RECLAMATION

Managing Water in the West

Equus Beds Aquifer Storage Recharge and Recovery Project

Equus Beds Division, Wichita Project, Kansas

Draft Environmental Impact Statement

U.S. Department of the Interior
Bureau of Reclamation

June 2009

Abbreviations/Acronyms

ASR	Aquifer Recharge (Storage) and Recovery Project
ac-ft	acre-feet
AHERA	Asbestos Hazard Emergency Response Act
BMP	Best Management Practice
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cfm	cubic feet per minute
cfs	cubic feet per second
CO	carbon monoxide
CO2	carbon dioxide
CWA	Clean Water Act
dB/A	noise level in weighted decibels
DHHS	U.S. Department of Health and Human Services
DWR	Department of Water Resources (Kansas Department of Agriculture)
EBWF	Expanded Burrton Well Field
EIA	Economic Impact Area
EIS	Environmental Impact Statement
e-mail	computer message
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
ELWF	Expanded Local Well Field
FEIS	Final Environmental Impact Statement
FPPA	Farmland Protection Policy Act
FWCA	Fish and Wildlife Coordination Act
FWS	U.S. Fish and Wildlife Service
GHG	greenhouse gases
GMD2	Groundwater Monitoring District No. 2
GRP	Gross Regional Product
ILWSP	Integrated Local Water Supply Plan
IMPLAN	Impact Analysis for Planning Model
IPCC	Intergovernmental Panel on Climate Change
KCC	Kansas Corporation Commission
KDA	Kansas Department of Agriculture
KDHE	Kansas Department of Health and Environment
KGS	Kansas Geological Survey
KWO	Kansas Water Office
KDWP	Kansas Department of Wildlife and Parks
KDWR	Kansas Department of Water Resources
KS	Kansas
KSHS	Kansas State Historical Society
LEEDS	Leadership in Energy and Environmental Design Standards
LWF	Local Well Field
M&I	municipal and industrial
MDS	Minimum Desirable Streamflow
MGD	million gallons per day
mg/l	milligrams per liter (parts per million)
mg/m3	milligrams per cubic meter (parts per million)
MOA	Memorandum of Agreement
MSA	Metropolitan Statistical Area
msl	mean (average) sea level
MW	megawatt (1 million watts)

NCLC	National Consumer Law Center
NEPA	National Environmental Protection Act
NGVD	National Geodetic Vertical Datum
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service
NOA	Notice of Availability
NOAA	National Oceanic and Atmospheric Administration
NOI	Notice of Intent
NO2	nitrite (nitrogen dioxide)
NO3	nitrate (nitrogen trioxide)
NOx	nitrous oxides
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
NRHP	National Register of Historic Places
O&M	operation and maintenance
PAC	Powder Activated Carbon
Pers. comm.	personal communication
pH	per hydrion constant (measure of acidity)
PM10	particulate matter less than 10 microns in diameter (refers to air quality)
PM25	particulate matter less than 2.5 microns in diameter (refers to air quality)
ppm	parts per million
PSD	Prevention of Significant Deterioration (refers to air quality)
RCRA	Resource Conservation and Recovery Act
RDA	Rural Development Act (USDA)
RESNET	Reservoir Network (model)
RIA	Regional Impact Analysis
ROD	Record of Decision
RPC	Regional Purchase Coefficient
SCADA	Supervisory Control and Data Acquisition System
SCS	Soil Conservation Service (USDA, now the NRCS)
SDWA	Safe Drinking Water Act
SHPO	State Historic Preservation Officer
SMCL	Secondary Maximum Contaminant Levels (EPA)
SO2	sulfur dioxide
SWTP	surface water treatment plant
TDS	total dissolved solids
TOC	total organic carbon
TSCA	Toxic Substances Control Act
TSS	total suspended solids
µg/cm3	micrograms per cubic centimeter
µg/L	micrograms per liter (parts per billion)
µg/ml	micrograms per milliliter (parts per million)
µmhos/cm3	electrical conductance in micromhos per cubic centimeter
USACE	U.S. Army Corps of Engineers
USBOL	U.S. Bureau of Labor
USC	U.S. Code
USDA	U.S. Department of Agriculture
USDA-RDA	U.S. Department of Agriculture, Rural Development Act
USDHHS	U.S. Department of Human Services
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WAM	Water Availability Modeling

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Aquifer Storage Recharge and Recovery Project

Equus Beds Division, Wichita Project, Kansas
Harvey, Sedgwick, and Reno Counties, Kansas

Draft Environmental Impact Statement

Lead Agency
United States Department of the Interior
Bureau of Reclamation
Great Plains Region
Oklahoma-Texas Area Office

Abstract

This Environmental Impact Statement (EIS) has been prepared in compliance with the National Environmental Policy Act (NEPA). The Lead Agency is the Department of the Interior, Bureau of Reclamation (Reclamation). Cooperating agencies are the Environmental Protection Agency and U.S. Fish and Wildlife Service. Consulting agencies are the U.S. Geological Survey, U.S. Army Corps of Engineers, Kansas Department of Agriculture, Kansas Department of Health and Environment, Kansas Department of Wildlife and Parks, Kansas Geological Survey, Kansas Water Office, Equus Beds Groundwater Management District No. 2, and Wichita Water Utilities.

The document evaluates potential impacts from the Equus Beds Aquifer Storage Recharge and Recovery Project (ASR). Two alternatives are considered in the EIS. The *Preferred Alternative* would divert a total of 100 MGD of water from the Little Arkansas River[1] during high flows to recharge the Equus Beds Aquifer for later municipal and industrial (M&I) use by the City. The Federal government would fund (cost-share) up to 25% (or $30 million, whichever is less) of the construction costs, of Phases IIb, III and IV of the ASR. The City has already completed Phase I and is working on Phase IIa. No Federal funding was used for these early phases. As the City would complete the project without the Federal cost-share, the same 100 MGD ASR is considered as the *No Action Alternative*. There would be no Federal funding in No Action and all costs would be passed on to City rate payers.

