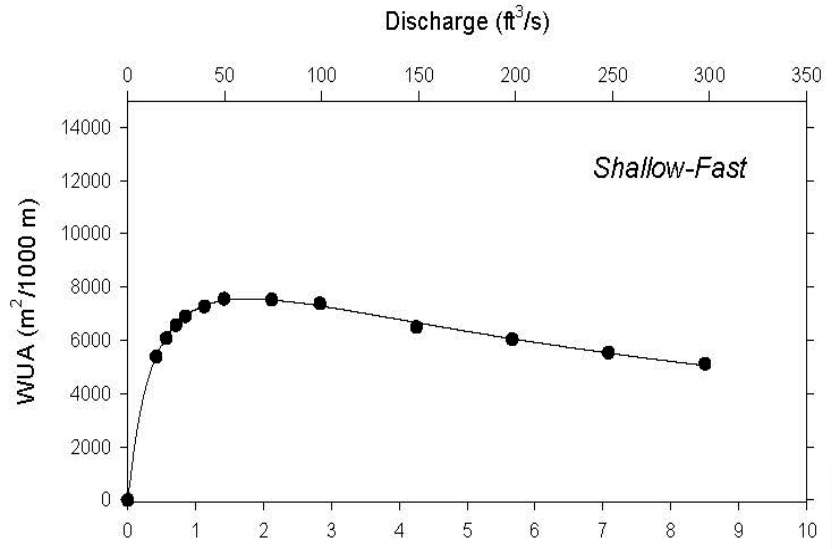
Flint Creek Fish Assemblage Habitat

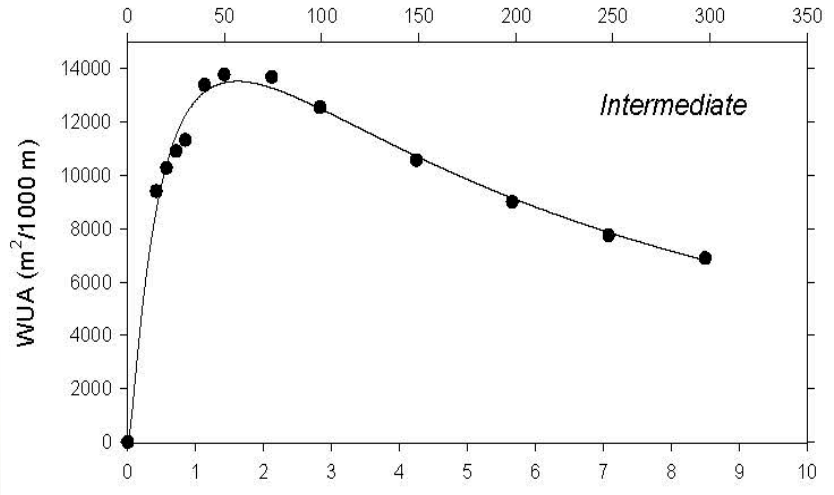


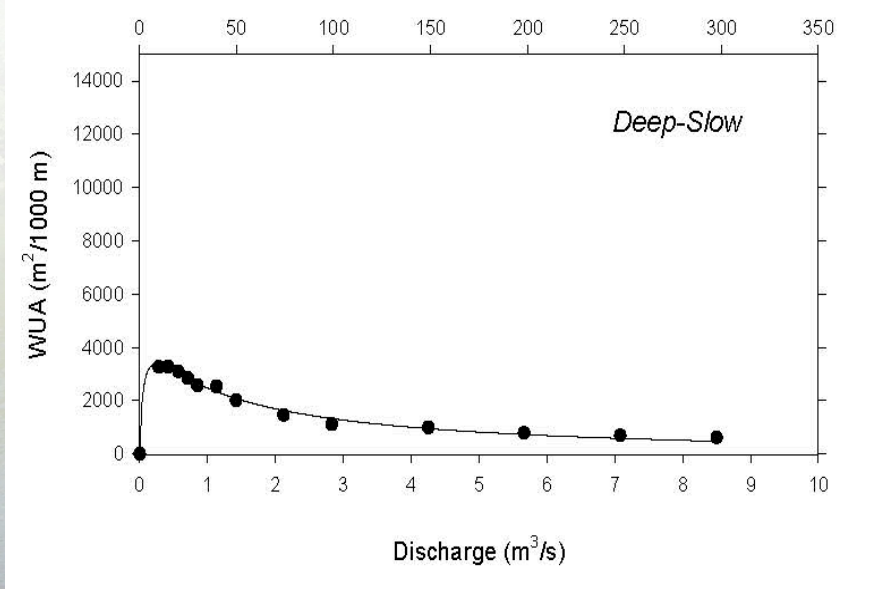
Barren Fork Creek Smallmouth Bass Habitat



Barren Fork Creek Fish Assemblage Habitat







Summary

- Flows in the Illinois River basin are largely unregulated
- Water diversions from the river are minimal (1-2%)
- Water quality is not a major issue related to instream flows
- The extensive riparian corridors support many important ecological process and resources
- The basin supports >70 species of <u>native</u> fish
- Illinois River supports recreational use of about 400,000 user days annually
- Summer/fall base flows average ~250 cfs (Illinois R), 36 cfs (Flint Cr), and 57 cfs (Barren Fork Cr)

Conclusions

- Preferred flows for Illinois River floating are 400-1,200 cfs
- Minimum flows for rafting (most popular means) is 250 cfs
- Flows providing good rearing habitat conditions for most fish species:
  - Illinois River : 100 – 300 cfs
  - Flint Cr : 20-60 cfs
  - Barren Fork Cr: 40-100 cfs
- Prescriptions for channel maintenance flows are important to preserve the ecological process associated with the study streams
- Desired flows for fish and recreation are not in conflict

Conclusions (continued)

- Decision Making Considerations:
  - River basin goals
  - All stream-related resources and priorities
  - Water availability
  - Ecological flow needs

Questions

TECHNICAL STUDY WORKGROUP MEETING SUMMARY

PROJECT: Instream Flow Workgroup Assistance Phase 2- Oklahoma Instream Flow Pilot Study

DATE: December 17th, 2014 (10:30 pm- 12 pm CST)

LOCATION: Teleconference call

ITEM	DISCUSSION
1. INTRODUCTIONS & TECHNICAL STUDY WORKGROUP MISSION	Present at the call: Barry Bolton, ODWC; Kimberly Elkin, Nature Conservancy; Derek Smithee, OWRB Shannon Brewer, OSU; Mike Fuhr, Nature Conservancy; Anna Childers, CH2M Jim Burrows, ODWC; Forrest Olson, CH2MHILL Tony Clyde, USACE; Shannon Phillips, OK Conservation Commission Invited but not present: Kevin Stubbs, USFWS Call attendees introduced themselves and mentioned briefly of any ongoing data collection and sampling effort by their agencies within the Illinois River. Forrest Olson, the Technical Study Lead, mentioned that the purpose for the call was two-fold: 1) inform the Technical Study Workgroup of the ongoing effort for the Instream Flow Workgroup Assistance Phase 2- Oklahoma Instream Flow Pilot Study Project and 2) identify the functions of the Technical Study Workgroup throughout the project phases & leadership for the group. Forrest emphasized that the overall purpose of the Project is to establish an ISF study process in the upper Illinois River. **The overall tasks for the Technical Study Workgroup include:** • **Attended three Illinois River Stakeholder meetings:** (1st: Jan22; 2nd: April, 2015 and 3rd: Late May, 2015 or TBD) • **Provide technical support and guidance to the pilot study approach** • **Supply data and information summaries** • **Peer review** • **Support in preparation of the Programmatic Work Plan** (including details of additional information needed, how it will be obtained, schedule, estimate of costs for the remainder of the project) Forrest proposed a "mission statement" for the Technical Study Workgroup: **"Provide technical support and guidance associated with the Illinois River Instream Flow Pilot Study**"… within the parameters outlined in the approved scope of work. The mission for the Technical Study Workgroup (TSWG) differs from the ISF Advisory Group in that the TSWG supports the technical execution of the Pilot Study Approach. **ACTION ITEMS**: • Review, modify as necessary, and approve the TSWG mission statement before January 22nd stakeholder meeting (Forrest)—by Jan 20, 2015 • Invite Ed Fite to be part of the TSWG (Derrek)—by Dec. 19th • Assemble contact information list for TSWG—by Dec. 22nd (CH2MHILL)

	• Prepare a flow chart of the study phases and connections to TSWG—by Jan. 20, 2015 (Forrest) • Obtain bios of each TSWG member (TSWG)—by Jan. 15th, 2015.
2. REVIEW STUDY OUTLINE/APPROACH (CURRENT SCOPE OF WORK)	As part of the Advisory Group's Phase I effort in 2013, an Instream Flow Incremental Methodology (IFIM) was proposed as most suitable approach for addressing comments and concerns of the ISF Advisory Group. The current Project phase of the study includes three separate yet interconnected tasks toward implementation of the IFIM. The project is conducted collaboratively with USACE, Tulsa District and OWRB under the Planning Assistance to States (PAS) agreement. The contractor for the study: CH2M HILL, will provide the technical and stakeholder facilitation services for the project. The study purpose is to help define a *study process* that could be used for development of ISF recommendations for water resources planning purposes in other watershed if the state was to move forward with an ISF program. Therefore; the primary focus for the study is to assess the "process" of evaluating issues associated with instream flows. The primary tasks of the scope of this project include: • Stakeholder Facilitation • Initial Physical Analysis • Study Planning • Study Work Plan • Initial Studies for PHABSIM The Illinois River upstream of Tenkiller Reservoir was the suggested study area for piloting the IFIM process. The stream reach is mostly unregulated. The study area also includes two tributaries Barren Fork and lower Flint Creek. The Barren Fork has already been studied (IFIM) and we will simply integrate those results. The reach of the Illinois River and these tributaries are part of Oklahoma's Scenic River system protected by OK Scenic Rivers Act. Forrest clarified that although the study outline largely follows the IFIM process, the ongoing Project does not include the "problem identification" phase (Phase 1 of the IFIM process). The more actuate terminology for the Phase 1 is "Issue Identification" because the study is not focused on a specific problem or a proposed watershed development. The TSWG discussed the challenges of estimating the economic impacts of ISF in the Illinois River study reach. Derek mentioned that the costing should include the identification of the consequences of having identified instream flows protected: costs associated with implementing ISF study as well as the impacts to fishermen, boaters, and other outfitters. Stakeholder comments may identify other economic or cost issues. Phase 1 only identifies potential economic issues; it does not analyze them. **ACTION ITEMS**: • Provide the TSWG the executed scope of work for the ongoing project (Forrest)—by Dec 19, 2015 • Prepare and distribute a study plan/outline and timeline to the TSWG (Forrest)—by Mar 1, 2015

3. BACKGROUND INFORMATION	Forrest and Derek mentioned that one of the main roles for the TSWG is to supply any available data summaries and research in support of the study approach. Each of the organizations has on-going data collection programs or special technical expertise that will be useful for the Pilot Study. Forrest Olson remained everyone that the study scope is limited to the Illinois reach above Tenkiller reservoir. Shannon Brewer said that the ongoing study phases seem to be more planning than actual data collection. She was interested in the timeline for the first 2 phases of the IFIM process. Forrest clarified that even though the different IFIM phases operate sequentially, some of the baseline data collection will be performed concurrently with the ongoing study phases and don't depend on the proceeding study phases. The data needs would include baseline data items that would need to be collected regardless of the resource management emphasis of the pilot study. Therefore, the initial data collection can be initiated. Forrest added that the first two phases will take approx. 6 months. The final Illinois River stakeholder group meeting is tentatively scheduled to occur sometime in May 2015. The actual field portion of the ongoing effort of work (Phase III of the IFIM) is anticipated to begin in early summer 2015. Kim Elkin mentioned that they have ongoing stream monitoring effort at the Nicholls preserve. In general, TNC has plenty of stream water quality data available. Tony Clyde mentioned water temperature model that was developed for the Illinois River as part of the ODEQ/EPA TMDL project. It wasn't clear which reach of the river the model was developed for. Forrest went through the following list of topics for which data summaries will be needed. Several members of the TSWG volunteered to assist in identifying and summarizing information. Forrest will prepare a list of assignments and expectations for these efforts based on the understanding from the call. • Hydrology • Water rights and usage • Fish populations (and other aquatic organisms?) • Recreational fishing • Water quality • Recreational boating • Description of watershed and activities affecting instream resources (landuse) **ACTION ITEMS**: • Prepare a data request table ("blue print") and preferred format to TSWG members (Forrest)—by Jan. 20, 2015 • Set up a sharesite "data depository" for data submittals (CH2MHILL)—by Jan 20, 2015
4. POTENTIAL ISSUES AND CONCERNS	Shannon Brewer inquired if the study aimed to establish a resource management plan/goal. Barry Bolton stated that the goal is stated in the OK Scenic River Act; the Act should define the goal. Derek also clarified that the study will yield, in addition to the process evaluation, recommendations/guidelines for ecological instream flows. Deciding on how or if

	those recommendations are implemented is for future consideration beyond this study.
5. STAKEHOLDER MEETING IN JANUARY	*The Stakeholder Involvement* will be conducted in collaboration with OWRB and the contractors. The Illinois River Watershed Stakeholder group is not a formal group (more *ad hoc)* and is open to public. OWRB is in the process of identifying stakeholders to invite to the stakeholder meetings and a press release. Derek solicited the TSWG of any additional interest groups to invite to participate in the stakeholder meetings. Ed Fite is helping with the effort. **Schedule:** • **TSWG meeting at Scenic Rivers Commission offices at 3:00 pm** • **Stakeholder meeting #1 at Tahlequah: Armory at 6:30 pm** The purpose for the Stakeholder meeting include: 1) provide background and summary of the previous work and synopsis of the current project; 2) provide context about how the current effort fits into the long-term goal (e.g., what's included and what's not included in this study); and 3) solicit information & data for issue identification (e.g., "what's important to you about the river and its uses"). Forrest reminded that it is important to state the objectives to the study and meetings so that meeting materials can be prepared and that the meetings don't get carried away to side issues. The meeting agenda would be provided in advance of each meeting. Forrest will prepare technical presentations for the meetings. CH2MHILL will collect comments at each meeting and group those per themes and record them for possible posting on the OWRB website after each meeting. The findings and comment responses will be addressed after the meeting. **ACTION ITEMS**: • Distribute TSWG stakeholder identification list—by Dec. 23rd (Derek/Forrest) • Inform Derek/Forrest on any additional attendees—by Dec. 29th (TSWG) • Send out invitations & press release to stakeholders and TSWG—by Dec. 23rd (Forrest/Derek) • Prepare an agenda (both TSWG and stakeholder meetings) and presentation (stakeholder meeting) for TSWG for review and comment—by Jan. 12th (Forrest)
6. NEXT STEPS	Action items identified separately within each item above.

Meeting Discussion Topics for TSWG

12-17-14

- Workgroup Membership – introductions, expertise, roles, responsibilities
- TSWG Mission (draft): Provide technical support and guidance associated with the Illinois River Instream Flow Pilot Study within the parameters outlined in the approved scope of work.
- Review study outline/approach (current Scope of Work)

  (Note that we are roughly following the IFIM <u>process</u> but it needs to be tailored to the fact that we don't have a "proposed water development project alternative" and thus no real "problem" to diagnose).

- Background information needs for characterizing the stream flow dependent resources. Assignments
  - Hydrology
  - Water rights and usage
  - Fish populations (and other aquatic organisms?)
  - Recreational fishing
  - Water quality
  - Recreational boating
  - Description of watershed and activities affecting instream resources

- Potential Issues/concerns (a list that works for any stream, not just Illinois)
- Stakeholder meeting in January (review agenda and table)
- Assignments
- Next steps (schedule for TSWG involvement)

TECHNICAL STUDY WORKGROUP MEETING #2 Summary

PROJECT: Instream Flow Workgroup Assistance Phase 2-
Oklahoma Instream Flow Pilot Study

DATE: January 22th, 2015 (3 pm-4:30 pm CST)

LOCATION: Oklahoma Scenic Rivers Commission

Invited to the meeting:

Barry Bolton, ODWC _x_ Kimberly Elkin, Nature Conservancy_ x_
Derek Smithee, OWRB_ x Shannon Brewer, OSU_ x _
Mike Fuhr, Nature Conservancy_ x _ Tony Clyde, USACE ___
Jim Burrows, ODWC_ x_ Shannon Phillips, OK Conservation Commission_ x _
Kevin Stubbs, USFWS___ Ed Fite, OK Scenic River Commission_ x _
Forrest Olson, CH2MHILL _ x __Anna Childers, CH2MHILL_x _

ITEM	LEAD & SCHEDULE	DISCUSSION/NOTES
1. INTRODUCTIONS & HOUSE KEEPING NOTES	Derek Smithee/ Anna Childers 5 mins	Derek Smithee introduced everyone and thanked Ed Fite and the Scenic Rivers Commission for providing the meeting space for today's meeting. Derek stated the goals and objectives for the meeting: help in developing the Watershed Background information for characterizing the stream flow dependent resources. Also, the TSWG would be given resource area sections to complete for the watershed background report. Anna Childers distributed the scope of work and other meeting materials and briefly reviewed the meeting summary from Dec. 2015 teleconference call with the TSWG.
2. BACKGROUND INFORMATION REVIEW- INFO NEEDS, SOURCES, AND ASSIGNMENTS	Forrest 20 mins	Forrest Olson referred to Dec. 2015 study kickoff meeting with the TSWG how the watershed background sections would be completed. He reminded everyone that the watershed background section to the technical report will be done collaboratively with the TSGW members. He provided an assignments table per resource area. The TSWG reviewed the sections and discussed the different available data and information. The lead authors of each resource section were identified. CH2M would set up a SharePoint site for TSWG to share literature and other resources. The main topics for the watershed background report include: • Watershed Characterization • Study Stream Descriptions (general physical) • Water Rights and Water Usage • Fish Populations • Stream-dependent Wildlife • Recreational Fishing • Hydrology • Recreation • Cultural • Water Quality (focus on streamflow affected parameters) A separate task and references list would be provided to the TSWG members.

		The TSWG recognized that cultural uses of the water may have the least public information available. Derek Smithee said he would contact the Cherokee Nation for information.
3. STUDY PLAN DEVELOPMENT	Forrest 20 mins	Forrest Olson provided the "Study Planning Discussion Topics"- list for the TSWG to review and discuss. The topics included: • Study Reaches • Habitat characterization surveys • Site and transect selection • Access • Field techniques • Equipment needs • Velocity measurements • Calibration flows • Surveying • Substrate descriptors and codes • Habitat suitability criteria • Hydraulic modeling The TSWG would discussed the study reach in general. Shannon Brewer was interested in the selection of study sites. The study incudes two on the Illinois River (above and below Flint Creek), one on lower Flint Creek, and use the existing study for Barren Fork Creek. Derek Smithee reminded the TSWG that the Instream Flow Advisory Group decided to limit the study to just the designated scenic section above Tenkiller at this time. Shannon also raised a concern that the study has been presented as a way to develop a methodology for the entire state and if limited to the upper tributaries will only represent a very small portion of the issues. Derek explained that we are only intending to recommend flows that could potentially be used as guidelines, or "speed limits" in protecting the stream resources. Forrest added that one of the recommendations that may come out of the study will be to determine how the study process (IFIM or other) used in the upper river could be used or modified for application to the lower river.
4. SCHEDULE	Forrest 10 mins	Phase 1: ongoing: The Illinois River Public Stakeholder meetings will be held in January 22, 2015. The next two meetings will be held in mid-point of data collection and at the end of the field work and modeling. Phase 2: next: The field data collection study plan will be developed with the input from the TSWG and provided for the TSWG for review and comment. This will be started in January 2015. The study plan will follow the general recommendations and approached outlined for the Advisory Group in the *2013 Instream Flow Pilot Study Work Plan*. Phase 3: Following the approved study plan, CH2MHill along with Normandeau and Associates, will initiate the field data collection. The first event is scheduled for spring 2015 to set up transects. Depending on the target flows, the field data collection will be conducted in the spring and summer 2015 and finished in the late fall of 2015. The data analysis and modeling will competed in the spring of 2016.

		Forrest invited the TWSG to participate the field data collection efforts with the study team. He remained that the flow data collection depends entirely on target flows, thus it is impossible to determine a detailed schedule for the field data collection ahead of time. However, he said he would be able to predict target flows and inform the TSWG early so they can prepare for field data collection if they wanted to participate
5. STAKEHOLDER EXPECTATIONS	Forrest 10 mins	Forrest Olson reviewed the different phases of the IFIM. The third phase of the IFIM, Study Implementation, will be the final phase to be executed under current scope of work. The remaining phases of IFIM will be completed under separate scope of work based on available funds. The goal in IFIM is to develop a process and thus the IFIM process generally does not result in a single "best" flow. Rather, the IFIM generates estimates over a range of flows (or for alternative flow time-series) for each target species. The process estimates form the basis of negotiations among interested parties, including the stakeholders identified in Phase 1.
6. OTHER TOPICS	Forrest 10 mins	Discussed in the above topics.
7. NEXT STEPS	Forrest 15 mins	Discussed in the above topics.

TECHNICAL STUDY WORKGROUP (TSWG) MEETING SUMMARY MINUTES

PROJECT: Instream Flow Workgroup Assistance Phase 2- Oklahoma Instream Flow Pilot Study

DATE: January 22, 2016 (1st meeting: 9:30 am – noon & 2nd meeting: 2 pm – 5 pm)

LOCATION: Oklahoma Scenic Rivers Commission (OSRC), Tahlequah, OK

ITEM	DISCUSSION
1. 1ST MEETING	Participants :

Barry Bolton, ODWC	Monty Porter, OWRB
Jim Burrows, ODWC	Derek Smithee, OWRB
Shannon Brewer, USGS/OSU	Forrest Olson, CH2M
Ed Fite, OK Scenic Rivers Commission	Anna Childers, CH2M
Mike Fuhr, Nature Conservancy (TNC)	Steve Miller, CH2M
Owen Mills, OWRB	John Rehring, Carollo

Derek Smithee welcomed everyone and thanked the Technical Study Workgroup (TSWG) members for participating in the meeting. Derek Smithee briefly stated the purpose for the meeting: 1) inform the TSWG on the ongoing study; 2) solicit input from the TSWG on the study technical elements and recommendations for the next steps, and 3) gain consensus to finalize the technical phase of the ISF PS in 2016.

Derek Smithee reminded the group that the current Project objectives and scope are based on a recommendation of the 25-member Instream Flow (ISF) ISF Advisory Group and OK Comprehensive Water Plan to conduct an ISF pilot study in a scenic river reach to gain a better understanding of potential benefits and challenges of an ISF program.

Forrest Olson thanked the TSWG for their help preparing the Background Report. Forrest Olson reminded the group that one of the goals set for the TSWG in 2014 was to provide technical support in preparing the Study Plan and the Background Report. The Study Plan was drafted in May and completed in September 2015; it is currently being implemented in the field data collection effort. The Background Report is in a Final Draft phase. Comments and information provided by the TSWG have been included in the Report, and the Draft Final was emailed to the TSWG on January 19. Forrest Olson noted that the TSWG members are welcome to provide additional comments. They also can provide comments when the Background Report is included as a chapter in the Draft Technical Report later in the spring. Forrest Olson added that any feedback from the public stakeholder meeting that night (January 22) might be included to enhance the Draft Final Background Report.

	The TSWG discussed the issue of why the flow data that Kim Elkins (TNC) and Shannon Brewer developed were not included in the Draft Background Report. Forrest Olson replied that he did not effectively communicate what was needed in the Report. The figure formats differed from those used in the Report; instead of using these figures, Forrest Olson had a CH2M hydrologist summarize the flow duration curves and prepare the figures. The group discussed the need for better communication with any future requests. Shannon Brewer emphasized the need to use citations more thoroughly in the Report and to use a uniform referencing protocol. The group discussed the best means to communicate future report revisions, agreeing that group emails work best. A TSWG teleconference call also can be arranged, if needed. The TWSG revisited the overall study objectives. As the overall purpose of the Project is to establish an ISF study process in the upper Illinois River, the TSWG members deliberated how this process can be used as a "blueprint" going forward. Derek Smithee emphasized that it is imperative to gain consensus from the TSWG on the ongoing phase of the study to move forward. The group recognized that there are differences among rivers and watersheds, and PHABSIM may not be best suited for all rivers. In some circumstances water use data may be lacking, but matters such as these will be dealt with on a case-by-case basis within the framework of the lessons learned from the pilot study. Involvement from the Tribes, and the presence of endangered species were identified as similar variables to be considered while moving forward. Barry Bolton emphasized the importance of enforceability. That is, if instream flow requirements are ultimately developed, they need to be legally enforceable. Barry referenced a water use permit website developed and used by the State of Michigan as a good example of an ideal product or outcome for Oklahoma. While there seemed to be consensus among the group on the importance of enforceability, Derek Smithee emphasized the need to first develop defensible science that can be relied upon. The legal and policy questions will ultimately need to be addressed, but the primary objective now is to develop a technical platform based on defensible science. Shannon Brewer raised the concern about the cost of conducting additional instream flow studies. Cost was recognized by the group as a factor that will be considered moving forward, likely on a case-by-case basis. With regard to future advisory groups, Jim Burrows emphasized the importance of clarifying authority, roles, and definitions from the onset. Mike Fuhr said he would engage Secretary Mike Teague, Oklahoma Secretary of Energy and Environment, to see if he would be an advocate for an instream flow program. After much discussion, the TSWG members recommended that a chapter or memorandum titled "Observations and Lessons Learned," be added as an appendix to the Technical Report. This would, in part, detail concerns that were introduced by TSWG members but not addressed by the pilot study, and what this experience tells us for future application to other streams. The TSWG discussed the next steps, timeline, and the role of the TWSG. Derek Smithee emphasized how important it is for the TSWG to support the ongoing study in developing an ISF process for a scenic river reach using this pilot study. Once the technical study

phase is completed, the TSWG will review the study results and provide comments on what the study results mean for the resources of concern.

In addition to the immediate near-term action items, the TSWG members discussed the next steps after the completion of the technical work. These included involving the advisory group, higher-up decision makers, and policy planning. No decisions were made, but it was recognized that these policy- and decision-making steps will be critical to the pilot study success.

ACTION ITEMS:

- **Revise Final Draft Background Report (CH2M):**
  - Submit Revised Final Draft report to TWSG –Completed and submitted to TSWG 1/19/16
  - TSWG submit any additional comments/edits
  - Ensure effective and timely communications to include all the feedback
  - Arrange final review teleconference call with TSWG, if necessary
- **Final Modeling Results:**
  - Provide results and analysis to TSWG (CH2M) by March 1
  - Review results and provide feedback to CH2M (TSWG)
  - Discuss the results and make recommendations in meeting of the TSWG possibly a conference call

2. 2nd MEETING

Participants:
All the attendees of the 1st meeting and:

Kimberly Elkin, Nature Conservancy	Brooks Trammel, OK Conservation Commission
Dave Martinez, USFWS	Tony Smith, Carollo

Invited but not present:
Tony Clyde, USACE Shannon Phillips, OK Conservation Commission (Brooks Tremmel represented OCC)

Derek Smithee welcomed the rest of the TSWG members and thanked them for their time and participation. Derek Smithee stated the goals for the second part of the TSWG working meeting that Forrest Olson had previously shared with the TSWG: 1) inform them on the feedback gained during the first working meeting earlier in the day; 2) provide an update on the field work and consequences of the flood; 3) brief explanation of the habitat modeling; 4) review of preliminary results; and 5) a discussion of next steps following the completion of the technical work.

Derek Smithee summarized the output from the first meeting and action items (see above notes). Forrest Olson then briefed the TSWG on the recent floods. The Post-Floods Study Briefing TM was provided to TSWG on January 19, 2016 summarizing the impacts. The two December flood events (early and late December) impacted the study transects to limit future study collection for the PHABSIM (the model) development. Forrest Olson recommends that the model be completed with the data collected during the earlier field events (October, early December) before the floods. Forrest Olson believes the data are adequate for Flint Creek and the lower Illinois River sites to run hydraulic and habitat models. Forrest Olson cautioned that the model extrapolation much above the highest

	measured flow (900 cfs for Illinois River and ~115 cfs for Flint Creek) is not recommended because of reduced confidence in the hydraulic models at those higher flows. Flow velocity calibration measurements were not collected for the upper Illinois River site above Flint Creek due to the floods. Therefore, the study will not have data for this reach. However, flow recommendations for fish can be determined for the upper reach using the lower Illinois River site, minus accretion flow between sites. In addition, Forrest Olson noted that the elevation profiles on the stream banks above the earlier-determined water line will need to be estimated for the lower Illinois River transects. The effort will be completed using ground photos. Forrest Olson stated that the accuracy of bank profiles is not that critical in the model development because we will not be extrapolating that far up. Shannon Brewer asked if there was a way to determine confidence intervals for the habitat model results. Forrest Olson indicated that the results are not conducive to that type of statistical analysis but that there are other ways to analyze the data to assess general confidence in the results. One example is to randomly split the transect data into two sets, weight the transects per the habitat surveys, and then run the habitat models for each set. Similarity of results of the two runs would suggest that the model is robust. There are also other modeling options that can address concerns about meso-habitat preferences by some fish and prime versus marginal habitat. Forrest Olson discussed the preliminary results of the modeling. The modeling did not include the substrate variables yet, and that may change the results some. The preliminary results indicate that the higher habitat values occur below 500 cfs and as low as 200 cfs for some of the fish habitat guilds. These "good" habitat flow ranges fall between our high and low flow field measurements, thus indicating that the flow extrapolation limits of the model are acceptable. The field data collection and review of aerial maps revealed an extensive network of secondary channels along the river corridor. The importance of these channels and the need to protect them will be discussed at the stakeholder meeting. They also will be assessed in the Technical Report. The TSWG then reviewed the technical presentation during the working session. The following comments were provided and revisions were made when feasible: • Revise the order of study goals (bullets in slide 2) • Surface water use: revise table to remove % of total (slide 9) • Revise water quality: study emphasis is not WQ (slide 12) • Fisheries: revise to include "most fish are native" (not: "nearly all"); Include Shannon Brewer's sunfish photo (slide 13) • Recreation use: revise annual floaters 100,000 (not: 150,000). Ed Fite should have updated information on the numbers of commercial operators. Add sunfish as a primary fishing activity (along with bass) (slide 14) • Suggestion: could a trend/correlation be developed between the season (month/year 2003 - 2008) and number of floaters and historic flows? **Action**: CH2M will look into this (slide 15) • Bankful event: recommend to have a representative photo in the study area to better explain this. **Action**: CH2M will follow up with OWRB to get a representative photo (Monte)(slide 20)

	• Fish (bass) habitat and flow curves: ensure explanation is clear to the audience; simplify message. Explain the relevance to this study. Include Shannon Brewer's bass photo (slide 30) • Next steps: immediate tasks for the technical phase of the study (slide 32) • Add new slide: future work (slide 33) After the review of the presentation and revisions, the TSWG adjourned to participate in the pubic stakeholder meeting at the Municipal Armory in Tahlequah.
3. NEXT STEPS	Action items identified separately within each item above.

Instream Flow Assessment of the Illinois River, OK

Study Update and Next Steps

Presented to
Public Stakeholder Meeting in Tahlequah, OK

Presented by
Forrest Olson, CH2M HILL

January 21, 2016

US Army Corps of Engineers

WRB

ch2m

What is an instream flow?

OWRB working definition of instream flow:

"Flows necessary to provide for a healthy ecosystem and support water-related recreation (such as fishing, hunting, swimming and boating) as well as tourism."

What are instream resources?

- Fisheries, wildlife, water quality, recreation, aesthetics, and the ecological processes that support these resources.

Primary Study Goals:

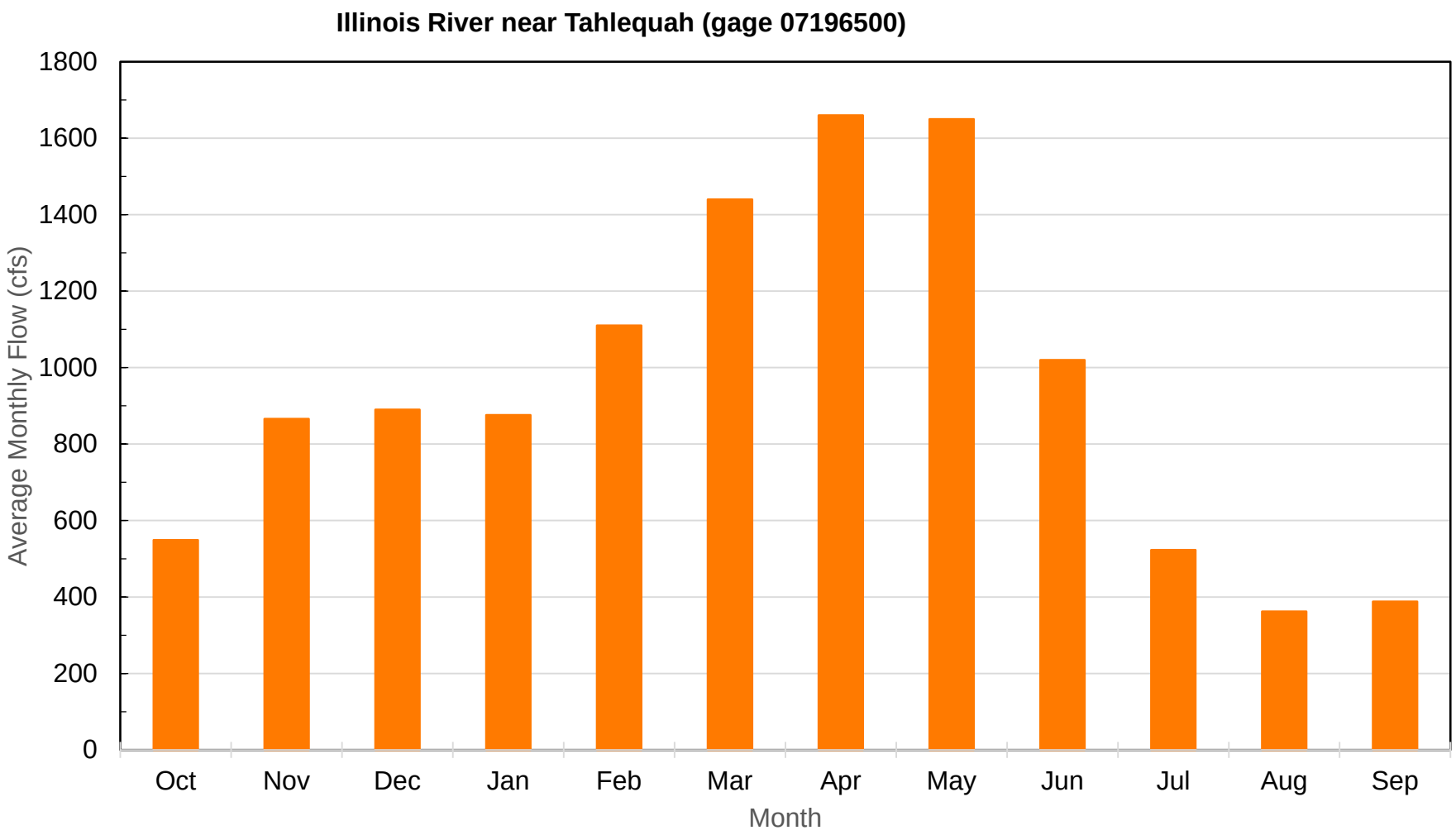
- Develop seasonal instream flow recommendations for the Illinois River including Barren Fork and Flint creeks.
- Gain a better understanding of the implications of a process to deal with instream flow issues consistent with the overall goal of managing water resources in Oklahoma for multiple uses. The study would help define a conceptual framework and study process that could be used statewide.

