State of Oklahoma
OWRB
WATER RESOURCES BOARD
the water agency

Oklahoma Comprehensive Water Plan
Supplemental Report

Instream Flow
Issues & Recommendations

February 2011

This study was funded through an agreement with the Oklahoma Water Resources Board under its authority to update the Oklahoma Comprehensive Water Plan, the state's long-range water planning strategy. Results from this and other studies have been incorporated where appropriate in the OCWP's technical and policy considerations. The general goal of the 2012 OCWP Update is to ensure reliable water supplies for all Oklahomans through integrated and coordinated water resources planning and to provide information so that water providers, policy-makers, and water users can make informed decisions concerning the use and management of Oklahoma's water resources.

Oklahoma Comprehensive Water Plan
OCWP

Instream Flow Issues and Recommendations

The following consensus report was developed as a part of the 2012 Update of the Oklahoma Comprehensive Water Plan to address the issue of instream flows in Oklahoma. This work is the result of countless hours of effort by many dedicated individuals representing industry, municipalities, agriculture, oil and gas, environmental groups, tribes and federal and state agencies. This report outlines the issues associated with an instream flow program and recommends the steps necessary to continue the dialogue about such a program in Oklahoma.

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Photo on front cover: Beavers Bend State Park, Oklahoma.

Executive Summary

The state of Oklahoma is blessed with abundant water resources. For more than 100 years of statehood Oklahomans have beneficially used the state's water resources for agriculture, industry, water supply, navigation, mining, oil and gas production, recreation, and fish and wildlife. The beneficial use of water has been the basis of Oklahoma water policy since before statehood, and has served the state well. Oklahomans have always operated under the statutory concept that their water supplies are to be beneficially developed, used and enjoyed by its citizens and the environment. However, nationwide water conflicts are occurring as cities, industries, agriculture, energy producers and other interests compete for limited supplies of water and Oklahoma is no exception. Recently, there have been several examples in other states where federal courts have usurped state control over water use to address significant controversies between states or between consumptive and non-consumptive uses of water, particularly relating to aquatic life and threatened or endangered species. In some cases, courts have invoked the public trust doctrine and taken draconian action, mandating decreases to amounts authorized to be diverted by existing water users, or requiring releases of water from reservoir storage to protect instream flows. The Oklahoma Water Resources Board seeks to be proactive on instream flows to keep the management of the state's water resources strictly within the state's purview.

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. Stakeholders determine the balance of needs and scientists develop a flow regime that meets the requirements of the stakeholders. A flow regime may be a single-value minimum flow recommendation, but more often describes a range of natural flow conditions that vary according to the time of year and the needs of those depending on that water. Instream flow studies necessarily include lakes and reservoirs in the basin because they are important in regulating flow. Once a flow regime is recommended, successful implementation should be consistent with state and regional water resources management plans and should result in the long-term sustainability of the surface water supply in that basin.

In Oklahoma, the Legislature seeks to minimize pollution of the waters of this state and further defines pollution as the contamination or other alteration of the physical, chemical or biological properties of any natural waters of the state[1]. The public policy of the state[2] is to conserve[3] and

[1] See Title 82, Oklahoma Statutes, Sec. 1084.2 (effective July 1, 1993).
[2] See Title 82, Oklahoma Statutes, Sec. 1084.1 (effective July 1, 1993).
[3] Before a significant overhaul effective July 1, 1973, the declared policy of the Oklahoma Groundwater Law was "to conserve and protect" groundwater resources. After July 1, 1973, the policy is to "utilize" the groundwater resources, which change in policy has been recognized by the Oklahoma Supreme Court.

utilize the waters of the state, and to protect, maintain and improve the quality thereof for public water supplies, for the propagation of wildlife, fish and aquatic life and for domestic, agricultural, industrial, recreational and other legitimate beneficial uses. The Oklahoma Water Resources Board is charged with managing and protecting the water resources of the state, now and in the future. To meet that goal it must develop a long-range comprehensive water plan that considers how to meet the future needs of all water users, including those that require some water to remain in the state's streams and rivers for non-consumptive purposes. It is not clear if the laws, rules and policies currently in place offer sufficient protection for all of these needs.

To help determine what should be done, if anything, on instream flows in Oklahoma, the Oklahoma Water Resources Board requested a description of instream flow programs in other states. Some states have very specific statutory mandates to conduct instream flow studies and while there are some interesting programs in states far afield, the regulatory framework in Oklahoma is most similar to its neighboring states and the existing programs in Colorado, Kansas, Arkansas and Texas. The methodology for conducting instream flow studies varies enormously even from state to state, but it is clear that while the science has improved enormously since studies began in the 1970's, the role of stakeholders and the desire of water resources managers to involve all interested parties in the development of instream flow needs is what has progressed more. There is no scientifically credible rule of thumb for defining the amount of water that should remain in a river to satisfy all instream flow needs and while scientists have dramatically improved their understanding of the impacts of altering the flow in rivers, how much change is acceptable is a complex trade-off between human values and benefits. The only way to develop an instream flow recommendation that satisfies everyone is to create an inclusive, transparent and fair stakeholder process that allows all water interests to be heard. This approach results in flow allocation decisions that are regarded as fair and reasonable by all parties.

In late 2009 the Oklahoma Water Resources Board initiated a process to solicit input from stakeholders on an instream flow policy for the state. An instream flow Advisory Group was created composed of 19 members plus alternates and Oklahoma Water Resources Board staff. The Advisory Group met in person five times, discussing many issues related to instream flows and water resources planning. The main purpose for forming the Advisory Group was to seek guidance on a process whereby the issue of instream flows can be considered in Oklahoma.

Significant disagreement occurred during the meetings and it is clear that a number of questions need to be answered before instituting an instream flow program in Oklahoma. Some of these questions are technical in nature, while others are more policy-oriented. The main questions raised form the basis of the recommendations summarized below. Research to answer many of these questions can and should be done in parallel, rather than sequentially. The recommendations and timeline for answering the associated questions are discussed in more detail in Section 4.

1) There are a number of outstanding legal and policy issues to be considered and decisions to be made prior to implementing instream flow recommendations. For example, what factors can legally be considered in making an instream flow recommendation, what is the process for implementing a flow recommendation, and are there statutory changes needed for an instream flow program to be created? Some of these questions can be answered up front by state leadership, while others need further investigation. Once these questions have been answered, state leadership will be in a better position to determine the need for an instream flow program.
2) Prior to conducting an instream flow study in Oklahoma, the state should consider the role that the domestic use set-aside plays in protecting instream flows, and whether there are other mechanisms that would accomplish the same goal more efficiently.
3) To better understand the time and resources required, the role of stakeholders, the form of flow recommendations and a process for implementation, the state should develop a draft methodology for conducting instream flow studies in Oklahoma.
4) Prior to carrying out an instream flow study in Oklahoma, the state should determine how much studies would cost and the likely economic consequences (positive or negative) of implementing the resulting instream flow recommendations. The state should also consider the costs associated with managing an instream flow program.
5) Subject to the results of recommendations 1 through 4, the state should consider initiating a pilot study to determine the instream flow needs for one of the Scenic Rivers. A pilot study would help answer the remaining questions about the process for developing a flow recommendation.
6) The role of stakeholders will continue to be very important and it is recommended that the Advisory Group be retained to help maintain the dialog between the Oklahoma Water Resources Board and the water community on this important subject. The membership of the Advisory Group may change over time, but the Oklahoma Water Resources Board should make sure that it remains balanced and representative of all interest groups. The Advisory Group should be involved in the review of any instream flow reports that are produced for or by the state and also periodically report to the Oklahoma Water Resources Board and the Legislature on any developments with respect to instream flows.

It is expected that this report will help shape a chapter on instream flows in the upcoming Comprehensive Water Plan update, which will be presented to the Legislature. Ultimately it will be up to the Legislature to determine if addressing instream flows in Oklahoma is appropriate. The Oklahoma Water Resources Board will continue to discuss the issue of instream flows with the Advisory Group and state leadership.

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1. Introduction

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 instream flow describes the quantity of water set aside in a stream or river to ensure downstream environmental, social and economic benefits are met. An instream flow quantity can range from a minimum flow value to an all encompassing flow regime. A successful instream flow study results in a flow regime recommendation that is usually described by a hydrograph of desired flows that varies according to the time of year and the needs of those that depend on that flow. Additionally, some states prescribe flows that vary according to the climatic conditions in a particular year. For example, the flow requirements during a drought would be lower than those required during a wet period.

Typically, the goal of an instream flow study is to ensure the long-term sustainable use of water in a particular river basin. Instream flow studies require the integration of many disciplines, including hydrology and hydraulics, ecology, economy, sociology, geomorphology, water quality and communication. The reward of a successful instream flow study is an improved water management plan that provides for a sustainable supply of water, while meeting the region’s long-term economic needs and protecting the ecological integrity of the river basin. Maintaining some level of flow in rivers during periods of drought and minimizing the degree to which the hydrologic regime is altered can be very beneficial to the environment, but also to other users of that water, whether that use is consumptive or non-consumptive. However, the full consequences (positive and negative) of an instream flow recommendation need to be determined prior to implementation.

1.1 The hydrologic setting

Oklahoma occupies portions of two major river basins: the Arkansas and the Red. The Red River basin covers approximately one third of state – the southern portion – while the northern two thirds of the state are in the Arkansas River basin. Both flow to the east and eventually join the Mississippi River, subsequently entering the Gulf of Mexico near New Orleans.

The single most important determinant of flow in the rivers of Oklahoma is rainfall and there is a large difference between the western Panhandle, which receives an annual average 16 inches per year, and the southeast, where in excess of 50 inches of precipitation falls in a typical year. Oklahoma has suffered from the extremes of precipitation – extended droughts and extreme flood events, both of which have caused hundreds of millions of dollars in damage.

There are three classes of water in Oklahoma water law: sheet flow, groundwater and stream water. Sheet flow describes water before it infiltrates or flows into a definite stream and is not subject to regulation. In other words, sheet flow or rainwater can be captured by any landowner and used for any purpose. Groundwater is a property right in Oklahoma, but its use is regulated by state law. Landowners have the right to use groundwater for domestic purposes (such as household use, watering farm and domestic animals and small-scale irrigation) without obtaining a permit; however for non-domestic purposes the landowner must obtain a permit from the Oklahoma Water Resources Board (OWRB). Stream water (also known as surface water) on the other hand is considered "public water" in Oklahoma and is subject to appropriation for the benefit and welfare of the people of Oklahoma.

The state has a combined stream length of 12,294 miles, when considering rivers streams and creeks with a length of 20 miles or more. There are 34 major reservoirs in the state, storing in excess of 13 million acre-feet of water when full. In addition, there are many small private and Natural Resources Conservation Service (formerly the Soil Conservation Service) structures across the state. In fact the Oklahoma Water Atlas identifies more than 2,300 public and private lakes in Oklahoma and a further 2,000 NRCS watershed protection structures; there are some 220,000 additional farm ponds in the state. The total surface area of lakes and ponds in Oklahoma is approximately 1,120 square miles.

1.2 Federal and state agency roles in water resources

Many state and federal agencies have jurisdiction, responsibility or an active interest in the state's water resources. There are some 18 state agencies that have statutory mandates related to water in Oklahoma and while the federal government is heavily involved in flood control and the regulatory aspects of water, the state has primacy over water resources. In addition to being the regulatory agency dealing with water rights permitting, the OWRB is the state agency responsible for water resources planning for the state. In order to meet the long-term needs of all Oklahomans and encourage the use of water resources in a manner that best serves the needs of the population, the OWRB develops an update to the comprehensive state water plan approximately every ten years. Each plan has a 50-year planning horizon. Planning is a dynamic process and significant social, political, economic and environmental changes occur between updates.