[1] Some of this water comes from bank storage wells

After completion, the ASR would become the Equus Beds Division of Reclamation's Wichita Project. Operation, maintenance, replacement, and liability of the new division would be the responsibility of the City. The ASR would help meet M&I water demands of the City through 2050.

Some impacts to soils, land use, water, air quality, noise, esthetics, wetlands, riparian zones, vegetation, wildlife, and socioeconomics would be expected. Some would be temporary but some would last the duration of the ASR.

Long-term improvements in surface and groundwater quality and availability should result from the ASR. Base flow should increase in both the Arkansas and Little Arkansas rivers, and greater flows should improve aquatic habitat. Aquifer storage should help reduce impacts from evaporation and quality degradation. The ASR should also increase water levels in the aquifer to near-historic levels and help slow saltwater degradation.

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Draft Environmental Impact Statement No. **DES 09-27**

Date Filed with EPA: **July 10, 2009**

Summary

Public Law 109-299 authorizes the Secretary of the Interior to help the City of Wichita, Kansas, complete the *Aquifer Storage Recharge and Recovery Project* (ASR) of the City's *Integrated Local Water Supply Plan* (ILWSP). The purpose of the project is to provide municipal and industrial (M&I) water to the City and surrounding region through the year 2050. The ASR would pump water from the Little Arkansas River basin into the region's Equus Beds Aquifer for storage and later re-use. When completed, the ASR would become the "Equus Beds Division" of the U.S. Bureau of Reclamation's Wichita Project. Reclamation, an agency of the Department of the Interior, provides water to 17 western states, including the State of Kansas.

The Equus Beds aquifer lies under about 900,000 acres in six Kansas counties. The ASR would cover only a small part of this area, however, in northern Sedgwick and southern Harvey counties.

P.L. 109-299 requires Reclamation to use to the extent possible the City's ASR plans, designs, and analyses. Federal funding for the project would be capped at 25% of total costs, or $30 million (indexed to 2003 prices), whichever is less.

Reclamation has responsibility under NEPA to review, publicly document, and disclose the environmental impacts of the ASR before Federal action is taken. This EIS describes the impacts of the project.

Purpose and Need

The City needs water because of population growth and consequent growth in water demands. The City currently has capacity to meet average daily water demands until 2016, while with the ASR, the City would be able to meet demands until 2050. The ASR would provide a safe and reliable M&I water supply by preventing the continuing decline of water levels in the Equus Beds aquifer. About 32% of the City's water comes from the Equus Beds. Use of the aquifer for M&I, rural, and agricultural needs throughout the region over the past 60 years has caused a drop in the water table of up to 50 feet in some locations. It is estimated that the ASR would restore original water levels to the aquifer within 21 years after beginning operation.

The project would also protect water quality in the aquifer. Saltwater encroachment has become a problem because—as freshwater levels drop—saltwater infiltration from the Arkansas River and other sources has become more pronounced. Continuing saltwater encroachment could degrade water quality to the point where water would require much more treatment to make it drinkable. The ASR would help maintain a safe gradient between fresh and saltwater sections, thereby protecting the aquifer from saltwater encroachment.

Proposed Action

The Proposed Action is for Reclamation to help fund the *100 MGD ASR Plan with 60/40 Option*, as described by Burns & McDonnell (2003).

The ASR, as part of the ILWSP, would draw water from the Little Arkansas River, pre-treat it, and recharge the Equus Beds Aquifer in phases. Sixty percent of the water would come from surface water intakes, the rest from diversion wells installed along the river bank. Three recharge basins and 99 recharge recovery wells connected by pipelines would recharge the aquifer. Water would also be pumped directly from the river intakes.

Alternatives

The Preferred Alternative is for Reclamation to provide up to 25% of project costs or $30 million (indexed to 2003) whichever is less to fund and implement the remaining phases of the 100 MGD ASR (60/40). The City, having already completed Phase I and at work on Phase IIa, does not intend to ask for Federal help for this work, but is requesting Federal help for Phases IIb, III, and IV. Total cost of construction for the project would be more than $500 million, including the $27 million already spent during Phase I and $250 million estimated to be spent during Phase II. Operations and maintenance costs would be the responsibility of the City.

Under the No Action Alternative, the City would proceed with construction and operation of the ASR without Federal reimbursement of up to 25% of the total cost of the project, or $30 million, whichever is less. This alternative would have the same facilities built in the same sequence for the same construction and operation and maintenance costs as the Preferred Alternative but without Federal reimbursement. The City would provide 100% of the construction, operation and maintenance costs of the project. The Secretary of the Interior would not enter into a cooperative agreement or other appropriate agreements with the City and no Federal funds would be expended for the Equus Beds Division.

Affected Environment

Reclamation determined some of the environmental concerns to be analyzed in the EIS, and the public, City, and cooperating agencies provided others. By this process, these environmental factors were established:

- Geology
- Soils
- Land Use
- Surface Water Resources
- Surface Water Levels
- Surface Water Quality
- Surface Water Rights
- Groundwater Levels
- Groundwater Quality
- Groundwater Rights
- Air Quality
- Noise
- Esthetics
- Climate Change
- Biological Resources
- Socioeconomics
- Environmental Justice
- Cultural Resources

Environmental Impacts

Analyses have shown that the Preferred and No Action Alternatives would differ only in socioeconomic and environmental justice impacts. Impacts are summarized below and are detailed in Chapter 4.

Geology

Construction of facilities would cause minor changes to surface geology, except in the case of recharge basins, where the removal of topsoils would be permanent.

Soils

About 266 acres would be permanently disturbed by construction of pre-treatment plants and other facilities.

Land Use

About 65 acres of prime farmland would be permanently disturbed by construction of facilities.

Surface Water Resources

Base flows in the Little Arkansas River would increase slightly, but overall flows would be reduced where the Little Arkansas joins the Arkansas River. Discharges from Cheney Reservoir down the North Fork of the Ninnescah River would increase slightly.

Surface Water Levels

Base flows in both the Little Arkansas and Arkansas rivers would increase slightly, while total flows would decrease levels in both rivers. Water levels in Cheney Reservoir and the Ninnescah River system would increase slightly.