*Note: This study is **not** being done in response to a proposed water development project.*

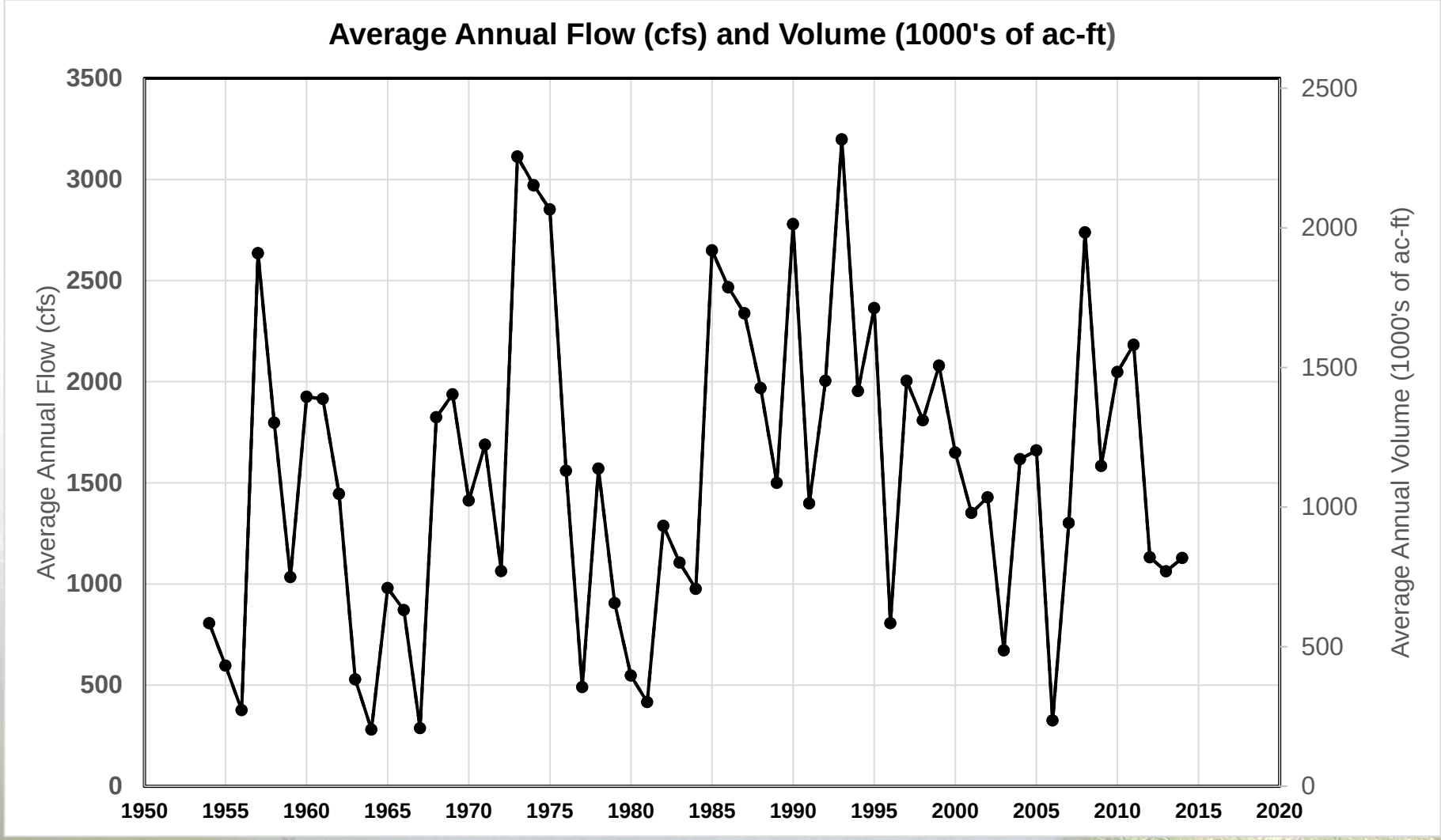
Study Area

Rogers
Springdale
Fayetteville
Kansas
Siloam Springs
Flint Creek
Osage Creek
Watts
Lake Francis
Illinois River
Illinois River
Westville
Arkansas
Oklahoma
Baron Fork Creek
Lincoln
Eldon
Tahlequah
Caney Creek
Stilwell
Lake Tenkiller
USGS Gage
City
Lake
Scenic River
Major Stream
Other Stream
N
W
E
S
0
5
10
Miles

Illinois River Average Monthly Flows



Average Annual Flows for the Illinois River near Gore



Illinois River December 27, 2015

Peak Flow Recurrence Intervals

Peak Flow Return Period (Year)	Probability (%)	Flow (cfs)		
		Illinois River near Tahlequah	Illinois River near Watts	Barren Fork at Eldon
2	50	19,535	18,868	16,250
5	20	38,289	33,947	29,836
10	10	53,919	45,185	37,328
25	4	77,173	60,390	44,675
50	2	96,925	72,233	48,789
100	1	118,643	84,362	51,962

Average Annual Surface Water Usage (acre-feet) in the Upper Illinois River Basin (OK) above and including Barren Fork

Water Use	Total	Percent of Total
Irrigation	1,301.4	10.8
Agriculture	0	0.0
Public Supply	10,751.4	88.9
Rec, Fish, & Wildlife	0	0
Commercial	0	0
Industrial	0	0
Mining	0	0
Other	35.1	0.3
Total	**12,087.9**	**100.0**

Groundwater Usage

Deep Bedrock Aquifer	3,900 acre-feet (water right)	Little effect on streamflows
Shallow Alluvial Aquifer	1,050 acre feet (est. usage)	Direct but delayed effect on stream

Alluvial Groundwater use is equivalent to 1.5 cfs, which is 0.11 % of basin yield

Water Use Summary:

1. Surface water use in Oklahoma portion of Illinois River above Barren Fork is only 1.3 % of the average annual basin yield
2. Most water use is for public supply – mostly Tahlequah
3. Basin water use in Arkansas is similar to Oklahoma in quantity and use category
4. White River water for Fayetteville area municipal use augments flows in Illinois River
5. Flow augmentation from White River may totally offset other surface water withdrawals in both states on annual average basis
6. Ground water use has minimal effect on streamflows

Water Quality

- Basin’s major water quality concern is nutrient loading, primarily phosphorus
- Phosphorus affects the Illinois River and Lake Tenkiller
- Phosphorus loading is trending downward in Illinois River and Barren Fork Creek, not in Flint Creek
- Phosphorus concentrations are related to streamflow, but indirect common effect of runoff
- Little evidence of contaminant concerns such as heavy metals or organics

Fisheries

1. Highly diverse fish community of >72 species
2. Nearly all fish species (except carp) are native to the basin
3. Smallmouth bass are the most sought-after game fish
4. The smallmouth bass are of the Neosho subspecies thus of high conservation value
5. No fish species are listed as federal or state threatened or endangered

Recreational Use

- Annual visitation ~400,000 to Scenic section
- Approximately 25 Commercial Floatation Device Operators
- Annual floaters (canoe, raft, kayak) ~150,000
- Annual recreational economic value (above Tenkiller) ~ $12 million
- Fishing is a popular activity, primarily for bass. No estimates of angler use or catch for Illinois River (some for Barren Fk)

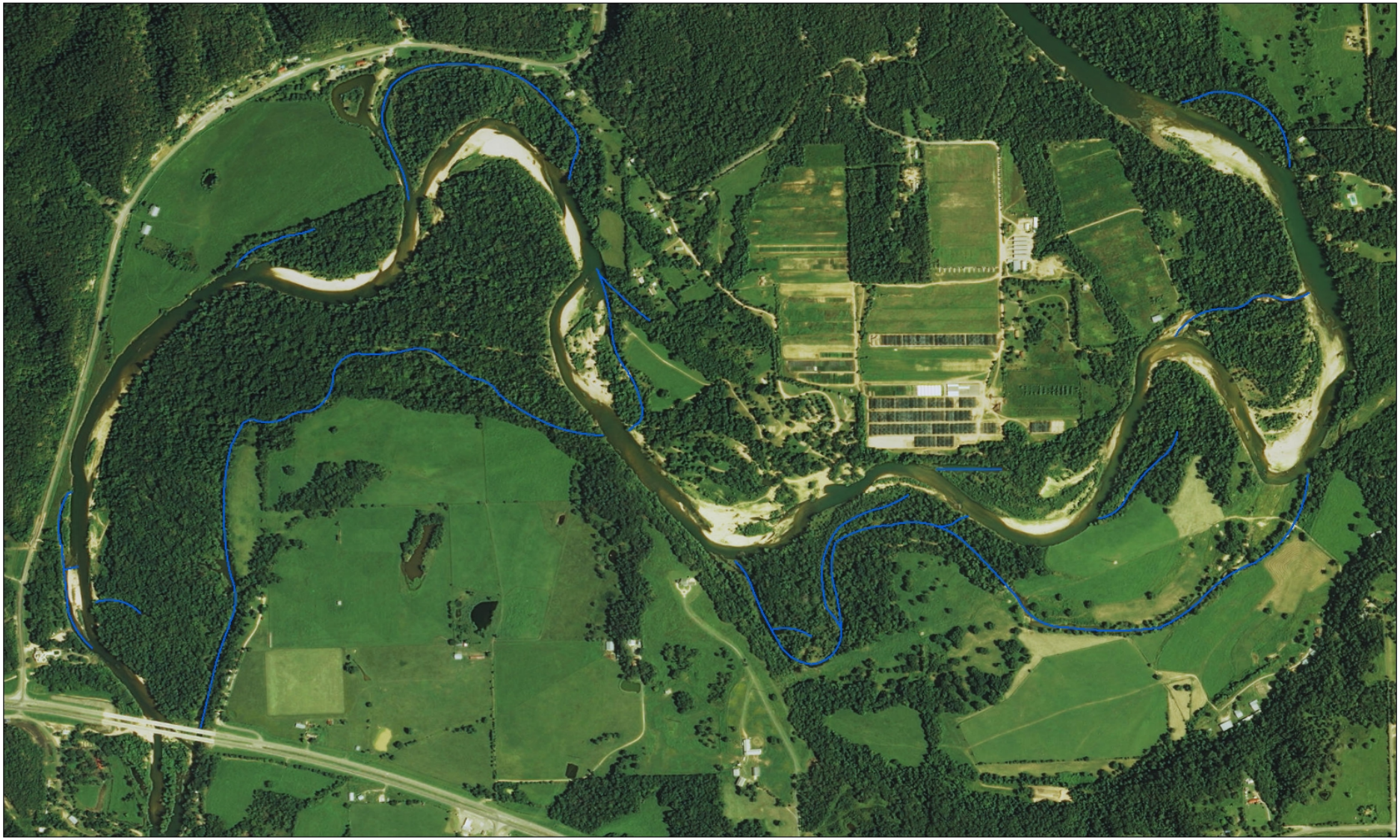
Illinois River Monthly Float Users, Average Annual for 2003-2008

Month	Commercial	Private	Total
January	1	35	36
February	2	34	36
March	110	19	129
April	348	81	429
May	9,938	411	10,349
June	22,734	681	23,415
July	37,441	1,094	38,535
August	24,540	804	25,344
September	8,657	400	9,057
October	878	93	971
November	76	24	100
December	6	48	54
Total	**104,731**	**3,724**	**108,455**

Flow Ranges for Recreational Floating (Tahlequah Gage) (source: OSRC)

Preferred range	400 – 1,200 cfs
Minimum for canoeing & kayaking	150 cfs
Minimum for rafting	250 cfs
Maximum for general safety	1,200 cfs
Maximum for experienced boaters	4,000 cfs

Secondary Channels



Ratio of secondary channel length to the main channel length in the Illinois River between Watts and Tahlequah, Oklahoma.

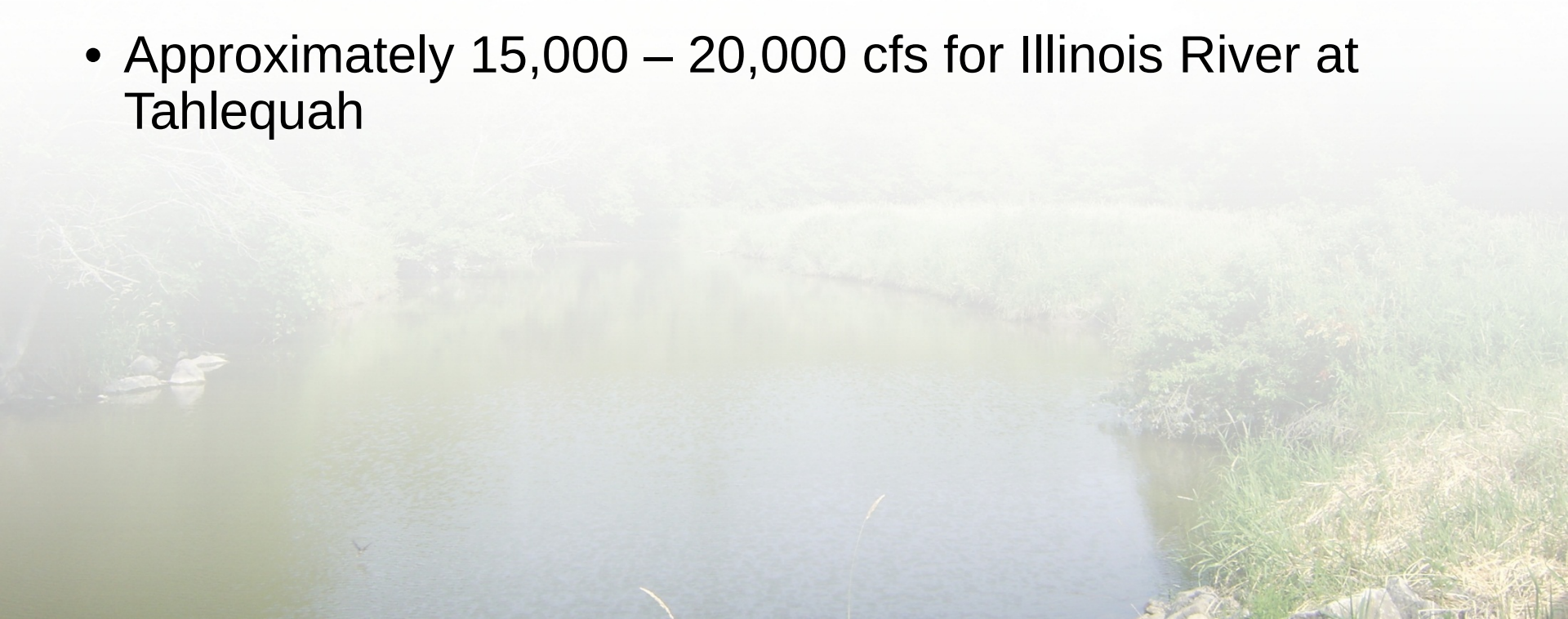
River Reach	Watts to Flint Creek	Flint Creek to Peavine	Peavine to Tahlequah	Total
River Reach Length (mi)	13.3	16.3	22.9	53
Secondary Channel Length (mi)	5.3	6.3	18.3	30.5
Ratio of 2ndary channel to main channel length	**44.4 %**	**38.7%**	**80.0%**	**57.5%**

Importance of Secondary Channels

- Rearing and refuge habitat for fish
- Support of many wildlife species that don’t tend to use the main channel
- Water quality (clarity and temperature)
- Floodwater relief
- Help govern the size and shape of the main channel

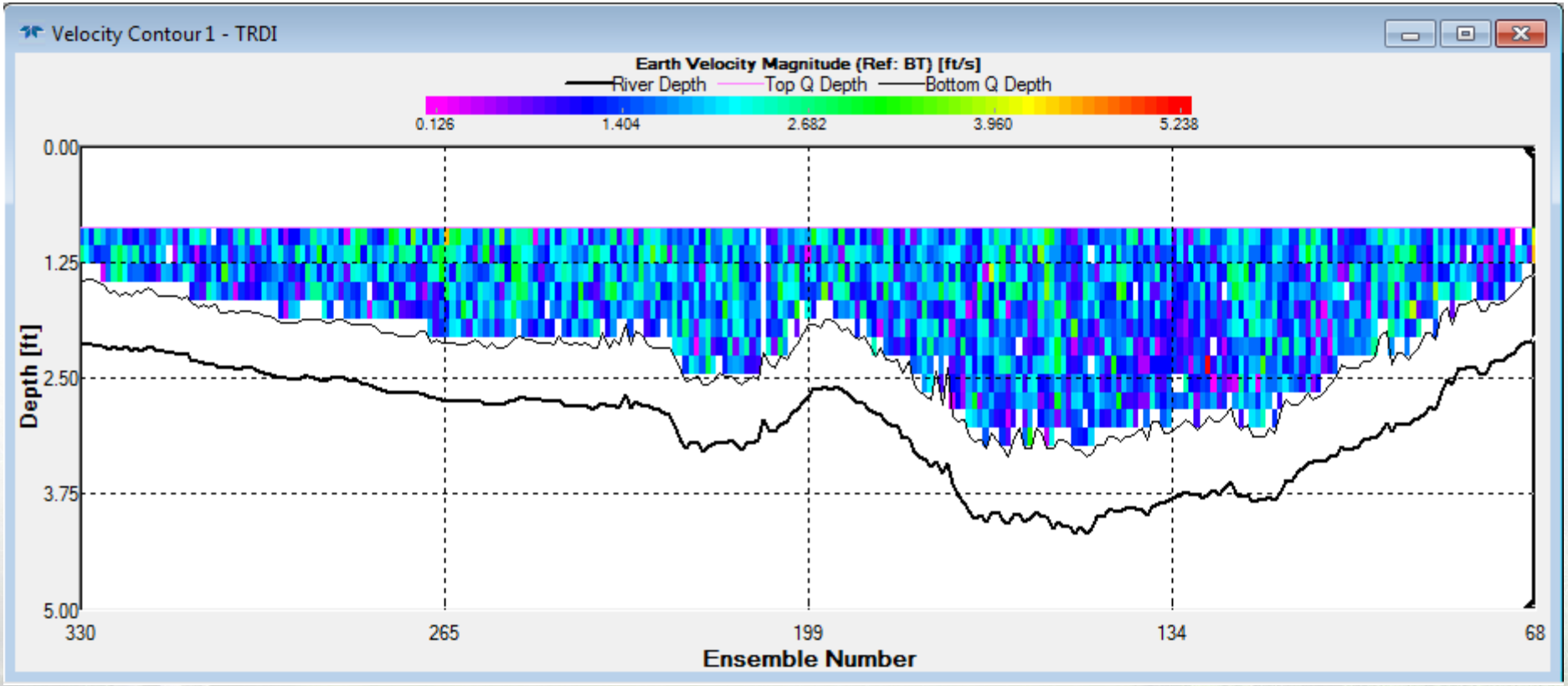
How to Protect Secondary Channels:

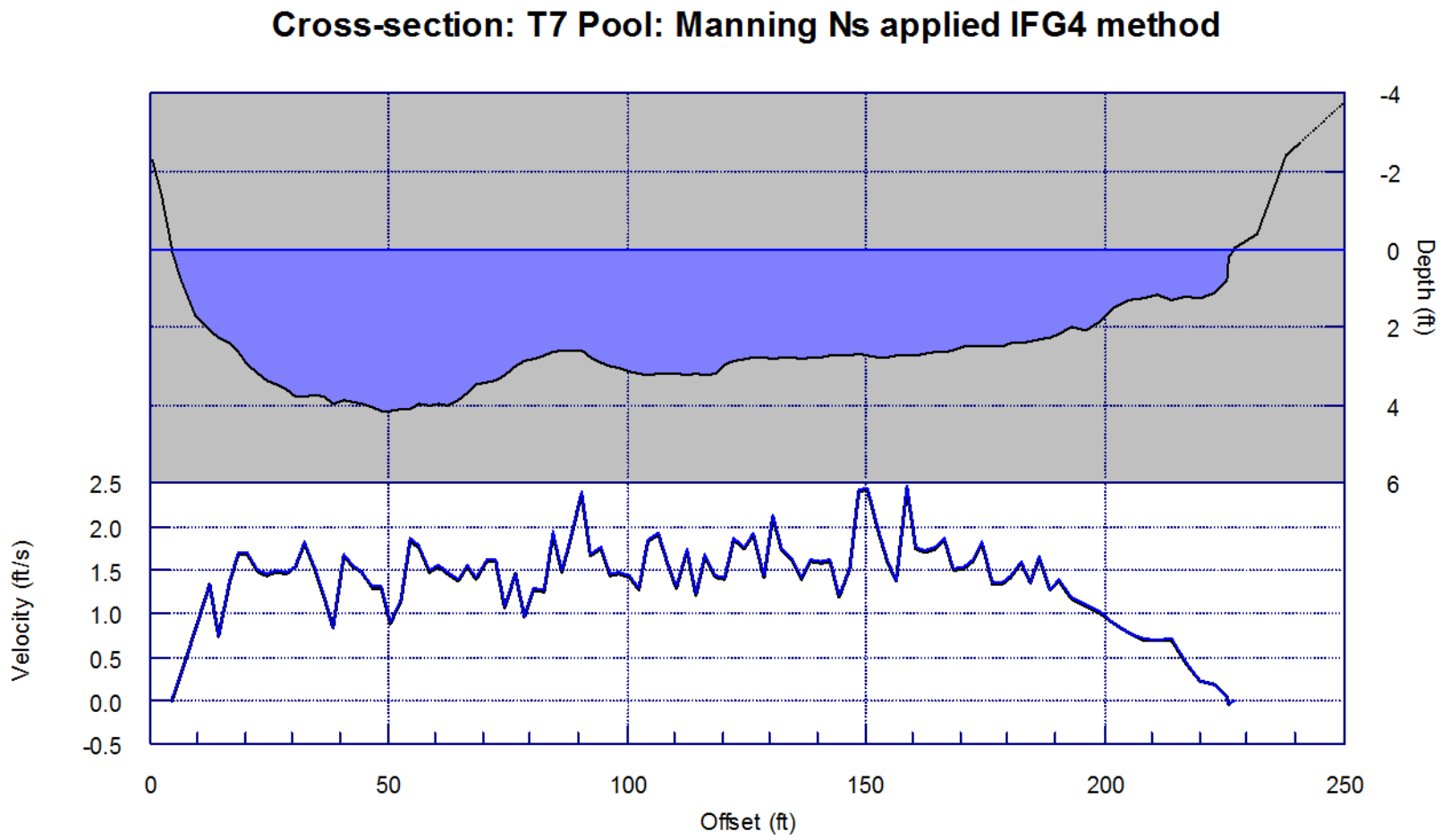
- Preserve bank-full/channel maintenance flows (frequency and magnitude)
- Typically equates to the 1.5- or 2-year recurrence flow
- Approximately 15,000 – 20,000 cfs for Illinois River at Tahlequah



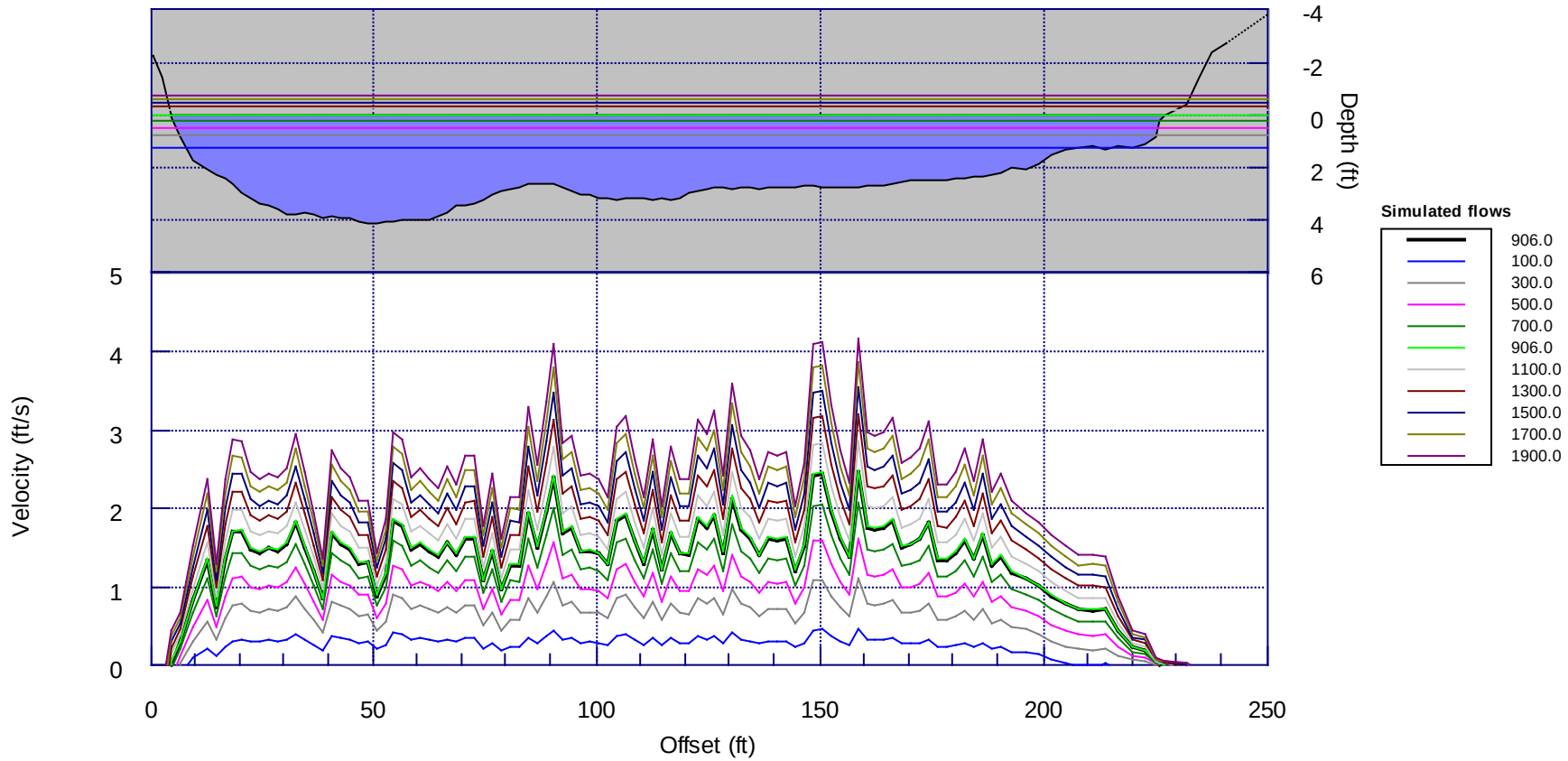
Fish Habitat Modeling

- Simple explanation of model
- Study sites (map with transects)
- Photos
- Example results (Barren Fork)


Velocity Contour 1 - TRDI
Earth Velocity Magnitude (Ref: BT) [ft/s]
River Depth
Top Q Depth
Bottom Q Depth
0.126
1.404
2.682
3.960
5.238
0.00
1.25
2.50
3.75
5.00
Depth [ft]
330
265
199
134
68
Ensemble Number


Cross-section: T7 Pool: Manning Ns applied IFG4 method
Depth (ft)
-4
-2
0
2
4
6
Velocity (ft/s)
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
0
50
100
150
200
250
Offset (ft)

Cross-section: T7 Pool: Manning Ns applied IFG4 method



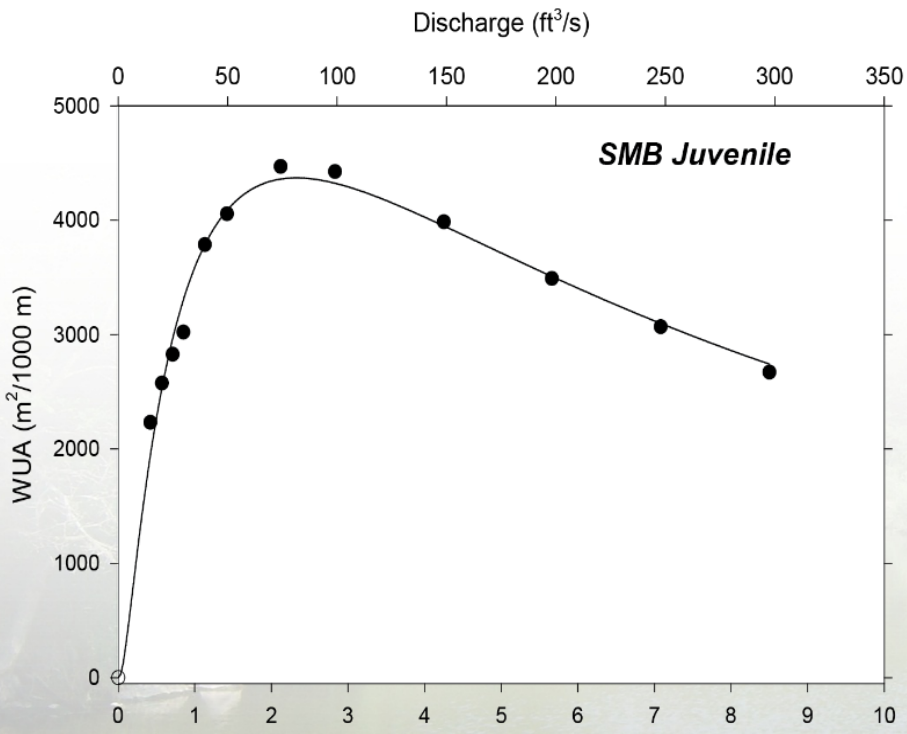
Lower Flint Creek

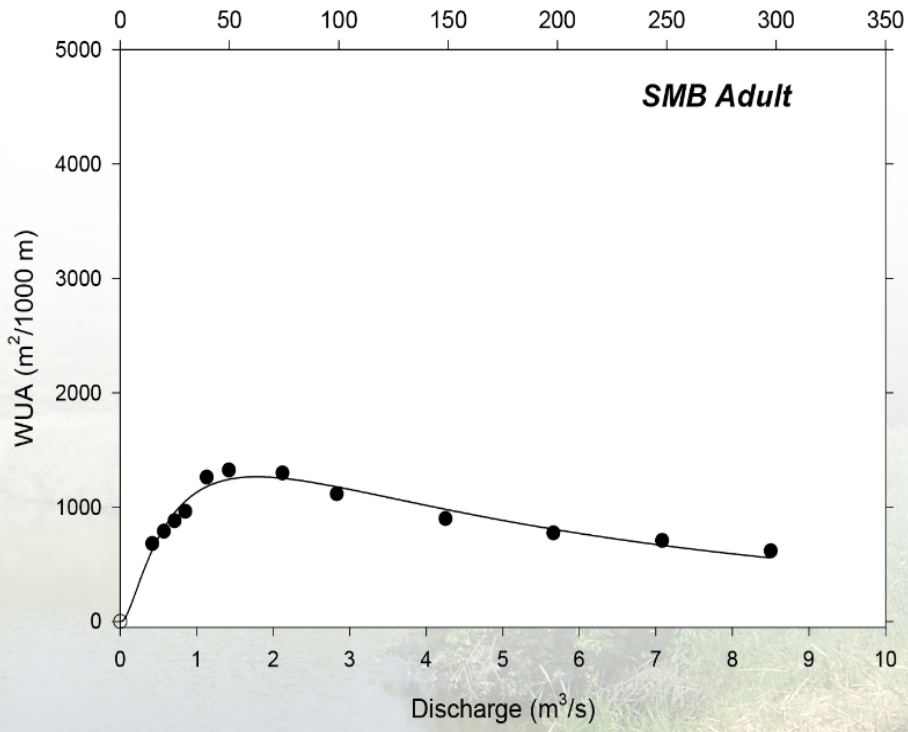
Flint Creek Study Transect

Lower Illinois River

Upper Illinois River Bedrock Pool Transect

Example (Barren Fork) of Fish Habitat Modeling Results





Implication of recent flood on study

- Fish habitat model extrapolation limited to < 1,000 cfs for Illinois River, <150 cfs for Flint Creek
- Upper Illinois River site above Flint Creek – insufficient data; site washed out.

Next Steps.

- Finish habitat modeling
- Complete Technical Report (late spring 2016)
- Develop decision-making process for recommending/establishing instream flows
- Identify/develop regulatory process to implement instream flows
- Examine how this study approach and decision making process would work on other streams in Oklahoma

Questions

TECHNICAL MEMORANDUM

December 2015 Post-Flood Study Briefing

PREPARED FOR:	Oklahoma Water Resources Board (OWRB)
COPY TO:	U.S. Army Corps of Engineers (USACE), Tulsa District
PREPARED BY:	CH2M
DATE:	January 11, 2016
PROJECT NUMBER:	665876

In light of the recent record-level flood on the Illinois River, CH2M would like to provide you with a brief overview of the implications of the flood on our ongoing instream flow study on the Illinois River and Flint Creek.

Data Collection Progress Prior to the Late December Flood

In early October (October 1-8, 2015) CH2M conducted habitat surveys for lower Flint Creek and for much of the Illinois River study reach. The study team then selected study transects on Flint Creek (total 15) and on the lower Illinois River between Flint Creek and Tahlequah (total 20). CH2M team also selected 16 transects on the upper Illinois River above Flint Creek. The data collection included establishing temporary bench marks, surveying head stakes for each transect, gaging the streamflow, and surveying water surface elevations at each transects. The streamflows were approximately 45 cubic feet per second (cfs) on Flint Creek, approximately 200 cfs on the upper Illinois, and approximately 280 cfs on the lower Illinois. Photographs were taken at each transect. These measurements constituted the study's low-flow data needs for the stream hydraulic modeling.

The second scheduled field data collection took place in early December (December 9-13, 2015) to collect high flow measurements (near mean annual flow), and specifically the velocity calibration data for each transect. A minor flood (12,500 cfs at Tahlequah) had occurred a couple of weeks earlier; however, inspection of the transects indicated that no channel profile changes occurred due to the high flow event. The CH2M field team was able to collect the velocity calibration data for the lower Illinois River transects and the Flint Creek transects. However, another storm event on December 13th cut the field data collection short. Flows exceeded flood stage again on December 14th. Because of this event, the CH2M field team was not able to obtain velocity profile data for the upper Illinois site (16 transects). Also, the team was unable to survey streambank elevations above the water line for the lower Illinois transects. The data collection was aborted on December 13, 2015, and the plan was to return to collect the remaining data after the holidays and when the high flows had receded to a level meeting the target flow range identified in the Instream Flow Pilot Study Plan.

Late December Flood consequences

Record flooding impacted parts of eastern Oklahoma in late December. The Tahlequah stream gage reached nearly 20 feet above flood stage on December 28th, 2015. The stage crest was 30.70 feet. The maximum flow reached 120,000 cfs. This exceeded the estimated 100-year flood event.

The major consequence of the flood on the current study is that the elevation profiles (cross sections) of the study transects have undoubtedly transformed enough to make any additional data collection of no value for the PHABSIM (model) development. As such, the study's Principal Investigator (PI), Forrest Olson (CH2M) proposes to conduct the modeling with the data collected so far, as discussed below.

Recommended Next Steps

An adequate amount of field data have been collected for Flint Creek and the lower Illinois River sites to run the hydraulic and habitat models. However, some limitations will exist. The Illinois River Pilot Study Plan proposed three or more sets of transect water surface elevation data to establish an accurate stage-discharge relationship for the hydraulic model. This typically allows the model results to be extrapolated from about 40% of the low-flow measurements to about 250% of the high flow measurements. However, with the limited data that were able to be collected before the major flood, the PI would not recommend extrapolating the model results much above the highest measured flows, which were approximately 900 cfs for the Illinois River and approximately 115 cfs for Flint Creek.

In addition, the elevation profiles on the stream banks above the earlier-determined water line will need to be estimated for the lower Illinois River transects. Use of the ground photographs taken at each transect will assist this effort. Accuracy of the bank profiles are not that critical in the model development in our situation since we will not be extrapolating the model much above the previously surveyed water line.

Flow velocity calibration measurements were not collected for the upper Illinois River site above Flint Creek due to the dangerous flow levels during the early December data collection. Therefore, it is recommended that we continue with the pilot study without results for this reach. Instream flow recommendations for fish habitat can still be determined for this upper reach using the results of the lower Illinois River site, minus accretion flow between sites. We can also apply the results of the habitat survey (pool-riffle-run) for the upper reach to the lower-reach transect data to more accurately estimate the shape of a habitat-flow relationship for the upper reach. Depending on the outcome of this approach, the study of the upper site can be resumed (essentially start over) if deem necessary.

We are currently entering our field data into the models and hope to have preliminary results for Flint Creek and the lower Illinois sites completed by January 21st for discussion with the Technical Study Workgroup (TSWG). Because of their very preliminary nature, we do not recommend presenting the results at the stakeholder meeting on the evening of January 21st.

We have also completed the second revision of the Background report and plan to send it out to the TSWG (and others) prior to the January 21st meeting. We are still considering this a final draft pending any additional input we may receive at the stakeholder meeting that would be worth adding to the report.

Meeting Agenda
Instream Flow Advisory Group and
Upper Illinois River ISF Pilot Study Technical Study Workgroup

Advisory Group Meeting #5

Date:	June 16, 2016
Time:	9:30 am
Location:	OWRB (Board Room) 3800 N. Classen, Oklahoma City

1. Welcome and Goals for Today 9:30-9:40 am
   - Introductions – ISF Advisory Group and Technical Study Workgroup
   - Review Agenda and Goals for Today

2. ISF Pilot Study Overview 9:40-9:50 am
   - Brief recap of key issues identified by Advisory Group for further evaluation
   - Roles of the ISF Advisory Group and Upper Illinois River Technical Study Workgroup
   - Overview of how the Technical Study results will be used as a key part of the overall Upper Illinois River Pilot Study program

3. Presentation: Instream Flow Assessment Technical Study Findings 9:50-10:30 am

4. Next Steps 10:30-11:00 am
   - Public/stakeholder meeting in Tahlequah tonight (6:30 pm at the Armory Municipal Center)
   - Next steps in the Pilot Study to assess ISFs in the Upper Illinois River basin
   - Advisory Group role
   - Information resources: ISF Website (www.owrb.ok.gov/isf)

Illinois River Instream Flow Pilot Study
Technical Study Workgroup / Instream Flow Advisory Group Meeting

June 16, 2016

OWRB

Oklahoma City, Oklahoma

US Army Corps of Engineers

State of Oklahoma
OWRB
Water Resources Board
the water agency

Agenda for Today's Discussion

Introductions and Goals for Today

ISF Pilot Study Overview

John Rehring, Carollo Engineers

Presentation:

Instream Flow Assessment Technical Study Findings

Forrest Olson, CH2M

Next Steps

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Instream Flow Advisory Group

J.D. Strong (Chair)
- OWRB

Shannon Brewer
- USGS

Tom Creider
- Oklahoma State Parks

Mark Derichsweiler
- Sierra Club

Tom Elkins
- Cherokee Nation

A.J. Ferate
- OIPA

Mike Fuhr
- The Nature Conservancy

James Gammill
- Oklahoma Rural Water Association

Bud Ground
- Environmental Federation of Oklahoma

Charlette Hearne
- ORWP

Michael Kelsey
- Okla. Cattlemen's Association

Mike Jackson
- Okla. Chamber of Commerce

Joe Long
- ODEQ

Mike Mathis
- Continental Resources

Sue Ann Nicely
- Okla. Municipal League

Marla Peek
- Oklahoma Farm Bureau

Tyler Powell
- Office of the Sec. of Energy & Environment

Jim Reese
- Okla. Dept. of Ag, Food & Forestry

Marsha Slaughter
- OKC Water Utilities Trust

Kevin Stubbs
- US Fish & Wildlife Service

Jeff Tompkins
- Bureau of Reclamation

Brooks Tramell
- Okla. Conser-vation Comm.

Support
- OWRB Staff
- CH2M
- Carollo

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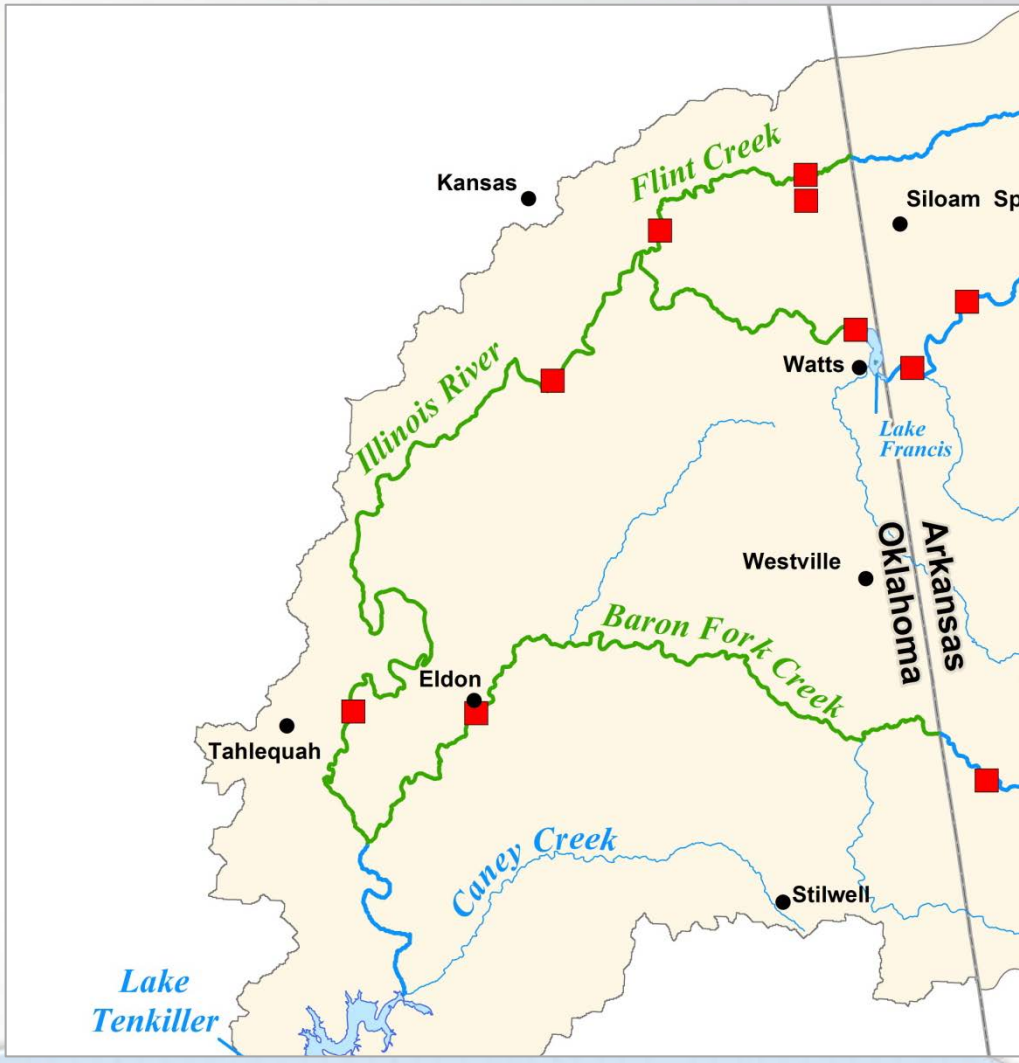
ISF Pilot Study Overview

- **Instream (or environmental) flows** are those necessary to provide for a **healthy ecosystem** and support **water-related recreation** (such as fishing, hunting, swimming, and boating) as well as **tourism**.



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ISF Advisory Group:
Process for Assessing Instream Flow

J.D. Strong (Chair) • OWRB	**Shannon Brewer** • USGS	**Tom Creider** • Oklahoma State Parks	**Mark Derichsweiler** • Sierra Club	**Tom Elkins** • Cherokee Nation
A.J. Ferate • OIPA	**Mike Fuhr** • The Nature Conservancy	**James Gammill** • Oklahoma Rural Water Association	**Bud Ground** • Environmental Federation of Oklahoma	**Charlette Hearne** • ORWP
Michael Kelsey • Okla. Cattlemen's Association	**Mike Jackson** • Okla. Chamber of Commerce	**Joe Long** • ODEQ	**Mike Mathis** • Continental Resources	**Sue Ann Nicely** • Okla. Municipal League
Marla Peek • Oklahoma Farm Bureau	**Tyler Powell** • Office of the Sec. of Energy & Environment	**Jim Reese** • Okla. Dept. of Ag, Food & Forestry	**Marsha Slaughter** • OKC Water Utilities Trust	**Kevin Stubbs** • US Fish & Wildlife Service
	Jeff Tompkins • Bureau of Reclamation	**Brooks Tramell** • Okla. Conser-vation Comm.	**Support** • OWRB Staff • CH2M • Carollo	

- Address the legal and policy questions.
- Study other mechanisms for protecting instream flows.
- Develop a draft methodology for instream flow studies in Oklahoma.
- Conduct a study on the economic impacts of instream flows in Oklahoma.
- 5. Perform an instream flow pilot study in a scenic river.
- Preserve the Instream Flow Workgroup.