The OWRB is responsible for the appropriation, distribution and management of the state's water resources. Use of water in the streams and rivers of the state is permitted by the OWRB as long as there is a demonstrated need, the water will be put to beneficial use and there is enough water for existing water right holders in the basin (the new permit must not cause an adverse impact to existing users). Furthermore, if the application is for an inter-basin transfer, the proposed use must not interfere with existing or proposed beneficial uses within the stream system. Beneficial uses of water include irrigation, power generation, agriculture, municipal and industrial water supply, navigation, recreation and the propagation of fish and wildlife, etc. Beneficial use of water requires that reasonable intelligence and reasonable diligence are exercised in its application for a lawful purpose and that it is economically necessary for that purpose. Wasting water is prohibited, even for domestic users.

The U.S. Army Corps of Engineers, Bureau of Reclamation and Natural Resources Conservation Service have all constructed reservoirs in Oklahoma. The primary purpose of federal reservoirs is typically flood control and/or erosion control. Of course many of these federal reservoirs also serve other needs, such as water supply, power generation, navigation and recreation. The Environment Protection Agency administers federal law related to water quality and the US Fish and Wildlife Service develops projects to protect fish and wildlife, including the operation of national wildlife refuges and their associated streams and reservoirs, and administration and implementation of the Endangered Species Act in inland waters. Where a federally listed species is involved, the US Fish and Wildlife may intervene in the management of water resources in a basin. The US Geological Survey has active water monitoring and science programs and the Federal Emergency Management Agency administers the National Flood Insurance Program. The U.S. Forest Service manages streams and reservoirs on national forests and national grasslands.

The state of Oklahoma is also party to four interstate stream compacts. These compacts cover all surface waters flowing into or out of the state. The compacts relate to the Canadian River (New Mexico, Texas and Oklahoma); the Arkansas River (Kansas and Oklahoma); a separate Arkansas River compact between Arkansas and Oklahoma; and the Red River (Arkansas, Louisiana, Oklahoma and Texas). Compacts are Congressionally-approved written agreements between the states and detail how surface water is to be apportioned between states. Compacts provide assurances on the amount of water that flows into Oklahoma and also places requirements on the amount of water that must flow out of state. The compacts create compact commissions who administer the compacts and review streamflow reports. The compact commissioners are supported by legal and engineering staff.

Particularly relevant to this report, the Oklahoma Scenic Rivers Act (82 O.S. Sections 1451-1471) provides for the maintenance of free-flowing conditions in designated scenic rivers. Scenic streams and rivers are described as those possessing "…unique natural scenic beauty, water conservation, fish, wildlife and outdoor recreation values…". The Oklahoma Scenic Rivers Commission's mission is to preserve and protect the aesthetic, scenic, historic, archaeological and scientific features of the Illinois River and its tributaries (Lee Creek, Little Lee Creek, Barren [Baron] Fork Creek and Flint Creek) and the Upper Mountain Fork. A location map of the designated Scenic Rivers is shown below, in Figure 1.1; details of the individual rivers are provided in Appendix A.

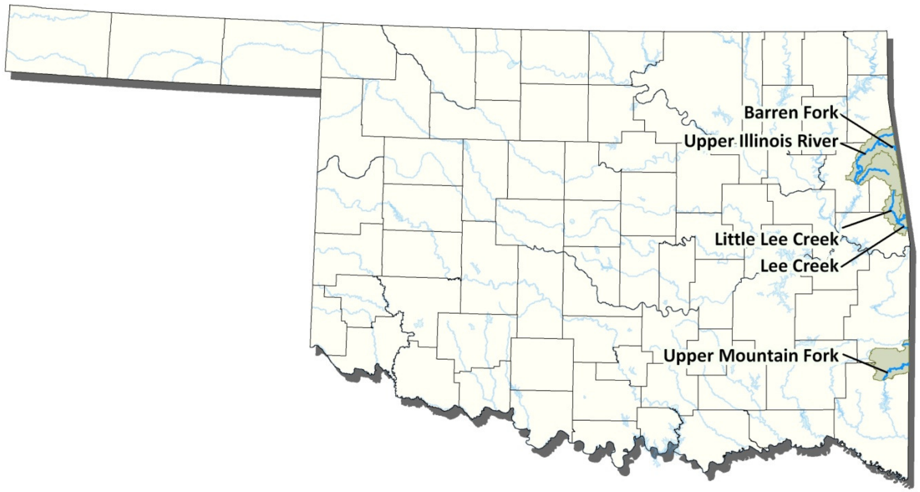

Figure 1.1 – Designated Scenic Rivers and Watersheds in Oklahoma.

1.3 Water availability

Determination of available surface water in Oklahoma is based strictly on the average runoff from years 1951-1980. At any point on a stream or river, average annual flow is calculated based on streamgage data, interpolated to the location of interest using Geographic Information System tools. Water available for appropriation is then estimated by subtracting existing permitted use, reservoir yield and domestic use for the watershed above and below the proposed diversion point to the next major tributary.

Allocating water uses based on the total annual flow may overestimate how much water is actually available for use and consequently how much water is assumed to remain in the stream or river. A significant percentage of most surface water annual flow occurs during flood events. Even very large diversion pumps and storage structures cannot generally capture the entire flood hydrograph. Furthermore, when a river is flooding there is typically a low demand for water. In fact most high demands occur during periods when stream and river flows are low due to persistently dry weather.

Land owners whose land touches the water course have the right to make "reasonable use" of the water for domestic purposes. Aside from the right of domestic users, all other surface water is subject to appropriation. In times of severe drought, all water users may be affected, and even municipal suppliers cannot demand that senior water users cease diverting. Under the prior appropriation doctrine that exists in Oklahoma, the permit filing date determines who gets the water: first in time, first in right.

The term "domestic use" refers to the use of water by an individual or by a family 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 for the growing of gardens, orchards, and lawns. Domestic use also includes: (1) the use of water for agriculture purposes by individuals, (2) use of water for fire protection, and (3) the use of water by non-household entities for drinking water purposes, restroom use, and the watering of lawns, provided that the amount of stream water used for any such purposes does not exceed five acre-feet per year. Unless evidence to the contrary is presented, the OWRB estimates the amount of water required to satisfy domestic use to be six acre-feet per household per year or three acre-feet per non-household domestic use.

Based on this information, OWRB policy has been to set aside six acre-feet of water per year per 160 acres of land to protect domestic uses. This assumes one household in each quarter section (four per square mile) on each watershed across the entire state. To make sure that domestic uses are protected, the OWRB staff subtracts six acre-feet of water per 160 acres from the average annual runoff within a watershed above a proposed diversion point in order to protect potential domestic use needs within the watershed (see OWRB Rule 785:20-5-5(a)(2)). This calculation is used unless an applicant or a protestant to an application submits evidence to the contrary. For the state as a whole the amount of water set aside for domestic use is: 68,667 sq. miles x 6 ac-ft/quarter section/year x 4 quarter sections/ sq. mile = 1.648 Million ac-ft/year. By contrast, the actual amount of self-supplied residential use (domestic use) was estimated at 29,543 ac-ft/year in 2007 (see Oklahoma Comprehensive Water Plan Water Demand Forecast Report, October 2009). Domestic use is projected to increase to 41,200 ac-ft/year by the year 2060. It should be noted that although an amount equivalent to the estimated domestic use is set aside in every stream and river in the state, Mother Nature does not always provide the domestic use amount everywhere in the state, even when diversions are not being made.

Domestic users are not required to obtain a water use permit, providing the diverted water is not used for commercial irrigation or industrial purposes. It has been argued that the domestic use set aside is overly conservative and indeed, setting aside six acre-feet per year per section for the entire basin would seem to be more than can realistically be used for domestic purposes in most parts of the state - especially considering that most properties do not have riparian access to the water and many use groundwater instead of surface water anyway. Additionally, at any particular point on the stream or river, domestic water is set aside for both upstream *and* downstream users (to the confluence with the next tributary). So even though upstream households may not have used the water, that water is set aside for domestic purposes and is not available for appropriation. However, this domestic use set-aside provides other benefits, including instream flow. In fact the domestic use set-aside may suffice for instream flow needs in some, most or all of the state. However, that cannot be determined without further investigation.

Surface water users in Oklahoma are not monitored by the OWRB or a water master and identification of illegal pumping is typically through complaints to Oklahoma Water Resources Board staff, though field investigations do sometimes occur, occasionally resulting in cease or curtail use orders from the Executive Director. During severe droughts causing surface water shortages, senior water users may call for the curtailment of junior water rights through complaints registered with the OWRB.

Groundwater accounts for approximately 65 percent of the total reported water use in the state (1,914,735 ac-ft/year); surface water use accounts for the remaining 35 percent (1,020,248 ac-ft/year). Groundwater in Oklahoma is used primarily for irrigation, while surface water is the main source for public water supply. Thermoelectric power generation and irrigation are also major users of surface water. As of April 2010, there were 2,093 active stream water rights, totaling 2,595,520.2 ac-ft/year and 10,671 active groundwater rights totaling 3,514,807.7 ac-ft/year.

An estimated 34 million ac-ft of water flows out of the state each year through Oklahoma's two major river basins. This equates to about 18 times the state's total annual water usage (OWRB, 2007). Detailed information on the hydrology, water demands and availability of Oklahoma surface water now and in the future can be found in the Comprehensive Water Plan and the Oklahoma Water Atlas, both published by the OWRB.

1.4 Why consider instream flow needs in Oklahoma?

The benefits of having access to water for consumptive use are significant and generate, directly and indirectly, billions of dollars in revenue for the state. There is clearly a need to be very careful on the development of an instream flow policy to ensure that it enhances, rather than impairs economic benefits, whether locally or statewide. Similarly, Oklahomans have long recognized the benefits of preserving flow in streams and rivers for uses other than water supply and navigation. In fact the 1975 Comprehensive Water Plan contains the following statement:*"…environmental impacts resulting from future resources development must be considered"*. This statement was echoed in the 1980 Comprehensive Water Plan. The 1995 Comprehensive Water plan goes a step further, suggesting that inadequate instream flow adversely affects all beneficial uses, including aquatic life, recreational activities, aesthetics, hydropower generation and navigation. However, the plan also cautions that pursuing an instream flow protection strategy is very difficult and controversial.

According to Oklahoma Department of Wildlife Conservation, over a million Oklahomans enjoy fishing, hunting and/or wildlife viewing in the state. There are 1,200 fishing tournaments in Oklahoma every year and retail sales for fishing activities in the state amount to millions annually. Tourism is the third largest economic impact driver in Oklahoma and that is largely due to the appeal of the state's streams, rivers, lakes and reservoirs. It is clear that maintaining healthy, productive rivers provides recreational benefits, but there is also a significant economic incentive to do so, providing the other economic activities are not adversely affected.

The Legislature has declared the public policy of the state[4] to conserve[5] and utilize the waters of the state and to protect, maintain and improve the quality thereof for consumptive purposes such as public, commercial and industrial water supply, irrigation and agricultural uses, but also for non-consumptive uses such as hydropower and for the propagation of wildlife, fish and aquatic life[6], aesthetics and recreational activities. Also under state law, the Board is charged with developing statewide and local plans to assure the best and most effective use and control of water to meet both the current and long-range needs of the people of Oklahoma. Accordingly, the Board is required to develop a statewide plan to assure the best and most effective use and control of water for both consumptive purposes and non-consumptive purposes. It is recognized that Oklahoma law does not establish a preference among beneficial uses of water, whether such beneficial uses can be categorized as consumptive or non-consumptive.

As guardian and protector of water and water rights in Oklahoma, the OWRB considers it their statutory duty to ensure the long-term sustainable use of water in the state's streams and rivers, thereby maximizing the benefits for everyone. To help determine an appropriate mechanism for considering instream flow needs in the state, the Board created an Instream Flow Stakeholder Advisory Group (Advisory Group). The Advisory Group was not charged with developing instream flow standards, or with identifying appropriate methodologies for conducting instream flow studies. Nor was the Advisory Group charged with determining the legal authority of the OWRB to conduct and implement instream flow study findings - that being an issue that will be raised by the OWRB with state leadership at a later date. Rather, the Advisory Group was asked to help the OWRB identify a process whereby the issue of instream flow could be considered over the 50-year planning horizon of the Comprehensive Water Plan. The process identifies studies that must be conducted before an instream flow program is implemented and the role of stakeholders in conducting studies on this subject. A list of the Advisory Group members is provided in Appendix B.