Surface Water Quality

Water quality in the Little Arkansas would improve slightly.

Surface Water Rights

There would be no impacts to surface water rights.

Groundwater Levels

Levels in the Equus Beds aquifer would rise.

Groundwater Quality

Rising groundwater levels would help protect the aquifer against saltwater intrusion from the Arkansas River, oilfield brine, and salt mining.

Groundwater Rights

There would be no impacts on groundwater rights.

Air Quality

Construction of facilities would cause localized, short term impacts, while continuing traffic and operation of equipment would cause minor, long term impacts.

Noise

Construction would temporarily disturb local residents and livestock and wildlife.

Esthetics

Construction would temporarily affect the project area, while facilities would have a permanent effect.

Climate Change

Carbon-based fuels would be expended during construction and operation of the project. Storage of water in the Equus Beds aquifer would protect it from losses to evaporation.

Biological Resources

There would be no impacts to critical habitat and no threatened, endangered, or candidate species would be affected. Some small wetlands could be temporarily affected by construction.

Socioeconomics

The net economic benefits of ASR construction within the region would depend upon the relative proportion of local to outside (Federal) funding. Should the government contribute zero dollars, the economic benefit (impact) to the region would be about - $75.6 million. Should all funding come from local sources, household expenditures normally reserved for other goods and services would be needed to pay for the project.

The average Wichita household currently pays about $342 per year in water bills. When this figure is added to the $124.50 in construction and O&M costs estimated for the project, the result is $467. This total is much lower than the EPA's estimated maximum household payment capability for water of $990, but neither of these payment amounts would necessarily protect poor or minority households.

Environmental Justice

EPA's study found 13 postal zip codes in the project area where household incomes averaged less than the study area. When project costs per customer were compared, it was found that No Action Alternative costs (No Federal funding) exceeded the EPA household cost of 2.5% of household income.

Cultural Resources

Should any cultural resource sites be discovered, protection and mitigation, including consultation with the State Historic Preservation Office, would be required before proceeding.

Cumulative Impacts

Impacts from parts of the ILWSP other than ASR, including expansion of the Local Well Field, re-opening of the Burton Reserve Well Field, continuation of the City's water conservation program, and other operations would cumulatively impact the environment. Impacts would be minor, except at the mouth of the Little Arkansas where it empties into the Arkansas River. Flows there would be reduced throughout most of the year to near-base flow. A series of low-head dams pool water in this reach; however, so flow elevations would remain nearly constant.

Review and Comment

Reclamation has prepared this EIS for comment. After review of the report, Reclamation will collect comments received from public meetings, e-mail, and mail, and use them to prepare a final EIS. No sooner than 30 days after publication of the final EIS, Reclamation will publish a Record of Decision, detailing the agency's course of action on the ASR, along with the rationale for selecting that alternative.

Table of Contents

Tables

Figures

Chapter 1: Introduction

The "Wichita Project Equus Beds Division Authorization Act of 2005" (Public Law 109-299) authorizes the Secretary of the Interior to help the City of Wichita, Kansas, in funding and implementing the *Aquifer Storage Recharge and Recovery Component* of the City's *Integrated Local Water Supply Plan* (ILWSP). The purpose of the ILWSP is to provide municipal and industrial (M&I) water to the City and surrounding region through the year 2050. The Aquifer Storage Recharge and Recovery Project (ASR) would pump water from the Little Arkansas River into the region's Equus Beds Aquifer for storage and later re-use. When completed, the ASR would become the "Equus Beds Division" of the U.S. Bureau of Reclamation's Wichita Project. Operation, maintenance, replacement, and liability of the new division would be the responsibility of the City.

P.L. 109-299 requires Reclamation to use, to the extent possible, the City's plans, designs, and analyses. The Federal funding cap would be 25% of total costs, or $30 million (indexed to January 2003), whichever is less. The full scale ASR system, costing over $500 million, would recharge the Equus Beds Aquifer with up to 100 million gallons of water per day (MGD).

This environmental impact statement (EIS) is required by the *National Environmental Policy Act* (NEPA). The Federal funding provided through Reclamation is a Federal action subject to NEPA. Alternatives are discussed in Chapter 2. The environment of the affected area is described in Chapter 3, and the impacts of the alternatives analyzed in Chapter 4. A list of agencies and interested groups consulted or coordinated with during the study is provided in Chapter 5.

Purpose and Need

One purpose of the project is to provide a safe and reliable source of drinking water for the City by preventing the continuing decline of water levels in the Equus Beds Aquifer. Federal funding is needed to help implement the ASR and defray costs.

Approximately 32% of the City's water supply comes from the aquifer. The Equus Beds also supplies irrigation and livestock water throughout the region. There are approximately 1,650 non-domestic water wells withdrawing about 157,000 acre-feet (51.2 billion gallons) of water per year from the aquifer. Use of the Equus Beds for both municipal and agricultural needs over the last 60 years has exceeded recharge. This has caused a drop in the water table of up to 50 feet in some locations. About 50% of the water used annually goes to agriculture, 34% to cities, 15% to industry and 1% to other users (GMD2 1995).

A **second purpose** of the project is to protect water quality in the aquifer. The decline in the Equus Beds water table has allowed water with higher salt content to seep into the aquifer. Saltwater encroachment has become a problem because as freshwater levels drop, more saltwater infiltrates from the Arkansas River and other sources. This change in "gradient" between fresh and saltwater allows poorer quality water into the aquifer. Continuing saltwater encroachment could degrade water quality to the point where the water would require much more treatment to make it drinkable. In addition, the use of saline water for irrigation would damage crops, reduce soil productivity, and cause more salt to be available for re-infiltration through the soil. The ASR would help maintain a safe gradient between fresh and saltwater sections, protecting the aquifer from saltwater encroachment.