Upper Illinois River Instream Flow Pilot Study

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ISF Advisory Group: Overall goals for the Upper Illinois River Instream Flow Pilot Study

- Better understand the benefits and implications of a possible ISF program
- Identify additional questions and concerns
- Test and refine the IFIM process to address questions and issues raised by the ISF Advisory Group
- Identify specific technical components of the approach that could be applied to ISF assessments in other watersheds

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Issues Identified by Advisory Group

General

- Certainty of supply
- Healthy economy / healthy environment

Water Law

- Priority of ISF vs. other uses

Benefits of ISF Program

- Recreation & tourism
- Healthy ecosystems
- Water quality

Concerns with ISF Program

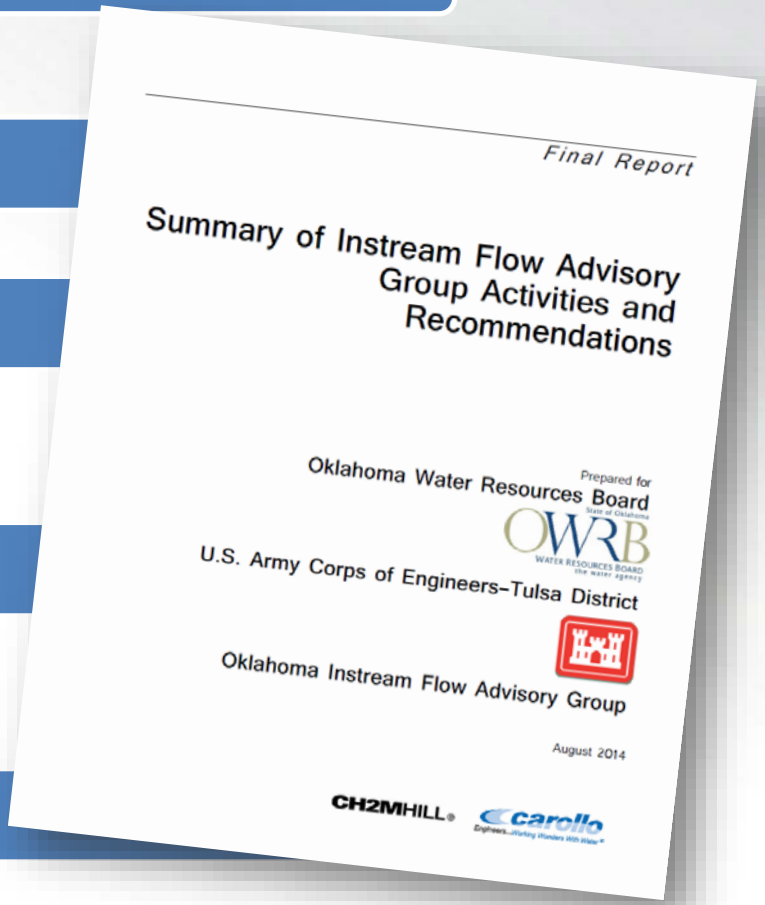
- Conflicts with other uses
- Economic impacts
- Impacts on reservoirs

Piloting and Measurements

- Measure benefits and impacts
- Test proposed methods

Potential Management Approaches

Protecting Existing and Future Consumptive Rights


Final Report

Summary of Instream Flow Advisory Group Activities and Recommendations

Prepared for

Oklahoma Water Resources Board

U.S. Army Corps of Engineers–Tulsa District

Oklahoma Instream Flow Advisory Group

August 2014

CH2MHILL

Carollo

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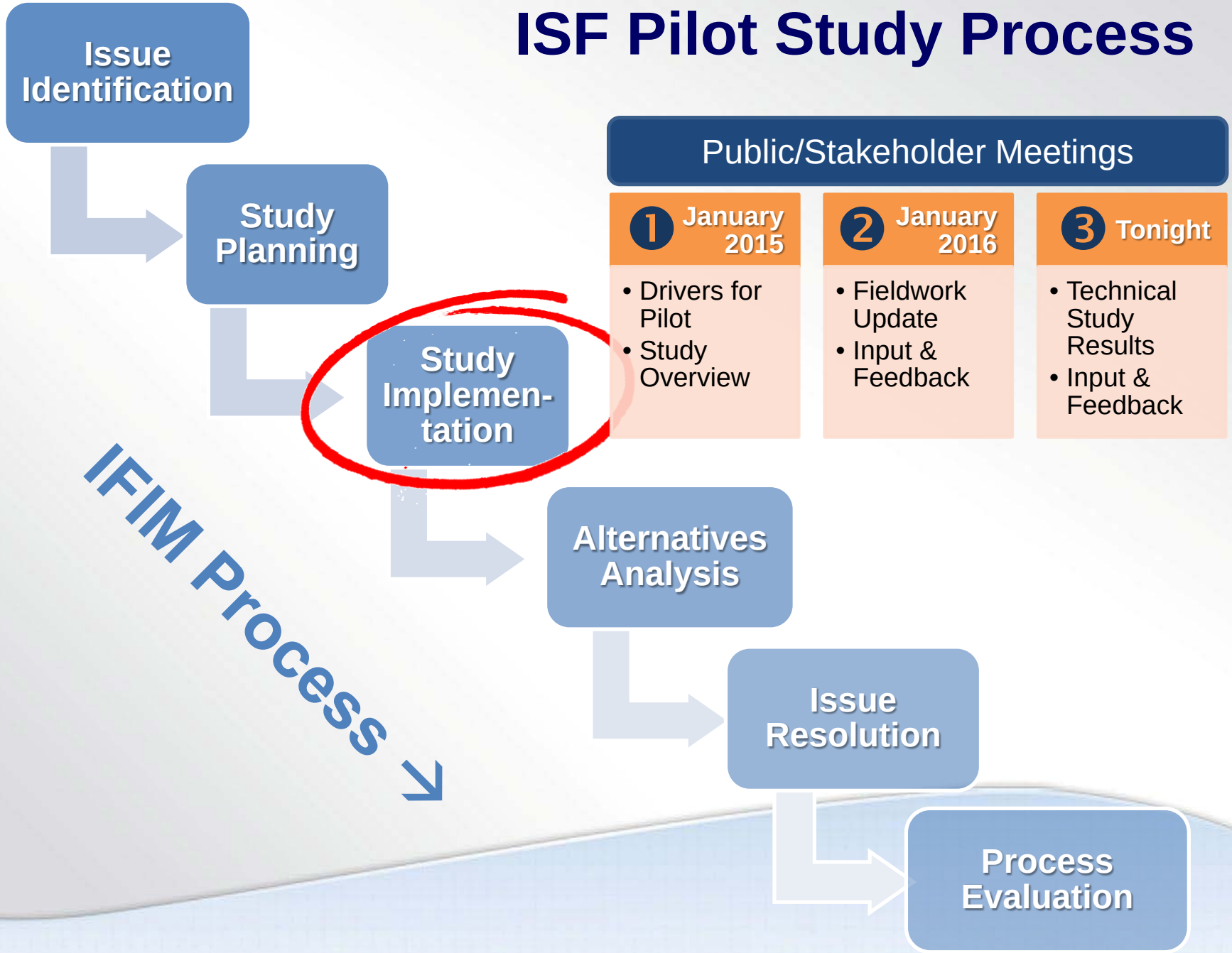
ISF Pilot Study Process



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Public/Stakeholder Feedback

Public/Stakeholder Meetings

1 January 2015
- Drivers for Pilot
- Study Overview

2 January 2016
- Fieldwork Update
- Input & Feedback

3 Tonight
- Technical Study Results
- Input & Feedback

Suggested Considerations

- Instream Recreation
- Related Recreation (hunting, camping, birding)
- Wetlands and Oxbows
- Stream/groundwater interactions
- Flow patterns
- Variability beyond historical data
- Potential maximum flows
- Cherokee Nation involvement
- Summer critical low-flows
- Changing erosion and channel dynamics
- Impact of recreation on landowners
- Tenkiller allocation impacts
- Interstate Compact conflicts

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Public/Stakeholder Feedback

Public/Stakeholder Meetings

1 January 2015	2 January 2016	3 Tonight
• Drivers for Pilot • Study Overview	• Fieldwork Update • Input & Feedback	• Technical Study Results • Input & Feedback

Suggested Considerations

- Economic evaluation should accompany policy dialogue
- Flow vs. water temperature and dissolved oxygen
- Potential flow impact of future water reuse in Arkansas
- Consider flow patterns, not just extremes
- Consider shifts in types of recreational boating
- Climate change considerations

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Instream Flow Assessment

Issue Identification

Study Planning

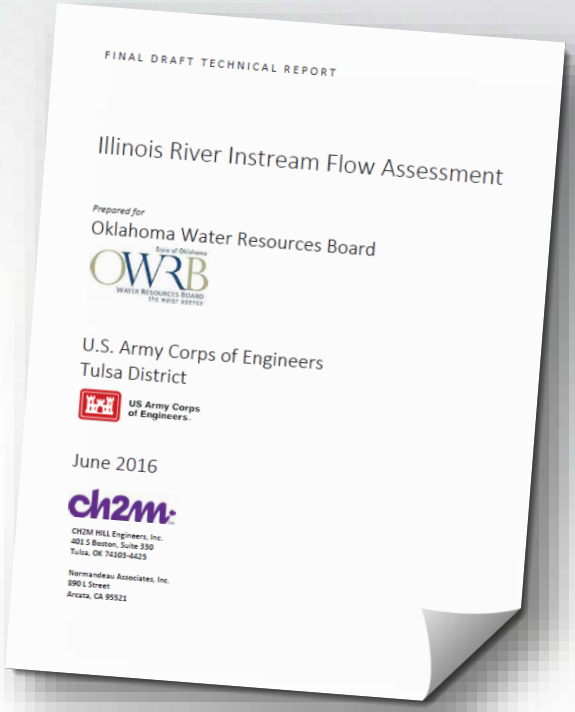
Study Implementation

Alternatives Analysis

Issue Resolution

Process Evaluation

IFIM Process


FINAL DRAFT TECHNICAL REPORT

Illinois River Instream Flow Assessment

Prepared for

Oklahoma Water Resources Board

U.S. Army Corps of Engineers
Tulsa District

June 2016

CH2M HILL Engineers, Inc.
401 S Boston, Suite 330
Tulsa, OK 74103-4425

Normandeau Associates, Inc.
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Arcata, CA 95521

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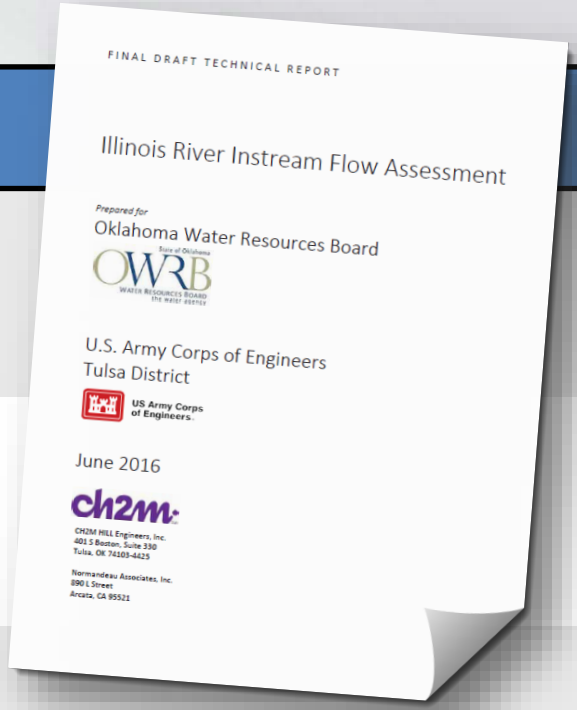
Agenda for Today's Discussion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Introductions and Goals for Today

ISF Pilot Study Overview

John Rehring, Carollo Engineers

Presentation:
Instream Flow Assessment Technical Study Findings

Forrest Olson, CH2M

Next Steps

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Illinois River Instream Flow Pilot Study
Technical Study Workgroup / Instream Flow Advisory Group Meeting

June 16, 2016

OWRB

Oklahoma City, Oklahoma

US Army Corps of Engineers

State of Oklahoma
OWRB
Water Resources Board
the water agency

Next Steps

- Public/stakeholder meeting in Tahlequah tonight (6:30 pm at the Armory Municipal Center)
- Next steps in the Pilot Study to assess ISFs in the Upper Illinois River basin
- Advisory Group role
- Information resources: ISF Website www.owrb.ok.gov/isf

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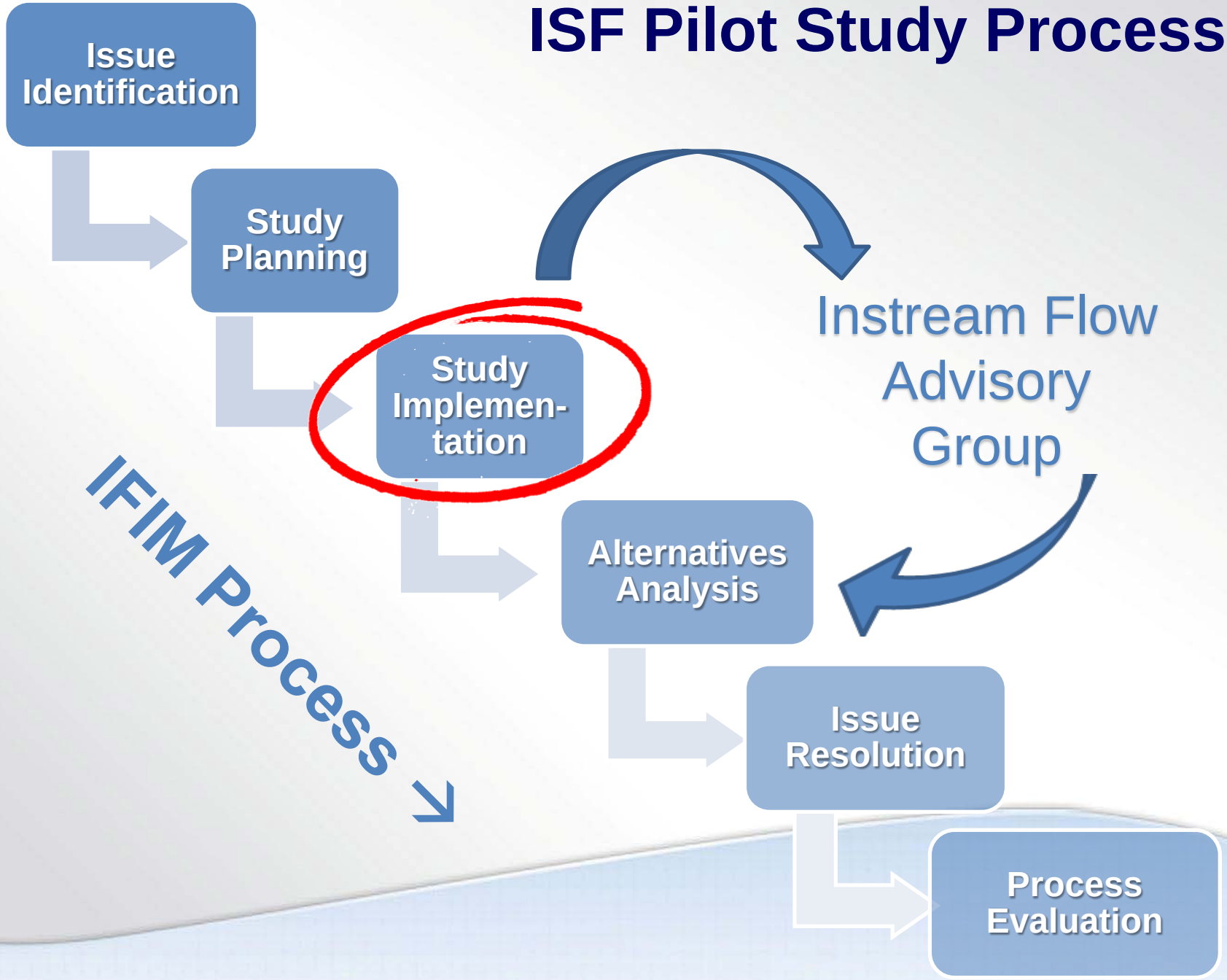
ISF Pilot Study Process



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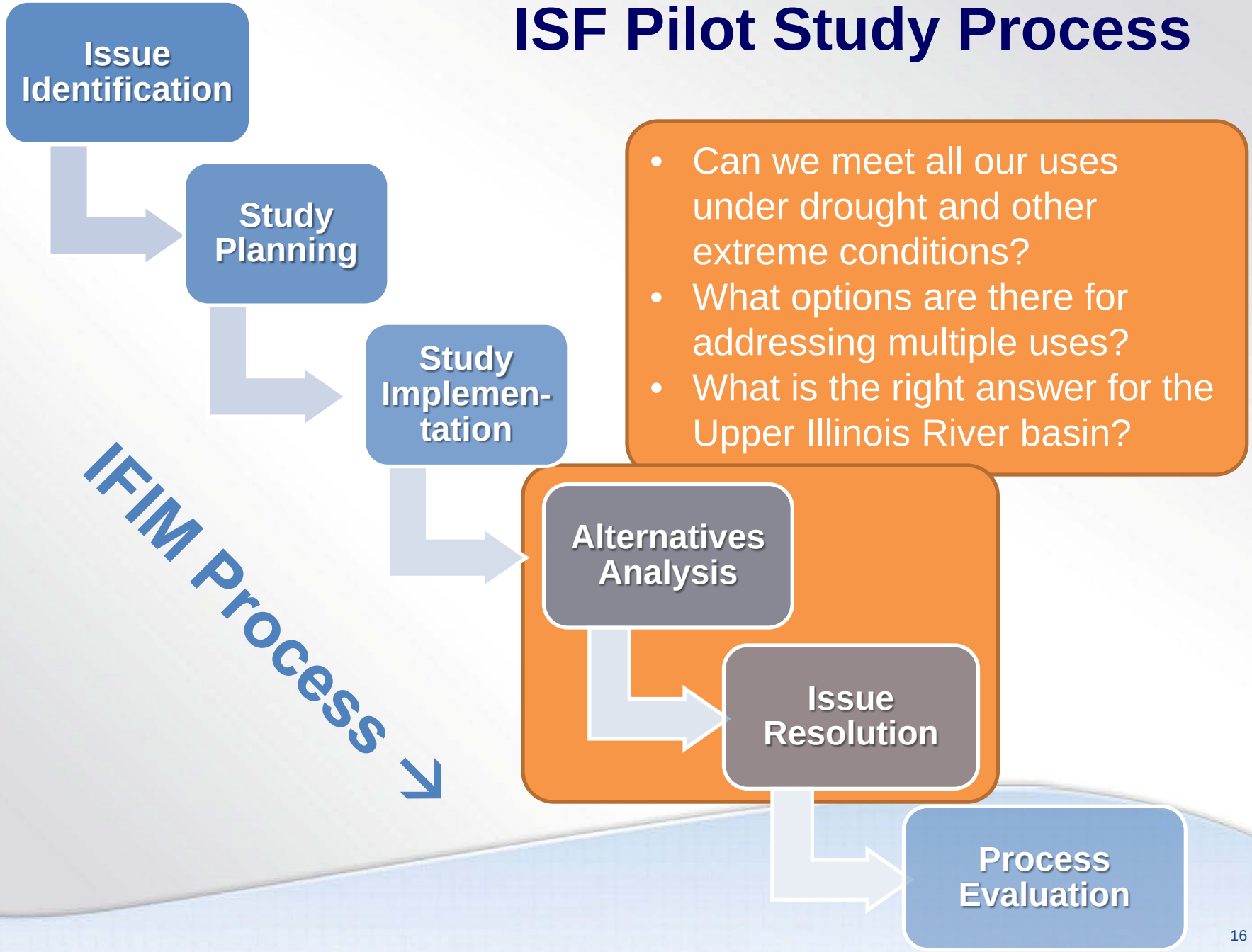
ISF Pilot Study Process



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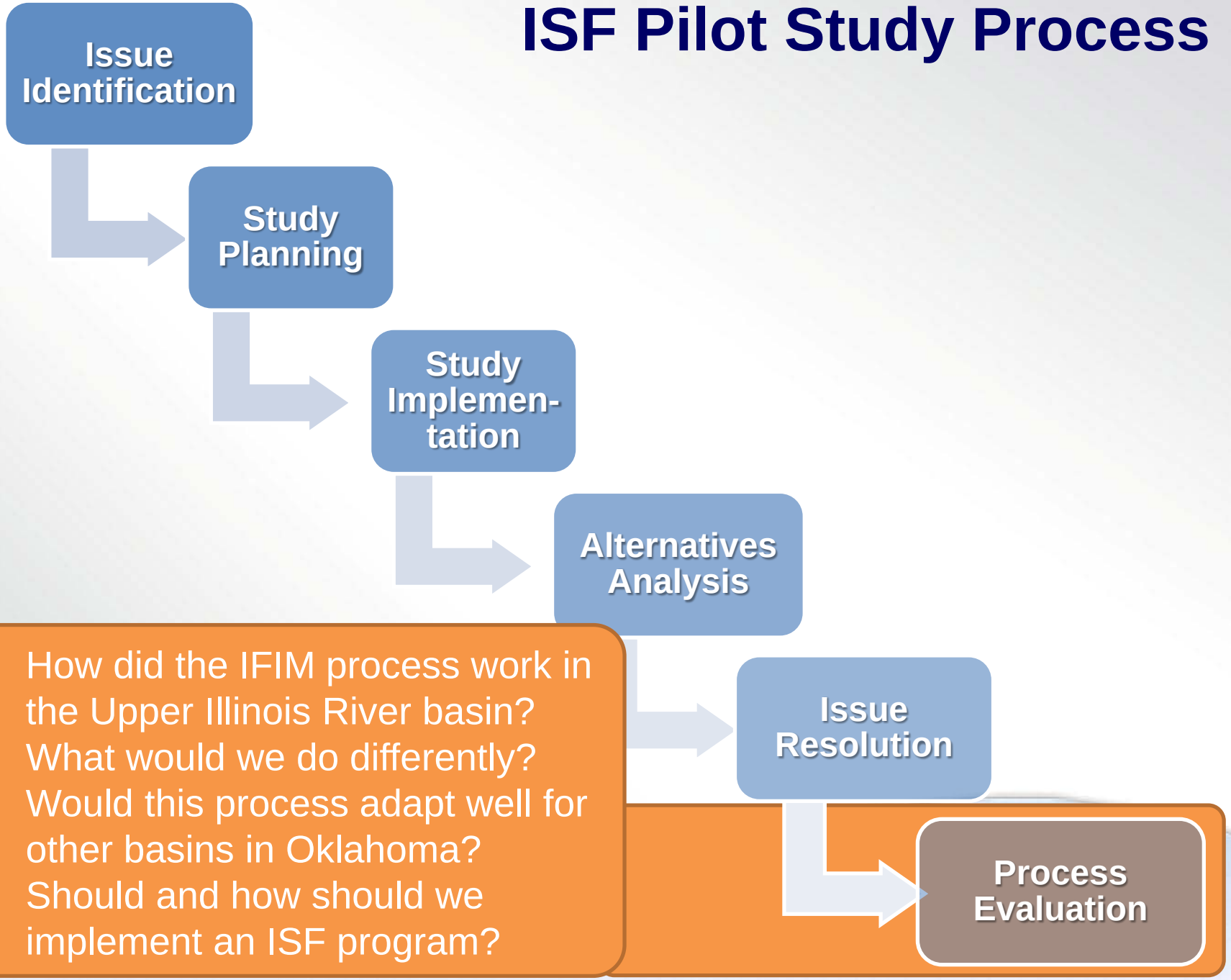
ISF Pilot Study Process



- How did the IFIM process work in the Upper Illinois River basin?
- What would we do differently?
- Would this process adapt well for other basins in Oklahoma?
- Should and how should we implement an ISF program?

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Illinois River Instream Flow Pilot Study
Technical Study Workgroup / Instream Flow Advisory Group Meeting

June 16, 2016

OWRB

Oklahoma City, Oklahoma

US Army Corps of Engineers

State of Oklahoma
OWRB
Water Resources Board
the water agency

Instream Flow Assessment of the Illinois River, OK

Summary of Technical Studies

Presented to
Oklahoma Instream Flow Advisory Group and Technical Study Work Group

Presented by
Forrest Olson, CH2M HILL

June 16, 2016

US Army Corps of Engineers

WRB

ch2m

What is an instream flow?

OWRB working definition of instream flow:

"Flows necessary to provide for a healthy ecosystem and support water-related recreation (such as fishing, hunting, swimming and boating) as well as tourism."

What are instream resources?

- Fisheries, wildlife, water quality, recreation, aesthetics, and the ecological processes that support these resources.

Technical Study Goal:

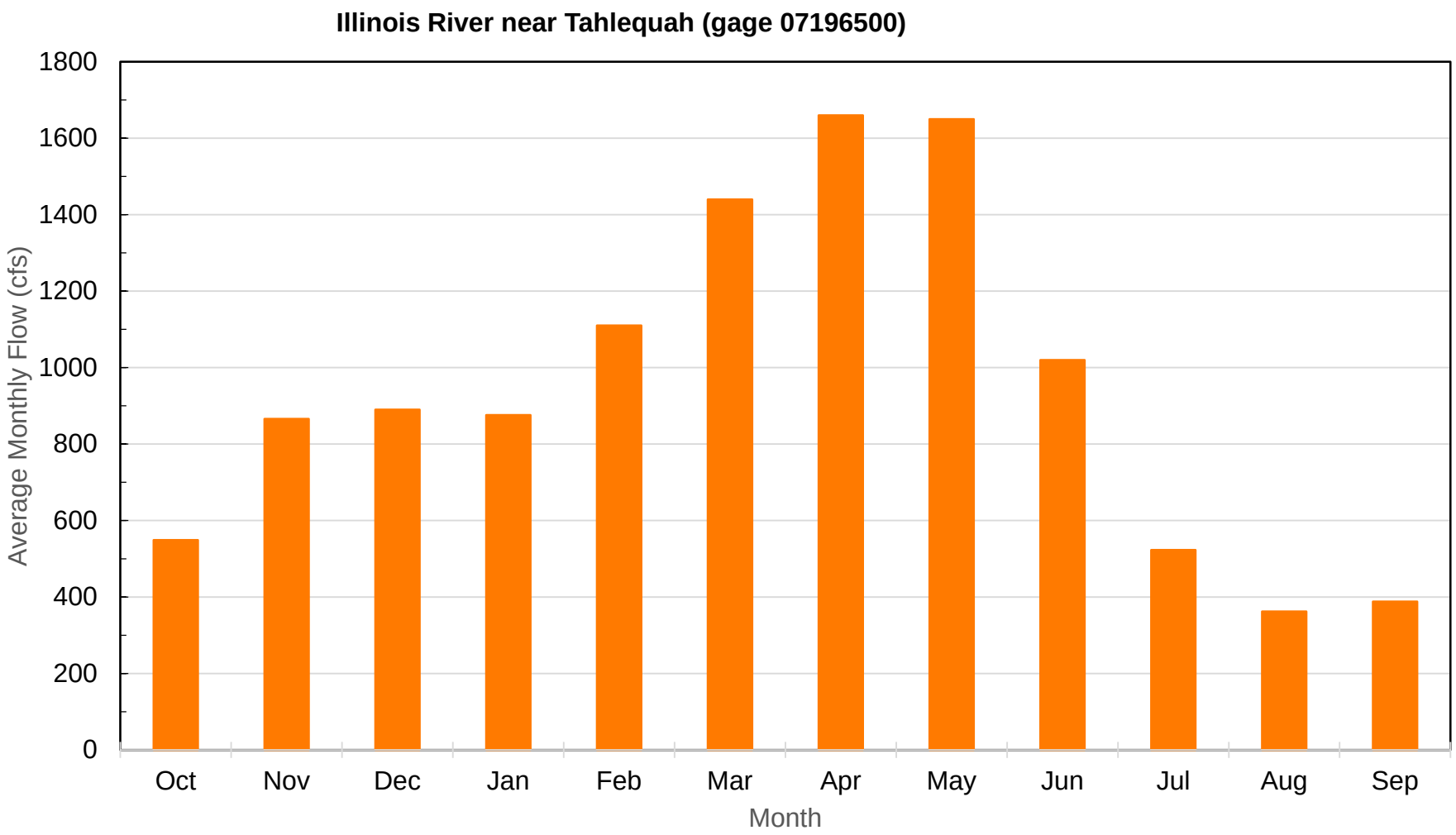
- Summarize technical resource information for use in supporting the decision making process in developing seasonal instream flow management prescriptions for the Illinois River including Barren Fork and Flint creeks.

*Note: This study is **not** being done in response to a proposed water development project.*

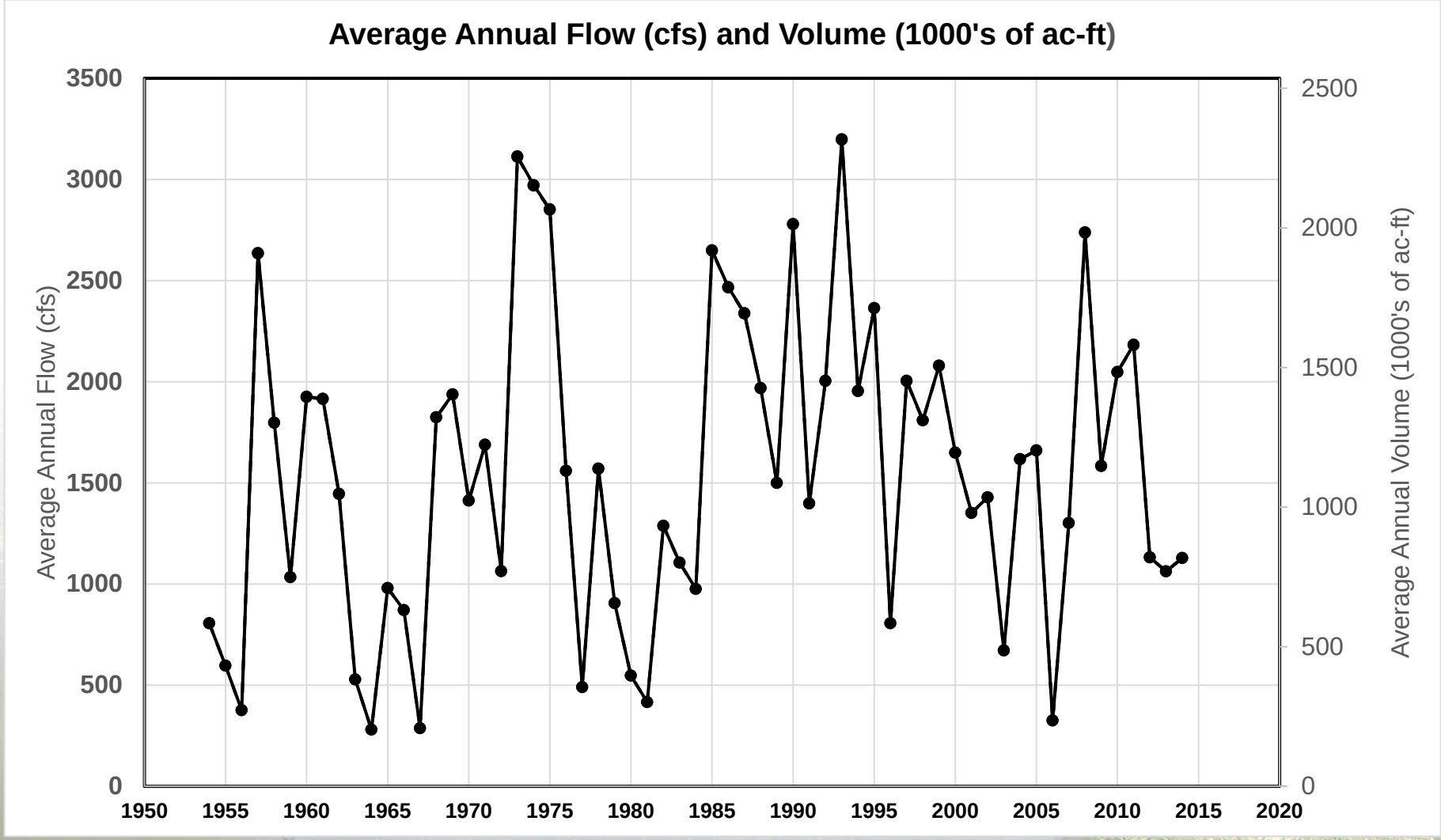
Study Area

Rogers
Springdale
Fayetteville
Kansas
Siloam Springs
Flint Creek
Osage Creek
Watts
Lake Francis
Illinois River
Illinois River
Westville
Arkansas
Oklahoma
Baron Fork Creek
Lincoln
Eldon
Tahlequah
Caney Creek
Stilwell
Lake Tenkiller
USGS Gage
City
Lake
Scenic River
Major Stream
Other Stream
N
W
E
S
0
5
10
Miles

Illinois River Average Monthly Flows



Average Annual Flows for the Illinois River near Gore



Illinois River December 27, 2015

Peak Flow Recurrence Intervals

Peak Flow Return Period (Year)	Probability (%)	Flow (cfs)		
		Illinois River near Tahlequah	Illinois River near Watts	Barren Fork at Eldon
2	50	19,535	18,868	16,250
5	20	38,289	33,947	29,836
10	10	53,919	45,185	37,328
25	4	77,173	60,390	44,675
50	2	96,925	72,233	48,789
100	1	118,643	84,362	51,962

Average Annual Surface Water Usage (acre-feet) in the Upper Illinois River Basin (OK) above and including Barren Fork

Water Use	Total	Percent of Total
Irrigation	1,301.4	10.8
Agriculture	0	0.0
Public Supply	10,751.4	88.9
Rec, Fish, & Wildlife	0	0
Commercial	0	0
Industrial	0	0
Mining	0	0
Other	35.1	0.3
Total	**12,087.9**	**100.0**

Groundwater Usage

Deep Bedrock Aquifer	3,900 acre-feet (water right)	Little effect on streamflows
Shallow Alluvial Aquifer	1,050 acre feet (est. usage)	Direct but delayed effect on stream

Alluvial Groundwater use is equivalent to 1.5 cfs, which is 0.11 % of basin yield

Water Use Summary:

1. Surface water use in Oklahoma portion of Illinois River above Barren Fork is only 1.3 % of the average annual basin yield
2. Most water use is for public supply – mostly Tahlequah
3. Basin water use in Arkansas is similar to Oklahoma in quantity and use category
4. White River water for Fayetteville area municipal use augments flows in Illinois River
5. Flow augmentation from White River may totally offset other surface water withdrawals in both states on annual average basis
6. Ground water use has minimal effect on streamflows

Water Quality

- Basin’s major water quality concern is nutrient loading, primarily phosphorus
- Phosphorus affects the Illinois River and Lake Tenkiller
- Phosphorus loading is trending downward in Illinois River and Barren Fork Creek, not in Flint Creek
- Phosphorus concentrations are related to streamflow, but indirect common effect of runoff
- Little evidence of contaminant concerns such as heavy metals or organics

Fisheries

1. Highly diverse fish community of >72 species
2. Nearly all fish species (except carp) are native to the basin
3. Smallmouth bass are the most sought-after game fish
4. The smallmouth bass are of the Neosho subspecies thus of high conservation value
5. No fish species are listed as federal or state threatened or endangered

Recreational Use

- Annual visitation ~400,000 to Scenic section
- Approximately 15 Commercial Floatation Device Operators
- Annual floaters (canoe, raft, kayak) ~150,000
- Annual recreational economic value (above Tenkiller) ~ $12 million
- Fishing is a popular activity, primarily for bass. No estimates of angler use or catch for Illinois River (some for Barren Fk)

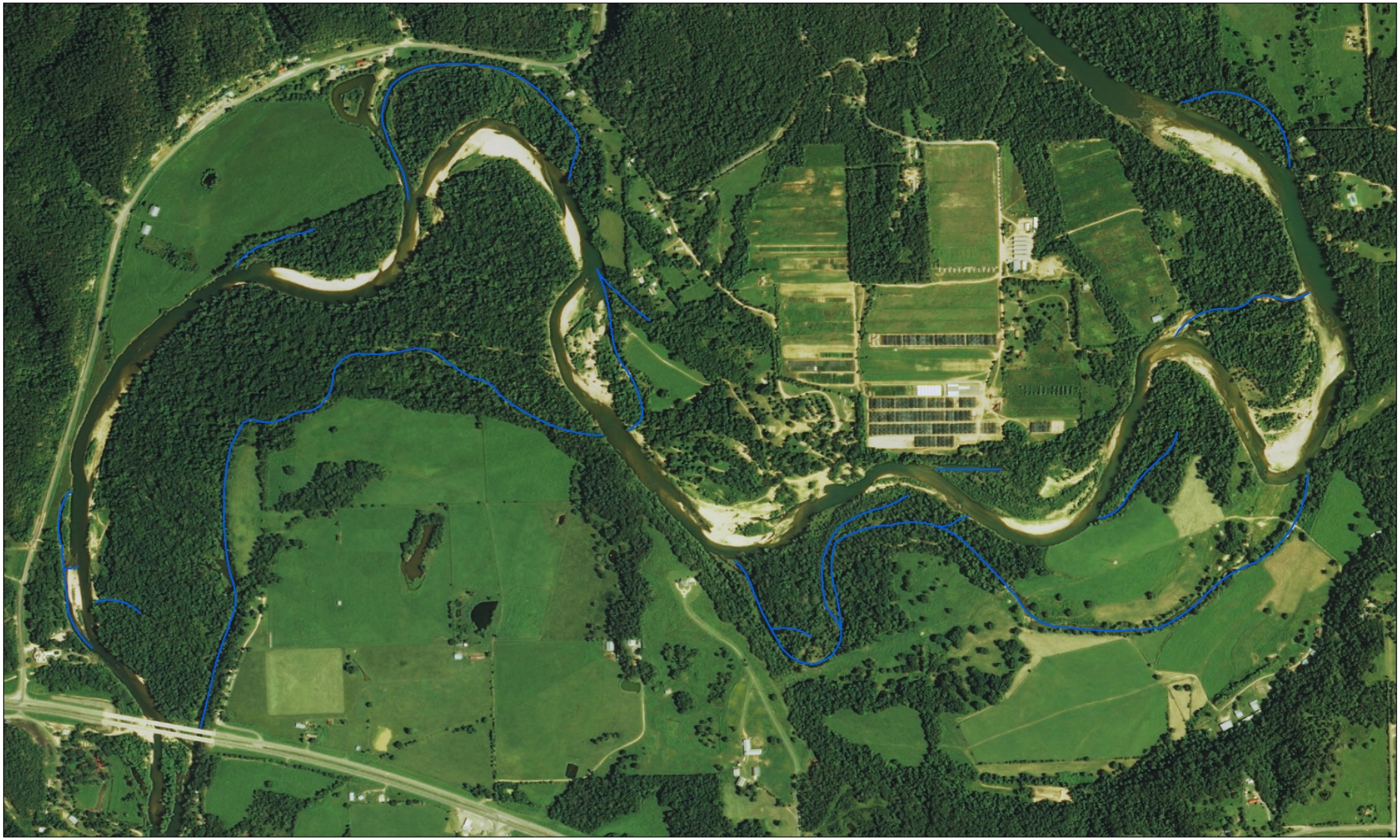
Illinois River Monthly Float Users, Average Annual for 2003-2008

Month	Commercial	Private	Total
January	1	35	36
February	2	34	36
March	110	19	129
April	348	81	429
May	9,938	411	10,349
June	22,734	681	23,415
July	37,441	1,094	38,535
August	24,540	804	25,344
September	8,657	400	9,057
October	878	93	971
November	76	24	100
December	6	48	54
Total	**104,731**	**3,724**	**108,455**

Flow Ranges for Recreational Floating (Tahlequah Gage) (source: OSRC)

Preferred range	400 – 1,200 cfs
Minimum for canoeing & kayaking	150 cfs
Minimum for rafting	250 cfs
Maximum for general safety	1,200 cfs
Maximum for experienced boaters	4,000 cfs

Riparian Corridor Secondary Channels



Ratio of secondary channel length to the main channel length in the Illinois River between Watts and Tahlequah, Oklahoma.