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[4] See Title 82, Oklahoma Statutes, Sec. 1084.1 (effective July 1, 1993).
[5] Before a significant overhaul effective July 1, 1973, the declared policy of the Oklahoma Groundwater Law was "to conserve and protect" groundwater resources. After July 1, 1973, the policy is to "utilize" the groundwater resources, which change in policy has been recognized by the Oklahoma Supreme Court.
[6] Oklahoma law, rules and policies are not clear whether domestic use can include non-consumptive purposes like instream flow protection for recreation, fish and wildlife protection.

2. Methods available for determining instream flow needs

There are some 200 methods available for determining instream flow needs. Some methods protect a minimum flow while others seek to protect a flow regime that mimics the natural hydrograph. Some instream flow studies are conducted using streamgage records as the only data source, while others take many years and involve multi-disciplinary fieldwork across the full range of flows and seasons. The various methods can be categorized as either hydrological, hydraulic, habitat or holistic models (Tharme, 2003). This model classification scheme underscores the technological sophistication and resource requirements for implementation, with hydrological models typically requiring less investment and the level of effort increasing up to the resource-intensive holistic approaches. Hydrological models tend to be older, with the more sophisticated models being developed more recently, aided by the evolution of computational and field measurement techniques. On a worldwide basis, the majority of models employed for instream flow assessments are hydrological models, followed closely by habitat models. Holistic models are used less frequently, yet their usage often also incorporates use of one or more hydraulic or hydrological models. This section provides a brief description of each model category and highlights the most popular models. The advantages and disadvantages of each method are also summarized. Choosing the right approach depends on many factors, including available data and resources, expertise available and degree of impairment of the stream or river, the costs and time required to implement the selected method, and the desires of the various stakeholder groups. The existing legal framework for water administration is also an important consideration.

2.1 Hydrological Methods

It has long been recognized that hydrology is the master variable that limits and controls the distribution and abundance of aquatic plant and fish species. Hydrological methods involve the analysis of recorded streamflow records to set instream flow requirements. These methods are also known as desktop methods, as they are generally less resource intensive to implement and may not require significant data collection or field work. The original and most commonly referenced hydrologic method is the Tennant or “Montana” method. This method focuses strictly on the ecological needs of the river and setting instream low-flow requirements as fractions of mean monthly discharges, recorded over the available stream flow period of record. The approach uses a percentage of annual flow to determine the quality of fish habitat. Using 58 cross sections from 11 different streams in Montana, Nebraska and Wyoming, Tennant concluded that a 10 percent of the average annual flow is the minimum for survival, 30 percent is considered sufficient to be able to sustain fair survival conditions, and 60 percent of the average annual flow provides excellent to outstanding habitat. These quantities, or variations thereof, are used across the United States and all over the world. In fact some states use a variation of this simple approach for decision-making on small water right applications. Texas, for example, uses the Lyons method as the default instream flow criteria for planning and permitting of minor direct diversion applications and absent any information that would suggest a different approach be used. The Lyons method provides for 40 percent of median monthly historical gaged flow for the months of October through February and 60 percent for the months of March through September. If the Lyons method number is lower than the 7Q2 in any month, then the 7Q2 is used for that month[7]. These numbers were derived based on a study of the Guadalupe River, below Canyon Dam in Texas.

Streamflow is strongly related to both physical and chemical characteristics of streams and rivers. The Hydroecological Integrity Assessment Process (HIP) can help identify ecologically relevant, stream-class specific hydrologic indices that characterize the five major components of the flow regime (magnitude, duration, frequency, timing and rate of change). The process is typically developed at a state or region scale but applied at the stream level. HIP has been tailored for use in New Jersey, Missouri, Texas and other places. Preliminary work has also been conducted in Oklahoma. The purpose of the tool is for classification of streams and rivers in terms of their flow indices and to allow water managers to determine the degree of alteration of these indices as a result of implementation of water management strategies. For example, HIP could be used to assess the degree of hydrologic alteration caused by a new or proposed reservoir to flows at points downstream. The software does not dictate what level of alteration is acceptable, that being recognized as a management and socio-political decision. HIP is available free of charge from the US Geological Survey. More information on HIP can be found at: http://www.fort.usgs.gov/Resources/Research_Briefs/HIP.asp

Advantages of hydrological methods are:

1) Simplicity – Statistical software exists for analyzing streamflow records
2) Data availability – streamflow records are commonly available, and methods exist for correlating flows in ungaged basins to local streamflow records.
3) Low investment of time and resources – field data collection efforts may not be needed since statistical analyses may be made by single or multiple trained individuals
4) Speed – assessments may be made rapidly pending data availability

The primary disadvantage of hydrological methods is that they are simplistic. Hydrological methods attempt to describe complex ecological interactions and other flow needs with basic statistics and therefore may not yield a flow regime conducive to maintaining a sound ecological environment and meeting the needs of stakeholders. Statistical analyses may also be misleading if performed improperly. Both of these disadvantages, however, may be mitigated if the user is well trained in engineering or biology and is highly familiar with the conditions of the region to which the resulting flow regulations will be applied.

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[7] The 7Q2 is defined as the seven-day average low flow with a recurrence interval of two years.

2.2 Hydraulic Methods

Hydraulic methods are based on the assumption that river integrity may be linked to measureable or calculable hydraulic parameters within areas of critical habitat within the stream or river. Most such methods were developed in the 1960s and 1970s as attempts to ensure the viability of economically important trout and salmon fisheries in the United States. The hydraulic parameters commonly considered are: 1) the quantity of the wetted perimeter, 2) flow depth, and 3) flow velocity. To implement such methods, field surveys are required where cross-section profiles of the river system are taken in riffle[8] habitat. Riffle habitat is often used as conserving such habitat is assumed to also allow for the conservation of pool and run habitats, which are likely less susceptible to changes in streamflow. With the cross-section data, hydraulic modeling techniques are then used to compute wetted perimeters, depths and velocities under varying flow conditions. Hydraulic modeling results are then typically coupled with biological opinions regarding locally important fish species.

Hydraulic methods have been used across the United States, Australia, and Europe, although their use may be declining in favor of holistic approaches (or as part of holistic approaches). The official state method for instream flow assessment in Colorado involves use of the R2Cross hydraulic model and usage of this model has led to the establishment of instream flow requirements for nearly 30 percent of the State's stream reaches.

Advantages of the method include:

1) Little field data collection requirements – typically one cross-section is measured per stream reach.
2) Modeling effort is minimal – programs such as R2Cross are well defined, established, and easy to use.
3) Minimal expertise required – modeling and biological interpretation of the results may be performed by one or two trained individuals.
4) Rapid assessment potential – studies may be completed rapidly (days to months).
5) Model results are generally easily understood and accepted by stakeholders.

Disadvantages of the method are that:

1) The assumed relationship between river integrity and hydraulic parameters may be incorrect.
2) The method appears most applicable to mountain stream environments.

Within Colorado, results from the R2Cross modeling are considered in conjunction with needs assessments of biological experts and analyses of historical streamflow records. Therefore the

[8] River hydraulics in instream flow studies is often characterized in terms of its mesohabitat type. "Pool" refers to deep slow-moving water; "riffles" describe fast-moving shallow water, typically over gravel bars in higher gradient river reaches. There are many other mesohabitat types described in scientific literature.

translation of hydraulic model results into flow regulations typically also requires hydrologic modeling. One potential reason for the recent decrease in usage of hydraulic models is that such models are now typically coupled with habitat models to directly compute habitat variability with flow conditions.

2.3 Habitat Simulation Methods

Habitat simulation models represent the next phase up from hydrologic and hydraulic models in that they link streamflow records and hydraulic model predictions to habitat suitability criteria. In this way, habitat models are designed to directly assess how streamflow affects the available habitat for aquatic species, reflecting the assumption that maintaining sufficient riverine habitat will ensure the target species will thrive in the reach. Typically studies are designed to determine habitat availability for one or two specific and well-studied species for which habitat preferences are known. Output from habitat models can include probability estimates of available habitat under historical flow conditions, or can provide spatial and/or temporal predictions of habitat suitability. Most current habitat simulation modeling efforts employ 2-dimensional or 3-dimensional hydraulic models and spatially explicit habitat metrics. Typically a GIS package is used to display and interpret the results. Example models include RMA-2 (Osting et al, 2003), RHYHABSIM (Jowett and Richardson, 1995), RSS (Alfredsen, 1998), and EVHA (Dunbar et al., 1998).

By far, the most commonly used method for assessing instream flow needs worldwide is the Instream Flow Incremental Methodology (IFIM), which includes its physical habitat simulation model PHABSIM. PHABSIM is used to simulate the relationship between streamflow and physical habitat for various life stages of fish or recreational activities. There are two basic components of PHABSIM: hydraulic simulation and habitat suitability criteria. The hydraulic simulation is used to describe the stream in terms of depth and velocity of water, and channel index as a function of flow. This information is then used to calculate area of habitat for a stream segment at a particular flow. Hydraulic simulations are then conducted at several flow rates to determine Weighted Usable Area of habitat for the various species of interest. PHABSIM is typically applied using a one dimensional hydraulic model and has received criticism from some quarters for that reason. One dimensional models typically do a poor job on split channels, high gradient riffles or where significant changes occur between cross-sections.

IFIM has been described as the most scientifically and legally defensible environmental flows assessment methodology and has been applied in 38 North American states and provinces as well as in over 20 countries.

Some advantages to habitat modeling in general and IFIM in particular include:

1) Model acceptance – the modeling methodology is generally well received in the scientific and lay communities, thereby easing policy implementation.

2) Scientifically rigorous – the approach requires careful study of the river system and a sophisticated modeling effort, relating model results to observed riverine conditions. This provides greater confidence in the appropriateness of the results.
3) Critical habitat availability is directly modeled, rather than using hydraulic parameters as proxy indicators of habitat.

The disadvantages of habitat modeling (with respect to hydrologic and hydraulic modeling) are:

1) Increased investment of time and resources – field data collection and modeling efforts are more expensive, require greater expertise and likely more personnel and longer times for study completion.
2) Portability of results – habitat suitability is largely dependent upon the selected study site and indicator species/object. Extending the results to other stream reaches or watersheds may be difficult.
3) Uncertainty in hydraulic and habitat model input/results may lead to incorrect interpretations of habitat availability. Uncertainty within the hydraulic and habitat modeling may be reduced with more accurate field data and/or greater experience of the model developer/user.

2.4 Holistic Models

Holistic models for instream flow assessments attempt to consider the entire river watershed in the analysis process. Typically they are based on the assertion that the health of the watershed is dependent upon the naturally varying flow regime of the river, which experiences periodic low flows and flooding events. Holistic methods often result in flow recommendations that closely resemble the natural flow regime. Properties of the flow regime that are commonly considered in this process are: 1) water quantity, 2) duration of low/flood flows, 3) timing of low/flood flows, 4) extent of flood flows, and 5) the rate of change of flow values. Holistic models are resource-intensive models, as their implementation requires much multidisciplinary expertise and input from project stakeholders. Model development also typically requires the use of hydrologic, hydraulic, and habitat simulation models as components within the over-arching holistic model. The holistic methods were developed and implemented in South Africa in the 1990's, and were developed separately in Australia around the same time. Various forms of holistic models are currently being developed in the United States. The scientific basis of the Ecological Limits of Hydrologic Alteration (ELOHA) methodology is described in Arthington et al. (2006).

Holistic models are best considered as model frameworks where specialized studies of all watershed processes are linked together to assess instream flow needs. Most holistic methods involve implementation of reach-scale hydraulic and habitat models, and also include hydrologic modeling efforts at various locations within the watershed. The specific methods by which system hydrology and hydraulics are modeled are rarely specified within existing holistic model frameworks, thereby providing flexibility to the organization charged with implementing the models. The approach usually involves determining preliminary minimum flow targets, then conducting hydraulic and habitat modeling studies to refine flow targets and calculate appropriate flow regimes.