The **ASR is needed** because population and resulting water demands of Wichita and surrounding areas are projected to increase significantly by the year 2050. The City currently has the capacity to meet average daily water demands until 2016 (Burns & McDonnell 2003). With the ASR, the City would have the capacity to meet average daily needs of 112 MGD in 2050. The project would also:

- Store surface water underground to prevent evaporation and reduce other losses
- Reduce the gradient between fresh and saltwater sections within the aquifer to protect water quality
- Capture surface water for storage during periods of high stream flow, and
- Protect stored water from short term, seasonal, annual or long term climate change.

Reclamation has a duty to review and disclose the environmental consequences of the project before a Federal action is taken.

Proposed Action

The Proposed Action is for Reclamation to help fund the *100 MGD ASR Plan with 60/40 Option*, as described by Burns & McDonnell (2003).

The ASR, as part of the ILWSP, would draw water from the Little Arkansas River, pre-treat it, and recharge the aquifer in four phases. Sixty percent of the water would come from surface water intakes. The remaining forty percent would come from diversion wells installed along the river bank. Three recharge basins and 99 recharge-recovery wells connected by pipelines would recharge the aquifer (see Figure 1-1.) Water would also be pumped directly from two river intakes. The first was constructed near Halstead during Phase I. A second intake is being constructed near Sedgwick during phase IIa. This intake could be expanded during Phase IV. Water from this intake would be piped to a second water treatment plant (Figure 1-1.)

The City, having already completed Phase I and at work on Phase IIa, does not intend to ask for Federal help for this work but is requesting Federal funding for Phases IIb, III, and IV. Total cost of construction for the 100 MGD ASR 60/40 Plan would be more than $500 million, including $27 million spent during Phase I and $250 million estimated to be spent during Phase II.

Congress has authorized Federal funding of up to 25% of these costs (or up to $30 million, indexed to 2003), whichever is less. Phases I and IIa of the ASR are ineligible for reimbursement, as they are independent of cost-sharing and precede Reclamation's NEPA process for the project.

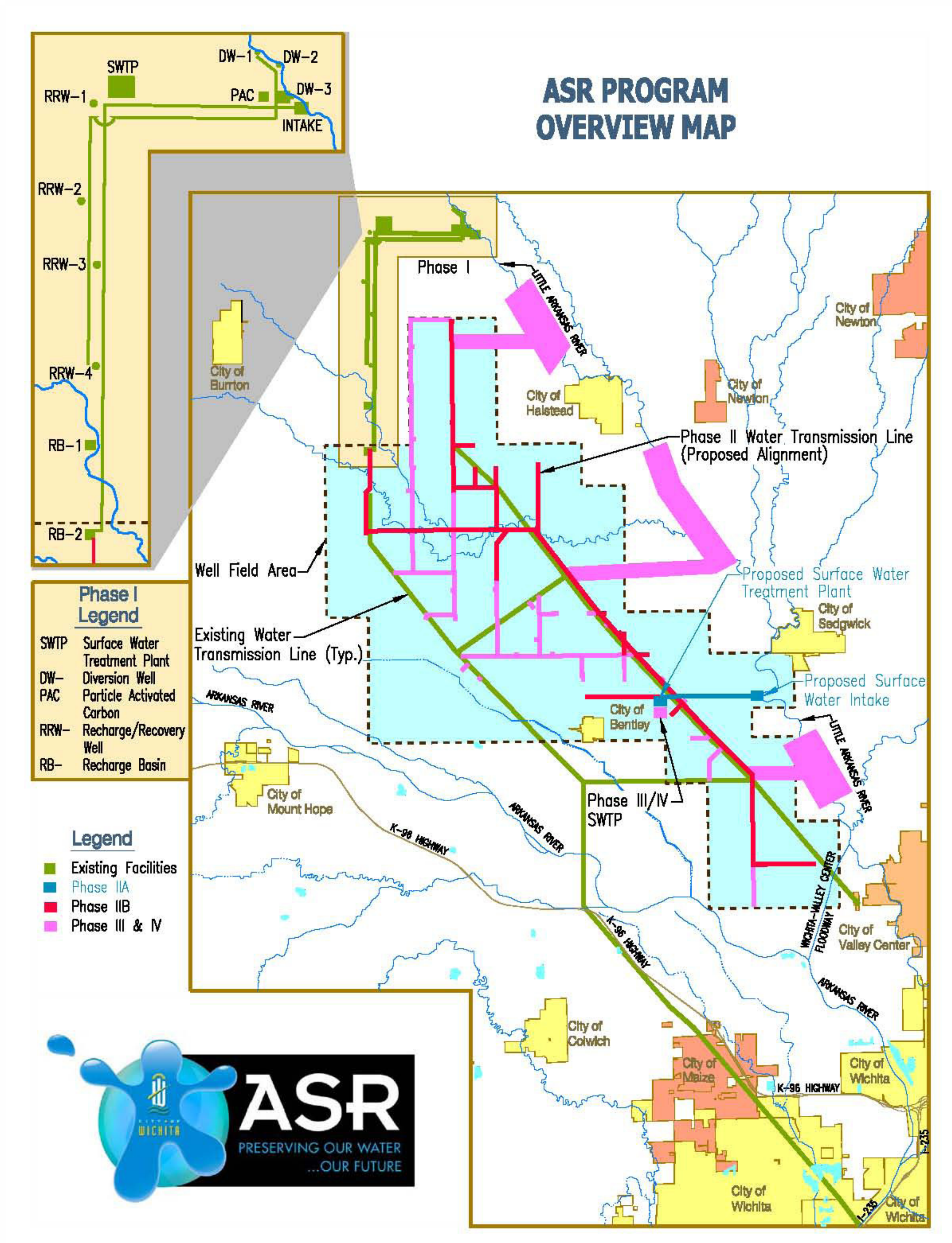

Figure 1-1: Overview of Phases II-IV

Location

The Equus Beds aquifer lies beneath about 900,000 acres in six Kansas counties. However, the proposed project would cover only a small part of this area. Construction would occur in northern Sedgwick and southern Harvey counties.

The Equus Beds and surrounding, impacted areas are shown in Figure 1-2.