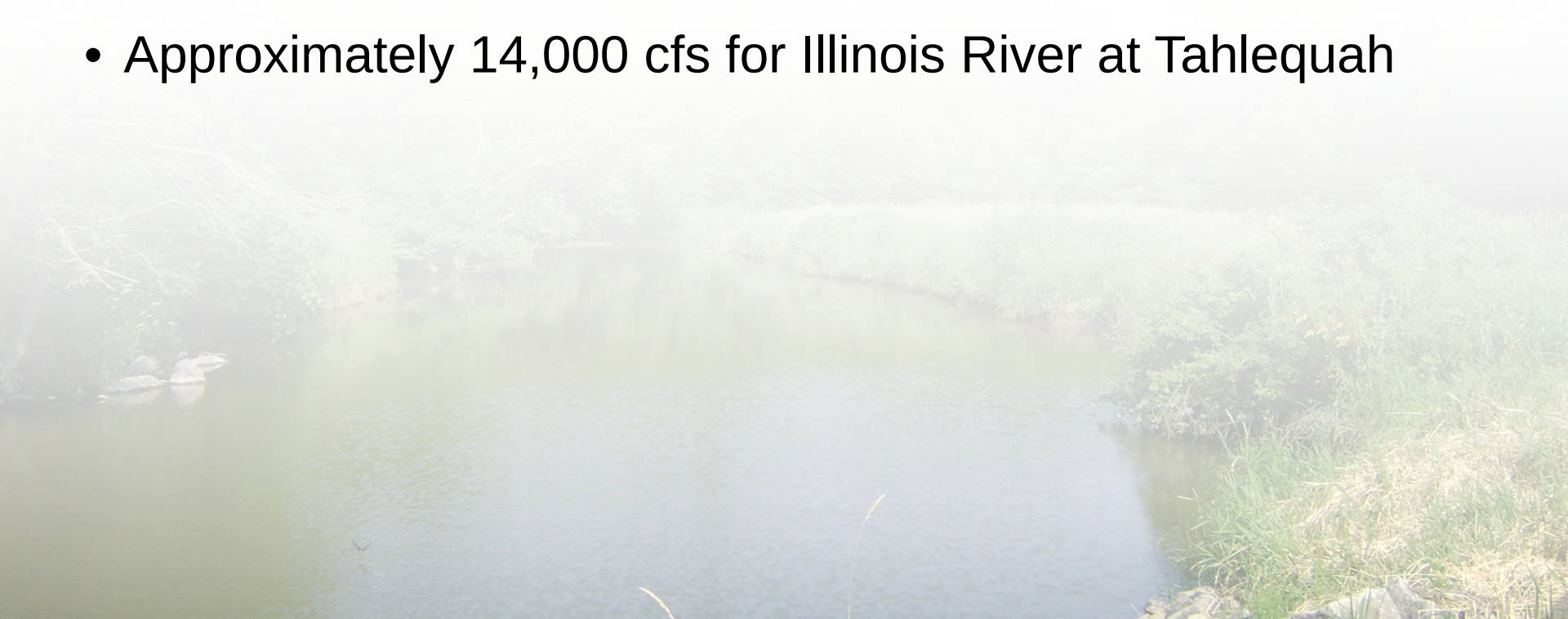
River Reach	Watts to Flint Creek	Flint Creek to Peavine	Peavine to Tahlequah	Total
River Reach Length (mi)	13.3	16.3	22.9	53
Secondary Channel Length (mi)	7.1	7.0	17.3	31.4
Ratio of 2ndary channel to main channel length	**53.1 %**	**42.9%**	**75.6%**	**59.2%**

Importance of Secondary Channels

- Rearing and refuge habitat for fish
- Support of many wildlife species that don’t tend to use the main channel
- Water quality (clarity and temperature)
- Floodwater relief
- Help govern the size and shape of the main channel

How to Protect Secondary Channels:

- Preserve bank-full/channel maintenance flows (frequency and magnitude)
- Typically equates to the 1.5-year recurrence flow
- Approximately 14,000 cfs for Illinois River at Tahlequah



Fish Habitat Modeling

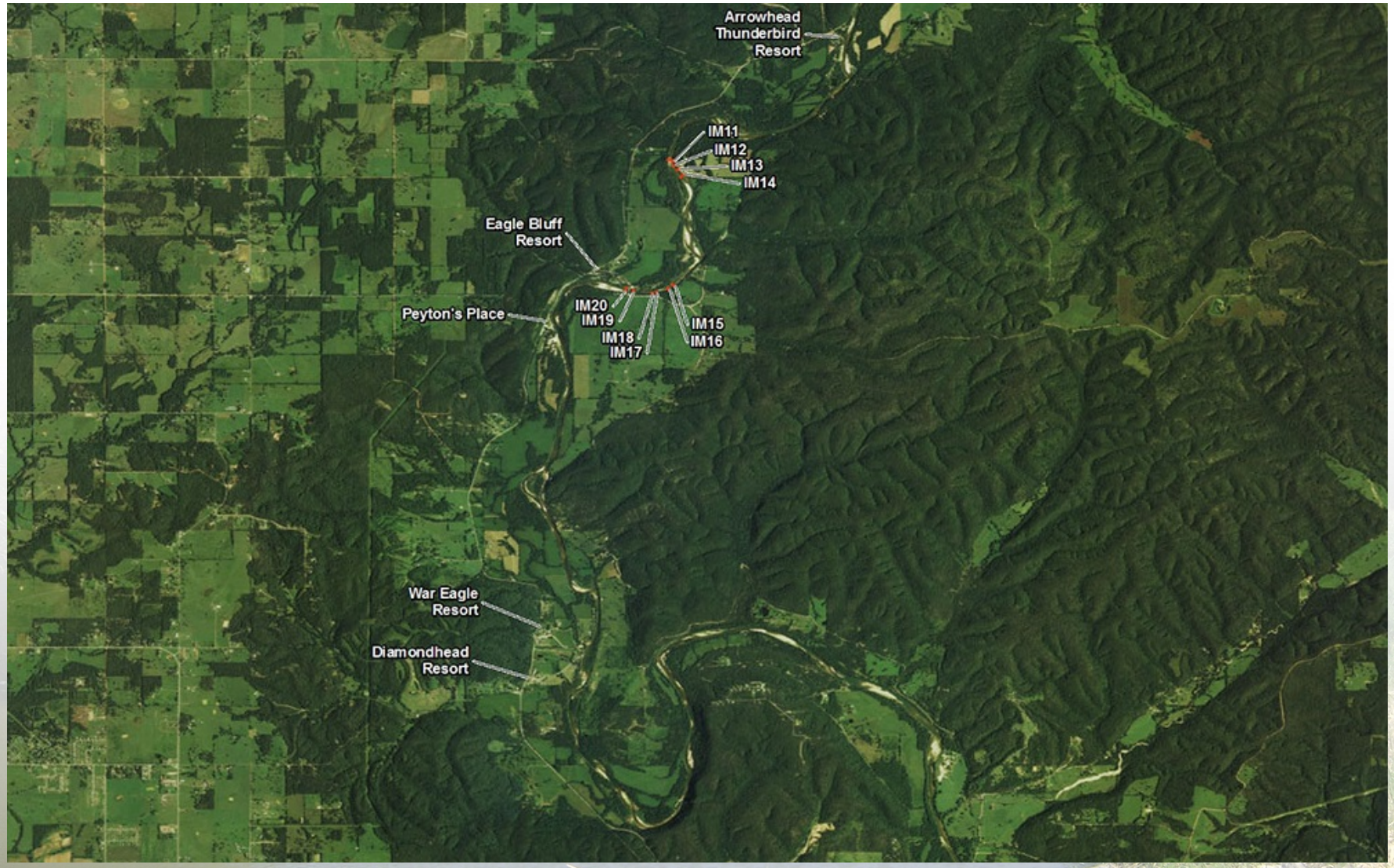
- Simple explanation of model
- Study sites (map with transects)
- Photos
- Results

Habitat-Type Survey Results (% by type)

Habitat Type	Illinois River	Flint Creek	Barren Fork Cr
Pool	57	35	42
Glide	12	20	0
Run	22	20	36
Riffle	9	25	22
Gradient ft/mi	**4.5**	**10**	**8**

Illinois River Habitat Study Transects

Illinois River Habitat Study Transects

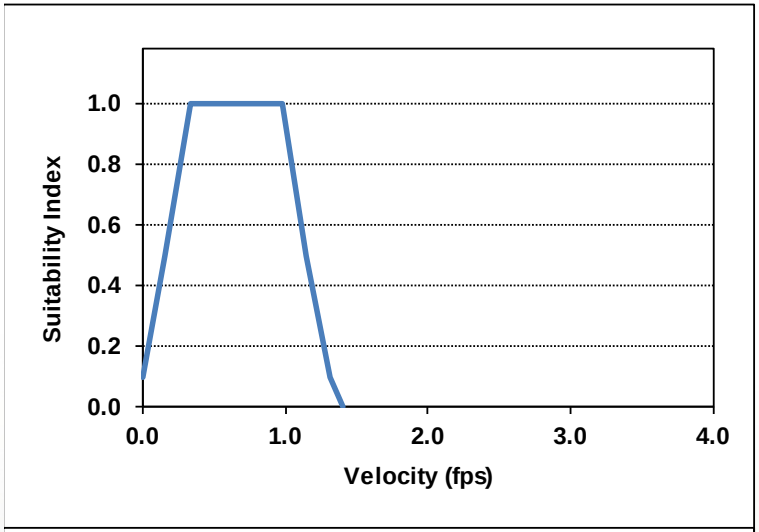


Flint Creek Habitat Study Transects

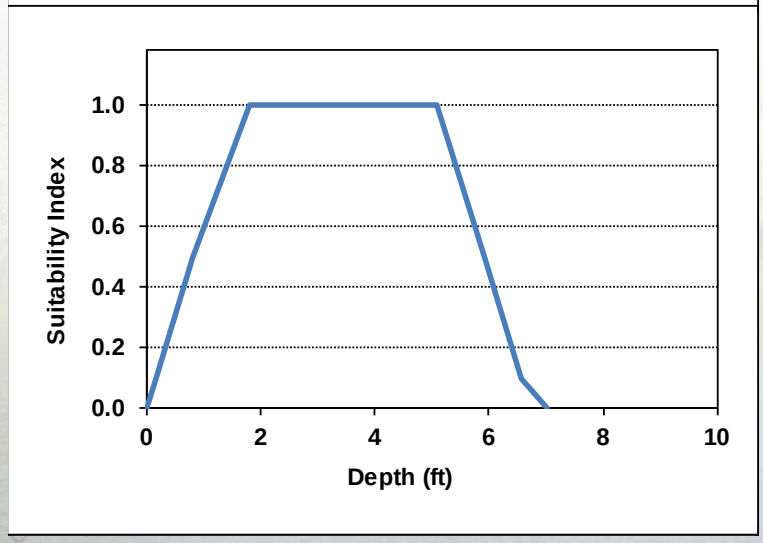
Fish Habitat Modeling

- Integrates a hydraulic model (that predicts water depths and velocities) with fish habitat criteria (expressed as preferred depth and velocity).
- Each measurement point (500-1,000) in the study site is evaluated separately as to its suitability for fish at a range of stream flows.
- The model then adds all the points (cells) together to get a total habitat vs flow relationship.

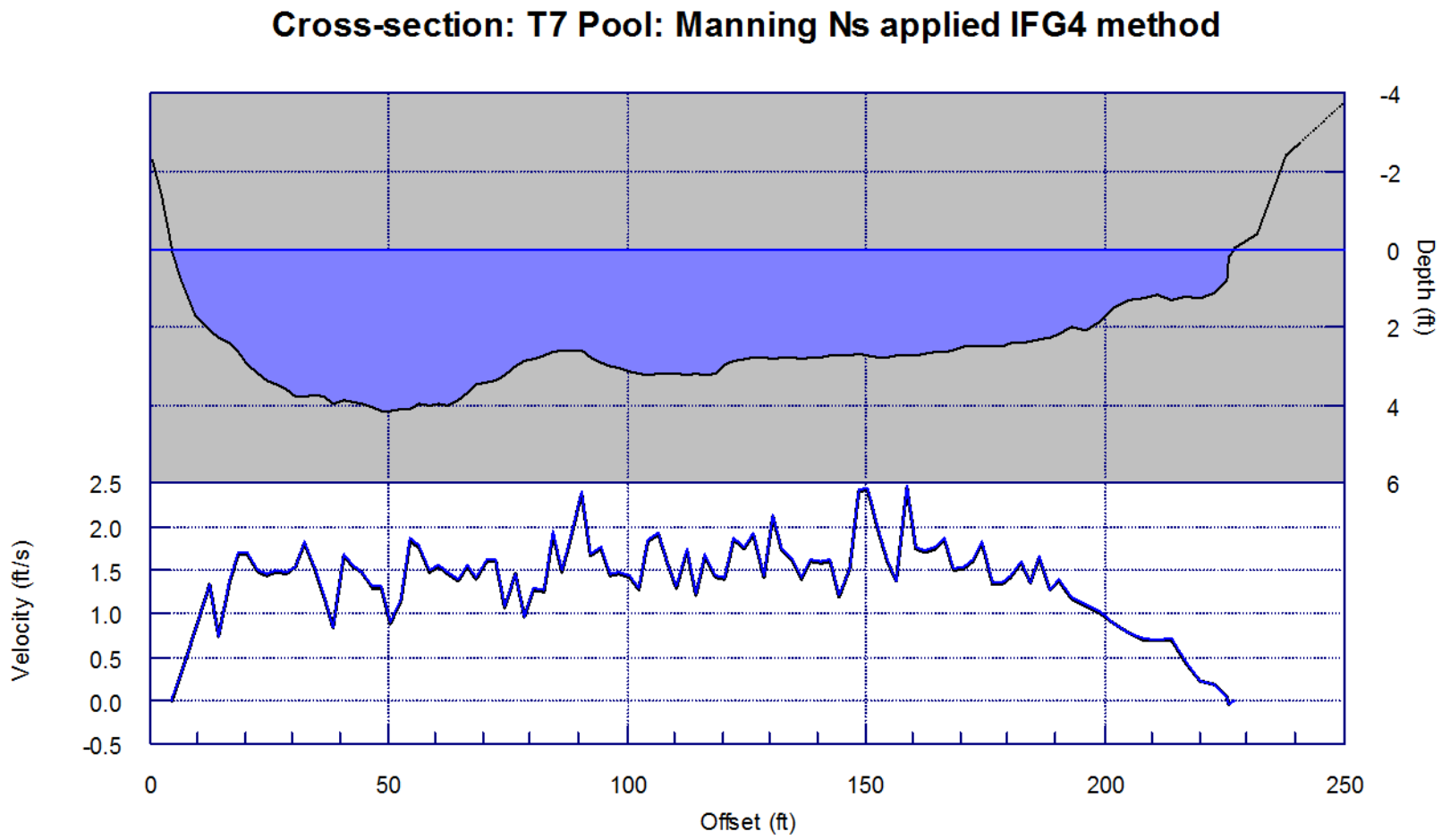
Smallmouth Bass Adult Habitat Criteria



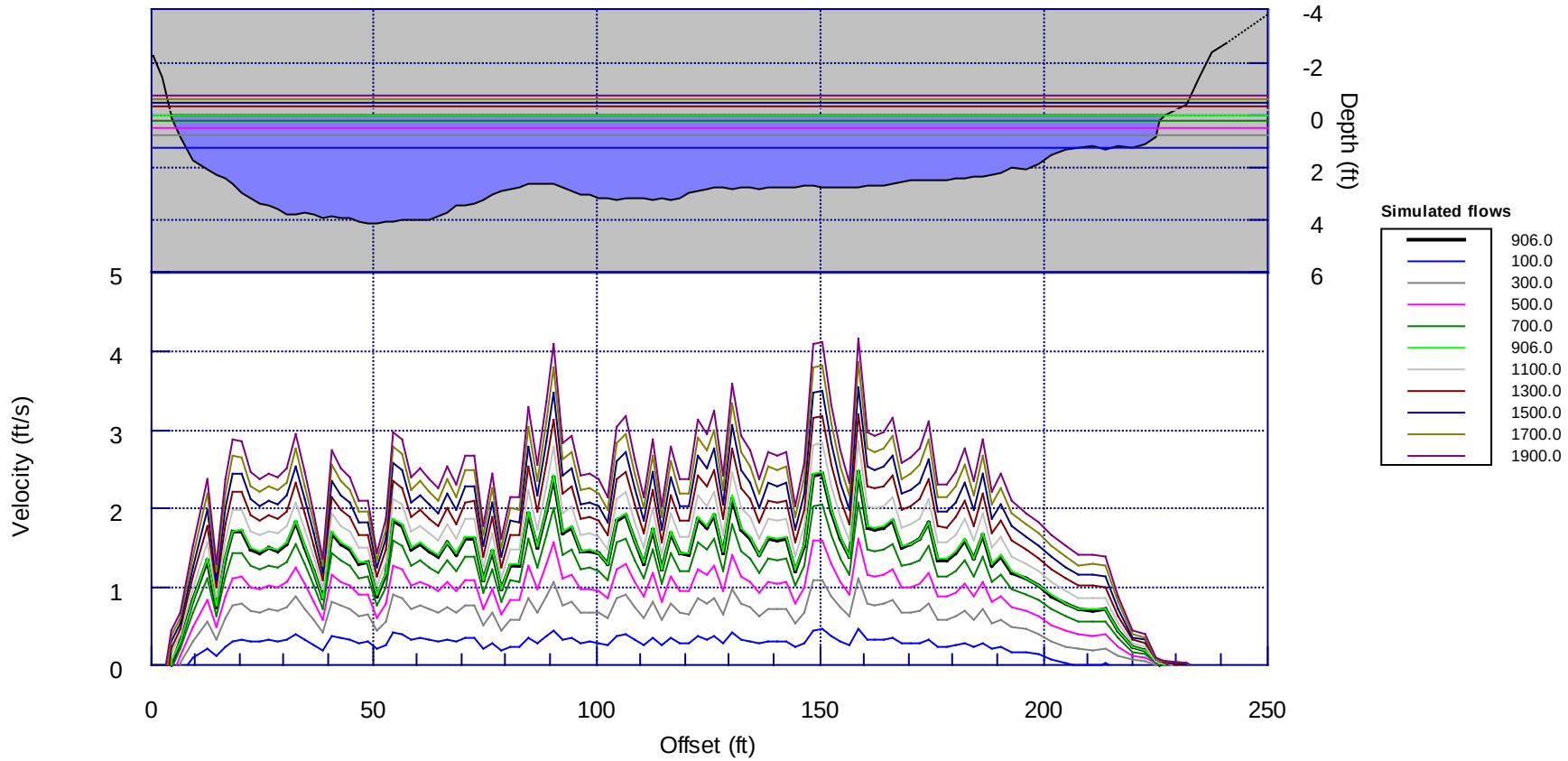
Velocity (ft/s)	SI
0.00	0.10
0.16	0.50
0.33	1.00
0.98	1.00
1.15	0.50
1.31	0.10
1.40	0.00



Depth (ft)	SI
0.00	0.00
0.16	0.10
0.82	0.50
1.80	1.00
5.09	1.00
5.91	0.50
6.56	0.10
7.00	0.00

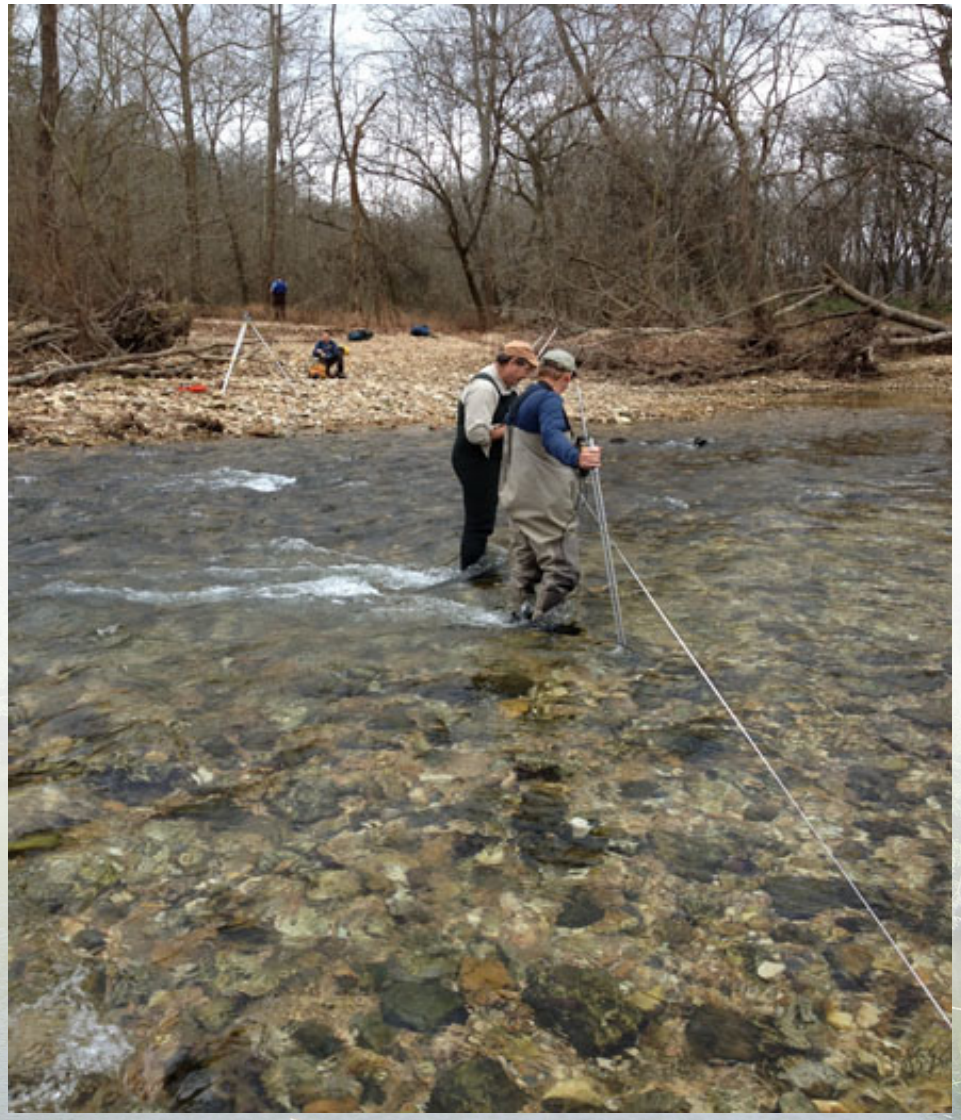

Cross-section: T7 Pool: Manning Ns applied IFG4 method
Depth (ft)
-4
-2
0
2
4
6
Velocity (ft/s)
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
0
50
100
150
200
250
Offset (ft)

Cross-section: T7 Pool: Manning Ns applied IFG4 method



Lower Flint Creek

Flint Creek Study Transect



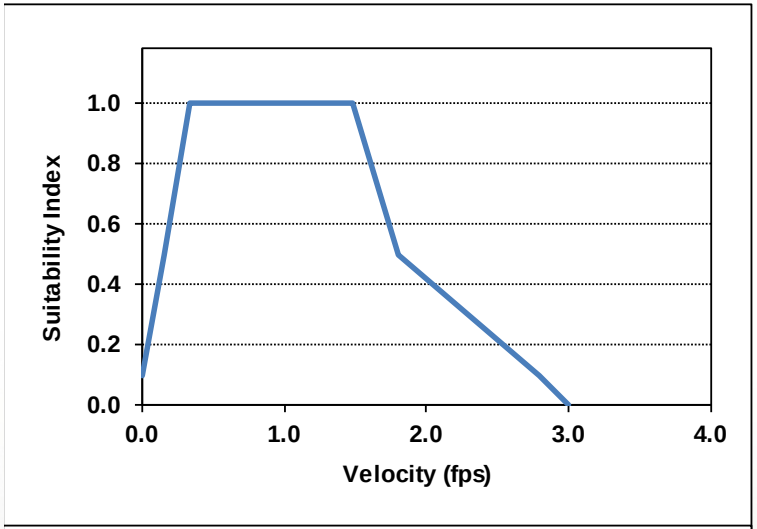
Lower Illinois River

Upper Illinois River Bedrock Pool Transect

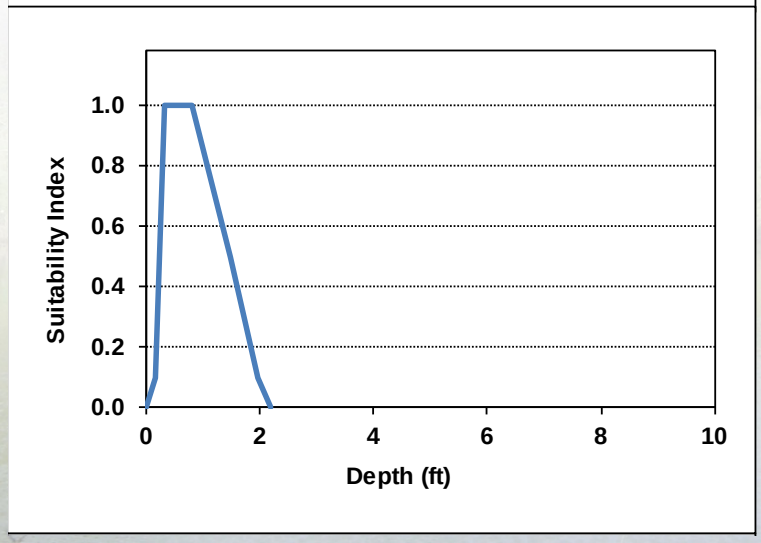
Fish Assemblages

Shallow Fast	Intermediate	Deep Slow
Darters (4)	Stoneroller (1)	Suckers (5)
Topminnow (2)	Chubs (3)	Sunfish (9)
Madtom (1)	Shiners (2)	Bullhead (3)

Shallow-Fast Habitat Criteria



Velocity (ft/s)	SI
0.00	0.10
0.16	0.50
0.33	1.00
1.48	1.00
1.80	0.50
2.79	0.10
3.00	0.00

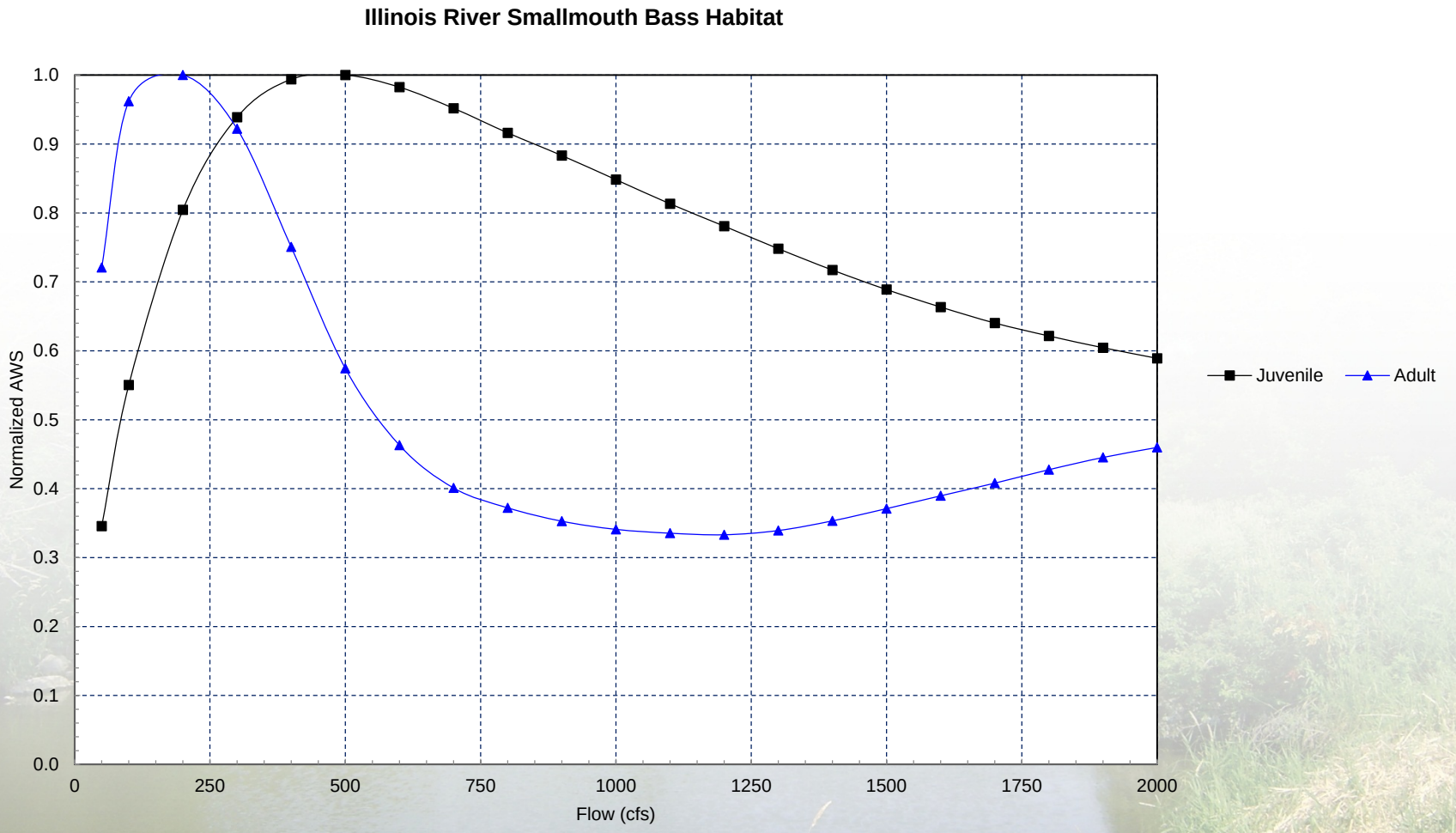


Depth (ft)	SI
0.00	0.00
0.16	0.10
0.33	1.00
0.82	1.00
1.48	0.50
1.97	0.10
2.20	0.00

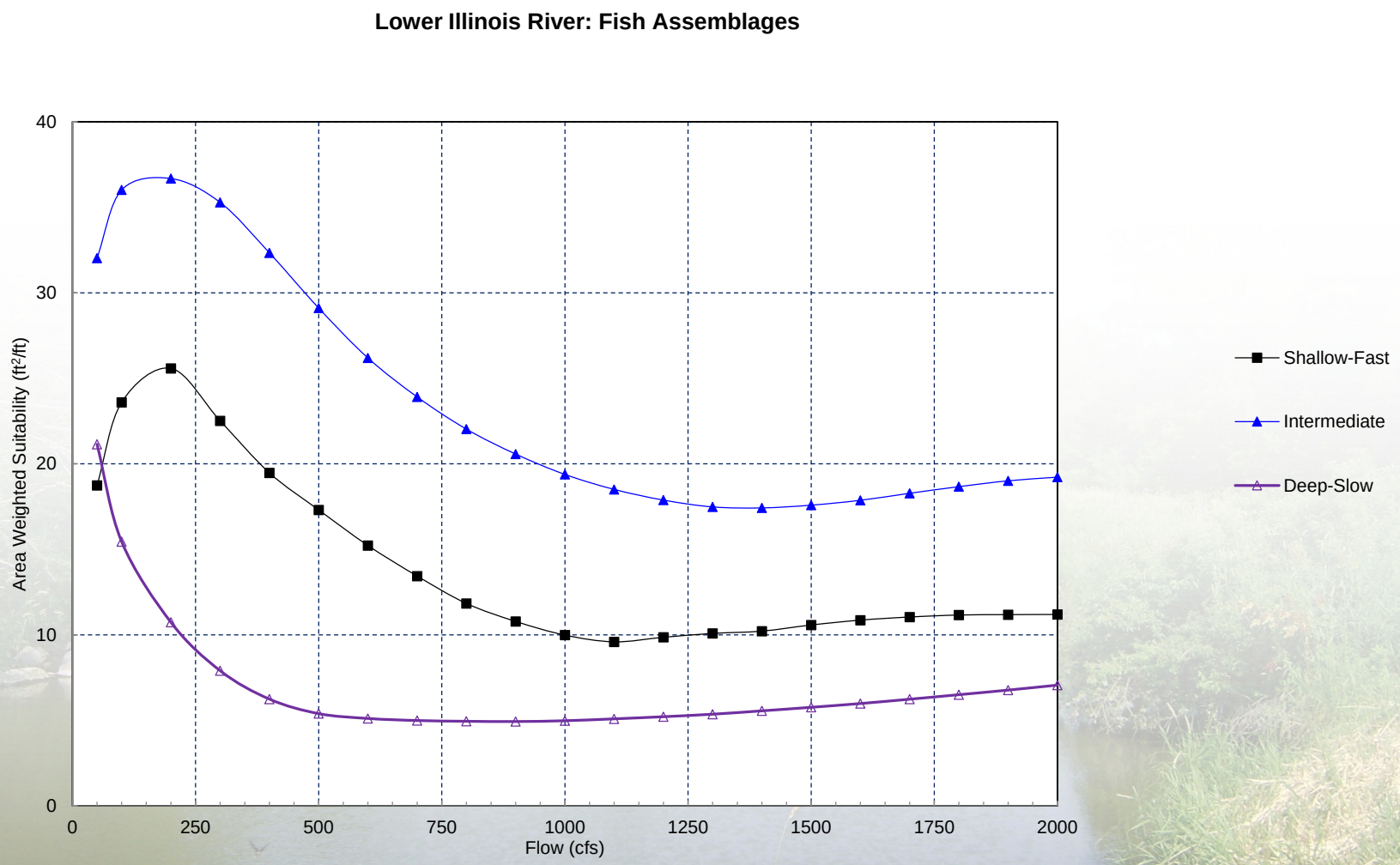
Median Stream Flows

Stream	Month					Average Median Flow
	July	August	September	October	November	
Illinois River	297	217	200	225	308	**249**
Flint Creek	40	31	29	31	49	**36**
Barren Fork Cr.	69	45	40	50	83	**57**