A good example of a holistic approach to determining instream flow needs is available from a neighboring state. In 2001 the Texas Legislature – through Senate Bill 2 – directed the Texas Water Development Board, the Texas Parks and Wildlife and the Texas Commission on Environmental Quality to establish and maintain an instream flow data collection and evaluation program. In addition, the agencies were directed to conduct studies and develop a methodology for determining flow conditions in the state's streams and rivers to support a sound ecological environment. The goal of the program is to identify flow regimes that conserve fish and wildlife resources while also providing sustained benefits for other human uses, including water supply and recreation. The instream flow program studies consider a wide range of variables including hydrology and hydraulics, biology, physical processes and water quality. Habitat availability (including connectivity of habitats) is also considered, ensuring a multi-disciplinary effort. Studies take multiple years and there is heavy stakeholder involvement. The methodology developed by the agencies was reviewed (and improved) by the National Academy of Sciences. More information on the Texas instream flow program can be found at: http://www.twdb.state.tx.us/instreamflows/about.html

Some advantages of using a holistic modeling approach include:

1) Model acceptance – the modeling methodology is generally well received in the scientific community and policy arena, thereby easing implementation.
2) Scientifically rigorous – requires carefully study of entire watershed, including the river system and socio-economic concerns. This provides greater confidence in the appropriateness of the model results.
3) Critical habitat availability is directly modeled, rather than estimated using hydraulic parameters as proxy indicators of habitat.
4) Public/stakeholder participation is common – typical holistic applications offer multiple opportunities for researchers to receive public/stakeholder comment and to revise study methodologies related to those comments.

The disadvantages of holistic modeling are:

1) Field data collection and modeling efforts are more expensive, require greater expertise, more personnel and longer times for study completion.

2) Results require development of complex models to understand instream flow requirements, often yielding complex instream flow regulations, which must be implementable within the state's legal framework.
3) Holistic models typically require environmental monitoring after flow regulations are implemented, and regulators typically have the ability to adjust flow regulations if the system is not behaving as expected. Such monitoring is likely to increase program costs, and addition of adaptive management capabilities to the water permitting process may be difficult within the legal framework of the project jurisdiction.

2.5 Developing an instream flow recommendation

While the science of instream flows has improved enormously in recent years, greater progress has been made in the associated planning and public outreach efforts. A flow recommendation needs to be implementable and stakeholders should be afforded the opportunity to voice concerns and help define the goals and objectives up front. The goals and objectives may be very different from basin to basin, even within the same region of the state.

Many instream flow studies in the past focused only on the ecological needs of the stream or river, without considering the myriad other uses and requirements of that water. These all need to be balanced and treated in a fair and equitable way. In fact there are many legal, policy and cost-related issues to be considered and decisions to be made prior to beginning an instream flow study, as well as subsequent to developing flow recommendations. The Texas instream flow program recommends the following chain of events (see Figure 2.1). Notice the development of a study design prior to initiation of the various study elements. The first step of the process also involves the identification of resources, human impacts, geographic scope and cooperators. Although not explicit in the diagram, there is a role for stakeholders in every study element. Independent peer reviewers are involved in the scientific evaluations and also review the study report. The flowchart stops short of the implementation phase, that being beyond the statutory mandate given to the agencies.

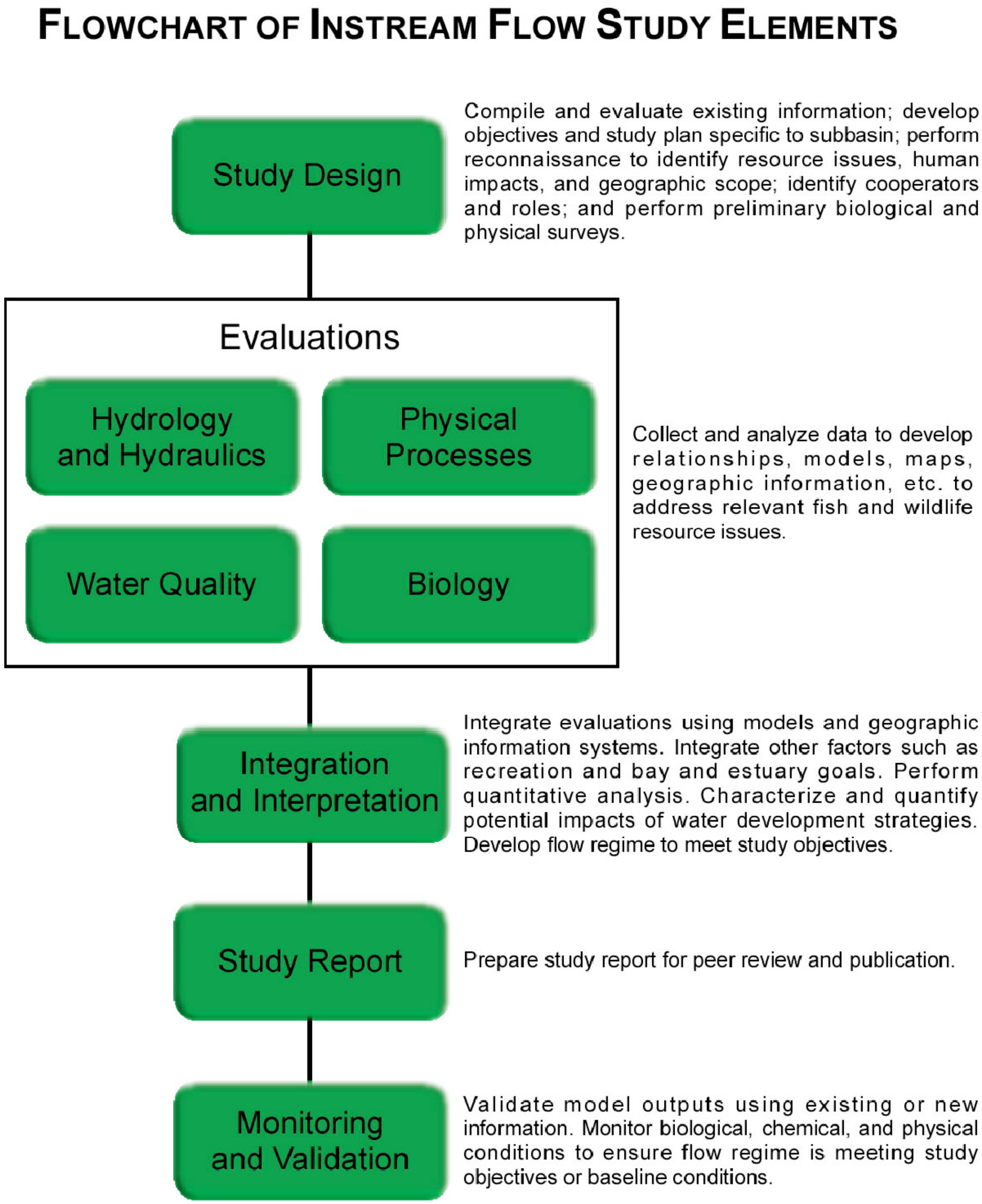

Figure 2.1 – Study flow chart from the Texas instream flow program.

2.6 What might work in Oklahoma?

Our understanding and implementation of instream flow standards has progressed and improved enormously over the past 50 years, but two areas in particular have received special attention lately: the role of stakeholders in developing flow recommendations and the integration of instream flows into the much broader realm of water resources planning and management. In past studies, the focus was primarily, if not exclusively on the biological needs. More modern instream flow studies recognize that successful programs focus on all aspects and all water needs in the basin, balancing these needs in a way that stakeholders feel is fair and equitable. Science cannot provide all the answers because the most difficult questions and persistent problems are not matters of science, but rather of values. Science can tell us what happens when flow is altered, but it cannot tell us what the appropriate level of alteration is, that being a matter of public policy and a thorough assessment and balancing of the various needs. If an instream flow program is desired in Oklahoma, sound science will need to be employed, but good laws and policies are just as important. Public involvement is a crucial component of every step of the process and the study of instream flow needs must be integrated into state and local water resources planning and management, to ensure that the full implications of instream flow implementation are considered, including the costs and benefits, and possible impacts to future water users.

While the development of a methodology for conducting instream flow studies is beyond the scope of this report there are a few lessons learned from neighboring states and other programs that Oklahoma should pay special attention to. It is clear that modern, successful instream flow studies involve the development of goals and objectives by stakeholders up front. Stakeholders define the various water uses such as public water supply, oil and gas production, water needs for cattle, canoeing, hydropower, water sports, industrial evaporative cooling, propagation of fish and wildlife, irrigation, and waste assimilation. Just as importantly, stakeholders define the desired future uses and condition of the stream or river. Through focused studies, scientists then determine the associated flow needs, usually developing a recommended flow regime, rather than a minimum flow value. Finally, policy-makers determine whether and to what extent to offer that flow protection. Implementation of instream flow values typically involves a rulemaking process conducted by the regulatory agency, offering ample opportunity for public input as well as a mechanism for the Legislature to weigh in.

Should the state of Oklahoma develop a methodology for conducting instream flow studies, the following key points should be considered:

1) **Address legal and policy questions, and estimate costs and benefits**
   There are many outstanding legal and policy questions regarding the development of instream flow recommendations and the implementation of findings in Oklahoma. Furthermore, it is important for the state to understand how much it will cost to conduct instream flow studies, the cost to the state to implement an instream flow program, and what the costs and benefits

will likely be to existing and future water users upon implementation. The recommendations in section 4 describe a process for developing information and answering these important questions.

2) A simple approach

Instream flow studies in Oklahoma must be cost and time efficient. There is a lack of data to draw upon and until such data exists, scientists must make do with the hydrologic data and any other pertinent information they can get their hands on (such as current and projected water use, known recreational activities, etc). This is conducive to the use a desktop approach. At a later date, it might prove useful to conduct a more comprehensive study, involving extensive fieldwork and hydraulic modeling on a basin that is representative of a larger region, but it must be recognized that this will take significant time and resources.

3) The role of stakeholders

Experience has shown that lack of stakeholder input both up front and throughout instream flow studies compromises the results and reduces the likelihood that flow recommendations will be implemented. It is important that stakeholders define the goals and objectives for the basin under consideration before the scientists and engineers start working on the instream flow recommendation. Furthermore stakeholders should be offered the opportunity to opine on the flow recommendation prior to implementation by the regulatory agency. The development of the SB3 environmental flow program in Texas came about because environmental groups and industry leaders came together to develop the statutory language authorizing and funding the program, and gave themselves a role in overseeing the studies. It is also important for outside independent peer reviewers to be involved in confirming that the science and engineering methods used to develop the flow recommendations conforms to standard practice.

4) Impact to existing water right holders

In considering instream flow recommendations, the impact to existing water right holders needs to be carefully considered. In other prior appropriation states with successful instream flow programs, impacts to existing water right holders are not allowed. Some states further specify that in times of extreme drought, instream flow needs are secondary. In other words, during drought conditions when existing water right holders might not be able to draw their full permitted amount of water, instream flow needs would be suspended so as to ensure no negative impacts to existing water users. The impact to lakes and reservoirs – specifically on water levels in these water bodies – should be a part of the any instream flow study. Any instream flow studies should expressly determine how regulated flow from lakes and reservoirs would impact domestic use and permit rights both upstream and downstream of the storage. In addition, consideration should be given to the intended purpose of the lake and reservoir and any legal requirements/obligations associated with them. Special attention needs to be dedicated to lakes and reservoirs because this subject was not extensively discussed in the Advisory Group meetings and yet they are very important in regulating flow. It is also important that instream flow recommendations not impact the state's ability to meet its interstate compact requirements, but at the same time if an increased delivery of water to a neighboring state results from an instream flow recommendation, this should be thoroughly investigated prior to implementation as well. The amount of water not subject to a compact flowing out of Oklahoma should be determined as part of any instream flow study and alternatives to implementing a flow recommendation should be identified. Finally, a determination should be made as to whether there are legal impediments under Oklahoma's legal framework to treating existing water right holders differently from future users.

5) **Impact to future water users**

Instream flow recommendations should carefully consider the impacts on future water users, and ensure any recommendation or policy is fair and equitable and is not unnecessarily burdensome or impacts the state's ability to attract new business or keep existing businesses in Oklahoma. The full impact of this paradigm involves many legal and policy questions, which must be thoroughly expressed and weighed.