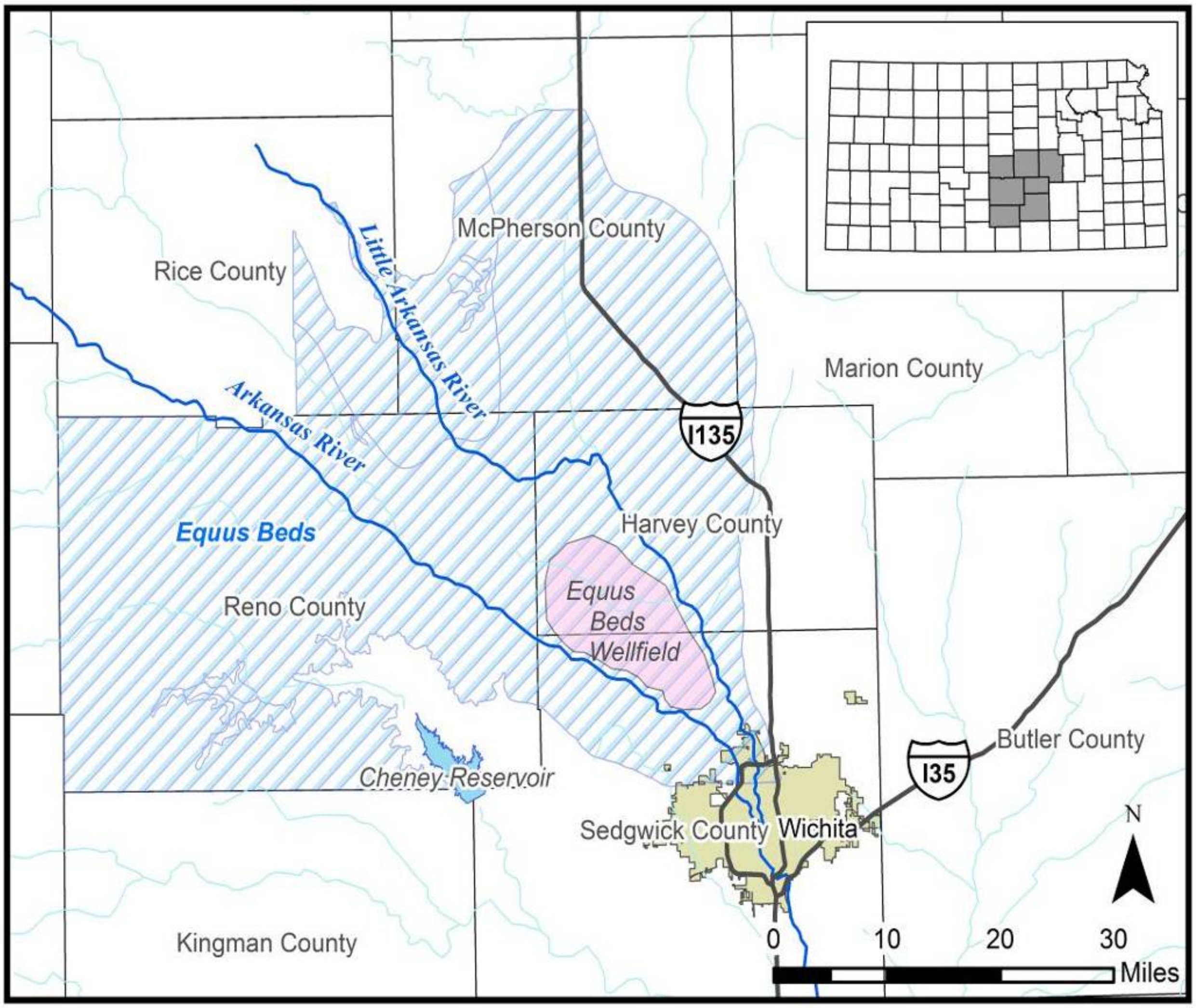

Figure 1-2: Equus Beds Aquifer (blue hatched area) as adapted from USGS

Background

City Water Sources and Facilities

The City and surrounding metropolitan area have many water sources, but only Cheney Reservoir and the Equus Beds have been dependable sources of supply (Burns & McDonnell 2003). The most important water sources and facilities are described below.

Integrated Local Water Supply Plan (ILWSP) – Including ASR

As described above, the City has completed Phase I of the ASR and is at work on Phase IIa. Phase I, at a cost of $27 million, was finished before Reclamation began work on this EIS. (In this report, it will be considered for its contribution to cumulative effects.) The City built a 7 MGD surface water treatment plant, three diversion wells, a 7 MGD river diversion and intake, 4 recharge-recovery wells, 2 recharge basins, 14 miles of overhead power lines, and a computerized *Supervisory Control and Data Acquisition System* (SCADA) system. The City also installed 35 monitoring wells at the request of the Kansas Department of Health and Environment (KDHE). Seven of these monitoring wells are located near diversion wells along the Little Arkansas River and 28 are found near recharge-recovery sites.

Figure 1-3: Monitoring Well near the River

Phase IIa will consist of a 66 MGD (33 MGD operational) diversion structure on the river, a 60 MGD surface water intake, 2.5 miles of pipelines, and a 30 MGD surface water treatment plant.

Equus Beds Well Field

Only shallow water wells (predominately hand-dug) were constructed in the Equus Beds before the 1930s. The need for a public water system arose as the population of the City grew. Increasing water demands were met by construction of the Equus Beds Well Field (EBWF, Figures 1-1 and 1-2). Another 30 wells were added during the 1950s, bringing the total number to 55.

The EBWF provided approximately 60% of the City's water through 1992. Since that time, the percentage has decreased to about 32%. Surface water from Cheney Reservoir and the Little Arkansas River supply about 68%.

Local Well Field

The Local Well Field (LWF) lies between the Little Arkansas and Arkansas rivers inside the City limits, just above the confluence. It contains 16 wells that pump bank storage water[1]. These diversion wells, constructed in 1949 and 1953, have only been lightly used.