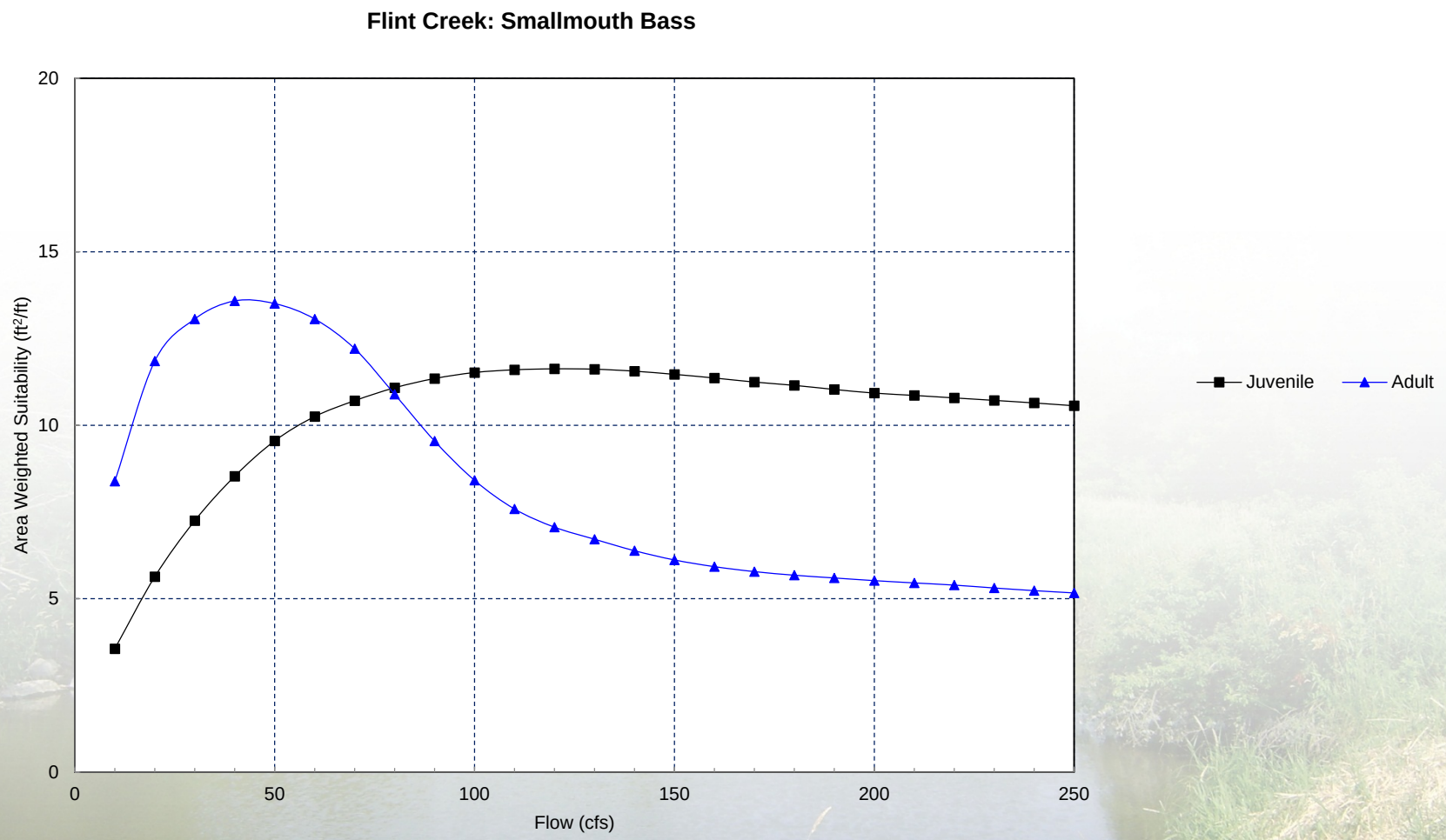
Illinois River Smallmouth Bass Habitat



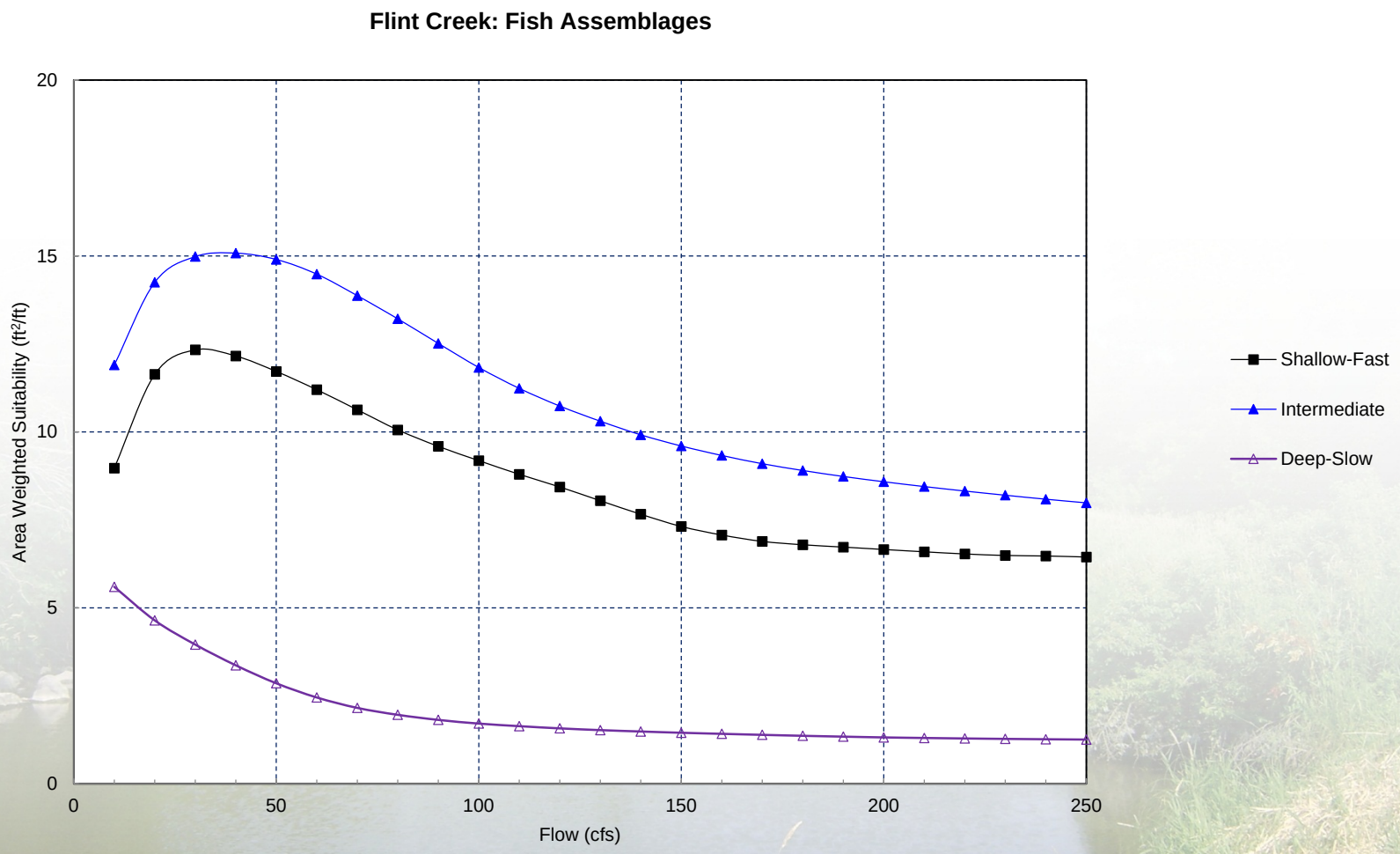
Illinois River Fish Assemblage Habitat



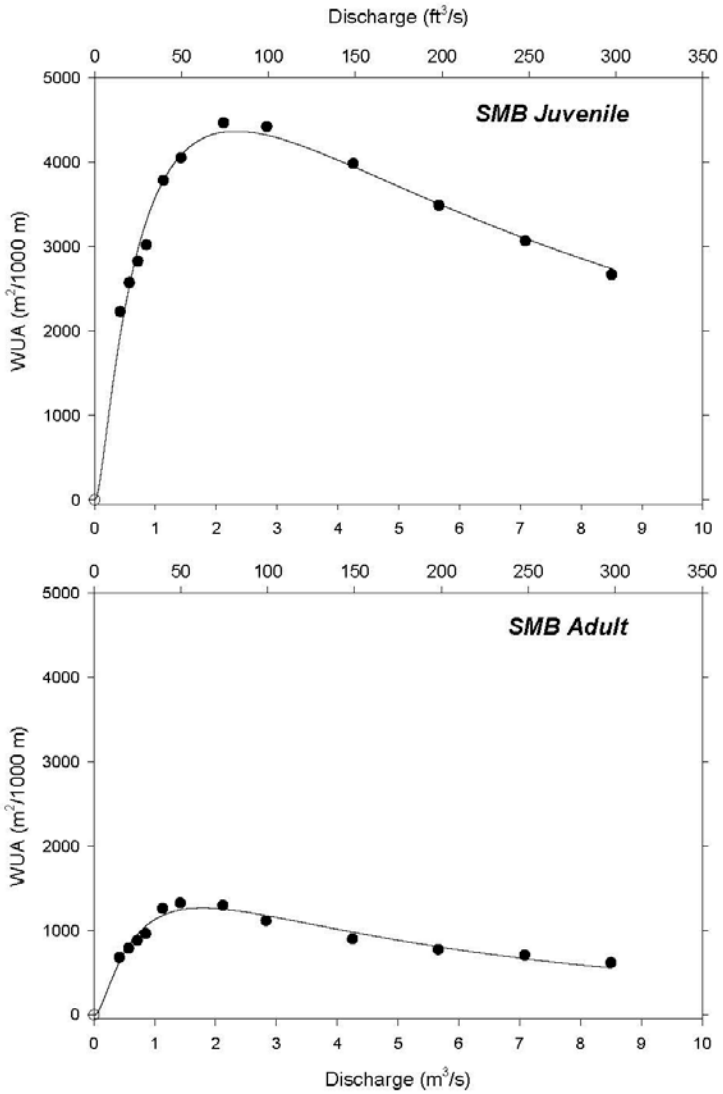
Flint Creek Smallmouth Bass Habitat



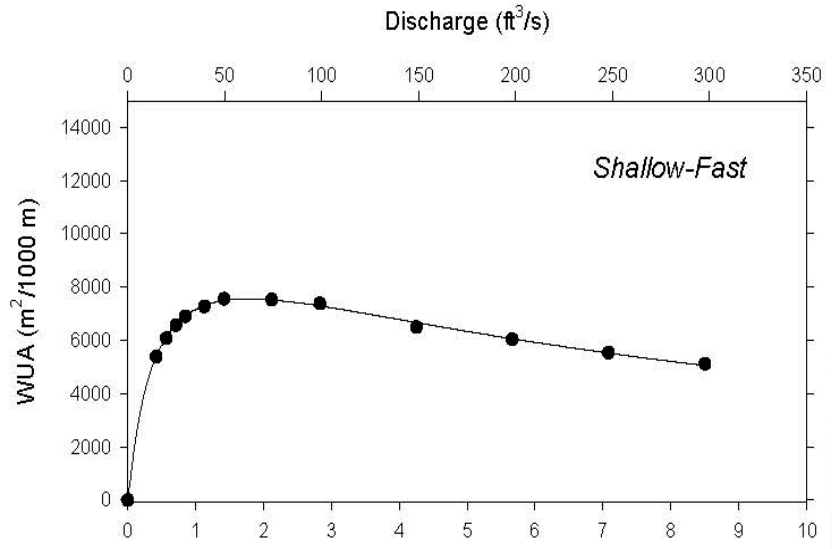
Flint Creek Fish Assemblage Habitat

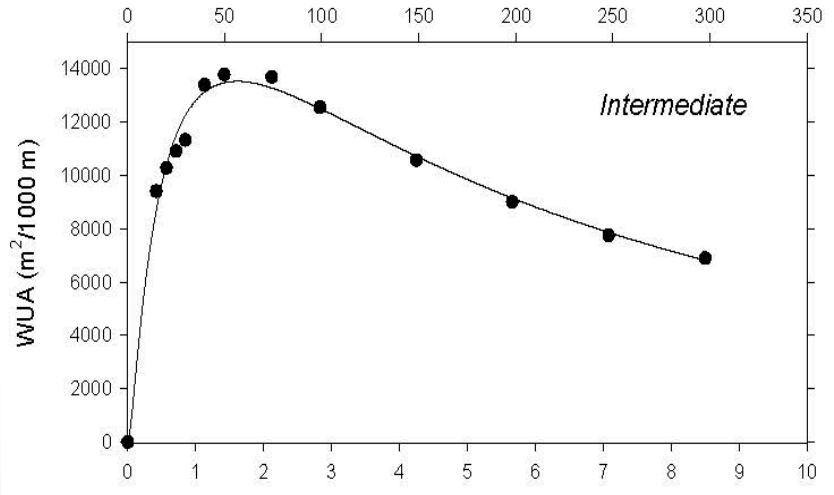


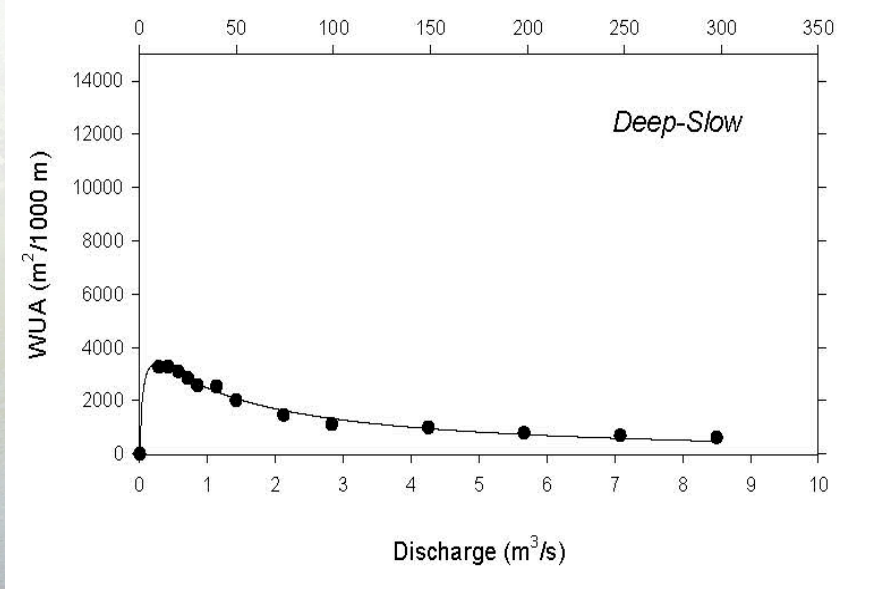
Barren Fork Creek Smallmouth Bass Habitat



Barren Fork Creek Fish Assemblage Habitat







Summary

- Flows in the Illinois River basin are largely unregulated
- Water diversions from the river are minimal (1-2%)
- Water quality is not a major issue related to instream flows
- The extensive riparian corridors support many important ecological process and resources
- The basin supports >70 species of <u>native</u> fish
- Illinois River supports recreational use of about 400,000 user days annually
- Summer/fall base flows average ~250 cfs (Illinois R), 36 cfs (Flint Cr), and 57 cfs (Barren Fork Cr)

Conclusions

- Preferred flows for Illinois River floating are 400-1,200 cfs
- Minimum flows for rafting (most popular means) is 250 cfs
- Flows providing good rearing habitat conditions for most fish species:
  - Illinois River : 100 – 300 cfs
  - Flint Cr : 20-60 cfs
  - Barren Fork Cr: 40-100 cfs
- Prescriptions for channel maintenance flows are important to preserve the ecological process associated with the study streams
- Desired flows for fish and recreation are not in conflict

Conclusions (continued)

- Decision Making Considerations:
  - River basin goals
  - All stream-related resources and priorities
  - Water availability
  - Ecological flow needs

Questions

Illinois River Instream Flow Analysis
Study Plan for Field Data Collection and Habitat Modeling

PREPARED FOR:	Oklahoma Water Resources Board
	U.S. Army Corps of Engineers, Tulsa District
PREPARED BY:	CH2M HILL
DATE:	September 24, 2015
PROJECT NUMBER:	652212

Introduction

In 2012 the Oklahoma Water Resources Board (OWRB) published its updated *Oklahoma Comprehensive Water Plan* (OWRB 2012). This plan as well as previous plans raised the issue of and made recommendations for evaluating non-consumptive uses of water including instream flows for environmental and recreational uses. Based on earlier recommendations the OWRB convened an Instream Flow Workgroup in late 2009 to solicit input from stakeholders and establish a path forward to further evaluate the need for and options for establishing an instream flow policy or program for Oklahoma. The Workgroup developed a report titled *Instream Flow Issues and Recommendations* (OWRB, February 2011). One of the recommendations in the report was to perform an instream flow pilot study on a state-designated Scenic River. In 2013, following completion of the 2012 Comprehensive Water Plan, OWRB created the Oklahoma Instream Flow Advisory Group to continue the efforts of the Workgroup. To further define whether and how an instream flow (ISF) program might be implemented, an ISF Pilot Study Approach was prepared and submitted to the OWRB, U.S. Army Corps of Engineers (ACOE), and the ISF Advisory Group (CH2M HILL June 15, 2014). The state-designated scenic reaches of the Illinois River and its tributaries, Barren Fork and Flint creeks, were identified as preferred study streams. The purpose of the pilot study is to gain a better understanding of the implications of a process to deal with instream flow issues consistent with the overall goal of managing water resources in Oklahoma for multiple uses. The Instream Flow Incremental Methodology (IFIM) was deemed most suitable for addressing the prevailing comments and concerns of the ISF Advisory Group. The fact that this will be a “pilot” study suggests that modifications to the approach or perhaps inclusion of other approaches and methods might be deemed appropriate for future studies for this or other river basins in Oklahoma.

The IFIM is a decision-support process that provides a comprehensive technical framework for addressing streamflow needs for fish and other aquatic resources while incorporating consideration of the institutional environment (i.e., recreational interests and consumptive water uses such as public water supply, crop irrigation, power generation, and industrial uses). It is the most commonly used and accepted methodology by state and federal agencies in the United States and internationally. The methodology typically is used to assess impacts of specific water development proposals (for example, a water diversion) where alternative stream flow regimes can be assessed. However, this is not the circumstance for the Illinois River, which is an unregulated stream with no foreseeable water development projects being contemplated. Therefore, the IFIM methodology for use for the Illinois River will have to rely on a range of “generated” instream flow alternatives to facilitate the “alternatives

analysis" and "issue resolution" steps. This will allow the habitat modeling component (Physical Habitat Simulation [PHABSIM]) of the IFIM to be used as a primary source of scientific information when establishing instream base-flow guidelines or standards even in the absence of a water development proposal. This is the intent of incorporating the PHABSIM results into the Illinois River Pilot Instream Flow Study.

The first phase of the IFIM includes identifying issues and watershed goals, and summarizing existing background information associated with instream resources in the study area. That effort began with a stakeholder meeting held in Tahlequah, OK, on January 22, 2015 sponsored by the OWRB and the Tulsa District of the ACOE. The background information review has been largely completed, and the draft report is currently under final review (as of September 11, 2015).

The second phase of the IFIM is to develop a technical study plan that describes the field data collection, PHABSIM modeling components, and associated cost estimates for the overall Illinois River Instream Flow Study. That is the focus of this document.

The methods described in this technical Study Plan support the Oklahoma Instream Flow Pilot Study Approach and are based upon standard procedures outlined in various IFIM manuals as well as discussions with OWRB and ACOE staff who helped develop and approve the general approach and scope of work for the project. In addition, a Technical Study Workgroup (TSWG), established by OWRB, provided input and suggestions to this plan. The TSWG also will help implement the study and provide important background information about the river's resources. This background information together with the results of the PHABSIM study component will be used to inform the decision making process regarding instream flow recommendations for the study streams. This study plan does not provide details of the decision making process, which will encompass the alternatives analysis and issue resolution steps. This process has yet to be defined by OWRB.

The Illinois River Instream Flow Pilot Study includes the state-designated Scenic reaches of the Illinois River including its two primary tributaries, Barren Fork and Flint creeks. A PHABSIM study has already been completed on the Barren Fork by Oklahoma State University (Fisher and Remshardt 2000) and those results will be incorporated into the overall Illinois River study. For consistency, many of the methods and criteria used in the Barren Fork study have been incorporated into this Illinois River study plan, as described below.

Illinois River Management Goals

Identifying management goals for a particular stream or river basin is an important early step in determining what types of information and studies are needed to further those goals. The Illinois River Management Plan (Oklahoma Scenic Rivers Commission 1999) lists 10 management goals for the river and its corridor. Of these, three relate directly to instream flows: 1) conserve and enhance instream biological and physical resources such as native fish and their habitats, and water quality, 2) maintain long-term protection of important instream and shoreline resources, including free-flowing character, water quality and quantity, and fish habitat, and 3) provide a diversity of high quality recreation opportunities that are compatible with each other and with river resources. These goals are consistent with the OWRB definition of instream flows as presented in the 2012 Oklahoma Comprehensive Water Plan (OWRB 2012): "flows necessary to provide for a healthy ecosystem and support water related recreation such as fishing, hunting, swimming and boating as well as tourism." The ultimate purpose of the Illinois River Instream Flow Pilot Study is to provide technical information to help formulate instream flow recommendations that would be consistent with these basin goals while recognizing the need to balance all beneficial uses of the water. The "pilot" component of the study is meant to assess how well

the study approach works for the Illinois River and how the approach might be applicable (with modifications) to other streams in Oklahoma.

PHABSIM Study Objectives

This study plan details the use of the PHABSIM portion of the IFIM process for assessing base flow needs for fish resources. The PHABSIM study will be used to determine the incremental relationship between stream flow and an index of habitat suitability, referred to as weighted usable area (WUA) or area weighted suitability (AWS) for various life stages of selected fish species or groupings (guilds) in the study area. PHABSIM is not used to assess flows associated with other ecological processes and functions of the stream, although the hydraulic models developed as part of PHABSIM can be useful for assessing some of these processes (e.g. bedload movement). Because stream flows in the Illinois River and its major tributaries are largely unregulated, an assessment of the higher flows needed for these stream processes should be able to be based on the common hydrologic indices typically associated with these processes.

PHABSIM relies on the collection of empirical hydraulic data used in the calibration and computer simulation models, plus fish species/life stage suitability criteria (also called habitat suitability criteria, or HSC) for the major habitat component variables of velocity, depth, and substrate/cover. The AWS index can be interpreted in the context of stream hydrology and species life history to evaluate impacts, and serves as a partial basis for determining alternatives and mitigation, along with the results of other studies. Since AWS does not represent actual physical area, it is more accurately described as an index that can be used comparatively to assess flow relationships with physical habitat.

The PHABSIM study has the following objectives:

- Verify and/or develop habitat index-flow relationships (AWS) for selected life stages of target fish species or groupings of fish species (guilds).
- Provide a calibrated hydraulic data file for potential application to habitat suitability indices for subsequently identified fish species, habitat guilds, or fish passage needs.
- Provide additional physical habitat information for application to other studies (e.g., riparian vegetation, water quality, recreational boating, or substrate particle incipient motion analyses) that may be part of the instream flow assessment.

Use in Decision Making

The results of the PHABSIM study are intended to provide information on habitat-flow relationships that, together with environmental data and results of other past and ongoing studies, can be used to assess effects of various flows on fish resources and to help formulate recommendations for protection of important instream resources consistent with agency management goals. Ultimately, the results of the PHABSIM study will be used in conjunction with known information for other stream-related resources (such as water quality, recreation, terrestrial, cultural, and sediment movement) and in consideration of potential future out-of-stream water uses (e.g. municipal) to recommend instream flows that best meet the multiple objectives of the watershed.

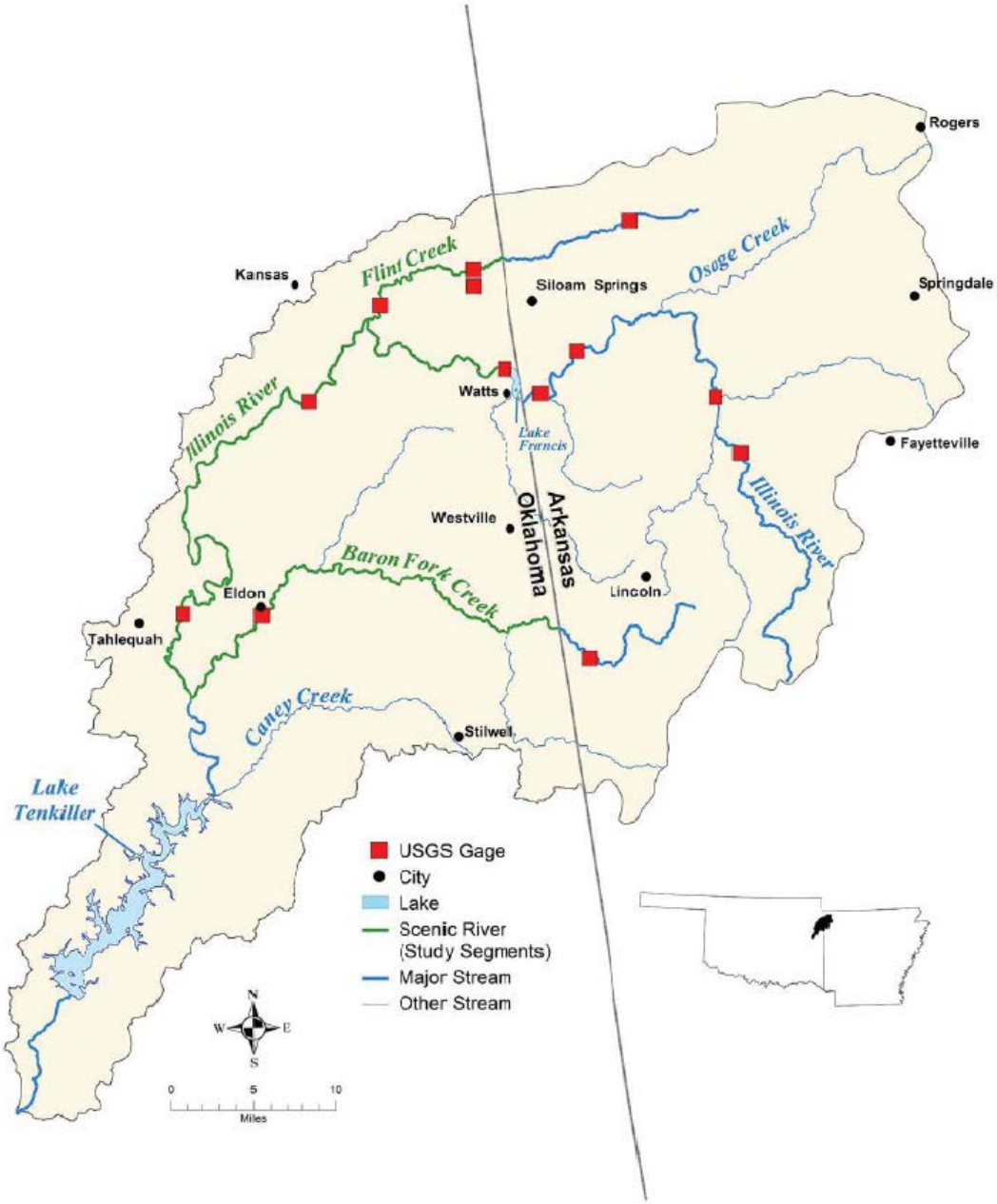
Study Area and Reach Boundaries

The geographic scope of the study includes the state-designated Scenic section of the Illinois River including Flint and Barren Fork creeks, which are also designated as Scenic (Figure 1). The Illinois River study area extends from the Oklahoma-Arkansas state boundary downstream to the confluence with Barren Fork Creek, a distance of about 60 miles. The 2-mile section of the Illinois River from Barren Fork to Tenkiller Reservoir and the 9-mile section below Tenkiller Dam to the Arkansas River confluence are

not part the study area. Twelve miles of Flint Creek is included upstream to the Arkansas state line. The Barren Fork Creek study area (Scenic reach) extends from its confluence with the Illinois River upstream to the Highway 59 Bridge, which is approximately 7 miles from the Arkansas border. The upper Illinois River and these sections of the two tributaries were designated as Scenic Rivers per the Oklahoma Scenic Rivers Act of 1970 (82.0 Sections 1451-1471).

Reach boundaries for PHABSIM study application are identified where major changes to the channel form or streamflow characteristics occur. Confluences with a tributary contributing more than 10% of the flow is a common reach boundary descriptor. A major change in gradient or valley width (often related) also constitutes consideration for reach boundaries. Gradient changes typically produce differences in the ratio of mesohabitats (e.g. pools, riffle, and runs), which usually can be observed on aerial or satellite photographs as well as seen during ground observations. Longitudinal gradient profiles for the Illinois River, Barren Fork Creek and Flint Creek are shown in Figures 2, 3, and 4.

FIGURE 1
Illinois River Study Area



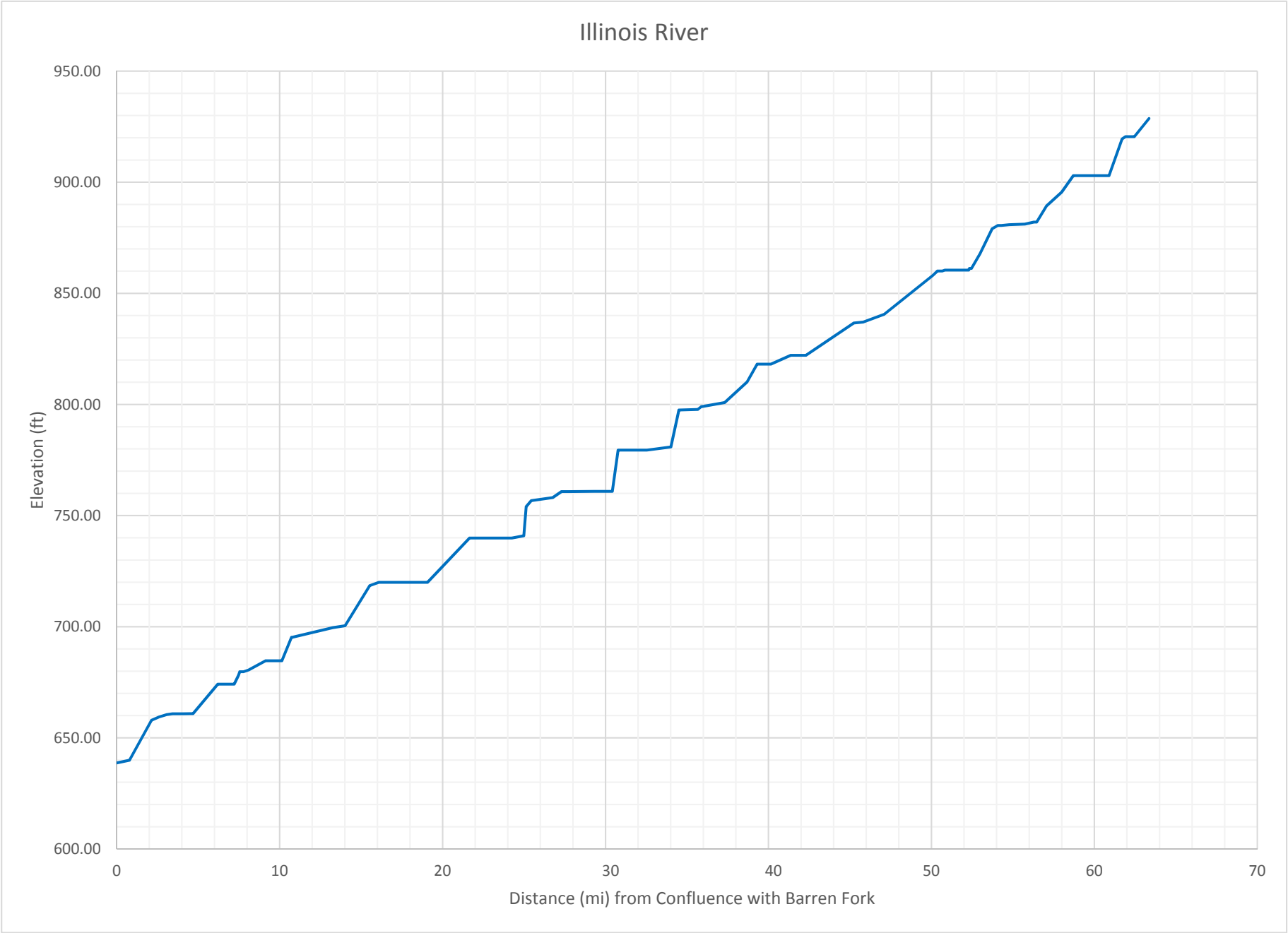


FIGURE 2
Illinois River Elevation Profile

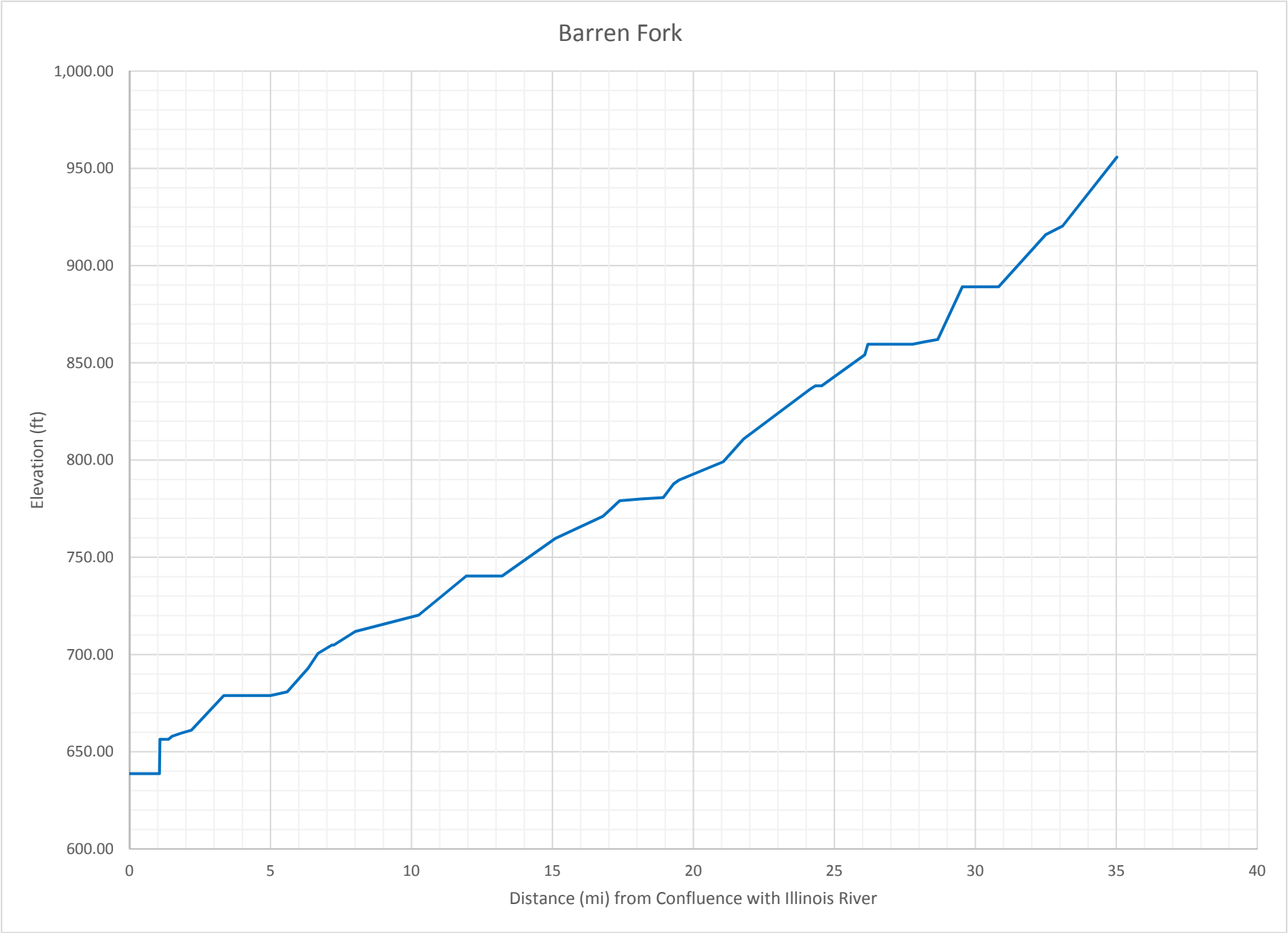


FIGURE 3
Barren Fork Creek Elevation Profile

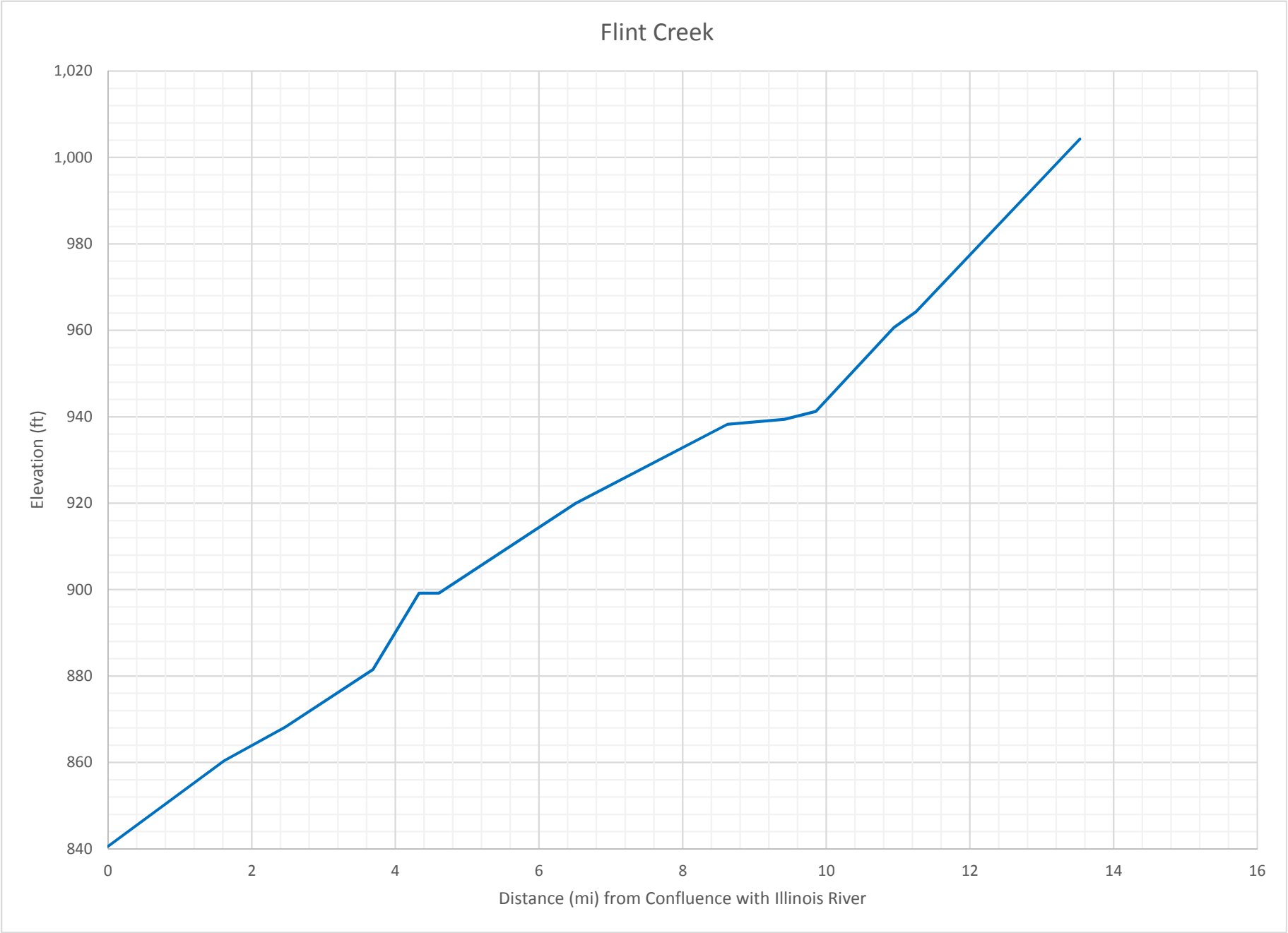


FIGURE 4
Flint Creek Elevation Profile

The gradient of the 63-miles of the Illinois River in the study area is quite consistent at 4.5 ft/mi. Barren Fork Creek has a gradient of approximately 8 ft/mi. Gradient in the lower 10 miles of Flint Creek is constant at about 10 ft/mi but increases to 16 ft/mi in the upper 4 miles nearest the Arkansas border.

Man-made features and structures that significantly affect flows, such as diversion dams, storage dams, and return flows points, also can constitute reach boundaries, and operation of such facilities are frequently the focus of an instream flow study. No major flow-modification structures occur in the Illinois River study area. Frances Dam, which spans the Illinois River near Watts, Oklahoma by the Arkansas border provides no active water storage, although the town of Siloam Springs in northwestern Arkansas withdraws some water from the reservoir for municipal supply purposes. Also, there is a small (6-ft high) dam and associated impoundment on lower Flint Creek near the town of Kansas, but there is no active storage or diversion of water from the impoundment.

Based on the above considerations, the Illinois River in the study area can be defined as two reaches. The lower reach extends from the confluence with Barren Fork Creek upstream to the confluence with Flint Creek. The upper reach is from the Flint Creek confluence upstream to the Oklahoma-Arkansas state boundary near Watts. Flint Creek contributes approximately a 15% increase in flow to the Illinois River at the confluence.

The lower reach of the Illinois River is 48 miles long, which is longer than typically constitutes a single reach for PHABSIM application. However, based on the gradient profile and satellite photo images, this reach appears quite uniform and contains no major tributaries. Mean annual flows at the lower end of the reach (Tahlequah gage) were 882 cfs in the four years 2011-2014. At the upper end of the reach just below the confluence of Flint Creek (Chewey gage), mean annual flow was 785 cfs during the same period. Thus, while the reach is of substantial length, the difference in flow is not by itself great enough to justify splitting the reach into two segments. However, study transects will likely be clustered at several locations within the reach.

The study transects for Flint Creek will likely be located in the lower two miles of the stream. Because the intent of the study is to recommend flows that could potentially be used as guidelines in protecting the stream resources, it makes sense to quantify those flows toward the lower end of our reaches assuming that is where flow compliance would be measured. This same concept will be considered when locating study transects in the 15-mile long reach of the Illinois River between Flint Creek and the Arkansas state border.

Methods

Habitat Mapping

Habitat mapping provides an overall instream mesohabitat (e.g., pools, riffles, runs, etc.) representation of each stream reach in the study area. The results of habitat mapping aids transect selection and is used for habitat weighting in reaches where fish habitat modeling is proposed.

Habitat classification schemes are based on hierarchical gradation ranging from 3 basic mesohabitat types (riffle-run-pool) up to 24 types. However, keeping the number of habitat types to a manageable level allows for more accurate and consistent visual classification. Furthermore, the primary use of the habitat surveys in this study is to develop habitat weighting ratios to apply to the PHABSIM habitat transects so that the model results for each study site are representative of the stream reach of interest. Therefore, we propose to delineate habitat units into six types, similar to what was done for the Barren Fork Instream Flow study.

The following habitat types and definitions will be used for mapping in the project area:

- **Pool** - Areas of scour within the stream channel with column velocities usually less than one foot per second (fps). Pools also generally lack surface agitation and commonly contain eddies or other slow water areas along one or both banks. This mesohabitat category includes main channel pools and scour pools. Other pool types that are generally noted include corner, plunge and trench. To be consistent with the Barren Fork Instream Flow Assessment, pools will be categorized as either 1) **backwater**, 2) **mid-channel**, or 3) **lateral**.
- **Run** - Areas of swift flow with little surface agitation and no major flow obstructions. May occur at heads or tails of pools. Between hydraulic controls, may appear as flooded riffles and might contain some waves. Mean column velocities are generally in excess of one fps.
- **Glide** – Generally wide uniform channels with no flow obstructions, no surface agitation and low velocities. May occur at tails of pools. Substrate usually consists of cobble, gravel and sand. Glides and runs are often combined as their differences are largely a function of stream flow.
- **Riffle** – Shallow areas with swiftly flowing, turbulent water often with some partially exposed substrate. Gradient < 4%, usually dominated by cobble or gravel substrate.

Habitat-type boundaries will be identified by breaks in stream channel slope or hydraulic controls. The minimum size of a habitat unit will be limited to the width of the wetted stream channel as is often prescribed. Habitat units with characteristics of more than one habitat type will be identified with a sub-type, though only the primary type will be used in calculating habitat type totals and percentages for use in the PHABSIM model.

Split channels (SPC) will be indicated where a large island or bar exists (usually vegetated) and generally 10% or more of the total flow is in the secondary channel. Habitat mapping will be done primarily by raft or canoe, especially in the Illinois River, but some of Flint Creek may be done by foot walking along the shore or banks. Individual mesohabitat types will be identified along the stream course, and reference points using GPS position and/or flagging will established at regular intervals to assist in relocating habitat units. Habitat unit lengths will be determined by GPS route coordinates taken at habitat boundaries. Width and some length measurements will be obtained with a laser rangefinder. Final habitat unit lengths will be based on a combination of GPS-determined lengths cross-checked with field measured lengths of some units.

Because the lower Illinois River reach is relatively long (48 miles) and uniform, it might be possible to subsample the reach for habitat characterization purposes. Segments to be sampled would be selected based on a review of satellite images of the river corridor and consideration of access points.

Study Site and Transect Selection/Placement

The primary goal of the study site and transect selection is to locate habitat units (pool, riffle, run) that are representative of those occurring throughout the study reach. This task initially involves a review of maps, aerial or satellite photos, and other information to help identify potential study reaches and sites. Access and logistical needs associated with collecting data at the sites must also be considered. Preferably, the habitat mapping task should be completed prior to site selection to help locate representative sites and habitat units for field measurements.

Identifying and establishing a single site per study reach is not necessary and, in fact, not commonly done. Typically, the study site consists of two or more sub-sites where several mesohabitats and associated transects can be clustered. Each cluster uses one temporary bench mark for elevation and water surface measurements.

At least two of each major mesohabitat type will be included in the study sites for each study reach. In most cases two or three transects will be placed across each mesohabitat type selected. With these guidelines each study reach will be represented by about 20 transects.
A field sketch will be made of each study site or sub-site to include details such as habitat unit description, landmark features, flow direction, and especially, a good description of the temporary benchmark used for elevation surveying. Numerous photographs of the sites and transects will be taken at each measured flow from both the upstream and downstream perspective.