6) **Coordination with the state water resources planning process**

The state has invested a lot of time and energy in the Comprehensive Water Plan and its updates. The subject of instream flow is addressed in the Comprehensive Water Plan and it is important that the results of instream flow studies are consistent with the water resources planning process and the recommendations in the Comprehensive Water Plan. A comprehensive planning process reduces the likelihood of future conflicts between the various needs (both present and future) for water in a basin. The OWRB should be at the front and center of both instream flow studies and water resources planning.

7) **Instream flow recommendations should be easy to implement**

The form of the instream flow recommendation should conform to the legal framework for administration of water rights and the state planning process. A one size fits all approach does not work for instream flow studies or implementation, and special attention needs to be paid up front to ensure that the results of studies can be implemented. Specifically, the following points should be considered:

a) Instream flow recommendations should have a strong scientific foundation and peer review to ensure credibility in legal proceedings.
b) Instream flow recommendations should be easily adapted when new information becomes available, such as site-specific studies.
c) The results of studies need to be easily incorporated in permit conditions, planning decisions, or other water management efforts.

8) **Adaptive management**

When a simple approach is used to conduct an instream flow study, it is inevitable that new data and science will eventually come to light that may cause water resources managers and regulators to want to revisit the instream flow recommendation. Furthermore conditions in the watershed may change such that the goals and objectives for that basin may also change. The philosophy of adaptive management for instream flow programs has gained traction in other prior appropriation states, where assurances have been made that existing water right holders will not be affected and future water right holders can only be impacted up to a certain agreed-upon amount after their permit is granted. The full impact of this paradigm involves many legal and policy questions, which must be thoroughly expressed and weighed.

2.7 References

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3. Instream flows in Oklahoma and elsewhere

The concept of instream flow is not new in Oklahoma. In 1981, a study led by Donald Orth concluded, based on a review of flow records from 24 Oklahoma streams, that the Tennant method could be used for developing a preliminary assessment of instream flow needs in the state. In 1999 the Oklahoma Water Resources Board completed a study assessing minimum instream flows for application to Oklahoma's Outstanding Resource Waters. The study compared three different methods for quantifying instream flow needs and concluded that the Instream Flow Incremental Methodology (IFIM) could be used to set flows to protect fish species and recreational users. The report also concluded that the instream flow thresholds could be used for making decisions on future appropriations.

A recently completed report developed jointly by Oklahoma State University and the U.S. Geological Survey documents the hydroecological classification of Oklahoma streams based on natural flow regime that incorporates natural flow variability. The classification completes the first 3 development steps of the Hydroecological Integrity Assessment Process (HIP). HIP allows users to study 171 ecologically-relevant hydrologic indices describing the magnitude, frequency, duration, timing, and rate of change of stream flows. The 27 most non-redundent, high information indices representing all five components of a flow regime were selected for use in the classification of 88 streamflow stations. Cluster analysis was then used to group streamflow stations with similar flow characteristics in two-cluster, four-cluster, and six-cluster groups. The groupings of streams fell roughly within specific ecoregions of Oklahoma. From a water resources management perspective, this information can be used to help develop regional instream flow standards. Currently, efforts are underway to finish the HIP study and incorporate the results into an Ecologic Limits Of Hydrologic Alteration (ELOHA) study.

State agencies in Oklahoma also have experience conducting instream flow studies and implementing flow standards. The OWRB has adopted only one flow condition by rule related to the use of surface water and that was in 2003, for a Scenic River. The rule prohibits direct diversion from Barren Fork Creek or its tributaries when the flow at the Eldon Gage (USGS Gage number 07197000) falls below 50 cubic feet per second. The exact language can be found in OWRB rule 785:20-5-5(e)2. It is important to note that this rule does not require a minimum flow be provided. Instead, it simply specifies under what circumstances direct diversion of surface water can occur. This is typically how instream flow standards are applied, except where a large reservoir is required to pass through flows or make releases from storage as a condition of its original permit. Most states operating under the prior appropriation doctrine apply instream flow standards only to new water rights. In other words, the instream flow standard does not apply to existing water rights and existing water right holders are not negatively affected. In fact they might be positively affected by the maintenance of flow standards in the future.

Full Instream flow programs have been active in other states for many years. In fact in a survey of the 18 western states conducted in 2009 for the OWRB, it was determined that only North Dakota and Oklahoma do not have active instream flow programs (CDM, 2009). The following few sections describe active programs in nearby states, and states where one or more aspects of their program is particularly interesting or relevant. These sections do not identify any problems associated with the instream flow programs, where they might exist, or teething pains that might have arisen in setting them up. The reader should bear in mind that when it comes to instream flow programs, one size does not fit all. For example, what works in Colorado will not work in Oklahoma because the legal framework for administering water rights is quite different. Furthermore, the flow conditions, ecosystems, recreational needs, climate, geology, stakeholder desires and the water resources planning methodology all need consideration.

3.1 Michigan: Instream Flows and Water Right Permitting

As of July 2009, the State of Michigan requires prospective new high-capacity water users to use an easily accessible on-line tool, called the Water Withdrawal Assessment Tool (WWAT), to determine whether their proposed withdrawals from surface or ground water would cause “adverse resource impact,” defined in terms of fish community structure. Both stakeholders and the state Legislature decided on the allowable impairment of a lake's or stream's ability to support its characteristic fish population compared to the current condition.

The WWAT uses ecological models to quantify how fish guilds in different types of Michigan streams would change in response to decreased base flows, defined as median streamflow in the lowest flow month (i.e., August or September). If the online tool finds that there will be no adverse resource impact, the applicant can pay the $100 fee via the on-line tool for their water diversion permit. The user is then required by law to report annual usage. If it is determined that there will be an impact, the applicant can work with the state to provide additional details (seasonality of use, amount of flow returned to river after use, etc.) to further analyze the withdrawal. In cases where it is determined that an impact is likely following this second look, the applicant is required to complete an in-depth hydrologic impact analysis. The Michigan Manufacturers Association, the Michigan Farm Bureau, and the Michigan Chamber of Commerce have all voiced support for this approach to conserving instream flow.

This is a nice example of where a hydrologic assessment tool has been used to define instream flow needs. The State of Michigan has taken it one step further by developing an online tool where users can determine how much water is available for appropriation based on instream flow needs and other permits in the basin. For planning purposes, this is tremendously useful and entirely transparent. There is also very little delay in obtaining a permit in basins with abundant water. Water right application backlogs are a real problem in some states.

3.2 Connecticut – Stream Classification and Instream Flow Standards

In October, 2009 the State of Connecticut posted for public comment proposed streamflow standards and regulations that would apply to all river or stream systems in the state. Under the proposed regulations, all state rivers and streams are to be grouped into classes 1-4, with each class permitting greater levels of streamflow alteration. Stream classifications and program implementation is to be at the direction of the Commissioner of the Connecticut Department of Environmental Protection. Once the regulations are implemented, dam operators and water managers would be required to release flows determined through statistical analyses of historical recorded streamflow, grouped temporally according to spawning requirements for various species. Provisions are included for antecedent moisture conditions, including drought conditions.

The flow standards and regulations proposed for Connecticut are based in part upon studies performed by The Nature Conservancy and U.S. Geological Survey, which used the IHA tool and ELOHA management framework to assess the impacts stream flow alteration due to dams within the Connecticut River Basin. Other entities, including local governments and private consulting firms, have performed site specific instream flow studies using the IFIM and PHABSIM methodologies.

3.3 Arkansas – Minimum Flow Standards in a Water-Rich State

Arkansas has historically enjoyed water surpluses, which has reduced the urgency with which the state has implemented water law and policy. Under the state's riparian doctrine, landowners along riparian zones have unrestricted reasonable access to the water provided due regard is afforded to the needs of other riparian and public users. Non-riparian water users are granted water usage rights only from excess surface water supplies, defined as water supplies greater than supplies needed to satisfy the sum of the following: 1) existing riparian rights, 2) water requirements of federal water projects, 3) firm yields of all existing reservoirs, 4) maintenance of instream flow for fish and wildlife, water quality, aquifer recharge and navigation, and 5) future water needs as projected in the State's Water plan.

The date of priority for existing riparian rights, federal water projects and reservoir firm yields is June 28, 1985. Non-riparian users may apply for water allocations of up to 25 percent of the excess surface water in any given year. Minimum stream flows were required after passage of Act 1051 in 1985.

To establish minimum stream flow standards, the Arkansas Natural Resources Commission (ANRC) reviewed the Tennant Method as well as applications of IFIM as developed by the US Geological Survey. The IFIM method was found to be too expensive and time consuming due to the field work requirements, and the Tennant method was therefore favored. ANRC performed statistical analyses of streamflow records to revise the Tennant method to be more applicable to Arkansas streams and wildlife, which are not as heavily affected by seasonal snowmelt and increased flows during the spring. The "Arkansas Method" divides the water year into three physical/biological units, each categorized by the physical processes that occur in the streams and the critical life cycle stage of the fish and aquatic organisms at different times of the year. The minimum flow requirements are: 60 percent of the mean monthly flow from November to March, 70 percent of mean monthly flow from April to June, and 50 percent of mean monthly flow for July to October.

Minimal effort has been undertaken to update Arkansas water policy since 1985. In 2001 and 2007, however, the ANRC conducted public hearings regarding re-establishing streamflow levels on the White River. Recent efforts have also been undertaken to establish minimum stream flow levels for tributaries of the White River. In 2009, the ANRC formally adopted revised minimum streamflow rules for the White River based on the studies and public hearings conducted from 2001 to 2007.

3.4 Colorado – Protecting Streamflow and Water Levels in Natural Lakes

In 1973, the Colorado Legislature passed Senate Bill 97 creating the State's instream flow program. The legislation directs the Colorado Water Conservation Board (CWCB) to protect streamflow and water levels in natural lakes. As of 2005, CWCB had appropriated instream flow rights to protect water levels in 486 natural lakes, and flows in approximately 30 percent of stream reaches within the state (8,500 miles – Figure 3.1). The CWCB has the sole authority to hold instream flow water rights, and these rights are treated as any other type of right under the prior appropriation system.

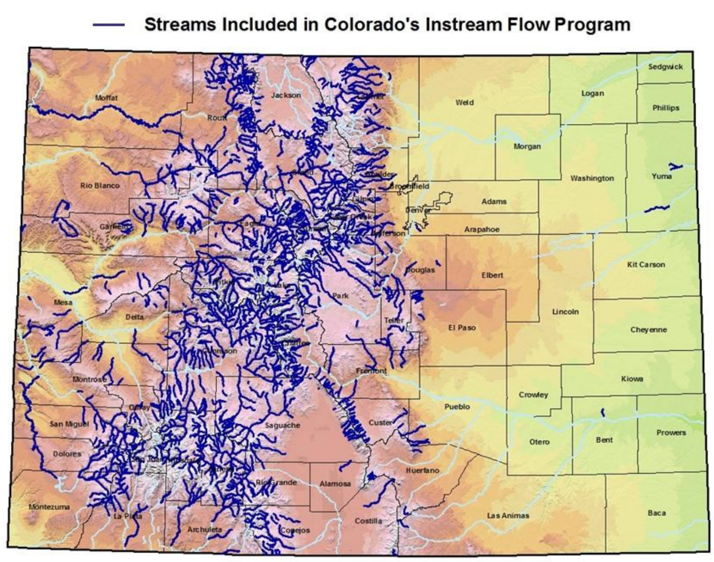

Figure 3.1 – Stream reaches for which instream flow rights have been authorized in Colorado (from the CWCB web site)

The CWCB has two mechanisms for obtaining Instream Flow rights:

1. New Appropriations – New junior instream flow water rights obtained by CWCB.
2. Water Acquisitions – CWCB acquiring existing water rights through donation or voluntary purchase.

The CWCB also maintains an engineering staff to monitor water availability (through modeling and streamgage measurements) and water usage by existing water right holders. The CWCB works closely with the Colorado Division of Wildlife (CDOW) in implementing, assessing, and monitoring the State's instream flow program.