Bentley Reserve Well Field

A drought in the 1950s led to development of a second aquifer along the Arkansas River. The well field lies 22 miles northwest of the City. The City drilled six wells, known as Bentley Reserve Wells, in 1956, but the water was too salty for standard treatment. The reserve well field was abandoned and water rights dismissed soon after the wells were drilled. However, the City recently obtained new water rights for the area (email, D. Ary to C. Webster, March 17, 2009).

Cheney Reservoir

Cheney Reservoir is a division of Reclamation's Wichita Project. The dam was constructed about 24 miles west of the City on the North Fork of the Ninnescah River during the 1960s. The top of the reservoir conservation pool lies at 1421.6 feet above mean sea level (msl). The impoundment holds approximately 167,074 acre-feet of water at this elevation (Reclamation 1981). The primary original purposes of the project were to furnish municipal water, protect against floods, and preserve and protect fish and wildlife. Cheney Reservoir now serves as an important recreational area and as the City's primary water supply.

City Water System

Wichita Water Utilities administers the municipal and industrial (M&I) water supply to residential and commercial customers inside the City and to 23 districts and towns outside the City. The supply consists of water from the Equus Beds aquifer and the Local Well Fields, as well as from Cheney Reservoir. Water is pumped to the City's water treatment plant and either piped to a pumping station for distribution throughout the region or stored in tanks during periods of low demand.

City Water Supply Study

Burns & McDonnell initiated a study during 1993 to plan for the future by comparing water sources, supplies, and system capacity to projected demands. The process included public meetings, discussions, and reviews with outside agencies. Review of the data indicated that

[1] Bank storage water refers to river water that has seeped into the bank

average daily demand by 2050 could more than double to 112 MGD from the present 55.2 MGD. Demand would rise despite the City's stringent conservation program. Maximum daily demand could rise to 223 MGD, up from today's 115.4 MGD. Study results indicated that water shortages for an average day's supply could occur during dry weather by 2026. Water shortages could also occur for the maximum daily supply.

The study proposed three comprehensive water supply plans, including the ILWSP. The ILWSP (including the ASR) would be completed in four phases (since divided into Phases I, IIa, IIb, III and IV). The primary aim of the ILWSP is to "maximize the use of storage in Cheney Reservoir, and to maximize the opportunities to recharge water into the aquifer, with use of water from the aquifer minimized except during drought conditions," (Burns & McDonnell 2003, p. 2-12.) Once all phases are completed, the ILWSP would consist of the following components:

- The ASR to transfer Little Arkansas River water into the Equus Beds Aquifer
- Expanded use of water from Cheney Reservoir
- Reuse of the abandoned Bentley Reserve Well Field along the Arkansas River (the saline water would be diluted with fresh water)
- Expansion of the Local Well Field along the Little Arkansas River
- Construction of a new water treatment plant
- Construction of more water pipelines, SCADA system and overhead power lines, and
- Adoption of expanded water conservation measures.

The ASR component is singled out for consideration for Federal funding in this EIS. The funding specified in Public Law 109-299 is to be used solely for Phases IIb, III and IV.

Information in the 2003 Burns & McDonnell report has been incorporated in this EIS where appropriate.

Study Participants

Agencies and organizations involved in development of the EIS include:

- U.S. Army Corps of Engineers (USACE)
- U.S. Environmental Protection Agency (EPA)
- U.S. Fish and Wildlife Service (USFWS)
- U.S. Geological Survey (USGS)
- Kansas Department of Agriculture (KDA)

- Kansas Department of Health and Environment (KDHE)
- Kansas Department of Wildlife and Parks (KDWP)
- Kansas Geological Survey (KGS)
- Kansas Water Office (KWO)
- Equus Beds Groundwater Management District No. 2 (EBGMD2), and
- Wichita Water Utilities (WWU).

The EPA and USFWS participated in on-site investigations and as cooperating agencies in the generation of the EIS. The remaining agencies provided information and assistance as needed.

Decisions to Be Made

Reclamation

Congress authorized the Department of the Interior (through Reclamation) to enter into a cost share agreement with the City for the Equus Beds ASR Project. A cost share agreement would guide Federal expenditures during Phases IIb – IV. Reclamation would not own or operate the project at any point during design, construction, implementation, or other process.

After publication and distribution of the EIS, Reclamation will solicit comments from the public and other agencies and organizations. Public hearing(s) could also be held, if needed. Appropriate changes will be made to the EIS and a final EIS (including the comments received on the earlier EIS and Reclamation's responses) will be published and distributed.

A record of decision (ROD) will be written to document the alternative selected. The ROD will explain Reclamation's rationale and reasoning for making the decision.

City of Wichita

The City implemented the Equus Beds ASR. Phase I of the project has already been completed and Phase IIa is under development. Without Federal assistance, the City could change water rates, continue or expand water conservation and education programs, continue development of both the Bentley Reserve and Expanded Local Well Fields, and begin other activities to pay for the changes. Costs associated with all phases of the ASR would be passed on to water service customers.

Environmental Concerns

The City and Reclamation have identified environmental concerns, as noted in this EIS. Concerns were also expressed by citizens participating in public scoping or other informational meetings, or by providing information electronically or by mail during the City's original scoping process in 1997 and during Reclamation's scoping process in 2008. Table 1-1 lists collected concerns and indicates geographic areas where they are especially relevant. Pages in this document where the concerns are discussed are provided also.