Data Collection

Calibration Flows

The flows at which field data will be collected for calibrating the PHABSIM hydraulic models have been identified considering water availability, physical safety, and desired flow range for habitat analysis (Table 1). Velocity data acquisition target flows (bold) are in part limited by physical safety for working in the rivers. Velocity data acquisition in the Illinois River will be by Acoustic Doppler Current Profiler (ADCP) operated from a boat or from shore depending on the concern for wading safety.

The target high flows indicated in Table 1 correspond to the approximate mean annual flow for the lower section of each stream reach. This range should provide ample coverage of the flows that might be considered for protection of fish habitat. In fact, the results of the PHABSIM model for the Barren Fork Creek (Fisher and Remshardt 2000) found that maximum habitat occurred at flows (50-100 cfs) considerable less than mean annual flow (330 cfs). These results suggest that the velocity calibration flows can be considerably less than those indicated in Table 1. This fact would provide some flexibility in deciding when to conduct field work in the event of persistent low flow conditions.

TABLE 1
Target Calibration Flows by Reach for the Illinois River Instream Flow Study
(bold is velocity data acquisition flow)

River Reach	Target Calibration Flow (cfs)		
Lower Illinois	220	450	**900**
Upper Illinois	150	300	**600**
Flint Creek	25	50	**100**

One complete set of depth and velocity measurements will be collected at the target high flow. Two additional measurements of water surface elevation for each transect and a single discharge measurement (per transect cluster) would be made at the remaining flow levels. These three flows should enable the model to simulate aquatic habitat conditions over the normal range of flows from 40% of the low measured flow to 250% of the high measured flow. The amount and type of data proposed to be collected will be suitable for use in a hydraulic simulation with the PHABSIM computer model in the one-velocity mode for the entire range of flows (Payne 1987).

Field Techniques

Field data collection and recording will basically follow the guidelines established in the field techniques manuals (Trihey and Wegner 1981; Milhous et al. 1984; Bovee 1997) developed by the US Fish and Wildlife Service, Instream Flow Group in Ft. Collins. CO. Additional quality control checks that have been found valuable with previous applications of the simulation models will be included. The techniques for measuring discharge will generally follow the guidelines outlined by Rantz (1982). A minimum of 20 wetted stations per stream transect will be established, with a goal of no less than 15 wetted stations at

the lowest measured flow. The boundaries of each station along each transect normally will be at even increments, but significant changes in velocity, substrate, depth, or other important stream habitat features may dictate additional stationing.

Considerable effort will be applied to maintaining strict quality control throughout all aspects of field data collection. To assure quality control in the collection of field data for the Illinois River instream flow studies, the following procedures and protocols will be used:

- Temporary staff gauges will be established and continually monitored throughout the course of collecting data on each transect. If significant changes occur, water surface elevations will be re-measured following collection of transect water velocity measurements.
- An independent benchmark will be established for each set of transects. This benchmark will be an immovable tree, boulder, or other naturally occurring object that would not be subject to tampering, vandalism, or movement. Upon establishment of headpin and tailpin elevations, a level loop will be shot to check the auto-level for measurement accuracy. Allowable error tolerances on level loops are set at 0.03 feet. This tolerance is also applicable to both headpin and tailpin measurements, unless extenuating circumstances (pins under sloped banks, shots through dense foliage, etc.) explain discrepancies and the accompanying headpin or tailpin is free of excessive error.
- Two or more water surface elevations at each flow will be measured across each transect. Transects with complex and uneven water surface elevations require a greater number of measurement locations. For example, a riffle transect may require more frequent water surface measurements, while a pool transect may require fewer. Water surface elevation measurements at each calibration flow will be made at the same location across each transect.
- All pin elevations and water surface elevations are calculated during field measurement and compared to previous measurements. Changes in stage since the previous flow measurement are calculated. Patterns of stage change are compared between transects and determined if reasonable. If any discrepancies were discovered, potential sources of error were explored and noted.
- Efforts will be made to schedule field measurements after the probability of high flows declines. This approach minimizes the possibility of bottom profile changes occurring during a high flow event once data has been collected at a lower flow level. Significant changes in bottom profile between calibration flows can limit the use of that transect's data in an instream flow analysis.
- All survey and transect flow calculations are to be completed in the field. Pin elevations, change in water surface elevations, and cell depths will be compared between flows on the same transects. Calculated discharges will be compared between transects at the same flow. If an excessive amount of discharge (greater than 10% of the streamflow) is noted for an individual transect cell, additional adjacent stations can be established to more precisely define the velocity distribution patterns at that portion of the transect.
- Photographs will be taken of all transects from downstream, across, and from upstream at the three calibration flows. An attempt will be made to shoot each photograph from the same location at each of the three levels of flow. These photographs provide a valuable record of the streamflow conditions (including velocity and depth), water surface levels, and channel configurations that may need confirmed at the time of the hydraulic model calibration.

Velocity Measurements

Most velocity measurements will be taken with a RD Instruments Rio Grande Acoustic Doppler Current Profiler (ADCP). The ADCP gathers both depth and velocity information at very small steps, laterally and vertically, across each transect. The ADCP unit is operated either from shore with the unit encased in an Ocean Sciences Trimaran Riverboat, or towed by or mounted on a boat. When operated from shore the trimaran is secured to an overhead line and hauled back and forth across the channel with a rope and pulley system. The operator views data in real-time through a radio modem connection between the ADCP and a laptop computer. Because the ADCP can only accurately measure to a depth of approximately one foot, edge cell measurements will be obtained by wading to complete the velocity patterns in shallow areas for each transect.

For those stations requiring a hand held meter, the standard method for determining mean column velocity will be a single measurement at six-tenths of the water depth in depths less than 2.5 feet, and a two-tenths and eight-tenths measurement for depths between 2.5 feet and 4.0 feet. Mechanical velocity meters such as a Price AA meter or an electromagnetic meter such as a Marsh-McBirney meter will be used for those locations not suited for the ADCP. Attached algae may be a problem at some locations with use of the Price AA meter. Under these circumstances, a Marsh-McBirney meter is well suited.

Transect Substrate and Cover Coding

During field data collection at the low or medium flow level, when visibility is good, bottom substrate and cover (if present) will be identified and recorded at each station across each transect. These descriptive substrate/cover categories will be converted to numerical codes for modeling purposes as shown in Table 2 below.

TABLE 2
Categories of substrate and cover and their codes

Category	Code
Substrate	
Detritus	1
Vegetation floc	2
Clay (0.0005-0.004 mm)	3
Silt (0.004-0.0625 mm)	4
Sand (0.0625-2 mm)	5
Small gravel (2-8 mm)	6
Medium gravel (8-16 mm)	7
Large gravel (16-64 mm)	8
Small cobble (64-128 mm)	9
Large cobble (128-256 mm)	10
Boulder (>256 mm)	11
Bedrock (slab)	12
Bedrock (fractured)	13
Cover	
None	0
Undercut bank	1
Bedrock (fractured)	2
Log	3

TABLE 2
Categories of substrate and cover and their codes

Category	Code
Tree root wad	4
Aquatic vegetation	5
Boulder	6

Source: Fisher and Remshardt 2000.

Hydraulic Simulation

Software

PHABSIM was originally developed and maintained by the U.S. Fish and Wildlife Service Instream Flow Group (now U.S. Geological Service, Aquatic Systems and Technology Application Group, Fort Collins Science Center). PHABSIM calculates a habitat index in part based on simulation of river depths and velocities from one-dimensional (1-D) hydraulic models that represent the river by cross-sections.

For 1-D applications in this study, the hydraulic models and habitat index simulations will be derived from the computer program SEFA (System for Environmental Flow Assessment, http://sefa.co.nz/). This program was developed jointly by originators of the primary models used in instream flow studies, Bob Milhous (PHABSIM), Tom Payne (RHABSIM), and Ian Jowett (RHYHABSIM) and merges and expands on the capabilities of these older software packages. Primary upgrades include the addition of a second velocity calibration algorithm, sediment transport, and reach temperature and dissolved oxygen models.

The ADCP uses its own proprietary software (WinRiver, RD Instruments) for data acquisition and playback. Because the ADCP collects water velocities throughout the water column at relatively short intervals, it was necessary to synthesize and condense the output into a form usable by PHABSIM software. For this task an ADCP conversion program will allow the user to interactively view bottom profiles and velocity patterns and establish stationing, which can be directly entered into the hydraulic programs.

Stage-Discharge Calibration

Stage-discharge relationships for each transect will be developed from measured discharge and water surface elevations using either an empirical log/log formula or a hydraulic channel conveyance method. Under these methods, each transect will be treated independently. These methods require a minimum of three sets of stage-discharge measurements and an estimate of stage-at-zero-flow (SZF) for each transect. The quality of the stage-discharge relationships will be evaluated by examination of mean error and slope output from the model.

Channel conveyance only requires a single stage-discharge pair and utilizes Manning's equation to determine a stage-discharge relationship (Bovee and Milhous 1978). However, it is generally validated by additional stage-discharge measurements. In situations where irregular channel features occur on a cross section, for instance bars or terraces, channel conveyance is often better at predicting higher stages than log/log. Conveyance is most often used on riffle or run transects and is not suitable for transects which have backwater effects from downstream controls, such as pools. It can also be used as a test and verification of log/log relationships.

Velocity Calibration

A one-dimensional model represents a stream by means of vertical slices (transects) across the channel. Depths are simulated with the rise and fall of a single, level (in most cases) water surface. For simulating water velocities, the "one-flow" option will be used. This technique uses a single set of measured

velocities to predict individual cell velocities over a range of flows. Simulated velocities are based on measured data and a relationship between a fixed roughness coefficient (Manning's n) and depth. In some cases, roughness will be modified for individual cells if substantial velocity errors are noted at simulation flows. Velocity adjustment factors (VAF's) or velocity distribution factors (VDF'S) will be examined to detect any significant deviations and determine if velocities remain consistent with stage and total discharge. For those transects where velocities cannot be safely or accurately measured by any reasonable means, a combination of depth-calibration and roughness coefficient adjustment may be used to fill in missing data.

Target Species and Habitat Suitability Criteria

An important component of an instream flow study is the selection of target species and their corresponding Habitat Suitability Criteria (HSC) that typically describes the relative suitability of water depth, water velocity, stream substrate, and cover types for the fish species and life stages of interest in the study area.

Historically, PHABSIM has been used to describe fish habitat-flow relationships for specific target species, often those considered as important games species or designated species-of-concern. Including these species in an instream flow study also helps with public acceptance of the study. In the case of the Illinois River system, the smallmouth bass is clearly the most sought after and harvested game fish. This species has been the focus of numerous PHABSIM studies throughout the country and were included in the Barren Fork instream flow study (Fisher and Remshardt 2000). Therefore, we propose to include juvenile and adult smallmouth bass in the PHABSIM model for the Illinois River and Flint Creek as well. Review of the habitat criteria developed for smallmouth bass in the Barren Fork indicates that those criteria would be well suited for application to the Illinois River and Flint Creek PHABSIM. The streams are in the same river basin, share similar geomorphic characteristics (gradient, substrate) and hydrologic patterns, and support a similar fish community.

The Illinois River system, like many warmwater environments, supports over 60 species of fish. Each of the species and their life stages has a wide range of habitat needs. To facilitate this shear number of species in a habitat analysis the species are typically categorized into habitat-use guilds, or assemblages, that is, groups of fish that occupy similar habitats (Leonard and Orth 1988). This approach was also used in the Barren Fork instream flow study where HSC were developed from fish-use data collected in that stream (Fisher and Remshardt 2000). Analysis of these data identified three habitat-use assemblages defined as shallow-fast (riffles), deep-slow (pools) and intermediate. These categories and their associated attributes (depth, velocity) are comparable to those developed in other warmwater stream systems (Leonard and Orth 1988, Bain and Knight 1996).

The Barren Fork habitat criteria proposed for use in this study are presented in the Tables 3 and 4 below.

TABLE 3
Habitat suitability criteria for juvenile and adult smallmouth bass in Barren Fork, Oklahoma.

Habitat Quality Category	Habitat variable	
	Juvenile	Adult
Depth (cm)		
Optimal	35-115	55-155
Usable	15-135	25-180
Suitable	5-150	5-200
Velocity (cm/s)		
Optimal	25-80	10-30
Usable	10-95	5-35

TABLE 3
Habitat suitability criteria for juvenile and adult smallmouth bass in Barren Fork, Oklahoma.

Habitat Quality Category	Habitat variable	
	Juvenile	Adult
Suitable	0-105	0-40
Substrate (code)		
Optimal	7	8
Usable	7,8	6,8,11
Suitable	4,6-9	4,6-12
Cover (code)		
Optimal	1	4
Usable	1,4,5	1,4,6
Suitable	0,1,3-6	0,1,3,4,6

Source: Fisher and Remshardt 2000.

TABLE 4
Habitat suitability criteria for shallow-fast, intermediate, and deep-slow habitat-use assemblages of fish in Barren Fork, Oklahoma.

Habitat Quality Category	Habitat variable		
	Shallow-fast	Intermediate	Deep-slow
Depth (cm)			
Optimal	10-25	25-60	55-110
Usable	10-45	15-80	40-145
Suitable	5-60	5-115	25-200
Velocity (cm/s)			
Optimal	10-45	5-25	0-5
Usable	5-55	5-40	0-10
Suitable	0-85	0-80	0-25
Substrate (code)			
Optimal	1, 2, 5, 10, 13-15	1, 2, 5, 10, 13-15	1, 2, 5, 10, 13-15
Usable	1, 2, 4-15	1, 2, 4-15	1, 2, 4-15
Suitable	1, 2, 4-15	1, 2, 4-15	1, 2, 4-15
Cover (code)			
Optimal	0-3	0-3	0-4
Usable	0-3	0-4	0-6
Suitable	0-5	0-6	0-6

Source: Fisher and Remshardt 2000.

Habitat quality is classified into three classes (optimal, usable, and suitable). The optimal range contained the central 50% of the observations and is given a normalized suitability index of 1.0 following the formula:

$$NSI=2(1-P)$$

where NSI is the normalized suitability index and P is the proportion of the population under the curve (i.e., the 50%, 75%, and 95% ranges). Optimal habitat encompasses the central 50% (NSI=1.0), usable

habitat encompasses the broader central 75% (NSI=0.5) of the observations, and the broadest range of habitat, suitable, contains the observations within the 95% (NSI=0.1) range (Bovee 1986).

Water Craft Criteria**.** The Illinois River is heavily used by kayakers and canoeists. The need to consider the flow needs associated with these water craft was expressed by the public at a stakeholder meeting in Tahlequah on January 22, 2015. A water depth in riffles of >0.5 feet for at least a 4-foot wide section is a commonly used criteria to accommodate these boating activities (Hyra 1978). Given the fact that many of the kayakers and canoeists on the Illinois River are novices, and considering the size of the river, we recommend that alternative minimum widths greater than 4 feet (at >0.5 ft depth) be considered for used in the PHABSIM model to reflect a more realistic condition for these activities in the Illinois River. These criteria will be applied only to riffle transects in the Illinois River. In addition, the OSRC has estimated flows for the Illinois River that equate to minimum boat passage (without grounding), desired enjoyable flow ranges for most users, and flows above which safety concerns arise. These recreation flows, while not incorporated into the PHABSIM modeling, will be taken into consideration in the final decision-making process for setting instream flows guidelines for the Illinois River.

Physical Habitat Simulation

Once the hydraulic data is calibrated through standard methods, the weighted suitability index (AWS) by discharge will be generated using the approved species/guild criteria curves. The range of flows included in the habitat simulations will be determined by the calibration flows actually obtained in the field and by the suitability of the hydraulic data for extrapolation. All the satisfactorily calibrated hydraulic transects will be weighted according to the percentage of each of the major habitat types present in the study reach. The hydraulic and HSC data will be used to generate AWS relationships for each of the species/life stages and species guilds in the various reaches of the Illinois River and the two tributaries. The standard option for computing the habitat for each transect is by adding up the suitability of all of the cells within each transect. A cell's suitability is calculated by multiplying the individual variable suitabilities (depth, velocity, and substrate/cover) at the center of each cell.

Products and Report

At the conclusion of this PHABSIM study a technical report will be prepared that will describe the approaches, methods, results, and conclusions. The results and conclusions will then be summarized for inclusion in the larger report for the overall pilot study. The technical report will include:

- Detailed descriptions of field and analysis methods
- A listing of assumptions and adjustments made during modeling
- Weighted usable area of habitat results for each fish species and assemblage in tabular and graphic format
- A determination of modeling adequacy and limitations
- Streambed profile and wetted area plots
- Additional data as might be useful for interpretation of results

An appendix (in electronic format) will contain copies of collected field data as well as hydraulic and habitat simulation products and outputs. In addition, field documentation photographs will be made available upon request.

Schedule

The schedule for conducting this PHABSIM study will be highly dependent on streamflow conditions that will in turn affect when the field work can be conducted. Gage records reveal the high variability in streamflow by year, month, and even day. The preferred approach is to collect the velocity calibration data near the high target flow, which in our case is approximately at the mean annual flow. Records indicate that flows in this range often occur in late spring (May, June) and again in the fall. However, record rainfall and associated stream flows occurred in the Illinois River basin in May, June, and early July of 2015. Therefore, it is anticipated the field work would start in mid-summer or early fall. Subsequent data collection efforts will occur later in the fall or early winter. It is important to have the field work completed before the next spring when flood flows could potentially alter the cross sectional bottom profiles of the study transects.

Data entry will occur after each field trip and won't be completed until after the last trip. Computer modeling will occur soon after data entry is completed. We anticipate completion of the modeling effort in late fall or early winter.

The draft and final technical PHABSIM reports should be able to be completed in early winter of 2015/2016 assuming that the field work and modeling can be completed in the desired timeframe.

Staffing Requirements and Cost Estimate

Following are the staffing needs associated with the tasks described above:

- Habitat Mapping
  Senior Scientist – 1
  Staff Scientist – 1
- Transect Selection and Placement
  Senior Scientist – 1
  Staff Scientist – 1
- Velocity Measurements
  Principal Scientist – 1
  Senior Scientist – 2
  Staff Scientist – 2
- Additional Elevation Measurements
  Senior Scientist – 1
  Staff Scientist – 1
- Data Analysis
  Principal Scientist – 1
  Senior Scientist – 1

It is estimated that the total cost to implement this PHABSIM study plan is approximately $285,000 based on a preliminary work plan for the field work, data analysis (modeling), and reporting. The estimate assumed that all work would be done by qualified consultants without the help of agency or other volunteer personnel. However, participation by agency personnel is encouraged.

Equipment

Following is a list of basic equipment needed for completing the field work activities described in this work plan:

Flow Measurement Gear

- Acoustic Doppler Current Profiler (ADCP)
- ADCP boat mount
- Trimaran
- Satellite computer
- Backup computer
- Electronic flow meter
- Mechanical flow meter
- Wading rods
- Measuring Tapes
- Data forms
- Digital camera
- Ropes

Survey and Mapping Gear

- Stadia rod
- Autolevel
- Tripod
- Laser range finder
- Depth finder
- Handheld GPS unit
- Brush clearing: saws, machete, clippers
- Measuring tapes
- Survey notebooks
- Survey stakes, rebar, spikes
- 3# sledge
- Digital camera

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Appendix E
Consolidated Comments and Prepared Comment Responses

Comment Resolution – Illinois River Instream Flow Assessment Final Draft Technical Report, submitted for comment June 2016

Number	Comment	
TECHNICAL STUDY WORKGROUP COMMENTS		
Summary of Comments from the Technical Study Workgroup Meeting July 20, 2016, held at The Nature Conservancy – Oklahoma Chapter		
1	We need to continue forward using the weight of evidence approach; it is critical to the pilot project and all future ISF efforts.	Comment to be taken into consideration by the Technical Study Workgroup.
2	For the current efforts, it's important for decision makers to consider the fact that the Illinois, Barron Fork, and Flint Creek are all Scenic Rivers and deserve special protection as a result of this status. The recommendations from this group however should be science-based and focused on providing the protection dictated by the data.	Comment to be taken into consideration by the Technical Study Workgroup. Please note that the scenic river instream flow pilot study is being conducted using the Instream Flow Incremental Methodology (IFIM) to facilitate the development of recommendations and guidelines for instream flows. The pilot study is guided by the participation of stakeholder advisory groups for technical and policy evaluations. Deciding how or if instream flow recommendations are implemented in the Illinois River is for future consideration beyond the scope of the pilot study. This technical report is only one element of the IFIM (see the response to Comment 9). Legal and policy questions will ultimately need to be addressed, but the primary objective of this report was to develop a technical platform based on defensible science that will inform the overall process of evaluating instream flows through the application of a pilot study as recommended in the Oklahoma Comprehensive Water Plan (OCWP).
3	For each recommendation, we used average median flow to "check" recommendation.	Acknowledged.
4	Data associated with adult smallmouth bass was weighted more heavily than the data for juveniles because the young of the year bass tended to have higher tolerances for high temperatures, etc.	Acknowledged.
5	Future projects should identify methodologies that can account for seasonal variability where necessary. The IFIM approach only allowed for a single recommendation focused on a minimum flow.	The PHABSIM modeling was done only for fish rearing conditions, but the IFIM decision support system can accommodate any consideration including that of seasonal environmental flows. In the Illinois River Instream Flow Assessment Technical Report (pilot study) (Section 4.2), the need for environmental/ecological flows are discussed, and suggested flows and seasons are provided for consideration in making recommendations.
INSTREAM FLOW ADVISORY GROUP COMMENTS		
Comments from Mike Mathis, Regulatory Affairs Advisor, Continental Resources, Inc.		
6	Section 1 Introduction would be improved with possibly using some of the graphics on the ISF Pilot Study Process to help identify where this report fits in.	A new document has been drafted since the Draft Technical Report was submitted for comment. This new document is titled, *Attachment A - The Illinois River Instream Flow Pilot Study Supplemental Report to the Illinois River Instream Flow Assessment Final Report.* It includes an overview of the IFIM process and identifies the phases of the IFIM that have been completed to date in the instream flow pilot study.

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Number	Comment	
7	Section 2.3 Water Rights and Water Usage: Lots of good information here but really need to see more detailed breakdown of Use versus Time of Year versus Range of Flow (especially critical low flow conditions). This would be applicable to current use, permitted use, and projected Year 2060 use.	More detail on consumptive water uses would be useful for most streams being assessed for instream flow needs; however, for the Illinois River such detail was not provided given the relatively small quantity of water being diverted and projected to be diverted for consumptive uses compared to the availability of water in the basin.
8	Section 2.3 Water Rights and Water Usage: It would be good to see discussion of the various user sectors critical requirements for their water use – somewhat similar to the analysis for the fish habitat. This would help guide policy development as the OWRB overlays all sector requirements to see where commonalities exist along with identifying pressure points, if any.	The focus of the Illinois River Instream Flow Assessment Technical Report was instream resources rather than out-of-stream water uses. The information provided on water usage was intended as background context to the eventual need to balance instream and out-of-stream water needs. Developing a separate report that details the out-of-stream water uses and associated economics of those uses; in addition to the instream uses; is a future step in the pilot study. See response to Comment 2.
9	Section 2.7 Recreation: Lots of good information here but it seems out of place to include the economic impact discussion for recreation where there was not a similar discussion of the economic impacts of the various consumptive water users in Section 2.3. The economic impact of the City of Tahlequah alone would be quite large, I imagine. Per the discussion at the (Instream Advisory Work Group) meeting (of June 16, 2016), would it be appropriate to defer this economic information to the next study step?	The following statements pertaining to recreational economic impact have been deleted from the report: "*The OSRC estimates that recreation and tourism has an economic impact of approximately $12 million in the region around the upper Illinois River in Cherokee County (2009 dollars as reported in Andrews et al. 2010). An additional $30 million is spent each year by about 2 million visitors to Tenkiller Ferry Reservoir (Andrews et al. 2010).*" The economic value of recreational use will be addressed in a separate report to be developed as a future step. See response to Comment 8. The Technical Report marks the completion of the first three phases of the IFIM. To complete the scenic river pilot study, the final three phases of the traditional IFIM need to be considered. These phases are: Alternatives Analysis (Phase IV), Issue Resolution (Phase V), and Process Evaluation (Phase VI). The Alternatives Analysis is important to the IFIM process because the IFIM generally does not result in a single "best" flow value. Typically, establishment of instream flow(s) or flow-regime alternatives for a particular stream reach can be formulated by any interested parties (resource agencies and stakeholders) after reviewing both the institutional analysis and the results of the technical studies from previous study phases. Each alternative would be evaluated by different criteria and questions, such as effectiveness, physical feasibility, risk, and economics.
10	Section 4.3 Decision-Making Considerations: I was surprised to not see the consumptive water use sectors identified as a consideration or priority in this section. This is contrary to the second paragraph in the Section 1 Introduction.	See responses to Comments 8 and 9.

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Number	Comment	
11	Section 4.3 Decision-Making Considerations: I don't think there could ever be much support for an instream flow policy in the Illinois River system if the needs of Tahlequah, rural water district customers, and agriculture/industry weren't considered important.	See responses to Comments 8 and 9.
12	Section 4.3 Decision-Making Considerations: A consideration should be assessing how big of a potential problem/conflict (risk management) actually appears to exist versus the resources that will be required for the OWRB to fully administer an instream flow policy on this (or any other) reach. By way of example, the report states that 200-300 CFS might be a good low flow target that supports both the fishery and the recreation needs in the Illinois River portion. Some context is needed for these as 200 CFS is about 145,000 AF/Year and 300 CFS is about 217,000 AF/Year – this is approaching the range of what Oklahoma City and Tulsa use combined. These are huge amounts of water to consider for a default set-aside. Compare that to the 12,100 AF/Year actually used in the Illinois River portion by consumptive users and it begs the question if there really is an issue here that even warrants consideration of an instream flow policy. More comparative analyses (both hydrologic and economic) such as this are needed in the report. The bottom line: resources available to the OWRB (and all other state agencies) are stretched to the limit, which require prioritizing the most pressing issues for them to address, likely for the foreseeable future.	One reason the scenic reaches of the Illinois River was chosen for this pilot study is the absence of a major water-use conflict in the Illinois River, especially compared to other streams in Oklahoma. However, the purpose of any instream flow program is not only to correct existing environmental problems but to prevent future water conflicts and problems and to help regulatory agencies, landowners, and industries better plan for future water needs in the basin. See responses to Comments 8 and 9.
13	Overall, I was disappointed that the report was not more balanced in its analyses. I expected quite a bit of technical analyses of the fishery and recreation needs/impacts, but also expected similar treatment to the other consumptive uses. I was surprised at the lack of critical comparative analyses along with lack of context to understand the magnitude of the potential policy and administrative issue at hand. Additional effort in this regard could certainly improve the report.	See responses to Comments 8 and 9.

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Number	Comment	
Comments from Marla Peek, Director of Regulatory Affairs, Oklahoma Farm Bureau		
14	At our Instream Flow (ISF) Advisory Group meeting on June 16 (2016), we discussed the need for a document or documents to explain the reason for the Pilot study and the study process. It was also discussed that an in-depth economic analysis was needed in the Pilot Study. Those items and more were already noted as required elements of the ISF Pilot Study using the Instream Flow Incremental Methodology (IFIM) process. Although the Draft Technical Report (DTR) does not include all of the elements outlined in the IFIM, e.g., economic analysis, it is our understanding those elements will be considered at a later time within the IFIM process. We would appreciate a similar effort be made to address the other issues within the IFIM, as has been given to the DTR.	See responses to Comments 8 and 9. Also, included now with the Final Illinois River Instream Flow Assessment Technical Report is *Attachment A - The Illinois River Instream Flow Pilot Study Supplemental Report* to the *Illinois River Instream Flow Assessment Final Report*, drafted October 2016. This attachment documents the chronology of the instream flow Pilot Study to date, as well as anticipated future steps.
15	The definition of instream flows being used for ISF issues and ISF studies seems to be inconsistent. The *Oklahoma Comprehensive Water Plan Supplemental Report, Instream Flow Issues & Recommendations*, February 2011 states: "…for the purposes of this report instream flow describes the quantity of water set aside in a stream or river to ensure downstream environmental, social, and economic benefits are met." (1) The OWRB's website quotes an almost identical definition from the same *Issues & Recommendations* document. However, a different definition appears in the June 16, 2016, Illinois River ISF Pilot Study Public/Stakeholder Meeting PowerPoint: "Focus of Tonight's Discussion: Instream (or environmental flows) are those necessary to provide for a healthy ecosystem and support water-related recreation (such as fishing, hunting, swimming, and boating) as well as tourism." (5) Please explain the use of the two different definitions. If they are being used in different contexts, it would be helpful if their application was clarified and perhaps reviewed in pertinent documents.	Both definitions refer to resources associated with water left in the stream as opposed to water withdrawn from the stream. The newly drafted *Attachment A - Illinois River Instream Flow Pilot Study Supplemental Report to the Illinois River Instream Flow Assessment Final Report*, includes the following definition of instream flows: The term "instream flow" is usually defined as the quantity and timing of water flow required in a stream or river to sustain its freshwater ecosystem and the human livelihoods that depend on it. Although the term means different things to different people, for the purposes of this report, ISF describes the quantity of water set aside in a stream or river to ensure downstream environmental, social, and economic benefits are met. An ISF quantity can range from a minimum flow value to an all-encompassing flow regime.

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Number	Comment	
16	The *2012 Oklahoma Comprehensive Water Plan Executive Report* identified Instream/Environmental Flows as one of eight Priority Recommendations and gave these instructions: "The process developed by the OCWP Instream Flow Workgroup should be implemented and followed to ascertain the suitability and structure of an instream flow program for Oklahoma, with such process commencing in 2012 and concluding by 2015, as outlined by the Workgroup." (10) The 2011 Instream Flow Issues & Recommendations outlined the elements to be examined for a potential instream flow program and recommended the following Steps: 1. Address the legal and policy questions. 2. Study other mechanisms for protecting instream flows. 3. Conduct a study on the economics of instream flows in Oklahoma. 4. Perform an instream flow pilot study in a scenic river. 5. Preserve the Instream Flow Advisory Group. The IFIM system is being used to conduct Steps 1 – 5. The June 15, 2014, *Memorandum for the Instream Flow Pilot Study Approach* from CH2M HILL to the OWRB and the U.S. Army Corps of Engineers explains: "The primary goal of the pilot study is to gain a better understanding of the implications of a process to assess the ISF benefits and issues consistent with the overall goal of managing water resources in Oklahoma for multiple uses. This includes consideration of ISF needs, recreational uses of water, and consumptive uses of water in the watershed (e.g., public water supply, crop irrigation, power generation and industrial uses), drawing on significant involvement of stakeholders from all water interest groups in the watershed." (3) It is unclear whether Steps 1 and 2 are considered complete. Acting on recommendations and issues raised by the ISF Working Group, CH2M HILL has generated a wealth of supporting information that has been published in several documents. Will the ISF Advisory Group be discussing this supporting information again in concert with the DTR and the economic study yet to be completed for the Pilot Study?	The Illinois River Instream Flow Assessment Technical Report covers the technical "instream" resources *portion* of the scenic river pilot study. The scenic river pilot study is only one (Item 4) of the 2011 Instream Flow Issues & Recommendations. Subsequent work for the scenic river pilot study will include an economic assessment focused on the Illinois River Basin. The scope of the 2011 Instream Flow Issues & Recommendations Item 3 will be statewide, but it will be informed by the scenic river pilot study. Remaining items to be completed for the scenic river pilot study are outlined in the response to Comment 9. Items 1, 2, and 3 from the 2011 Instream Flow Issues & Recommendations are yet to be completed.

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Number	Comment	
17	The ISF Advisory Group has raised concerns about the economics of implementing an ISF program in Oklahoma, in terms of study costs and economic benefits/costs of developmental (out-of-stream water uses) and non-developmental (ISF-related) resources. Perhaps the Advisory Group should be provided with a statement of Pilot Study expenses to date. The final cost of the Pilot Study should be included in the final report.	See responses to Comments 8 and 9.
18	The OWRB website contains an abundance of information on the Instream Flow page. It's helpful to have all the information in one location; however, it can be difficult to maneuver, as several years of reports are included. It would be helpful to sort the information by topic in addition to by date, including specific publications names and dates. The Pilot Study references already-researched material in previous documents, e.g. the statutory framework and other mechanisms for protecting ISF. Organizing the materials for use in Phases 4 and 5 (*Memorandum*) and for inclusion in the Pilot Study final document would be helpful. If the elements were gathered now for the draft Pilot Study, we could see the issues we have already discussed and the information assembled for it.	See response to Comments 6.
19	We were disappointed the DTR contains policy positions, which we believe should be recommendations of the ISF Advisory Group, not the Technical Study Group.	It is not clear what policy positions are being referenced; however, Section 4.3 has been removed from the Final Technical Report so as not to be interpreted as policy positions. This information will be considered in subsequent phases of the pilot study. See responses to Comments 9 and 16.
20	Section 1 Introduction (regarding IFIM): "The methodology typically is used to assess the impacts of specific water development proposals (for example, a water diversion) where alternative streamflow regimes can be assessed. However, this is not the circumstance for the Illinois River, which is largely an unregulated stream with no foreseeable major water development projects being contemplated. Therefore, the development of alternatives and their analysis, including economic evaluation, may not be as important in this case." (1-1) This statement undermines the importance of Steps 1, 2, and 4 from *Issues & Recommendations*. Additionally, it conflicts with goals in Phases 1, 4, and 5 of the *Memorandum*. It should be reworded or removed from the DTR.	The following sentence has been deleted from the report: "Therefore, the development of alternatives and their analysis, may not be as important in this case."

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Number	Comment	
21	Section 2 Watershed Resources, 2.1 Watershed Overview: Generally, the DTR appears to focus on streamflow needs for fish and other aquatic resources, recreation, wildlife and water quality. It lacks a thorough study of consumptive uses, including public water supply, crop irrigation, power generation, and industrial use, which makes the DTR seem incomplete. Only six lines reference agricultural production in this section (2), but include several pages of information on watershed resources for fisheries, wildlife and recreation. Consumptive water uses should have received more consideration in the DTR.	See responses to Comments 8 and 9.
22	Section 4.3 Decision-making Considerations, 4.3.1 Need to Consider Basin Goals: "Understanding the established goals of the stream basin is critical in supporting instream flow management prescriptions. The expressed goals of the OSRA for the Illinois River basin streams are as follows…prescribing minimum instream flows is needed because this is where water use conflicts would be most likely to occur in the future…the use of the term 'free flowing' in the OSRA may not be enough by itself to provide the desired base flow protection." (3-4) The watershed goals referenced in the DTR refer to the goals stated in the Illinois River Management Plan (1999) published by the Oklahoma Scenic River Commission. Many people are not familiar with the IRMP, and it can't be located with a simple internet search. To the best of my knowledge, the ISF Advisory Group has not evaluated or adopted the IRMP with regard to this Pilot Study. Further, this section takes a policy position by stating prescribing minimum instream flows is needed, which has not been a conclusion of the ISF Advisory Group.	See response to Comment 19.
23	Section 4.3 Decision-making Considerations, Section 4.3.2 Need to Consider All Resources and Their Priorities: The resources are listed as recreation, fish habitat, wildlife, water quality and ecological processes (4-5). Consumptive uses should have been considered resources and included in the DTR.	See responses to Comments 8, 9, 16, and 19.

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Number	Comment	
24	Section 4.3 Decision-making Considerations, Section 4.3.3 Need to Consider Water Availability (Conclusion): "In conclusion, regarding the various flow components, establishing base flow prescriptions for the Illinois River, Flint Creek, and Barren Fork Creek is of utmost importance. These base flows would represent standards for use by the OWRB in assessing future out-of-stream water right applications…. These processes support the environmental values embodied in the goals established for these state-designated Scenic Rivers. Legal protection of these flows may be provided by the OSRA. However, it may be helpful from a regulatory standpoint to include protection of these ecological process flows, even if only in narrative form, in any instream flow prescription for the Illinois River, Barren Fork Creek, and Flint Creek." (5-6) Again, this section references the IRMP, which has not been evaluated or adopted as a watershed goal by the ISF Working Group. The DTR makes policy recommendations in favor of implementing minimum instream flows for the three scenic rivers through Oklahoma's water quality standards. Narrative protection of ecological process flows in the Illinois River would be adopted as water quality standards in Chapter 45 of the OWRB Rules, leading to the creation of water quality standards implementation criteria in Chapter 46. Adoption of water quality standards implementation criteria would create a new regulatory scheme for the affected streams/rivers, to be implemented by the various state agencies within their regulatory jurisdictions. The Conclusions should be rewritten focusing on the scientific results of the DTR, and omitting the policy recommendations.	See responses to Comments 8, 9, 16, and 19.
Comments from Anthony Ferate, Vice President of Regulatory Affairs, Oklahoma Independent Petroleum Association (OIPA)		
25	Recent court decisions must be considered to assure sufficient evidence is provided to withstand judicial review. Over the course of the past two U.S. Supreme Court sessions and in subsequent federal district court cases we are seeing the Court evolve away from a strict adherence to *Chevron* deference in favor of scrutiny of the record to determine if deference is deserved. The document these comments are written in response to is intended to potentially serve as a basis for future regulations determined by the OWRB. If it does	See responses to Comments 2, 9, and 16.