Potential candidate reaches for instream flow protection may be nominated by any entity at any time, and the CWCB holds specific workshops each February to receive such requests. Upon evaluating each request, CWCB and/or CDOW staff conduct field and desktop engineering analyses to determine appropriate levels of instream flow protection. CDOW often employs the R2CROSS method of assessing streamflow in riffles, correlating the average flow depth, wetted perimeter, and velocity to known preferences for biological species. Instream flow targets assessed based solely on biological criteria are then re-assessed by CWCB staff to determine if sufficient water is likely to be physically available for instream flow protection. Such assessments are made through statistical analyses of available streamgage data and through water budget/accounting analyses. Instream flow allocations are then made based on water availability, up to the levels recommended from the biological analyses. Flow recommendations typically vary by season and are generally highest from May through July.

3.5 Kansas – Minimum Desired Flow and Water Availability

The State of Kansas, as of 2006, did legally recognize instream flow as a beneficial use of water. However, the importance of instream flow was recognized as long ago as 1984 (K.S.A. 82a-703a-c), when the state Legislature authorized the development of Minimum Desired Streamflows (MDSs) for 33 locations on 23 streams (see Figure 3.2). MDS values were jointly determined by numerous agencies of the Kansas State Government, and were based on statistical analyses of streamflow records. Typically these were flow duration values which were exceeded between 80 to 90 percent of the time, but there were other considerations as well, such as state-line flow requirements from interstate river compacts, e.g., the Big Blue River Compact between Kansas and Nebraska. Given a 1984 priority date, MDS values were essentially managed as a water right within the prior-appropriation system. If streamflows are below the MDS values (as measured at USGS gages) for seven consecutive days, then water diversions by junior water right holders are curtailed.

In 2006, the Kansas Department of Agriculture, Division of Water Resources working under contract for Kansas Department of Wildlife and Parks, developed a methodology for assessing streamflow availability in the Verdigris and Neosho river basins (which flow into Oklahoma). The project report documents the use of a GIS-based water accounting tool (SWAMI) which uses either statistical or historical input hydrology (streamflow values) and water right data to assess water availability within the prior-appropriation water allocation system. The SWAMI model was used in conjunction with an OASIS model of the system-wide reservoir operations, designed to optimized reservoir releases to satisfy downstream water rights. Use of the SWAMI and OASIS models was indicated as a potential starting point for future instream flow assessments in Kansas.

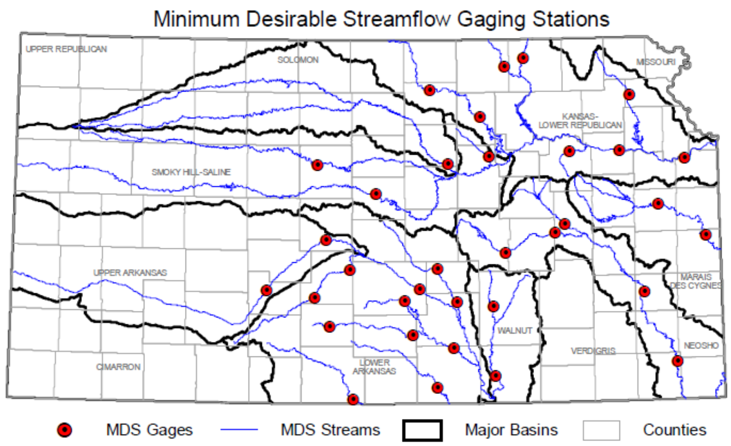

Figure 3.2 – USGS streamgage locations where Kansas Minimum Desirable Streamflows (MDSs) are implemented and monitored. (Source: Kansas Water Office http://www.kwo.org).

3.6 Texas – Senate Bills 2 and 3

The Texas Instream Flow Program is a joint program between the Texas Water Development Board (TWDB), the Texas Parks and Wildlife Department (TPWD), and the Texas Commission on Environmental Quality (TCEQ). These three state agencies are tasked with implementing state water laws, protecting state fish and wildlife resources, and performing state water planning and project financing for human and environmental needs. Details of the goals and objectives of the program and the methodology are described in the previous section. Instream flow studies have been planned or are underway in priority river basins, and involve evaluations of stream hydrology, hydraulics, physical processes, water quality, and biology. Study reports outlining the approach for each basin are peer reviewed so that river authorities and other affected water management entities within each basin are given the opportunity to participate in the study process. The Texas approach to ensuring a sound ecological environment is to recommend variable flows that mimic the temporal trends in streamflow before existing water uses were authorized. This approach attempts to recreate patterns of naturally varying flow hydrographs, focusing on four stages of flow: 1) subsistence flows, 2) base flows, 3) high pulse flows, and 4) over bank flows. The timing and duration of each flow level is determined so as to optimize benefits.

The Texas method of instream flow determination is a data/research intensive method, requiring field data collection, analysis, and computer modeling. The process also incorporates numerous opportunities for stakeholder involvement, which increases the program transparency and should increase the likelihood that the study results will be accepted by all interested parties. The state agencies have spent years refining their methodology, and have had the methodology reviewed by the National Academy of Sciences. The agencies also expect to generate final study reports by 2013, approximately five years after the studies began.

To hasten the implementation of instream flow recommendations for the entire state, the 2007 Texas Legislature passed Senate Bill 3, which required that preliminary instream flow standards be developed by local experts and used until study results from the Senate Bill 2 process become available. Methods under consideration for use in generating preliminary requirements include hydrologic/desktop analysis methods such as HIP, HAT, IHA, and HEFR.

3.7 Other Countries – Approaches to Environmental Flow Regulations

Instream flow studies are occurring in many countries throughout the world, and the rate of study inception has increased since the 1990's. As of 2002, there were instream flow programs and studies taking place in at least 44 countries (Tharme, 2003). The United States has used and developed most methods, followed by Australia and South Africa which have instigated the more recent trend toward holistic methods rather than hydrological or hydraulic/habit based approaches (see discussion in Section 2). Environmental flow regulation is more common in developed nations, and is used less frequently within Latin America and Africa.

Selection of an instream flow determination methodology is often linked to the resources available for environmental regulation and to the local needs of riparian communities. In Korea, university and government agencies used numerical modeling of water quality, specifically QUAL2E, along with surveys of public opinion on river aesthetics to set instream flow needs in the Keum river basin. In Pakistan, hydraulic modeling has been used to set minimum flows to satisfy depth requirements in many rivers. In Canada, Alberta Environment used bank-full assessments to determine instream flow needs for the South Saskatchewan River Basin instream flow study, using regime theory and geomorphic considerations to determine the magnitude of required channel maintenance flows. PHABSIM was also used to determine separate flow requirements for biological integrity. Similar study examples are available from all over the world.

In the Caribbean, 11 of the 19 countries surveyed by Scatena in 2004 had some type of standardized method for determining instream flow requirements. Most of these countries used historic low flows as a basis for their flow standard, relying to some extent on hydrologic data and sometimes hydraulic criteria, sediment transport, channel geometry and/or ecological habitat requirements, if available. The survey responses indicate a wide range of methods are being undertaken, although generally desktop methods are favored because they require minimum field work and monitoring efforts. The study did not address the effectiveness of the prescribed flow requirements in maintaining ecological integrity or recreational needs, nor the reasoning behind the method selection.

Larger, more detailed studies are typically undertaken in both South Africa and Australia - countries which have continually advanced the science of instream flows. The government of South Africa and local researchers developed the Building Block Methodology for instream flow assessment which is a frequently used holistic approach and formed the basis for development of alternative holistic methods. As a category, such methods consider flow effects on the entire ecosystem, rather than limiting focus on selected river reaches or aquatic species. One such holistic approach has been used for setting instream flow guidelines in the Australian Capital Territory. This approach aims to consider the complete river ecosystem including catchment, channels, storage, riparian zone ground water and wetlands to maintain integrity, natural seasonality and variability of flows.

China has recently joined with Australia to develop the Australian China Environment Department Partnership, a five year, $25M AusAID initiative started in 2007, with the objective of supporting and improving Chinese environmental policy and natural resources management. One project in this partnership is a 24-month effort to improve river conditions through river health monitoring and estimation of instream flow needs. The objectives are to successfully conduct field assessments and develop tools as well as, where relevant, draft national guidelines for river health and instream flow assessments. The project comprised elements which trial and adapt Australian approaches to river health and instream flow assessments and comprises both field elements and significant capacity building and communications elements focused on the Yellow River, Pearl River and Da Liao River Basin.

Perhaps the largest and most exhaustive environmental flows project was undertaken in support of the Lesotho Highlands Water Project (LHWP). This project transfers water from the mountain highlands of Lesotho to South Africa. The LHWP environmental flows study (completed in 2002) analyzed how changes to the way water was released from the project dams could reduce the impact on both downstream river ecosystems and on the livelihoods of people living alongside them (LHDA, 2002). A structured evaluation of the effects of different kinds of flow change was performed after two years of data collection. Predictions were made regarding social, health and economic outcomes that were linked with biophysical impacts of stream flow alteration. Modeling studies were then performed to simulate future release scenarios. Environmental concerns addressed in the study included changes in river form and function, and alteration to the abundance of riverine animals and plants in downstream riparian zones. An interesting feature of this instream flow study is that within the LHWP, economic issues were considered as part of the holistic process, and included potential loss of royalties from any reduced sales of water to South Africa due to instream flow requirements. The modeling scenarios formed the basis for protracted negotiations between the project sponsors, which led to agreements on the volume of water to be released from the dams, the timing of releases, and the compensation payments to be made to people living downstream. The resulting Instream Flow Requirement (IFR) Policy also specified operating rules for the dams and required the institution of a compliance monitoring program and some flexibility in the reservoir operating rules to account for adaptive management concerns and natural variations in climatic conditions.

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4. Recommendations

The instream flow Advisory Group met as a committee five times over the course of this project and communication between members also occurred via email and conference calls. The meetings were facilitated by an independent consultant (Barney Austin with INTERA) and typically included a presentation on some aspect of instream flow or water resources the Advisory Group was interested in (such as legal considerations in Oklahoma, desktop methodologies for instream flow studies, the domestic use set-aside and economic benefits of streams and reservoirs), followed by a dialog on how, or if, Oklahoma should address instream flows. While significant progress was made in understanding the complexities and challenges that would need to be addressed prior to implementing instream flow policies within the legal framework for water resources management in Oklahoma, several issues remain not fully resolved or poorly understood. For example, some of the Advisory Group members suggested that the domestic use set-aside or other mechanisms may provide sufficient protection for instream flow needs now and in the future. Others expressed concern that the financial resources required to conduct instream flow studies would be better spent elsewhere and that the impact of the implementation of an instream flow standard for a particular basin may have unintended economic consequences. On the other hand, some members expressed frustration on the lack of progress in dealing with instream flows to protect the environment and endangered species in Oklahoma. These discussions helped form the basis of this report.

Some of the recommendations presented below are technical in nature, while others clearly fall within the realm of policy. The Advisory Group discussed at length whether the policy questions should be answered first, or whether more information was needed in order to formulate sound policy decisions. The reality is that the two need to be conducted in parallel; some policy decisions can (and should) be made up front, while other decisions would benefit from more information. Recommendation 1 tackles many of the outstanding policy questions while Recommendations 2 through 5 are primarily technical in nature. Recommendation 6 calls for the preservation of the Advisory Group and describes its future role. The Advisory Group should be offered the opportunity to provide input and feedback on all of the recommendations, as they are performed. A timeline for completing these recommendations is presented at the end of the section.

Recommendation 1 – Address the legal and policy questions

There are a number of outstanding legal and policy issues that need to be considered and decisions made prior to developing and implementing instream flow recommendations. Major issues raised by the Advisory Group are presented below:

Factors that can legally be considered in developing a flow recommendation

There are many uses and benefits of flow in streams and rivers, but it is not clear if all can be legally considered in developing instream flow recommendations. A legal determination needs to be made as to which factors can be considered.