Table 1-1 Environmental Concerns, Geographic Locations, and Pages where Discussed

	Concerns	***Locations***	***Pages***
Groundwater Volume	Expansion of the Local Well Field could lower the water table in private wells	Northwest Wichita	111
	Changes in water storage, use, and precipitation could impact the aquifer	Project Area	111
Groundwater Quality	Expansion of the Local Well Field could disturb a hazardous groundwater site near 57th St. and Broadway	Northwest Wichita	App. A
	Arsenic and other trace metal concentrations could change in groundwater	Project Area	112
	Intrusion rates of highly saline water into the aquifer from the Burrton area could change	Project Area	112
	Greater use of the Bentley Well Field could increase saline water intrusion	Northern Project Area	114
	Greater withdrawals from the Local Well Field could	Northwest Wichita	114

Table 1-1 Environmental Concerns, Geographic Locations, and Pages where Discussed

	Concerns	*Locations*	*Pages*
Groundwater Quality (continued)	negatively impact ground water quality		
	Atrazine concentrations in the aquifer could be affected	Project Area	112
	Pharmaceutical and antibiotic concentrations in the aquifer	Equus Beds Aquifer	45
Surface Water Quality	Little is known about pharmaceutical and antibiotic concentrations in the Little Arkansas River	Little Arkansas River	107
River and Reservoir Volume	Storage volumes (total and sub-pool), water levels, surface area, and degree of fluctuation could change in Cheney Reservoir	Cheney Reservoir	103
	Minimum and seasonally variable releases from Cheney Reservoir could change	Cheney Reservoir	103
	Flows of the North Fork Ninnescah River below Cheney Reservoir could change	North Fork of Ninnescah River downstream from reservoir	104
	Duration of bank-full conditions, out-of-bank flows, greater base flow, and flow duration curves could change in the Little Arkansas River	Little Arkansas River	94
	Flows in the Arkansas River downstream of the Little Arkansas could be reduced	Arkansas River	100

Table 1-1 Environmental Concerns, Geographic Locations, and Pages where Discussed

	Concerns	*Locations*	*Pages*
Fish and Wildlife	Fisheries, riparian wildlife, birds, and habitat in the Little Arkansas, Arkansas, and North Fork of the Ninnescah rivers and Cheney Reservoir could be affected by changes in flows or water levels	Major streams in, around and below the Project Area	122
	Nesting conditions of the Interior least tern, which uses exposed sandbars in the Arkansas River, could be affected	Arkansas River downstream of the Project Area	122, App. E
Threatened and Endangered Species And Species of Special Concern	Federal and State Threatened and Endangered Species, migratory Species or species of concern could be affected	Project Area and major streams in, around, and below the Project Area	122
Social and Economic Conditions	The nature of the contract between Reclamation and the City on operation and ownership of Cheney Reservoir could be affected	Project Area	103
	Changes in operations at the reservoir could affect the public	Region	103
	Making Wichita the major hub for regional water supply could affect the public	Region	App. B
	Conjunctive use opportunities and constraints on water rights could be affected	Project Area	App. B

Table 1-1 Environmental Concerns, Geographic Locations, and Pages where Discussed

	Concerns	*Locations*	*Pages*
Social and Economic Conditions (continued)	Land and Water Conservation Fund properties like state, county, and City parks and wildlife areas could be affected	Project Area	89-93
	City water conservation measures could affect water use	Project Area	27
	Costs and expenditures could unfairly impact environmental justice	Project Area	139, App.B
	Construction in areas with elevated ethnic, minority, or poorer populations could unfairly impact environmental justice	Project Area	137, App.B
Land Use	Groundwater mounding in the aquifer could affect land owners and water users	Project Area	113
Prime and Unique Farmlands	Prime and Unique Farmlands could be lost to construction	Project Area	89
Air Quality	Construction and system equipment could affect air quality	Project Area	115
Recreation	Public recreation on Cheney Reservoir and in the North Fork of the Ninnescah could be affected	Cheney Reservoir and North Fork of the Ninnescah River	112

Table 1-1 Environmental Concerns, Geographic Locations, and Pages where Discussed

	Concerns	*Locations*	*Pages*
Noise	Construction and system equipment could affect air quality	Project Area	115
Climate Change	Long term operation and maintenance could impact climate change	Project and surrounding areas	117
Cultural Resources	Construction and excavation could adversely affect historic properties potentially eligible for the National Register of Historic Places	Project area, especially on terraces along Arkansas and Little Arkansas rivers	140
Human Health & Safety	Changing water quality could impact human and community health and safety	Project Area	144

Chapter 2: Alternatives

Development of Alternatives

P.L. 109-299 requires that Reclamation help the City of Wichita fund and implement the Aquifer Storage Recharge and Recovery Project of its Integrated Local Water Supply Plan, using the City's plans, designs, and analyses to the extent possible. The National Environmental Policy Act, on the other hand, requires Reclamation to consider a range of alternatives designed to meet the goals of ASR, including those outside the authority of the agency to implement. Reclamation had to plot a course between these two laws in this EIS.

The Burns & McDonnell study (2003) commissioned by the City produced a number of alternatives. They were examined by the technical team that put this EIS together. Most were dropped during the process (see the "Alternatives Considered But Eliminated" section at the end of this chapter.) Remaining alternatives represent a range in that they: provide for all necessary investments; achieve the purpose of the project and meet the need while minimizing environmental effects to the extent possible; and are acceptable to the public, City, and state.

The City was interested in satisfying a number of needs in order to satisfy its investment in the project. These included:

- Using reliable water sources, considering seasonal availability
- Using water treatable to drinking standards with conventional methods
- Limiting needs for land purchases or easements, for wells and pipelines
- Protecting Equus Bed's water quality
- Utilizing existing infrastructure within the City's water system
- Adopting technology developed in ASR Phase I, and
- Constructing an automated system with ease of maintenance.

In order to develop and evaluate project alternatives, more information on water sources had to be gathered using hydro-geologic field testing and soil boring. Information on water treatment technology, groundwater modeling and systems operation modeling, and for water demands were gathered and organized.

When the information was evaluated, several alternatives were developed for consideration. The City then evaluated economic, social, and environmental impacts of alternatives to provide an M&I water supply. Conceptual designs estimated construction costs, and estimated operation and maintenance costs were analyzed. In addition, regional water sources were evaluated for the following:

- Supply capability, now and in the future
- Water quality
- Legal issues
- Policy and social issues
- Planning horizons, and
- Environmental issues.

In general, it was determined that qualifying water sources must:

(1) Effectively and economically contribute to supplying the City's year 2050 projected average and maximum daily demands
(2) Protect Equus Beds Aquifer water quality, and
(3) Provide raw water treatable to drinking water standards using conventional water treatment processes.