Number	Comment	
	not sufficiently meet appropriate evidentiary standards future regulations based upon it are in jeopardy. OIPA recommends that this document be given a thorough review for completeness prior to becoming final to assure that any regulation based upon it cannot be considered arbitrary and capricious.	
26	The report insufficiently defines what an instream flow is, what it encompasses and why it excludes considerations such as analysis of localities. While the reader is guided through an analysis of impacts related to instream flow, at no point is the reader given a narrow, focused baseline assessment for how to determine if the data fit within a definition of instream flow. To some this may be an obvious term, however each individually may hold a different narrow window on what an instream flow encompasses. This elementary – but important – step should be taken to assure that all stakeholders are on the same page as they assess the validity of the draft.	See response to Comment 15.
27	Any economic analysis should be all-encompassing rather than picking and choosing particular industries. Section 2.7 focuses on recreation, but more narrowly diverges into an economic impact discussion. No other consumer is contemplated in the discussion, including major users in the area such as Tahlequah. It may be a wise course to expand the analysis of economic impact to all users or leave all economic impact discussion for a future report where the information can be more fully considered.	The following statements pertaining to recreational economic impact have been deleted from the report: "*The OSRC estimates that recreation and tourism has an economic impact of approximately $12 million in the region around the upper Illinois River in Cherokee County (2009 dollars as reported in Andrews et al. 2010). An additional $30 million is spent each year by about 2 million visitors to Tenkiller Ferry Reservoir (Andrews et al. 2010).*" The economic value of recreational use will be addressed in a separate report to be developed as a future step. See response to Comment 8.
28	The draft report fails to ask whether this analysis is even necessary and what harm it is attempting to overcome. OIPA's most significant concern with this draft study is that at no point does it explore the concept of whether this is a solution in search of a problem. In other words, why is it necessary? OIPA can find no significant reason or finding given upon which to base the need for all of the charts and data. This important piece of truly providing a strong basis for upholding any review of rules based upon it needs to be reconsidered and given significant coverage.	Based on recommendations of the 2009 Oklahoma Comprehensive Water Plan, the Oklahoma Water Resources Board (OWRB) convened an Instream Flow Workgroup in late 2009 to solicit input from stakeholders regarding the need for and options for establishing an instream flow policy or program for Oklahoma. The Workgroup developed a report titled *Instream Flow Issues and Recommendations* (OWRB, February 2011) which included several recommendations and a path forward. One of the Workgroup recommendations was to perform an instream flow pilot study on a state-designated Scenic River to demonstrate the process, results and potential policy implications in an actual location. To further this goal, scenic reaches of the Illinois River were chosen for this pilot study. The purpose of any instream flow program is not only to correct existing environmental problems but to prevent future water conflicts and

Number	Comment	
		problems and to help regulatory agencies, landowners, and industries better plan for future water needs in the basin.
29	OIPA is concerned that this report is a solution in search of a problem and may lead to poor or unnecessary regulation in the future.	See responses to Comments 2, 9, 16, and 28.
30	The draft report is incomplete to the point that any rule that is based upon findings in it may ultimately be insufficient to the courts, rendering this exercise a wasted effort.	See responses to Comments 2, 9, 16, and 28.
Comments from Michael Fuhr, State Director, The Nature Conservancy – Oklahoma Chapter		
31	This report does not include any flow prescription recommendations for the Illinois River, Barron Fork, or Flint Creek. From our perspective, the recommendations are one of the key components of a complete pilot project assessment, and are absolutely crucial to the next step in the process which is for the Oklahoma Water Resources Board (OWRB) to develop formal prescriptions to be enacted by OWRB staff as part of the permitting process. These recommendations, once formalized, will also be useful to other agencies, landowners, and corporations that want to plan for their future in the area as it relates to water. While the current comment period was extended two weeks to accommodate this recognized need, the time provided is not sufficient for members of the committee to carefully develop these recommendations. More importantly, the process is not served well by each member of the committee developing recommendations independently. We recommend an extension of the deadline to allow the committee to meet as a group and collaboratively develop flow recommendations to be incorporated into the Assessment.	See responses to Comments 2, 9, and 16. The emphasis of the pilot study was the process itself, not the specific flow recommendations that may be developed for the Illinois River system. The Illinois River background information together with the results of the PHABSIM study component can be used to inform the decision making process regarding instream flow recommendations for the study streams. The Illinois River pilot study does not provide details of the decision making process, which will encompass the alternatives analysis and issue resolution steps. This process will be defined by OWRB. Fish micro-habitat modeling results indicate that the following flow ranges provide good fish rearing habitat conditions for the respective fish communities: Illinois River 200-300 cfs, Flint Creek 30-50 cfs, and Barren Fork Creek 40-80 cfs. These flow ranges correspond closely with the existing base flows, based on monthly medians, during the July through November low flow period. Due to the dynamic nature of the study, limited funding, and the importance of the TSWG, the study team was flexible in receiving the comments from the TSWG on the pilot study. Some of the TSWG members attended a teleconference call on July 20th, 2016, to collectively comment on the pilot study. These comments are included in this comment response matrix and addressed accordingly.
32	Missing from the report is a background section that adequately describes the concept of environmental flows and the need to incorporate them into water management protocols in Oklahoma. Although this information is contained in several previous OWRB documents, it is crucial to understanding the context of this Assessment and therefore should be included.	The concept of environmental flows was not extensively covered in this report because it is contained in previous OWRB documents as noted in the comment. However, the concept and need for environmental flows (also referred to as ecological process flows) were discussed in Section 2.2 (Hydrology), and again in the Discussion Section 4.2 (Need for Ecological Flows). Also, the importance of ecological flows to maintain the extensive network of secondary channels in the Illinois River riparian corridor is discussed in section 2.8 (Riparian Corridor). A new document has been drafted since the Draft Technical Report was submitted for comment. This new document is titled, *Attachment A - Illinois River Instream Flow Pilot*

Comment Resolution – Illinois River Instream Flow Assessment Final Draft Technical Report, submitted for comment June 2016

Number	Comment	
		Study Supplemental Report to the Illinois River Instream Flow Assessment Final Report, and it includes the OWRB working definition of instream flows (Section 2.1).
33	It is important to include a brief discussion of the many varied methodologies available for developing instream flows. The pilot project uses only one of those, the Instream Flow Incremental Methodology (IFIM) approach; one not familiar with environmental flows could incorrectly assume that it is the only approach available. IFIM was originally designed for use on systems altered by dams or other large-scale water diversions, and may or may not be the most appropriate approach for other systems in Oklahoma. There are currently more than 30 different instream flow methods available for developing instream flows in rivers, streams and lakes. Annear et al. (2004) published a book titled 'Instream Flows for Riverine Resource Stewardship' which describes each of these approaches. Decisions about which methodology is most appropriate can be based on factors such as existing and proposed water diversions, available funding, and availability and amount of biological and hydrological data.	The scope of this technical report was to provide an overview of the Illinois River watershed resources for the context of an instream flow study, fish habitat modeling using PHABSIM, and a discussion of the modeling results. An overview of alternative methodologies for developing instream flows can be found in the Final ISF Pilot Study Work Plan (CH2M, June 15, 2014) that was approved by the OWRB, U.S. Army Corps of Engineers (USACE), and the ISF Advisory Group (included in the Attachment A - *Illinois River Instream Flow Pilot Study Supplemental Report to the Illinois River Instream Flow Assessment Final Report*). An Instream Flow Incremental Methodology (IFIM) process was deemed most suitable for addressing the prevailing comments and concerns of the ISF AG regarding the process for establishing the appropriate environmental flows to maintain the key fish species. IFIM was selected in part because it is by far the most commonly used instream flow methodology in the country. As noted, the methodology was intended to assess existing or proposed water development projects; however, it is also commonly used as a component in setting instream flow prescriptions for non-regulated streams. Unfortunately, the IFIM has become synonymous with PHABSIM modeling for fish habitat, probably because fish habitat modeling is done in nearly all IFIM studies. This does not, however, mean that other technical issues such as water quality, sediment transport, or ecological process flows cannot be included in the IFIM decision support process. Attachment A - *The Illinois River Instream Flow Pilot Study Supplemental Report to the Illinois River Instream Flow Assessment Final Report* includes a description of the IFIM process.
34	There are several analyses and graphs that were developed by Conservancy staff and other members of the TAG that were not included in this report, but are important to the overall interpretation of the data, and ultimately the development of specific flow recommendations. We recommend that they be incorporated into the main body of this report.	Most all of the hydrologic data provided by TNC and other TSWG members were included in the report in some fashion or another. In many cases tabular data were converted to graphs or vice versa. Some table and chart formats were changed to make them consistent throughout the report. Please note that the high flow recurrence data provided by TNC appear to have some erroneous values as can be observed in the data. For the report, the USGS standard Log Pearson Type III analysis was used to compute peak recurrence flows (shown in Table 2.3 of the report).

Comment Resolution – Illinois River Instream Flow Assessment Final Draft Technical Report, submitted for comment June 2016

Number	Comment	
Comments from Barry Bolton, Chief of Fisheries Division, Oklahoma Department of Wildlife Conservation and Dr. Shannon Brewer, Assistant Unit Leader, Oklahoma Cooperative Fish and Wildlife Research Unit		
General		
35	The process for implementing instream flows for Oklahoma has been emphasized from the first meeting of the Instream Flow Advisory Group. The IRIFA fails to outline that process. I have no problem with the suggestion that this could be a stand-alone document but at a minimum it should be referenced in the IRIFA.	The Illinois River Instream Flow Assessment Technical Report was intended to be a stand-alone technical document, not a process document outlining steps to be taken to implement instream flows. The implementation process is a critical next step along with the need for an economic analysis to facilitate the balancing that OWRB is required to consider in their decision making process. See response to Comments 2, 9, and 16.
36	ODWC believes specific flow recommendations should be included in the IRIFA. During the 16 June 2016 meeting, the OWRB agreed to include this section in the final document. The Technical Advisory Group (TAG) met on 18 July 2016 to develop flow recommendations for each of the study streams. ODWC supports the recommendations of the TAG.[1]	The Illinois River Instream Flow Assessment Technical Report contains the technical information needed to support instream flow recommendations for those resources related to instream flows. Flow range recommendations were made by the Technical Study Workgroup during the meeting of July 18, 2017. These included a range of flows for base flow needs only. They did not include other environmental flows such as those needed for channel maintenance.
37	It is critical to remember the Scenic Rivers involved in this study deserve special protection and decisions should be science-based.	Comment to be taken into consideration by the Instream Flow Advisory Group.
38	Setting environmental flows is meaningful only if enforcement measures are implemented to ensure compliance.	Comment to be taken into consideration by the Instream Flow Advisory Group.
39	ODWC continues to stress the need to move the process forward in a timely fashion. An economic impact study and other components could begin before the IRIFA is finalized.	Comment to be taken into consideration by the Instream Flow Advisory Group.
Specific		
40	Page 1-1 (paragraph 3) Discussion of the "process" or reference to stand-alone process document is needed.	A new document has been drafted since the Draft Technical Report was submitted for comment. This new document is titled, Attachment A - *The Illinois River Instream Flow Pilot Study Supplemental Report to the Illinois River Instream Flow Assessment Final Report* and it includes a description of the IFIM process.
41	Page 1-1 (paragraph 4) Many elements of this study were put into motion with little input from the various agencies. A review of correspondence would reveal several instances where comments were not incorporated into the IRIFA.	It is not clear what the commenter refers to by “many elements of this study” or “several instances.” All the review comments were incorporated and additional review time was provided to the TSG when requested. A new document has been drafted since the Draft Technical Report was submitted for comment. This new document is included with the technical report titled, Attachment A - *The Illinois River Instream Flow Pilot*

[1] The meeting of 18 July 2016 was a meeting of the Technical Study Workgroup rather than the Instream Flow Advisory Group.

Comment Resolution – Illinois River Instream Flow Assessment Final Draft Technical Report, submitted for comment June 2016

Number	Comment	
		Study Supplemental Report to the Illinois River Instream Flow Assessment Final Report Appendix B and includes TSWG meeting notes, actions, and decisions.
42	Page 2-6 (paragraph 1) You should present a range of variation expected from potential climate-change estimates rather than characterize the impacts as "uncertain".	An extensive evaluation of climate change effects was not intended for this study. However, the author considered it informative to make note of the recent model projections by the Oklahoma Water Survey (OWS) for the region encompassing the Illinois River. The term “uncertain” (used in the OWS citation) referred only to the behavior of the runoff such as drought and flood.
44	Page 2-12 (paragraph 3) Is a reference available for " ... most of this water use is for Tahlequah's public water supply which primarily affects (several grammar issues were found throughout the report) only a three-mile reach of the river?	The distance from the city’s diversion to the point of discharge (Tahlequah Creek) back to the Illinois River was determined from Google maps.
45	Page 2-16 (paragraph 3) Bigmouth buffalo are not suckers. You should point out that many of the species which occurred only in Barren Fork Creek or Flint Creek are present in other systems.	Bigmouth buffalo (*Ictiobus cyprinellus*) are in the sucker family (Catostomidae). The following sentence has been added to the report: “Many of the species which occurred only in Barren Fork Creek or Flint Creek are present in other systems.”
46	Page 2-19 (paragraph 5) I am unfamiliar with the terminology "non-fish aquatic species" and "pearly freshwater mussels".	The term “pearly freshwater mussels” is commonly used but more appropriately should be referred to as “freshwater pearl mussels.” The term “non-fish aquatic species” refers to mussels, macroinvertebrates, amphibians, and any other species that reside primarily in water.
47	Page 2-23 (paragraph 1) I understand the importance of secondary channels but why is it important to quantify them in this report. Also, why does the topic come under the heading of "Riparian Corridors"?	The purpose of quantifying the secondary channels was to demonstrate the extensive nature of these channels along the Illinois River and to support the need to protect them as a key component of the ecological processes associated with the stream. Because these channels are all within the riparian corridor, that subsection title was chosen.
48	Page 2-23 (paragraph 5) The first sentence is unclear.	The sentence has been reworded.
49	Page 2-27 (paragraph 1) This paragraph could be moved to the first paragraph of the discussion of secondary channels to outline why it is important to quantify them.	Text has been rearranged as recommended.
50	Page 3-1 (paragraph 4) It should be noted the Technical Workgroup emphasized the importance of including the lower Illinois River below Tenkiller Dam.	The decision to include only the designated Scenic reach of the Illinois River was made by the Instream Flow Advisory Group. Attachment A - *The Illinois River Instream Flow Pilot Study Supplemental Report to the Illinois River Instream Flow Assessment Final Report* Appendix B includes TSWG meeting notes and decisions.

Comment Resolution – Illinois River Instream Flow Assessment Final Draft Technical Report, submitted for comment June 2016

Number	Comment	
51	Page 3-3 (paragraph 3) Who decided to focus the study on this 21-mile section in the lower reach of the Illinois River?	See response to Comment 33. The Instream Flow Advisory Group decided to include only the designated scenic reach of the Illinois River. The study area included the entire Illinois River above Barren Fork to the Arkansas state border. Unfortunately, the habitat modeling study site in the upper reach (above Flint Creek) was washed out by the 100-year flood event in late December 2015 before sufficient data was obtained for modeling.
52	Page 3-3 (paragraph 4) Why was it assumed that flows should be quantified "toward the lower end of the reaches assuming that is where flow compliance would be measured"?	It is not necessary that study sites be located near an existing stream gage or near the lower end of a defined reach. However, it is convenient for the modeling results be related directly to an existing gage without having to account for much accretion flow. Also, from a compliance and enforcement standpoint it is are convenient to use an existing gage that closely relates to the instream flow prescriptions derived from a nearby study site.
53	Page 3-3 (paragraph 5) The term "glide" is not commonly used to describe Ozark streams.	Acknowledged, but this term is commonly used in reference to stream habitat and morphology; commonly used in PHABSIM; and, a more appropriate term was not identified.
54	Page 3-4 (paragraph 4) " ... maximum microhabitat occurred at flows ... "	The term “microhabitat” has been included to better define the meaning.
55	Page 3-7 (paragraph 3) "The method can also be used as a test to verify IFG-4 relationships."	The text has been revised as noted.
56	Page 3-7 (paragraph 7) "Defined microhabitat criteria (depth, velocity, and substrate) suitable for PHABSIM ... "	The term “microhabitat” has been included to better define the meaning.
57	Page 3-8 (paragraph 1) You might consider use of more current references.	The references that relate to habitat guilds are those mostly commonly cited as related to use in PHABSIM modeling.
58	Page 3-8 (Table 3-3) a. Page 3-3 defines pool, run and riffle. Table 3-3 uses headings including "shallow-fast, intermediate and deep-slow". Consistent terminology throughout the document would be useful. b. Mosquitofish and topminnows are not typically found in riffle habitat. c. Largemouth and smallmouth bass are not normally found in the same habitat. d. Non-native fish (common carp) could be removed from the report.	a-The definitions of riffles, runs, and, pools are similar to but not quite the same as the shallow-fast, intermediate, and deep slow categories. The latter categories are defined only in terms of depth and velocity and therefore are suitable for use in PHABSIM modeling (for habitat guilds). The former categories include other hydraulic characteristics such as turbulence and substrate are used for transect weighting to insure that the study site is representative of the overall study reach. The use of these two types of mesohabitat categories is consistent with the approach used on the Barren Fork Instream Flow Study (Fisher and Remshardt 2000). b and c – The assignment of species to the different assemblages (habitat guilds) followed that of Fisher and Remshardt (2000) developed for the Barren Fork Creek. d- Common carp has been removed from the table.

Comment Resolution – Illinois River Instream Flow Assessment Final Draft Technical Report, submitted for comment June 2016

Number	Comment	
59	Page 3-9 (Table 3-4) a. A depth of 5 cm is suitable habitat for adult smallmouth bass? b. More current references would be helpful.	a- The 5 cm depth is at the very lower end of the suitability range and has a relative weighting of only 0.1 compared to a maximum (optimum) of 1.0. b- Most of the smallmouth bass habitat criteria development work for PHABSIM modeling occurred prior to 2000. The criteria adopted from Fisher and Remshardt were based on data collected in Barren Fork Creek and a review of results of other similar studies.
60	Page 3-25 (paragraph 1) The statement that 90% of juvenile smallmouth bass habitat is maintained at flows of 250-900 cfs is misleading. These fish often do well in prolonged summer low-flow events. Broad habitat criteria possibly led to these results. Perhaps habitat should be revised to microhabitat.	“Habitat” has been revised to “microhabitat.” The results of PHABSIM modeling are expressed as an index of microhabitat as defined by the fishes’ preferences for water depth and velocity and bottom substrate. Other factors, both biotic and abiotic, can affect fish populations and should be considered when interpreting the microhabitat modeling results.
61	Page 3-31 (paragraph 1) Uncertainty related to sample size and suitability criteria suggests additional effort could be focused here.	Uncertainty is always a factor in any modeling exercise. Most efforts to reduce uncertainty in PHABSIM modeling have revolved around the number of study site transects and especially the need to weight these transects to best represent the stream reach being assessed.
62	Page 4-1 (paragraphs 2 and 3) " ... flow curves (AWS) presented in the PHABSIM modeling portion of this report are simply relationships between fish rearing habitat and streamflow ... " " ... study results must be interpreted as to their biological meaning to the fish community as a whole.'' What does this mean and why use this approach if it doesn't easily transfer to flow prescriptions?	PHABSIM modeling is a tool that provides scientific information on habitat-flow relationships that then can be used, in conjunction with other information, to support instream flow recommendations. It is intended to support, not replace, sound scientific interpretation by experienced biologists.
63	Page 4-1 (paragraph 5) "Of the various mesohabitat types ... This paragraph is true but needs more concise explanation.	To avoid the risk of losing context or meaning in an attempt to make the paragraph more concise, the original text was left as written.
64	Page 4-1 (paragraph 6) " ... it is unlikely that the amount of pool habitat at any flow is a population limiting factor ... " Why wasn't the approach structured to reflect these considerations?	Potential population limiting factors should always be taken into consideration when interpreting any study results. However, understanding what these limiting factors may be for such a diverse fish community is always a challenge even for an experienced fisheries biologist.
65	Page 4-1 (paragraph 7) ... "maximum habitat occurs at 200 cfs ... "	Many factors are involved in the well-being of a fish population, but physical habitat has been traditionally considered one of the most important; and, one that can be greatly affected by stream-flow conditions.

Comment Resolution – Illinois River Instream Flow Assessment Final Draft Technical Report, submitted for comment June 2016

Number	Comment	
	But ... more micro habitat does not necessarily mean more fish which is a major limitation of this approach.	
66	Page 4-2 (paragraph 5) " ... such flows would represent a minimum flow management prescription ... " Variation is important even at low flows.	While flow variability is an important component of environmental flows, in the unregulated upper Illinois River, flow variability will occur naturally and probably does not need to be included in an instream flow prescription. For a highly regulated river, flow variability should be considered.
67	Page 4-3 (paragraph 3) It seems obvious that channel maintenance is not impacted by timing of high flow events. It should be emphasized that most ecological functions are impacted by timing of these flows.	As noted, the seasonal timing of high flow events is an important consideration when prescribing instream flows with respect to ecological function. This is briefly discussed in Section 4.2 of the draft report as follows: “In terms of maintenance of the channel itself, it probably does not matter which month the high flow event occurs. However, there are other ecological functions associated with these high flow events that do depend on their season of occurrence. These may include fish spawning and migration, seed and plant germination in riparian areas, and wildlife life history needs.”
68	Page 4-3 (paragraph 5) "Higher flood events ... " Floodplain events are important. They contribute to nutrient spiraling, energy exchange, fish rearing, etc. which are important in maintaining high quality rivers. Obviously, we would not recommend 500-year flood events but the "active floodplain" is typically much lower.	Floodplain flow events are important, and this would be a major topic for consideration for any highly regulated (e.g. flood control) system.
69	Page 4-5 (paragraph 1) " ... Water quality should not be a high priority ... " This may not be a true statement in the future.	Text has been deleted pursuant to Comment 19.
70	Page 4-5 (paragraph 3) ... Habitat availability at these base flows are what fish populations tend to track ... " This is only true if habitat elements are limiting.	Physical habitat availability is often considered a major population-limiting factor for most fish species sometime during their life (e.g. spawning, rearing, over-wintering); and, that forms the common basis for protecting habitat in general. Pursuant to Comment 19, the first paragraph and Table 4-1 under draft Section 4.3.3 have been moved to Section 4.2 under the heading “Base flows.”

Table 1. Summary of Review Comments- Final Review Comments Received on May 17, 2017

Illinois River Instream Flow Assessment

Comment Number	Section	Page Number	Reviewer	Type	Comment	Response
1	2	2-12	K. Elkins/TNC	Comment	You can't accurately give a flow recommendation if these types of withdrawals don't require a permit.	Did not change.
2	2	2-16	M. Porter/OWRB	Comment	Northern hogsuckers were present in many of the collections as were 4 redhorse species. The report observations appear to be inaccurate. – Monty Porter	Updated language to remove reference to Northern hogsuckers and redhorse – it did not seem to add or detract from report.
3	3	3-3	K. Elkins/TNC	Text/comment	"Mapping was conducted by canoe in the Illinois River and on foot in Flint Creek". (This doesn't include Barren Fork mapping?)	Added notes that Barren Fork Creek data was derived from Fisher and Remshardt, 2000.
4	3	3-4	K. Elkins/TNC	Table 3-1 / comment	Should label what reaches and why no Barren Fork included. Are you just using Fisher 2000 study?	Added notes that Barren Fork Creek data was derived from Fisher and Remshardt, 2000.
5	3	3-6	K. Elkins/TNC	Comment	Photos of the ADCP boat should be inserted into this report because the large IF advisory group has no clue what one looks like.	Added photo. New Figure 3-2.
6	3	3-7	K. Elkins/TNC	Comment	Insert a photo of the ADCP at work	Added photo. New Figure 3-2.
7	3	3-8	O. Mills/OWRB	Text	Change 'PHABSIM' to 'PHABSIM and ultimately for IFIM'	Complete.
8	3	3-8	O. Mills/OWRB	Table 3-3	Delete mosquitofish altogether and don't move to another group	Complete.
9	3	3-11	K. Elkins/TNC	Figure 3-2 / comment	Are these from Fisher et. al. study in 2000 or curves developed for this project?	Updated figure title to indicate source.
10	3	3-11	K. Elkins/TNC	Figure 3-2 / comment	Figure headings should line up with the graphs. These are too far to the right	Complete.
11	3	3-16	K. Elkins/TNC	Comment	This only highlights Illinois and Flint. Why not Barren Fork? It was part of this study?	Added sentence that AWS relationships for smallmouth bass on Barren Fork Creek were previously generated by Fisher and Remshardt, (2000).
12	3	3-16	K. Elkins/TNC	Comment	Due to effects upstream of Tenkiller Reservoir (creating a reservoir environment), you are performing a study on a lake environment which is not conducive to ISF for river dominant species. I suppose they have adapted but we need to perform an ISF study on a river environment for enough upstream to avoid effect of the reservoir downstream.	Added: Mapping along the lower Illinois River was conducted upstream of U.S. Highway 62 near Tahlequah, OK and was more than 12 miles upstream of the approximate backwater effects of Tenkiller Reservoir.
13	3	3-17	K. Elkins/TNC	Comment	Lots of pool habitat in all the reaches is not conducive to provide accurate IF for a	Added: Mapping along the lower Illinois River was conducted upstream of U.S. Highway 62 near Tahlequah, OK and was more

Table 1. Summary of Review Comments- Final Review Comments Received on May 17, 2017

Illinois River Instream Flow Assessment

Comment Number	Section	Page Number	Reviewer	Type	Comment	Response
					range of species. The next study should be in reaches with all habitat types present.	than 12 miles upstream of the approximate backwater effects of Tenkiller Reservoir.
14	3	3-17	K. Elkins/TNC	Comment	All 11 transects suitable for a study?	Yes. No change made to text.
15	3	3-19	K. Elkins/TNC	Figure 3-7	Put in landmarks to identify why at in the river	Complete.
16	3	3-19	K. Elkins/TNC	Figure 3-7	Remove notes	Complete.
17	3	3-19	K. Elkins/TNC	Figure 3-7	Should Figure 2 caption be removed? The figure caption or project name. Not necessary to the reader.	Complete.
18	3	3-19	K. Elkins/TNC	Figure 3-7	Align figure 3-7 heading with the figure. Move left.	Complete.
19	3	3-21	K. Elkins/TNC	Figure 3-9 / comment	Where is the map for the Upper Illinois River? These maps include on the lower Illinois twice and Flint Creek	Added new Figure 3-11 (upper Illinois River transect locations).
20	3	3-22	K. Elkins/TNC	Table 3-13 /comment	We should be including winter flows. I know it's too late now for this project but something to consider for future projects.	The relevance of winter flows to model calibration flows in Table 3-13 is not clear. The hydraulic model does not consider seasonal variation. Monthly average flows and monthly exceedance flows (25, 50, and 75 percent exceedance) are shown in Figures 2-2 and 2-3, respectively.
21	4	4-2	K. Elkins/TNC	Comment	Are these flows based of the PHABSIM study and not the recommended flows of the IF technical workgroup? We sent recommended flows to Forrest which were never incorporated into this document.	Added sentence - As stated in Section 1, the purpose of this Report is to summarize the methods and results of an ISF pilot study, which modeled the availability of suitable mesohabitat for key fish species at different life cycles under different flows. OWRB is ultimately responsible for evaluating these modeling results while considering other stakeholder needs as well as water use policy before making final ISF recommendations. Additional information regarding the Technical Study Workgroup recommendation can be found in Attachment A of this Report. -
22	Appendix A- Main report		K. Elkins/TNC	Comment	All the aerial maps from pages 81-112 need landmarks or nobody is going to know where there are at on the river	Complete.
23	Att-A	ES-VII	K. Elkins/TNC	Comment	Are these based of IF technical workgroup recommendations? Should be included as separate letter that was written by TNC. Not in the current TNC letter attached to this report	The original Attachment A has been summarized and incorporated into the main report: Study Findings Section 4. The TNC comments are included in Appendix E of the report.
24	Att-A	ES-VII	K. Elkins/TNC	Comment	Recommendation: If a process and not specific flow recommendations, then what is the point of this project?	The original Attachment A has been summarized and incorporated into the main report: Study Findings Section 4. The TNC comments are included in Appendix E of the report.

Table 1. Summary of Review Comments- Final Review Comments Received on May 17, 2017

Illinois River Instream Flow Assessment

Comment Number	Section	Page Number	Reviewer	Type	Comment	Response
25	Att A-Appx D		K. Elkins/TNC	Comment	TNC letter: Also, the different IF methodologist were written up by TNC staff and this was to be included in this report so that other people know that IFIM and PHABSIM are not the only options for IF studies. It is not included in this report. It would have come from TNC.	(Note: source of this comment is a comment letter from Mike Fuhr (TNC) dated July 15, 2016 to Forrest Olson/CH2M.) Consideration of the concept of environmental (or ecological) flows into water management decisions is important for most streams. However, a detailed review of environmental flows as part of the flow management decisions or an assessment of feasibility of the various modeling approaches, were not part of the study scope (see the ISF Advisory Group recommended Final Study Plan in Appendix B). The report includes significant discussion of the importance of ecological flow needs in the Hydrology Section 2.2, and especially in the report's Discussion Section 4.2. Although much of the report focus was on fish habitat modeling, as is typically done for instream flow assessments, the IFIM "process" is intended to accommodate consideration of other streamflow-related resources including ecological processes. The importance of nonfish resources as well as ecological processes in the Illinois River basin is further highlighted in Section 4.2. (The previous Appendix D of Attachment A is now Appendix E of the main report.)
26	Att A-Appx D		K. Elkins/TNC	Comment	TNC letter: This is where a separate letter was drafted by the IF Technical Workgroup recommended specific flows for each of the study sites. This needs to be included.	Added email from Mike Fuhr with flow recommendations. (The previous Appendix D of Attachment A is now Appendix E of the main report.)

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July 15, 2016

Forrest Olson
CH2M
1100 112th Avenue NE
Suite 500
Bellevue, WA 98004

Re: Comments on the June 2016 draft of the Illinois River Flow Assessment report (Assessment)

Dear Mr. Olson:

Thank you for the opportunity to provide comments on the June 2016 draft of the above-referenced report. Our comments can be found below.

As noted in your last correspondence with the Technical Advisory Group, this report does not include any flow prescription recommendations for the Illinois River, Barron Fork, or Flint Creek. From our perspective, the recommendations are one of the key components of a complete pilot project assessment, and are absolutely crucial to the next step in the process which is for the OK Water Resources Board to develop formal prescriptions to be enacted by OWRB staff as a part of the permitting process. These recommendations, once formalized, will also be useful to other agencies, landowners, and corporations that want to plan for their future in the area as it relates to water. While the current comment period was extended two weeks to accommodate this recognized need, the time provided is not sufficient for members of the committee to carefully develop these recommendations. More importantly, the process is not served well by each member of the committee developing recommendations independently. We recommend an extension of the deadline to allow the committee to meet as a group and collaboratively develop flow recommendations to be incorporated into the Assessment.

Also missing from the report is a background section that adequately describes concept of environmental flows and the need to incorporate them into water management protocols in Oklahoma. Although this information is contained in several previous OWRB documents, it is crucial to understanding the context of this Assessment and therefore should be included. The following is taken directly from the OWRB web page a version of which could easily be incorporated:

> *The meaning of the term "instream flows" has evolved over the years but usually describes the amount of water set aside in a stream or river to ensure downstream environmental, social and economic benefits are met (Instream Flow Issues & Recommendations, OCWP Supplemental Report, February 2011).*

Minimum streamflows can contribute to the basic ecological integrity of the aquatic environment, support endangered species, and facilitate interstate compact compliance. Tourism and recreation, Oklahoma's third largest industry, relies heavily upon dependable streamflows. This industry generates more than $6 billion per year while fish and wildlife enthusiasts alone spend upwards of $1.3 billion annually. While there are definite benefits in maintaining minimum instream flows in some Oklahoma streams, there are likewise valid concerns to consider, such as potential impacts to consumptive users due to reduced water availability, changes in the location of that availability, and related economic development implications.

The OCWP Instream Flow Workgroup conducted a thorough review of existing ISF programs in Oklahoma as well as in surrounding and western states. The majority of western states manage water via an appropriation system where water rights are granted for beneficial uses to fulfill irrigation, industrial, and municipal needs. Beginning in the 1970s, a number of western states began to incorporate ISFs, including protection for hydropower and navigation uses, into their existing appropriation systems.

The terminology and mechanisms used to legally protect ISFs vary from state to state. Some states issue specific water rights for ISFs while others set aside ISF reservations or environmental flows. Kansas does not have ISF water rights or reservations but uses "minimum desirable streamflow" as established by its legislature in 1984. Texas and California also do not have ISF water rights, but those states issue permits for new water uses conditioned for environmental flows. Oklahoma and North Dakota are the only two western states that do not legally define ISFs. While ISFs are not specifically defined in Oklahoma water law, they receive indirect flow contributions through the state's current water use programs and policies, including appropriative water rights, domestic use protection rules, the Scenic Rivers Act, reservoir release schedules, and interstate stream compacts.

Similarly, it is important to include a brief discussion of the many varied methodologies available for developing instream flows. The pilot project uses only one of those, the Instream Flow Incremental Methodology (IFIM) approach; one not familiar with environmental flows could incorrectly assume that it is the only approach available. IFIM was originally designed for use on systems altered by dams or other large-scale water diversions, and may or may not be the most appropriate approach for other systems in Oklahoma. There are currently more than 30 different instream flow methods available for developing instream flows in rivers, streams and lakes. Annear et al. (2004) published a book titled 'Instream Flows for Riverine Resource Stewardship' which describes each of these approaches. Decisions about which methodology is most appropriate can be based on factors such as existing and proposed water diversions, available funding, and availability and amount of biological and hydrological data. A proposed discussion of available methodologies is attached to this letter for consideration as Appendix 1.

Finally, there are several analyses and graphs that were developed by Conservancy staff and other members of the TAG that were not included in this report, but are important to the overall interpretation of the data, and ultimately the development of specific flow recommendations. We recommend that they be incorporated into the main body of this report. The information developed by Conservancy staff is attached to this letter in Appendix 2.

Again, thank you for the opportunity to serve as a member of the Technical Advisory Group, as well as provide these comments. If you have any questions or require more information, please feel free to contact me at (918) 633-7960.

Sincerely,

Michael Fuhr
State Director

Appendix 2

Hydrology of the Illinois River

The following hydrologic information from the Illinois River should be included in the final project report because it provides the ecological flow components necessary for providing instream flows. This information is critical for mean monthly discharge, minimum and maximum discharges, exceedance flows, recurrence interval for high flows and ecological process flow needs.

The Illinois River watershed is 1600 square miles and divided almost equally between Arkansas and Oklahoma. There are two continuous United States Geological Survey (USGS) gages located in Oklahoma at Tahlequah and Watts. The Tahlequah gage has been operating since 1935, and the Watts gage has been operational since 1955. Discharge and gage height have been continuously recorded every 15 minutes every day for these gages. The hydrology, hydraulics, biology, water quality and geomorphology are all important riverine components to consider when developing an instream flow for the Illinois River.

The mean monthly discharge over a period of record of 79 years at Tahlequah ranges from 362 to 1660 cfs. The mean monthly discharge over a period of record of 59 years at Watts ranges from 251 to 1110 cfs. Minimum and maximum flows at each gage ranged from 3.15 to 6742 cfs at Tahlequah to Watts ranging from 14.9 to 4286 cfs.

The percent exceedance values at Tahlequah were: Q10=68.2; Q50=614 and Q90=646. The percent exceedance values at Watts were: Q10=58.9; Q50= 579 and Q90=530.

The recurrence high flow for a two year period at Tahlequah was 14,500 cfs. The recurrence high flow for a two year period at Watts was 18,200 cfs.

Annual flow duration curves show multiple fluctuations among years of high and low flows during the period of record for both Illinois River gages in Oklahoma.

Table 1. Illinois River at Tahlequah mean monthly discharge

Month	Monthly Discharge (cfs) (1935-2014)
January	876
February	1110
March	1440
April	1660
May	1650
June	1020
July	523
August	362
September	388
October	543
November	872
December	890
Minimum	388
Maximum	1660

Justification: Mean monthly discharges over a 79-year period of record provide detailed information on changes in flow during the seasons. This can provide detailed information when developing monthly instream flows on the Illinois River.

Table 2. Illinois River at Watts mean monthly discharge

Month	Monthly Discharge (cfs) (1935-2014)
January	595
February	699
March	971
April	1,110
May	1,020
June	659
July	382
August	251
September	315
October	370
November	617
December	643
Minimum	251
Maximum	1110

Justification: Mean monthly discharges over a 79-year period of record provide detailed information on changes in flow during the seasons. This can provide detailed information when developing monthly instream flows on the Illinois River.

Table 3. Illinois River at Tahlequah minimum and maximum yearly discharge

Year	Minimum Discharge (cfs)	Maximum Discharge (cfs)
1936	10.5	577.7
1937	214.1	2916
1938	95.3	4661
1939	49.6	1036
1940	112.6	944.9
1941	118.1	2786
1942	255	3690
1943	120.6	6979
1944	154.8	3285
1945	193.9	6695
1946	119	3116
1947	93.5	2328
1948	206.7	3907
1949	241.6	2911
1950	214.6	8397
1951	237	4139
1952	94.1	1713
1953	62.5	1941
1954	3.15	1349
1955	45.6	1450
1956	5.4	987.7
1957	223.6	622.2
1958	235.5	2491
1959	152.1	1792
1960	154.2	3441
1961	291.7	1565
1962	309.5	1750
1963	45.7	388.4
1964	89.7	580
1965	105.4	3035
1966	84.5	1111
1967	88.4	1361
1968	216.5	2597
1969	125.1	2464
1970	247.6	2808
1971	137.7	1786
1972	123.7	2338
1973	379.5	4592

1974	376.3	4407

Table 3 continued.

Year	Minimum Discharge (cfs)	Maximum Discharge (cfs)
1975	409.7	3495
1976	201.8	3050
1977	156.3	1114
1978	152.5	2865
1979	139.1	1840
1980	48.1	714.4
1981	103.3	809.1
1982	122.1	2277
1983	104.1	1551
1984	134.2	4096
1985	238.2	2797
1986	333.7	5222
1987	231.3	4067
1988	144.7	3080
1989	160.2	2415
1990	357.7	3941
1991	147	2498
1992	246.3	4258
1993	377.2	3390
1994	281.3	2987
1995	246.2	3181
1996	156.9	3465
1997	246.9	2105
1998	167.5	3355
1999	178.1	3093
2000	266.5	3355
2001	236.1	3093
2002	185.1	5933
2003	141.8	3940
2004	207.9	2477
2005	132.9	1078

Table 3 continued

Year	Minimum Discharge (cfs)	Maximum Discharge (cfs)
2006	130	3347
2007	218.9	3969
2008	401.4	1457
2009	344.4	2400
2010	251	1686
2011	265.4	6742
2012	105.6	1834
2013	286.6	2517
2014	287.8	1180

Justification: The yearly minimum and maximum discharges provide a snapshot of how low and high the flows can be on a yearly basis.

Table 4. Illinois River at Watts minimum and maximum discharge

Year	Minimum Discharge (cfs)	Maximum Discharge (cfs)
1955	60.4	108.1
1956	14.9	714.8
1957	174.7	3936
1958	185.6	1807
1959	115.8	1029
1960	113	2013
1961	184.6	4286
1962	217	1155
1963	44.2	255.3
1964	50.7	293.6
1965	73.5	1592
1966	70.8	768.5
1967	69.9	1057
1968	188.1	1755
1969	104.9	1658
1970	104.4	1917
1971	97.4	1150
1972	154.2	1508
1973	241.3	3119
1974	232.1	2630
1975	280.7	2291
1976	128.2	1880
1977	97.3	817.4
1978	119	1876
1979	113.8	1384
1980	39.4	388.5
1981	86.3	439.9
1982	100.6	1859
1983	81.4	1016
1984	110	1493
1985	211.1	1759

Table 4 continued

Year	Minimum Discharge (cfs)	Maximum Discharge (cfs)
1986	221.3	2734
1987	164.1	2786
1988	115.1	1265
1989	124	1389
1990	318.4	3382
1991	114.6	1638
1992	194	2564
1993	265.6	2058
1994	142.7	1923
1995	181.3	2139
1996	167.5	2757
1997	210.4	1516
1998	138.7	2307
1999	154.4	2024
2000	176.6	3552
2001	168.8	2361
2002	176.6	3552
2003	168.8	1544
2004	159.5	1722
2005	129.1	788.7
2006	158.7	1234
2007	102.9	2396
2008	99.3	986.7
2009	168.3	1591
2010	327.2	3425
2011	274.1	2343
2012	190.4	1111
2013	196.8	5280
2014	223.5	1774

Justification: The yearly minimum and maximum discharges provide a snapshot of how low and high the flows can be on a yearly basis.

Table 5. Illinois River at Tahlequah

Recurrence High Flow Year	Discharge (cfs)
2	14,500
5	5,600
10	68,800
50	45,700
79	8,630

* gage record not long enough for 100-year recurrence interval

Table 6. Illinois River at Watts

Recurrence High Flow Year	Discharge (cfs)
2	18,200
5	51,600
10	26,800
50	8,060
98	8,840

* gage record not long enough for 100-year recurrence interval

Justification: Discharges that recur every 2 years are referred to as 100-year flood events. These are important to recognize because these events are happening more frequently due to the changing climate.

Month	Monthly Mean Discharge (cfs)	25% Exceedance	50% Exceedance	75% Exceedance
January	876	657	590	219
February	1110	833	891	278
March	1440	1079	1018	360
April	1660	1247	1259	416
May	1650	1237	1101	412
June	1020	768	724	256
July	523	393	333	131
August	362	272	251	90.6
September	388	291	262	97
October	543	409	269	136
November	872	656	398	219
December	890	663	487	221
*1936-2014				

Table 7. Monthly exceedance flows for the Illinois River at Tahlequah

Table 8. Monthly exceedance flows for the Illinois River at Watts

Month	Monthly Mean Discharge (cfs)	25% Exceedance	50% Exceedance	75% Exceedance
January	595	446	451	149
February	699	524	558	175
March	971	728	763	243
April	1110	831	867	277
May	1020	762	716	254
June	659	494	420	165
July	382	286	242	95.5
August	251	188	188	62.8
September	315	236	200	78.8
October	370	281	200	93.75
November	617	470	337	157
December	643	489	356	163
*1955-2014				

Justification: Monthly exceedance flows provide discharges that describe the percent of time for which an observed discharge is greater than or equal to a defined discharge such as the mean monthly discharge. This provides discharges that are not normally distributed so it is important to recognize the bell curve.