Effect on current and future water right holders

Stakeholders who rely on consumptive and non-consumptive uses of water must understand the potential effect of the implementation of an instream flow recommendation on both existing and future users. In most states, existing water right holders are legally protected from new instream flow standards. However those that had expected to be able use water in a basin for their future water supply needs, but do not have a permit, can be impacted. This philosophy might be appropriate for Oklahoma, but it is a major policy decision that state leadership needs to provide input on.

Process for implementing flow recommendations

Once a flow recommendation has been developed, it is important for all parties to understand how the flow recommendation will be implemented. In particular, opportunities for stakeholder input and peer review should be clearly identified. This question should be answered in conjunction with the development of the draft methodology, described in Recommendation 3.

Statutory changes

Through developing responses to the issues listed above and recommendations outlined below, if it becomes obvious that existing statutes need to be changed or amended, it is important that this takes place before progressing with instream flow studies to develop flow recommendations.

Is an instream flow program necessary in Oklahoma?

Following completion of Recommendations 2 through 4, the OWRB in conjunction with the Advisory Group and state leadership should determine whether in fact there is a need to proceed with instream flows studies and the development of an instream flow program.

Recommendation 2 – Study other mechanisms for protecting instream flows

The state should evaluate the degree of streamflow protection offered by the domestic use set-aside. This subject was addressed in the Advisory Group meetings, but needs to be investigated further. Specifically, estimates of actual flow, naturalized flow, actual water use, timing of actual water use, the domestic use set-aside and the amount of water available for appropriation in each basin need to be examined at representative locations across the state. There are several software tools available for analyzing the resulting hydrographs from an instream flow perspective. Supplemental information such as future water supply needs, water quality, endangered species, recreational interests, geomorphology characteristics, and societal concerns could also be considered, where available. The study should also investigate other forms of flow protection, such as interstate compacts and differences between permitted diversions and actual use. The resulting analysis would enable scientists and policy-makers to examine the degree of hydrologic alteration resulting from current and future water use, and the amount of flow protection provided by the domestic use set-aside or other forms of flow protection that may already be in place, or could be easily implemented. This information will be useful in future dialogs on instream flows.

Recommendation 3 – Develop a draft methodology for instream flow studies in Oklahoma

If it is determined that the domestic use set-aside and other mechanisms do not, or may not fully protect instream flow needs, there are still some questions that need to be answered regarding the process for developing instream flow recommendations and the form of those recommendations. These questions could be answered by developing a draft methodology and a process framework for conducting studies and implementing the findings. In fact these subjects were discussed in the Advisory Group meetings and Section 2 offers some suggestions on what might work for Oklahoma. The technical methodology is probably best developed by individuals with a technical background, while the process framework should be developed by those with an intimate knowledge of the regulatory framework. Both should be developed in concert with state leadership and policy-makers. The methodology should detail how a flow recommendation is developed, from a practical viewpoint. The methodology should also include a description of how the economic impacts will be estimated and provide a more detailed definition of instream flows, tailored to conditions and requirements in Oklahoma. The report should be developed with input from the Advisory Group and the methodology should be subjected to an independent peer review.

Recommendation 4 – Conduct a study on the economics of instream flows in Oklahoma

The relationship between the economy and the environment in the western states is not as clear as it used to be - resource managers used to have to decide between the economy and the environment. However, people want to live, work and have access to areas of natural, scenic beauty where opportunities for recreation and outdoor activities exist and that desire has economic implications. This doesn’t mean that instream flows need to be protected at all costs because there are many needs for the water in rivers, including consumptive uses – for example irrigated agriculture, public water supply and industrial applications. The need for instream flows must be reconciled with other uses of that water and a successful instream flow recommendation balances these various needs. As the balance of needs changes in the future, so may the instream flow recommendation in the future.

Subject to the findings of the recommendations described above, more information on the economic impacts would need to be developed prior to the implementation of instream flow recommendations in Oklahoma. Some of the Advisory Group members expressed concern about the cost of instream flow studies and the economic impacts in the receiving basins. While the cost of conducting an instream flow study is fairly easy to estimate given a methodology, the economic impacts of preserving flow in a watershed or even at a point on a river is notoriously difficult to calculate and meaningful results are often elusive. However, it has been suggested that both be considered prior to conducting any instream flow studies in Oklahoma and certainly before implementing any instream flow recommendations. The following economic studies are suggested:

a) **Cost of studies**

Comprehensive, holistic instream flow studies can cost over a million dollars per site, while a simple desktop approach such as the Tennant method described in Section 2 requires minimal resources to develop a flow recommendation. With the draft methodology developed in Recommendation 3, it would be fairly straight-forward to determine how much it would cost to perform a single instream flow study somewhere in the state of Oklahoma, though costs are typically site-specific and based somewhat on the need for data that may or may not already exist. Costs should include any additional monitoring required. It should also be noted that instream flows studies are often conducted for a whole basin or region, rather than a specific location or sub-basin. If appropriate, the results are then applied to a larger geographic area. The costs of these larger scale studies may be slightly more, but there is an economy of scale that needs to be factored in.

b) **Cost of managing an instream flow program**

Beyond investigating the cost of studies, it would be beneficial to obtain the full cost to the state to manage an instream flow program. Neighboring states should be contacted and information on their program budgets requested. There will be large differences between states and any financial figures presented should carefully describe what is provided, with their associated budget. During the study, it would be beneficial to determine the cost of mechanisms already in place versus an instream flow program for protecting flows in Oklahoma.

c) **Economic impact of implementation**

Several studies on the economic costs and benefits of maintaining instream flows have been conducted across the United States in recent years. Studies typically focus on the ecosystem and recreational benefits and the economic consequences of a basin being deemed fully appropriated where there might have been water available had an instream flow recommendation not been made. In addition, the economic consequences should address the impacts to future water users in comparison to current conditions, i.e. where water is available and no instream flow values have been assigned. It is recommended that information be gathered on this subject and the findings summarized in a report. A determination should also be made as to how relevant the findings are to streams and rivers in Oklahoma. The Advisory Group members are particularly interested in case studies where interstate compacts are involved and any parallels that exist to the current situation in Oklahoma.

Recommendation 5 – An instream flow pilot study in a scenic river

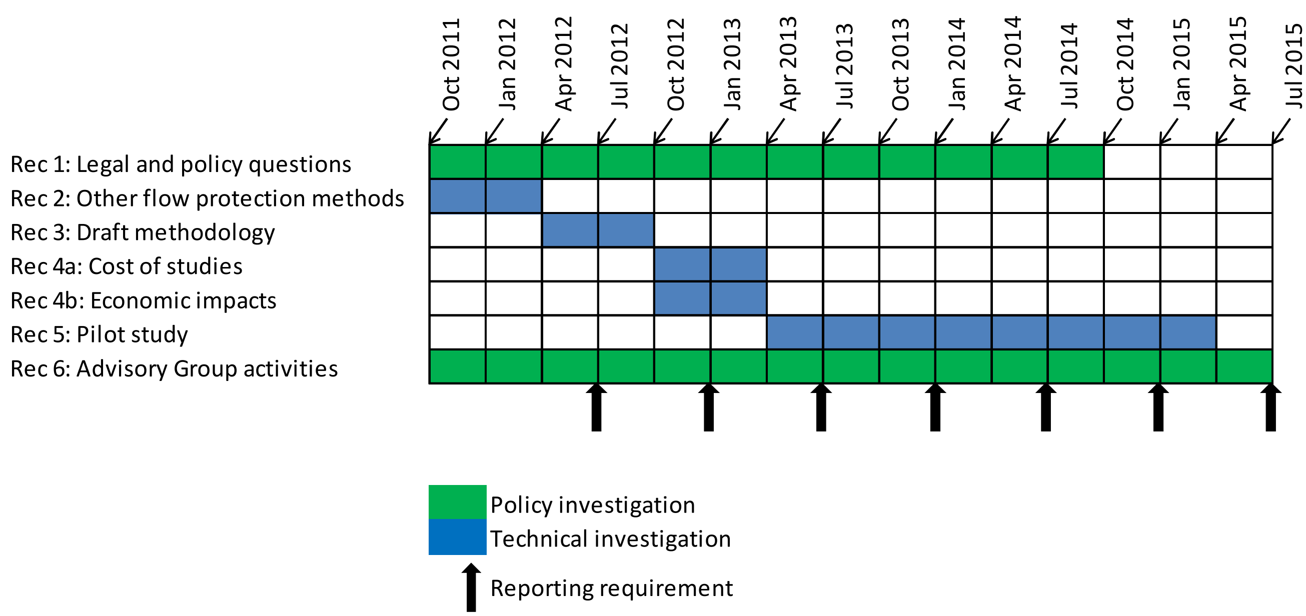
If the state still has an interest in pursuing instream flow studies for the state of Oklahoma after the recommendations presented above have been carried out and the findings fully discussed, then the remaining questions can only be answered by carrying out a pilot study. Different methodologies for conducting instream flow studies are described in Section 2 and the development of a proposed methodology for Oklahoma is outlined in Recommendation 3 of this section. Some of the methodology will be difficult to define clearly without a working example. Furthermore, many of the outstanding questions regarding how an instream flow recommendation is developed in a public forum could be answered through a pilot study. Targeting one of the designated scenic rivers for the study would be less controversial, and more information on flow needs might be available within one of these protected areas. The purpose of the pilot study is to firm up, with stakeholders, the specifics for conducting studies (including the process for developing of goals and objectives for the basin, and the role of scientists and the public) that everyone is comfortable with. The results and recommendations of the study would be reported to the legislature, the Advisory Group, and other interested stakeholders for review and input, allowing the opportunity for discussion on the proposal prior to the OWRB beginning the development of a policy on instream flows.

Recommendation 6 – Preserve the instream flow Advisory Group

Throughout this process, the instream flow Advisory Group has been very useful in providing input and guidance on how (or if) an instream flow program should come about and issues of importance to the members. Significant progress can be made when representatives from industry and environmental groups are on the same page regarding instream flows. Having a mechanism in place whereby water resources planners and the developers of water policy can effectively discuss issues as they relate to instream flows has been very useful and will likely continue to be useful in the future. The existing Advisory Group committee members are interested in continuing to provide input on instream flows and they would like to be kept apprised of any developments. They may also help coordinate the peer review process. Furthermore, members have suggested that they periodically provide reports to the Legislature on progress the group has made and information they have gathered on the subject of instream flows. It is suggested that the Advisory Group develop these progress reports on a six-monthly basis, corresponding to key milestones in the timeline described below.

The membership of the Advisory Group will probably change over time, and communication methods between members may take a different form in the future, such as email, discussion board or conference calls to reduce time and resources required. For individual studies, it may be that a subset of the Advisory Group is used or additional stakeholders needed, however the existing Advisory Group should be offered the opportunity to participate in the process. All members should have an interest in preserving the beneficial use of water in the state or basin.

The following Gantt chart shows the suggested order and time frame for completing the recommendations. The timeline should be revisited once scopes of work have been developed for each recommendation and may need to be adjusted periodically, subject to the results of the technical studies and policy decisions. In the timeline presented below, the Advisory Group is given three months after completion of each report to review and provide feedback to the OWRB, the Legislature and other interested parties.



Appendix A

Designated Scenic Rivers of Oklahoma

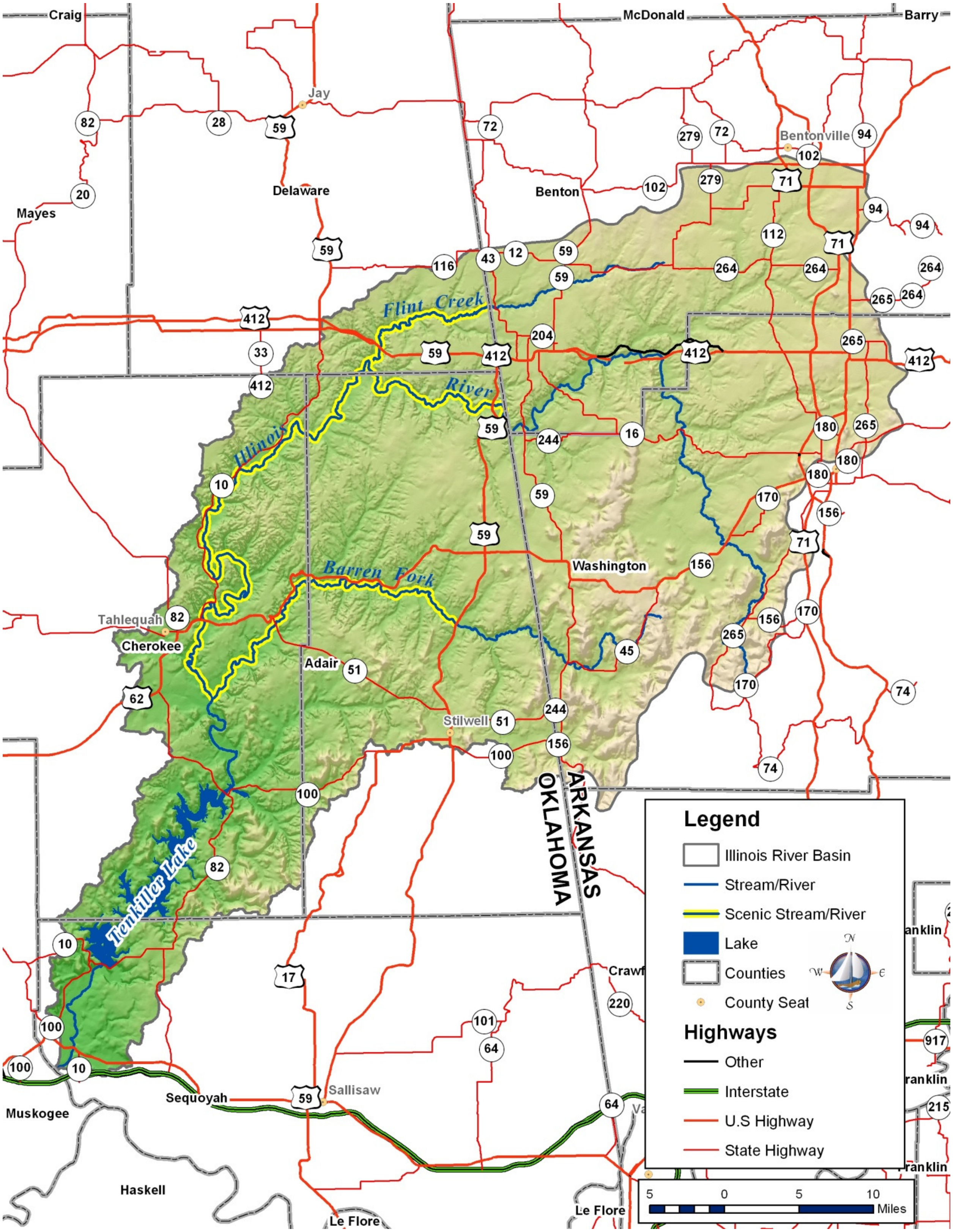


Figure A1 – Flint and Barren Fork Creeks and the Illinois River.

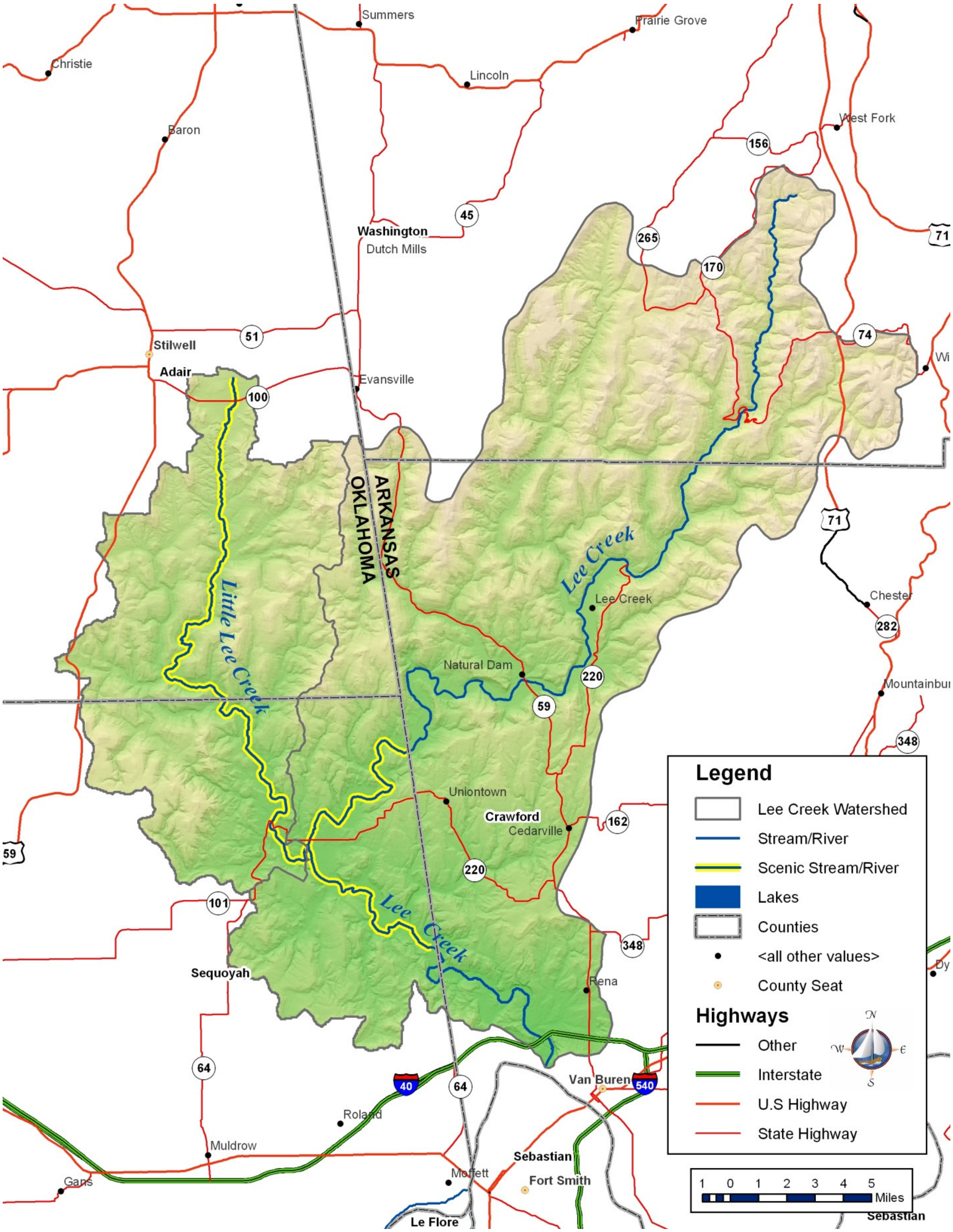


Figure A2 – Lee Creek and Little Lee Creek.

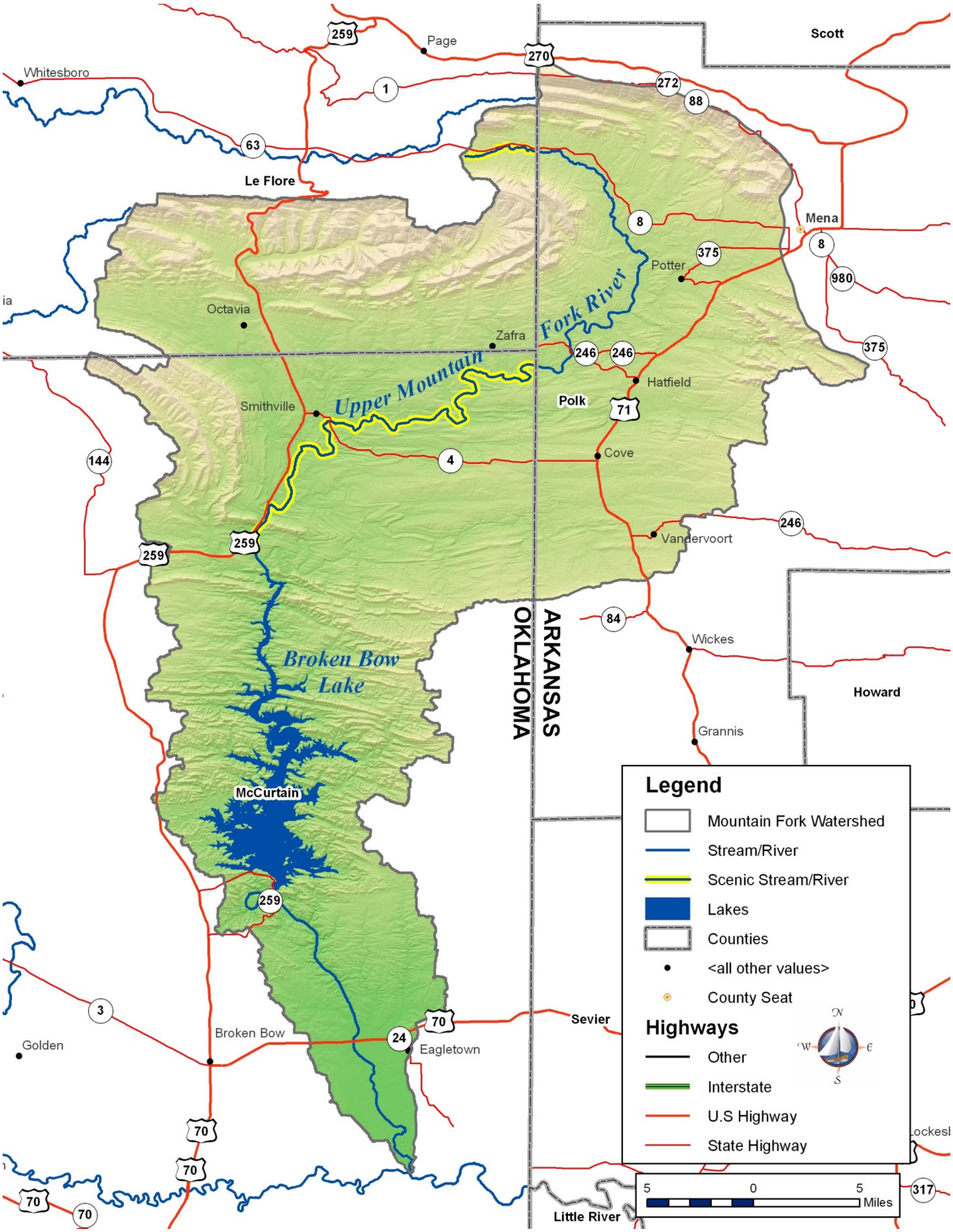


Figure A3 – Mountain Fork River.

Appendix B

Instream Flow Advisory Group Members and Affiliations

Name		Organization
Derek	**Smithee**	Oklahoma Water Resources Board
Mark	**Derischweiler**	Oklahoma Department of Environmental Quality
Brooks	**Tramell**	Oklahoma Conservation Commission
Angie	**Burckhalter**	Oklahoma Independent Petroleum Association
Terry	**Peach**	Oklahoma Department of Agriculture, Food & Forestry
Amanda	**Storck**	Office of the Secretary of Environment
Jeff	**Tompkins**	Bureau of Reclamation - Oklahoma City Office
Gene	**Lilly**	U.S. Army Corps of Engineers - Tulsa District
Barry	**Bolton**	Oklahoma Department of Wildlife Conservation
Scott	**Dewald**	Oklahoma Cattlemen's Association
Tom	**Elkins**	Cherokee Nation
Rachel	**Esralew**	U.S. Geological Survey
	Alternate:	Kim Winton
Gene	**Whatley**	Oklahoma Rural Water Association
Diane	**Pedicord**	Oklahoma Municipal League
	Alternate:	Cheryl Dorrance
Jim	**Barnett**	Environmental Federation of Oklahoma
Marla	**Peek**	Oklahoma Farm Bureau
Mike	**Fuhr**	The Nature Conservancy
Kevin	**Stubbs**	U.S. Fish & Wildlife Service - Tulsa Field Office
Mike	**Mathis**	Chesapeake Energy Corporation
Ronn	**Cupp**	State Chamber of Commerce
Tom	**Creider**	Oklahoma State Parks
Barney	**Austin**	INTERA