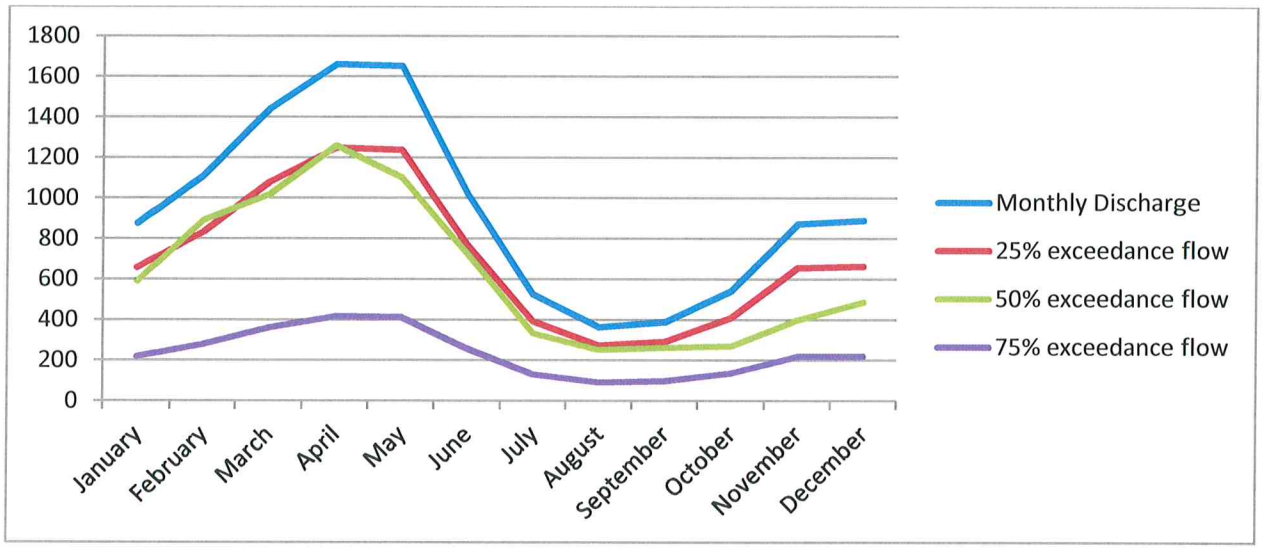

Figure 1. Illinois River at Tahlequah monthly discharge and exceedance flows

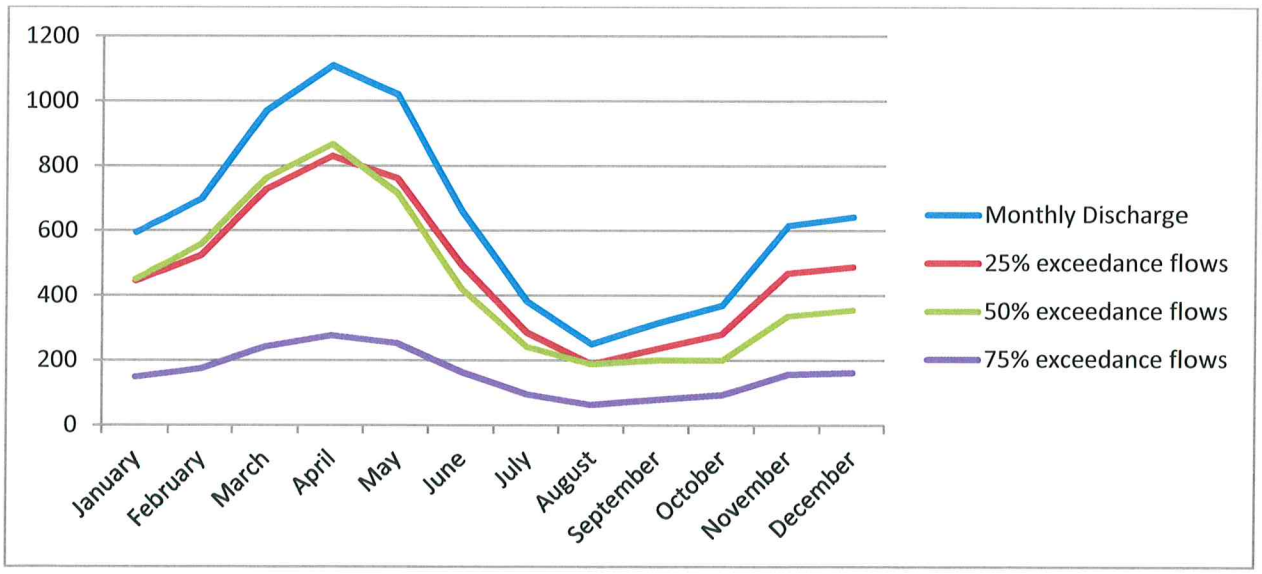

Figure 2. Illinois River at Watts monthly discharge and exceedance flows

The monthly discharge for figures one and two include a period of record at Tahlequah from 1936-2014 and from 1955-2014 at Watts.

Justification: Establishment of instream flows is based on exceedance flows so it is important to recognize these flow values.

Ecological Process Flow Needs

There are four flow components based on the Texas Instream Flow Program that need to be addressed in the Illinois River Watershed. These riverine components are: biology, hydrology & hydraulics, water quality and geomorphology.

Table 9. Texas Instream Flow Program riverine components of importance for instream flow

Biology	**Hydrology & Hydraulics**	**Water Quality**	**Geomorphology**
Understand relationship between aquatic communities, life histories and habitats	Address natural flow regime that includes magnitude, duration, frequency, timing and rate of change of flow conditions in addition to subsistence flows, baseflows, high flows and overbank flows	Analyze water temperature, conductivity, pH, turbidity and dissolved oxygen levels	Analyze variations in baseflows, subsistence flows, high flows and overbank flows which contribute to geomorphological changes
Understand physical processes that create and maintain system habitat, water quality and hydrology	Understand habitat conditions such as current velocity, depth, substrate composition and instream cover	Analyze nitrogen and phosphorus issues due to poultry farms and other farming practices	Analyze characteristics of available sediment supply
	Analyze lateral, longitudinal, vertical and temporal aspects of hydrology	Analyze watershed geology, land use, climate, organic matter and nutrients	Analyze land use changes that could trap sediment such as reservoirs
	Analyze distribution of depths and velocities in cross sections		

Table one is important to consider when developing an Instream Flow Program for Oklahoma. All of these riverine components contribute to the health of the Illinois River watershed. The natural flow

regime will be important to be maintained for all the stream dependent wildlife that utilize the Illinois River Watershed.

Stream Dependent Wildlife

1. Wetlands/Oxbows:

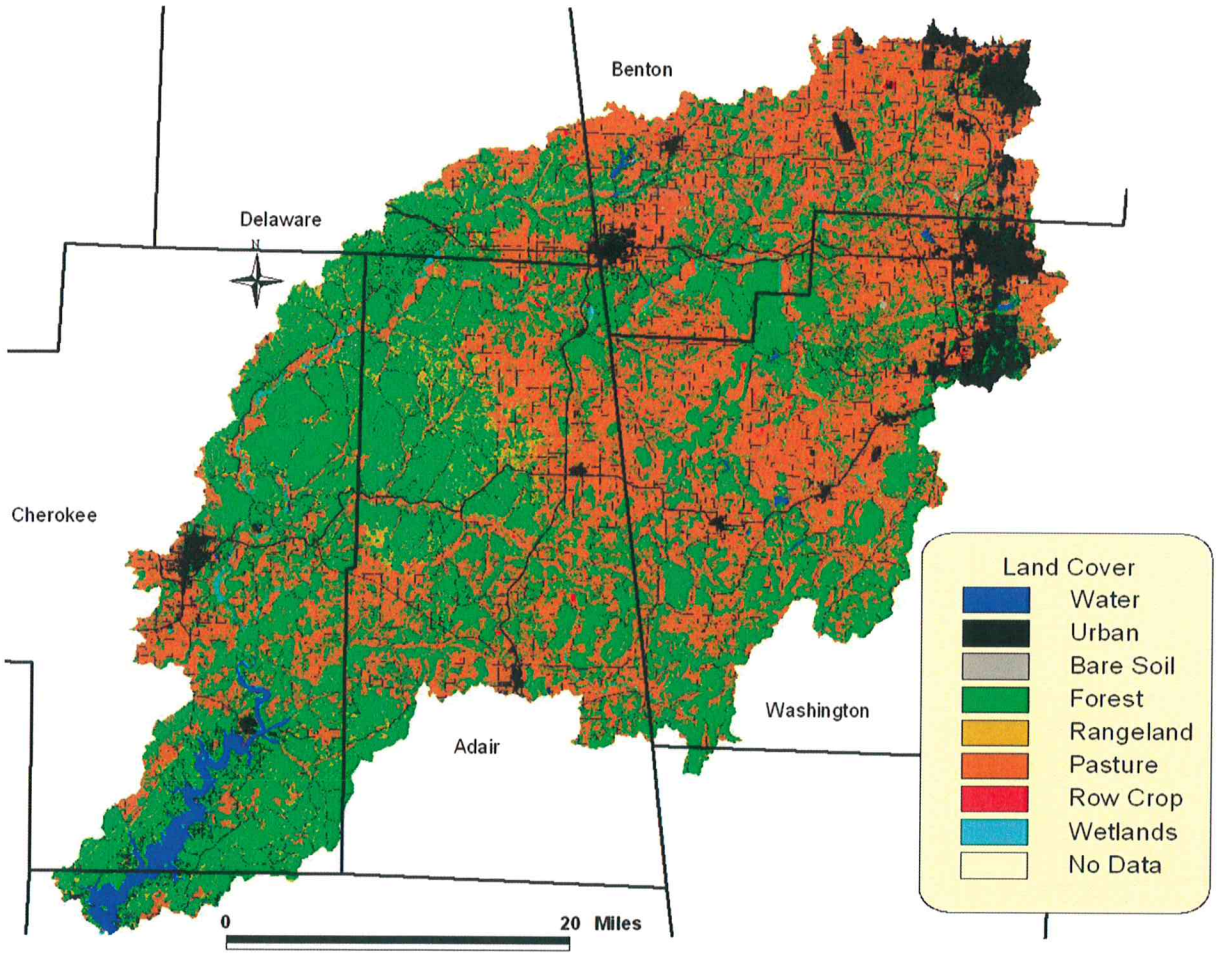

Figure 2.2 Modified 30-meter 2001 National Land Cover Dataset with county boundaries for the Illinois River Basin (Storm et al. 2010)

See report labeled Hydrologic Modeling of the Illinois River Basin report 2010.pdf

Oklahoma has 62 oxbow lakes but these are located in Southern and Eastern Oklahoma. The Illinois River watershed doesn't have any oxbow lakes that documentation could prove. Wetlands are found in small areas along the Illinois River indicated by Figure 2.2 above.

2. Wildlife: E&T Species, natural resources, wildlife, vegetation

   The Rabbitsfoot mussel is listed as threatened, and the Neosho Mucket mussel is listed as endangered in the Illinois River watershed.

The Neosho mucket mussel has a 4-inch, round shell that's light tan on the outside and bluish-white on the inside. It lives in the Illinois, Neosho and Verdigris river watersheds in Arkansas, Kansas, Missouri and Oklahoma. Threatened by dams and pollution from agriculture and mining, it can no longer be found in more than 60 percent of its historic range. The Service is proposing to list it as "endangered" and to protect 484 river miles as "critical habitat" to ensure its survival. The mucket has been on a waiting list for protection since 1984 (http://www.biologicaldiversity.org/news/press_releases/2012/2-mussels-5-fish-10-15-2012.html)

The rabbitsfoot mussel grows to about 6 inches in length, with a rectangular, olive shell featuring gorgeous black triangles on the outside and iridescent purple or white inside. It has disappeared from 65 percent of its historic range. The Service is proposing to list it as "threatened" and to protect 1,654 river miles in Alabama, Arkansas, Illinois, Indiana, Kansas, Kentucky, Missouri, Mississippi, Oklahoma, Ohio, Pennsylvania and Tennessee as critical habitat. The rabbitsfoot was historically known from 139 streams in 15 states, but today it survives in only 49 streams and has been lost from Georgia and West Virginia. It is threatened by water pollution, mining, dredging, dams and displacement by exotic mollusks. It has been waiting for protection since 1994 (http://www.biologicaldiversity.org/news/press_releases/2012/2-mussels-5-fish-10-15-2012.html)

The Gray Bat and the Indiana Bat are also federally listed in the Illinois River watershed of Oklahoma.

Gray Bat (*Myotis grisescens*) – Gray bats have long, glossy, light to dark brown fur, distinguishing them from other bat species. Gray bats inhabit caves year round. In the winter they hibernate in deep vertical caves found in the karst region of the southeastern US. During the summer they roost in caves near rivers so they have access to prey. They eat flying aquatic and terrestrial insects. They do not inhabit barns and houses (http://www.fws.gov/arkansases/docs/ESDay/Photographs%20of%20Endangered%20Species%20in%20Arkansas.pdf)

Indiana Bat (*Myotis sodalis)* – The Indiana bat is a small relative of the gray bat. Their fur is dark-brown to black. They occur in the Ozark, Boston, and Ouachita Mountain region of Arkansas. Indiana bats hibernate in large numbers in only a few caves, making them vulnerable to disturbance. Females may roost in groups up to 100 bats or more, during the summer, under the loose bark of trees. They forage along the forest edge, preying on flying insects. They can eat up to half their body weight in insects each night. Cave and forest habitat destruction and modification were the primary threats that led to this species endangered status. Hibernating bats are dying in record numbers due to a new wildlife health crisis called white-nose syndrome. The affliction was first documented in New York during the winter of 2006-2007 and is rapidly spreading across the eastern US and afflicting numerous bat species, including the Indiana bat. It has not been documented in Arkansas yet, but could affect our bat populations within a couple of years (http://www.fws.gov/arkansases/docs/ESDay/Photographs%20of%20Endangered%20Species%20in%20Arkansas.pdf)

For additional information on natural resources, wildlife and vegetation, view the document labeled: Downloads_GetFile.pdf

Additional wildlife species include the Northern River Otter, Beaver, Eagle, Great Blue Heron, Green Heron

Vegetation: River cane, variety of oaks, longleaf pine

Literature Cited

Krause, R.E. Jr. 2004. An environmental history of the Illinois River basin in Eastern Oklahoma and Northwest Arkansas. Master Thesis. Oklahoma State University.

Storm, D.E., P.R. Busteed, A.R. Mittelstet, M.J. White. 2010. Hydrologic modeling of the Oklahoma/Arkansas Illinois River Basin Using SWAT 2005. Final Report. Oklahoma Department of Environmental Quality. Oklahoma State University.

http://www.fws.gov/arkansases/docs/ESDay/Photographs%20of%20Endangered%20Species%20in%20Arkansas.pdf

http://www.fws.gov/arkansases/docs/ESDay/Photographs%20of%20Endangered%20Species%20in%20Arkansas.pdf

http://www.biologicaldiversity.org/news/press_releases/2012/2-mussels-5-fish-10-15-2012.html

http://www.biologicaldiversity.org/news/press_releases/2012/2-mussels-5-fish-10-15-2012.html

From:	Michael Fuhr
To:	Tony.Clyde@usace.army.mil; barry.bolton@odwc.ok.gov; shannon.brewer@okstate.edu; david_martinez@fws.gov; Ed.Fite@osrc.ok.gov; jim.burroughs@odwc.ok.gov; julie.cunningham@owrb.ok.gov; Kimberly Elkin; monty.porter@owrb.ok.gov; Owen.Mills@owrb.ok.gov; Shanon.phillips@conservation.ok.gov; Derek.Smithee@owrb.ok.gov; kevin_stubbs@fws.gov; Childers, Anna/TUL; JRehring@carollo.com; Amanda Tubbs; Ashley Dubriwny; Jay Pruett; Olson, Forrest/SEA
Subject:	Flow Meeting Follow-up [EXTERNAL]
Date:	Wednesday, July 20, 2016 8:10:01 PM
Attachments:	image001.png image005.png

Hi Everyone:

Here's the notes from the meeting earlier this week. Thanks to everyone for getting together on such short notice. Take a look and please clarify anything I captured incorrectly and/or add anything I missed.

At Meeting: Mike, Barry, Shannon, Derek, Monte, David, JB
On Phone: Forrest, Kim, Owen, Steve, Ed

We discussed the overall pilot project and noted a few details worth including with the flow recommendations:

- We need to continue forward using the weight of evidence approach; it is critical to the pilot project and all future ISF efforts
- For the current efforts, it's important for decision makers to consider the fact that the Illinois, Barron Fork, and Flint Creek are all Scenic Rivers and deserve special protection as a result of this status. The recommendations from this group however should be science-based and focused on providing the protection dictated by the data.
- For each recommendation, we used average median flow to "check" recommendation.
- Data associated with adult smallmouth bass was weighted more heavily than the data for juveniles because the young of the year bass tended to have higher tolerances for high temperatures, etc.
- Future projects should identify methodologies that can account for seasonal variability where necessary. The IFIM approach only allowed for a single recommendation focused on a minimum flow.

Flow Recommendations:

Barron Fork
Flow range: 40-75 cfs

Flint Creek
Flow Range: 35-55 cfs

Illinois River
Flow Range: 225-350 cfs

Critical for these recommendations, as well as future environmental flow projects, is the need for the implementation to include enforcement for the flows that are ultimately adopted.

Mike

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From:	Mike Mathis
To:	Olson, Forrest/SEA
Cc:	JD Strong (JD.Strong@owrb.ok.gov); Smithee, Derek (Derek.Smithee@owrb.ok.gov)
Subject:	Illinois River Instream Flow Assessment - Draft Report [EXTERNAL]
Date:	Thursday, July 14, 2016 11:48:05 AM
Attachments:	crlogo-color29.png

Forrest: Thanks for your presentation of the draft technical report at the OK Instream Flow Advisory Work Group meeting on June 16. You had asked for any comments on the report within 1 month of the meeting. I just wanted to again offer the comments that I made at the meeting along with some additional thoughts, as follows.

- Section 1 Introduction would be improved with possibly using some of the graphics on the ISF Pilot Study Process to help identify where this report fits in.

- Section 2.3 Water Rights and Water Usage: Lots of good info here but really need to see more detailed breakdown of Use versus Time of Year versus Range of Flow (especially critical low flow conditions). This would be applicable to current use, permitted use and projected Year 2060 use. It would also be good to see discussion of the various user sectors critical requirements for their water use – somewhat similar to the analysis for the fish habitat. This would help guide policy development as the OWRB overlays all sector requirements to see where commonalities exist along with identifying pressure points, if any.

- Section 2.7 Recreation: Again, lots of good info here but it seems out of place to include the economic impact discussion for recreation where there was not a similar discussion of the economic impacts of the various consumptive water users in Section 2.3. The economic impact of the City of Tahlequah alone would be quite large, I imagine. Per the discussion at the meeting, would it be appropriate to defer this economic information to the next study step (??)

- Section 4.3 Decision-Making Considerations: I was surprised to not see the consumptive water use sectors identified as a consideration or priority in this section. This is contrary to the second paragraph in the Section 1 Introduction. I don't think there could ever be much support for an instream flow policy in the Illinois River system if the needs of Tahlequah, rural water district customers and agriculture/industry weren't considered important. I also think that a consideration should be assessing how big of a potential problem/conflict (risk management) actually appears to exist versus the resources that will be required for the OWRB to fully administer an instream flow policy on this (or any other) reach. By way of example, the report states that 200-300 CFS might be a good low flow target that supports both the fishery and the recreation needs in the Illinois River portion. Some context is needed for these as 200 CFS is about 145,000 AF/Year and 300 CFS is about 217,000 AF/Year – this is approaching the range of what Oklahoma City and Tulsa use combined. These are huge amounts of water to consider for a default set-aside. Compare that to the 12,100 AF/Year actually used in the Illinois River portion by consumptive users and it begs the question if there really is an issue here that even warrants consideration of an instream flow policy. More comparative analyses (both hydrologic and economic) such as this are needed

in the report. The bottom line: resources available to the OWRB (and all other state agencies) are stretched to the limit, which require prioritizing the most pressing issues for them to address, likely for the foreseeable future.

- Overall, I was disappointed that the report was not more balanced in its analyses. I expected quite a bit of technical analyses of the fishery and recreation needs/impacts, but also expected similar treatment to the other consumptive uses. I was surprised at the lack of critical comparative analyses along with lack of context to understand the magnitude of the potential policy and administrative issue at hand. Additional effort in this regard could certainly improve the report.

Thanks again for all your efforts on this project. I appreciate the opportunity to participate in the process.

Mike Mathis
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July 27, 2016

Forrest Olson
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Forrest:

As requested in your 25 July 2016 email, I will outline Oklahoma Department of Wildlife Conservation comments regarding the final draft of the Illinois River Instream Flow Assessment (IRIFA). This document also includes some comments provided by Dr. Shannon Brewer Ph.D., Assistant Unit Leader, Oklahoma Cooperative Fish and Wildlife Research Unit.

GENERAL COMMENTS

1. The process for implementing instream flows for Oklahoma has been emphasized from the first meeting of the Instream Flow Advisory Group. The IRIFA fails to outline that process. I have no problem with the suggestion that this could be a stand-alone document but at a minimum it should be referenced in the IRIFA.
2. ODWC believes specific flow recommendations should be included in the IRIFA. During the 16 June 2016 meeting, the OWRB agreed to include this section in the final document. The Technical Advisory Group (TAG) met on 18 July 2016 to develop flow recommendations for each of the study streams. ODWC supports the recommendations of the TAG.
3. It is critical to remember the Scenic Rivers involved in this study deserve special protection and decisions should be science-based.
4. Setting environmental flows is meaningful only if enforcement measures are implemented to ensure compliance.
5. ODWC continues to stress the need to move the process forward in a timely fashion. An economic impact study and other components could begin before the IRIFA is finalized.

SPECIFIC COMMENTS

1. Page 1-1 (paragraph 3)
   Discussion of the "process" or reference to stand-alone process document is needed.
2. Page 1-1 (paragraph 4)
   Many elements of this study were put into motion with little input from the various agencies. A review of correspondence would reveal several instances where comments were not incorporated into the IRIFA.
3. Page 2-6 (paragraph 1)
   You should present a range of variation expected from potential climate-change estimates rather than characterize the impacts as "uncertain".

The Oklahoma Department of Wildlife Conservation is the state agency responsible for managing fish and wildlife. The Wildlife Department receives no general tax appropriations and is supported by hunting and fishing license fees and federal excise taxes on hunting and fishing equipment.

4. Page 2-12 (paragraph 3)
   Is a reference available for "...most of this water use is for Tahlequah's public water supply which primarily *affects* (several grammar issues were found throughout the report) only a three mile reach of the river?
5. Page 2-16 (paragraph 3)
   Bigmouth buffalo are not suckers. You should point out that many of the species which occurred only in Barren Fork Creek or Flint Creek are present in other systems.
6. Page 2-19 (paragraph 5)
   I am unfamiliar with the terminology "non-fish aquatic species" and "pearly freshwater mussels".
7. Page 2-23 (paragraph 1)
   I understand the importance of secondary channels but why is it important to quantify them in this report. Also, why does the topic come under the heading of "Riparian Corridors"?
8. Page 2-23 (paragraph 5)
   The first sentence is unclear.
9. Page 2-27 (paragraph 1)
   This paragraph could be moved to the first paragraph of the discussion of secondary channels to outline why it is important to quantify them.
10. Page 3-1 (paragraph 4)
    It should be noted the Technical Workgroup emphasized the importance of including the lower Illinois River below Tenkiller Dam.
11. Page 3-3 (paragraph 3)
    Who decided to focus the study on this 21 mile section in the lower reach of the Illinois River?
12. Page 3-3 (paragraph 4)
    Why was it assumed that flows should be quantified "toward the lower end of the reaches assuming that is where flow compliance would be measured"?
13. Page 3-3 (paragraph 5)
    The term "glide" is not commonly used to describe Ozark streams.
14. Page 3-4 (paragraph 4)
    "...maximum *microhabitat* occurred at flows..."
15. Page 3-7 (paragraph 3)
    "The method can also be used as a test *to verify* IFG-4 relationships."
16. Page 3-7 (paragraph 7)
    "Defined *microhabitat* criteria (depth, velocity, and substrate) suitable for PHABSIM..."
17. Page 3-8 (paragraph 1)
    You might consider use of more current references.
18. Page 3-8 (Table 3-3)
    a. Page 3-3 defines pool, run and riffle. Table 3-3 uses headings including "shallow-fast, intermediate and deep-slow". Consistent terminology throughout the document would be useful.
    b. Mosquitofish and topminnows are not typically found in riffle habitat.
    c. Largemouth and smallmouth bass are not normally found in the same habitat.
    d. Non-native fish (common carp) could be removed from the report.
19. Page 3-9 (Table 3-4)
    a. A depth of 5 cm is suitable habitat for adult smallmouth bass?
    b. More current references would be helpful.
20. Page 3-25 (paragraph 1)
    The statement that 90% of juvenile smallmouth bass habitat is maintained at flows of 250-900 cfs is misleading. These fish often do well in prolonged summer low-flow events. Broad habitat criteria possibly led to these results. Perhaps habitat should be revised to microhabitat.

21. Page 3-31 (paragraph 1)
    Uncertainty related to sample size and suitability criteria suggests additional effort could be focused here.
22. Page 4-1 (paragraphs 2 and 3)
    "...flow curves (AWS) presented in the PHABSIM modeling portion of this report are simply relationships between fish rearing habitat and stream flow..."
    "...study results must be interpreted as to their biological meaning to the fish community as a whole."
    What does this mean and why use this approach if it doesn't easily transfer to flow prescriptions?
23. Page 4-1 (paragraph 5)
    "Of the various mesohabitat types...
    This paragraph is true but needs more concise explanation.
24. Page 4-1 (paragraph 6)
    "...it is unlikely that the amount of pool habitat at any flow is a population limiting factor..."
    Why wasn't the approach structured to reflect these considerations?
25. Page 4-1 (paragraph 7)
    ..."maximum habitat occurs at 200 cfs..."
    But... more micro habitat does not necessarily mean more fish which is a major limitation of this approach.
26. Page 4-2 (paragraph 5)
    "...such flows would represent a minimum flow management prescription..."
    Variation is important even at low flows.
27. Page 4-3 (paragraph 3)
    It seems obvious that channel maintenance is not impacted by timing of high flow events. It should be emphasized that most ecological functions **are** impacted by timing of these flows.
28. Page 4-3 (paragraph 5)
    "Higher flood events..."
    Floodplain events are important. They contribute to nutrient spiraling, energy exchange, fish rearing, etc. which are important in maintaining high quality rivers. Obviously, we would not recommend 500 year flood events but the "active floodplain" is typically much lower.
29. Page 4-5 (paragraph 1)
    "...Water quality should not be a high priority..."
    This may not be a true statement in the future.
30. Page 4-5 (paragraph 3)
    ...Habitat availability at these base flows are what fish populations tend to track..."
    This is only true if habitat elements are limiting.

We appreciate the opportunity to participate in this process. Please contact me at 405-521-3721 if you require additional information.

Sincerely,

Barry Bolton
Chief of Fisheries Division
Oklahoma Department of Wildlife Conservation

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July 21, 2016

Mr. J.D. Strong, Executive Director
Oklahoma Water Resources Board
3800 North Classen Blvd.
Oklahoma City, OK 73118

RE: Comments on the Illinois River Instream Flow Assessment Draft Technical Report, June 2016

Dear Mr. Strong,

Oklahoma Farm Bureau appreciates the Oklahoma Water Resources Board including our organization on the Instream Flow Advisory Group. We submit these comments on behalf of our membership. OKFB is a statewide general farm organization with more than 90,000 member families and the voice of agriculture in Oklahoma. OKFB represents farmers and ranchers with operations of all sizes who grow and raise a wide variety of crops and livestock.

OKFB is a grassroots organization that updates its policy positions annually. Our *2016 Policy Book* contains fifteen pages with water issues. OKFB members have been interested in Oklahoma's scenic rivers since the legislature created them.

The number of OKFB member families residing within the counties of the study area for the 2015 membership year is: Adair, 1,111; Cherokee, 1,850; and Delaware, 1,046. Many of these members are directly affected by the legal, economic, scientific and social policies regarding the scenic rivers.

OKFB GENERAL OBSERVATIONS & RECOMMENDATIONS

Observation 1: At our Instream Flow Advisory Group meeting on June 16, we discussed the need for a document or documents to explain the reason for the Pilot Study and the study process. It was also discussed that an in-depth economic analysis was needed in the Pilot Study. Those items and more were already noted as required elements of the ISF Pilot Study using the Instream Flow Incremental Methodology process. Although the Draft Technical Report (DTR) does not include all of the elements outlined in the IFIM, e.g., economic analysis, it is our understanding those elements will be considered at a later time within the IFIM process. We would appreciate a similar effort be made to address the other issues within the IFIM, as has been given to the DTR.

Observation 2: The definition of instream flows being used for ISF issues and ISF studies seems to be inconsistent. The *Oklahoma Comprehensive Water Plan Supplemental Report, Instream Flow Issues & Recommendations*, February 2011 states:

> …for the purposes of this report instream flow describes the quantity of water set aside in a stream or river to ensure downstream environmental, social and economic benefits are met. (1)

The OWRB's website quotes an almost identical definition from the same *Issues & Recommendations* document. However, a different definition appears in the June 16, 2016 *Illinois River ISF Pilot Study Public/Stakeholder Meeting PowerPoint*:

> Focus of Tonight's Discussion: Instream (or environmental flows) are those necessary to provide for a healthy ecosystem and support water-related recreation (such as fishing, hunting, swimming, and boating) as well as tourism. (5)

Please explain the use of the two different definitions. If they are being used in different contexts, it would be helpful if their application was clarified and perhaps reviewed in pertinent documents.

Observation 3: The *2012 Oklahoma Comprehensive Water Plan Executive Report* identified Instream/Environmental Flows as one of eight Priority Recommendations and gave these instructions:

> The process developed by the OCWP Instream Flow Workgroup should be implemented and followed to ascertain the suitability and structure of an instream flow program for Oklahoma, with such process commencing in 2012 and concluding by 2015, as outlined by the Workgroup. (10)

The *2011 Instream Flow Issues & Recommendations* outlined the elements to be examined for a potential instream flow program and recommended the following Steps:

1. Address the legal and policy questions.
2. Study other mechanisms for protecting instream flows.
3. Develop a draft methodology for Instream Flow studies in Oklahoma.
4. Conduct a study on the economics of instream flows in Oklahoma.
5. Perform an instream flow pilot study in a scenic river.
6. Preserve the Instream Flow Advisory Group.

The IFIM system is being used to conduct Steps 1-5. The June 15, 2014, *Memorandum for the Instream Flow Pilot Study Approach* from CH2MHILL to the OWRB and the US. Army Corps of Engineers explains:

> The primary goal of the pilot study is to gain a better understanding of the implications of a process to assess ISF benefits and issues consistent with the overall goal of managing water resources in Oklahoma for multiple uses. This includes consideration of ISF needs, recreational uses of water, and consumptive uses of water in the watershed (e.g., public water supply, crop irrigation, power generation and industrial uses), drawing on significant involvement of stakeholders from all water interest groups in the watershed. (3)

It is unclear whether Steps 1 and 2 are considered completed. Acting on recommendations and issues raised by the ISF Working Group, CH2MHILL has generated a wealth of supporting information that has been published in several documents. Will the ISF Advisory Group be discussing this supporting information again in concert with the DTR and the economic study yet to be completed for the Pilot Study?

Observation 4: The ISF Advisory Group has raised concerns about the economics of implementing an ISF program in Oklahoma, in terms of study costs and economic benefits/costs of developmental (out-of-stream water uses) and nondevelopmental (ISF-related) resources. Perhaps the Advisory Group should be provided with a statement of Pilot Study expenses to date. The final cost of the Pilot Study should be included in the final report.

Observation 5: The OWRB website contains an abundance of information on the Instream Flow page. It's helpful to have all the information in one location; however, it can be difficult to maneuver, as several years of reports are included. It would be helpful to sort the information by topic in addition to by date, including specific publication names and dates. The Pilot Study references already-researched material in previous documents, e.g. the statutory framework and other mechanisms for protecting ISFs. Organizing the materials for use in Phases 4 and 5 (*Memorandum*) and for inclusion in the Pilot Study final document would be helpful. If the elements were gathered now for the draft Pilot Study, we could see the issues we have already discussed and the information assembled for it.

Observation 6: We were disappointed the DTR contains policy positions, which we believe should be recommendations of the ISF Advisory Group, not the Technical Study Group.

COMMENTS ON ISSUES WITHIN THE DTR

Section 1 Introduction (regarding IFIM)

> The methodology typically is used to assess the impacts of specific water development proposals (for example, a water diversion) where alternative stream flow regimes can be assessed. However, this is not the circumstance for the Illinois River, which is largely an unregulated stream with no foreseeable major water development projects being contemplated. Therefore, the development of alternatives and their analysis, including an economic evaluation, may not be as important in this case. (1-1)

OKFB comment: This statement undermines the importance of Steps 1, 2, and 4 from *Issues & Recommendations*. Additionally, it conflicts with goals in Phases 1, 4 and 5 of the *Memorandum*. It should be reworded or removed from the DTR.

Section 2 Watershed Resources
2.1 Watershed Overview

OKFB comment: Generally, the DTR appears to focus on streamflow needs for fish and other aquatic resources, recreation, wildlife and water quality. It lacks a thorough study of consumptive uses, including public water supply, crop irrigation, power generation, and industrial use, which makes the DTR seem incomplete. Only six lines reference agricultural production in this section (2), but include several pages of information on watershed resources for fisheries, wildlife and recreation. Consumptive water uses should have received more consideration in the DTR.

Section 4.3 Decision-making Considerations
4.3.1 Need to Consider Basin Goals

> Understanding the established goals of the stream basin is critical in supporting instream flow management prescriptions. The expressed goals of the OSRA for the Illinois River basin streams are as follows…prescribing minimum instream flows is needed because this is where water use conflicts would be most likely to occur in the future...the use of the term 'free flowing' in the OSRA may not be enough by itself to provide the desired base flow protection. (3-4)

OKFB Comment: The watershed goals referenced in the DTR refer to the goals stated in the Illinois River Management Plan (1999) published by the Oklahoma Scenic Rivers Commission. Many people are not familiar with the IRMP, and it can't be located with a simple internet search. To the best of my knowledge, the ISF Advisory Group has not evaluated or adopted the IRMP with regard to this Pilot Study. Further, this section takes a policy position

by stating prescribing minimum instream flows is needed, which has not been a conclusion of the ISF Advisory Group.

4.3.2 Need to Consider All Resources and Their Priorities

OKFB comment: The resources are listed as recreation, fish habitat, wildlife, water quality and ecological processes (4-5). Consumptive uses should have been considered resources and included in the DTR.

4.3.3 Need to Consider Water Availability (Conclusion)

> In conclusion, regarding the various flow components, establishing base flow prescriptions for the Illinois River, Flint Creek, and Barren Creek is of utmost importance. These base flows would represent standards for use by the OWRB in assessing future out-of-stream water right applications….These processes support the environmental values embodied in the goals established for these state-designated Scenic Rivers. Legal protection of these flows may be provided by the OSRA. However, it may be helpful from a regulatory standpoint to include protection of these ecological process flows, even if only in narrative form, in any instream flow prescription for the Illinois River, Barren Fork Creek, and Flint Creek. (5-6)

OKFB Comment: Again, this section references the IRMP, which has not been evaluated or adopted as a watershed goal by the ISF Working Group. The DTR makes policy recommendations in favor of implementing minimum instream flows for the three scenic rivers through Oklahoma's water quality standards. Narrative protection of ecological process flows in the Illinois River would be adopted as water quality standards in Chapter 45 of the OWRB Rules, leading to the creation of water quality standards implementation criteria in Chapter 46. Adoption of water quality standards implementation criteria would create a new regulatory scheme for the affected streams/rivers, to be implemented by the various state agencies within their regulatory jurisdictions. The Conclusion should be rewritten focusing on the scientific results of the DTR, and omitting the policy recommendations.

CONCLUSION

These comments are intended to contribute to the dialogue and help offer improvements to the IFIM process within the Pilot Study. We appreciate the opportunity to comment on this DTR. Thank you for your consideration in this matter.

Sincerely,

Marla R. Peek
Director of Regulatory Affairs

cc: Oklahoma Farm Bureau Board of Directors

OIPA OKLAHOMA INDEPENDENT PETROLEUM ASSOCIATION

Mr. J.D. Strong
Executive Director
Oklahoma Water Resources Board
3800 North Classen Boulevard
Oklahoma City, OK 73118

Delivered by electronic mail

RE: **Comments to the Illinois Instream Flow Pilot Study Draft Technical Report**

Mr. Strong:

The Oklahoma Independent Petroleum Association (OPIA) respectfully submits the below comments in response to the Oklahoma Water Resources Board (OWRB) draft technical report of the Illinois River Instream Flow Pilot Study.

OIPA represents approximately 2,600 small to large independent operators that are primarily involved in the exploration and production of crude oil and natural gas in the state. In addition, we represent a number of companies which provide services that support exploration and production activities. "Independent" producers are non-integrated companies which receive the majority of their revenues from production at the wellhead. They are exclusively in the exploration and production segment of the industry with no marketing or refining operations as compared to large, integrated, major oil and gas companies. Independent oil and gas companies range in size from large companies with thousands of employees to hundreds of smaller "mom and pop" type companies. In Oklahoma, independent producers make up the majority of the energy industry, producing 96% of the state's crude oil and 88% of the state's natural gas.

The oil and gas industry is the cornerstone of the state's economy and is an important component of the US energy industry. Oklahoma is the fourth largest producer of natural gas in the US and the fifth largest producer of crude oil. Our members live and work in the area where they explore, drill, complete and produce these critical resources. It is our hope that OWRB will thoughtfully consider the input from our association in the development of this study and any final proposed rules in addition to the oral comments expressed.

OIPA maintains concerns about the draft report and the potential implications from application of the draft as written. Specifically, our concerns extend to:

- **Recent court decisions must be considered to assure sufficient evidence is provided to withstand judicial review.**

Over the course of the past two U.S. Supreme Court sessions and in subsequent federal district court cases we are seeing the Court evolve away from a strict adherence to *Chevron*[1] deference in favor of scrutiny of the record to determine if deference is deserved[2]. The document these comments are written in response to is intended to potentially serve as a basis for future regulations determined by the OWRB. If it does not sufficiently meet appropriate evidentiary standards future regulations based upon it are in jeopardy.

OIPA recommends that this document be given a thorough review for completeness prior to becoming final to assure that any regulation based upon it cannot be considered arbitrary and capricious.

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[1] *Chevron U.S.A., Inc. v. Natural Resources Defense Council, Inc.*, 467 U.S. 837 (1984).

[2] *See Michigan v. EPA,* 576 U.S. ___ (2015), *and Encino Motorcars v. Navarro,* ___ U.S. ___; docket no. 15-415, (2016); *also see State of Wyoming v. U.S. Department of the Interior,* Case No. 2:15-CV-043-SWS, (2016).

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- **The report insufficiently defines what an instream flow is, what it encompasses and why it excludes considerations such as analysis of localities.**

While the reader is guided through an analysis of impacts related to instream flow, at no point is the reader given a narrow, focused baseline assessment for how to determine if the data fit within a definition of instream flow. To some this may be an obvious term, however each individually may hold a different narrow window on what an instream flow encompasses. This elementary - but important - step should be taken to assure that all stakeholders are on the same page as they assess the validity of the draft.

- **Any economic analysis should be all-encompassing rather than picking and choosing particular industries**

Section 2.7 focuses on recreation, but more narrowly diverges into an economic impact discussion. No other consumer is contemplated in the discussion, including major users in the area such as Tahlequah. It may be a wise course to expand the analysis of economic impact to all users or leave all economic impact discussion for a future report where the information can be more fully considered.

- **The draft report fails to ask whether this analysis is even necessary and what harm it is attempting to overcome.**

OIPA's most significant concern with this draft study is that at no point does it explore the concept of whether this is a solution in search of a problem. In other words, why is this necessary? OIPA can find no significant reason or finding given upon which to base the need for all of the charts and data. This important piece of truly providing a strong basis for upholding any review of rules based upon it needs to be reconsidered and given significant coverage.

Conclusion

OIPA is concerned that this report is a solution in search of a problem and may lead to poor or unnecessary regulation in the future. Further, the draft report is incomplete to the point that any rule that is based upon findings in it may ultimately be insufficient to the courts, rendering this exercise a wasted effort. OIPA strongly encourages serious consideration of the points raised herein in order to develop a meaningful and complete document.

Respectfully,

Anthony J. Ferate, JD
Vice President of Regulatory Affairs
Oklahoma Independent Petroleum Association