With one exception, sources that would not meet these requirements were eliminated. The City is re-opening the Bentley Reserve Well Field (BRWF) in Harvey County, despite high salinity of the water. It would be mixed with high quality water from other sources to dilute the salt concentration before treatment. These actions would occur with or without implementation of the ASR.

The City concluded that the ASR would best achieve the purposes of meeting water demands and protecting the aquifer from salt water intrusion. Additional actions, like expanding the Bentley Reserve and Local well fields, would contribute to the effects of the ASR.

The two alternatives remaining for analysis in this Draft EIS are:

- The Action Alternative (100 MGD 60/40 ASR with Federal funding,) and
- The No Action Alternative (100 MGD 60/40 ASR without Federal funding)

Alternatives

Preferred Alternative: 100 MGD ASR (60/40) with Federal Funding

This is Reclamation and the City's Preferred Alternative. Reclamation would provide up to 25% of project costs or $30 million (indexed to 2003) to help construct facilities and infrastructure to pump 60 MGD of surface

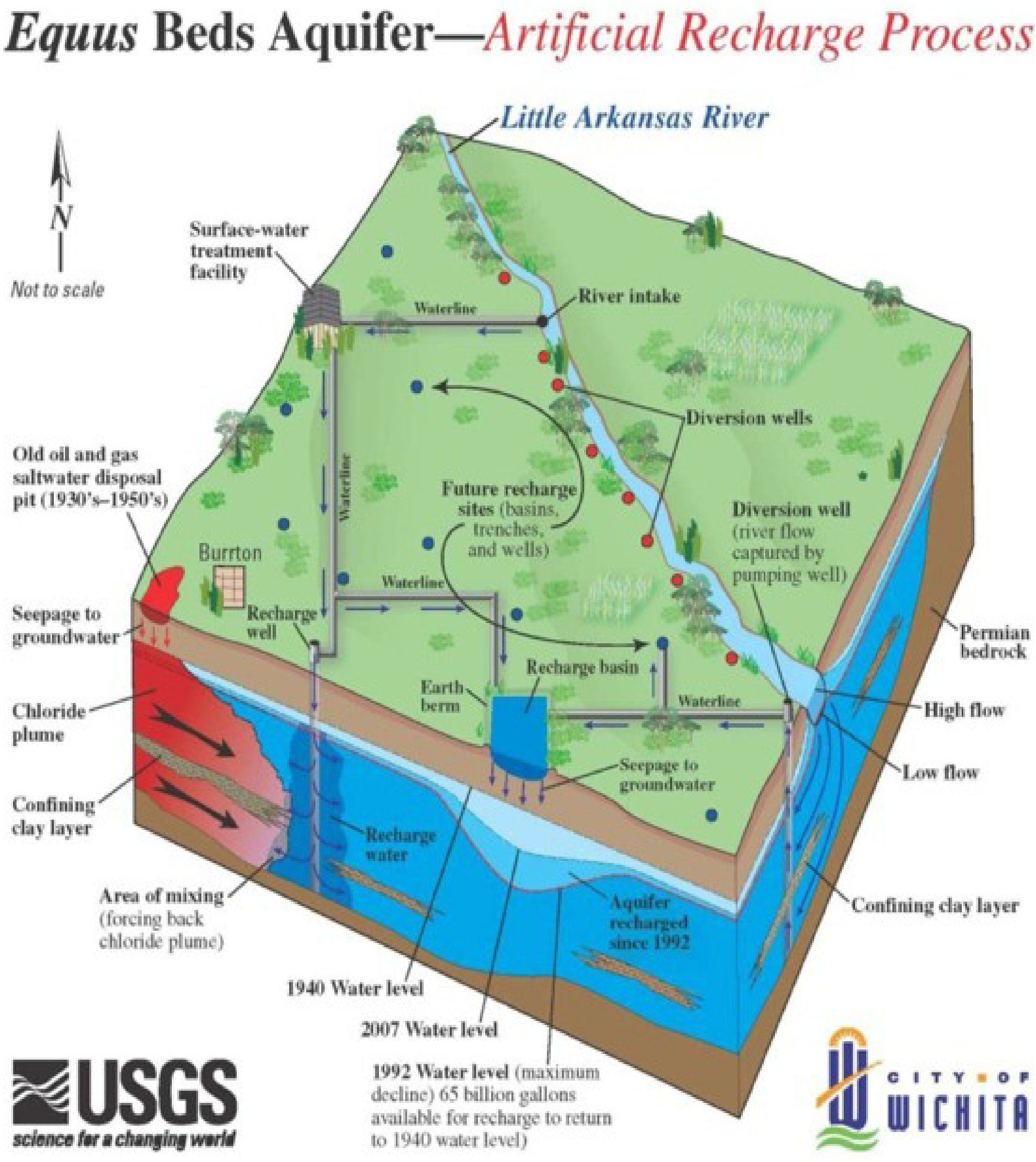

Figure 2-1: Overview of ASR

water and 40 MGD of diverted bank-water from wells along the Little Arkansas River during *above base flow* conditions (see Figure 2-1 for overview of the process). During primary irrigation months (spring through fall), the KDHE recognizes a base flow of 57 cfs in the Little Arkansas River at Sedgwick and 20 cfs at Halstead. The additional 37 cfs flow between sites is reserved for permitted agricultural diversion. Base flow in the river during winter months would be 20 cfs throughout.

If necessary, 60 MGD of surface water could be diverted, pre-treated, and conveyed directly to the City's water treatment facility. The City does not intend to pump surface water directly to the treatment plant, although they may choose to do so later. Should this option be pursued, further permitting and environmental analysis may be required. Regardless, Kansas law requires that *minimum base flows* be maintained.

Under Phases IIb, III, and IV of the 100 MGB ASR (60/40) Alternative (those phases for which Federal reimbursement would be possible), work would continue to complete and implement the project. These phases would increase the City's capacity to recharge and recover water from the aquifer, continue to increase protection from saltwater intrusion, and bring groundwater inflows to the Little Arkansas River (contributions to base flow) back to more natural levels.

Phase IIb would see installation of more recharge-recovery wells; construction of pipelines from these wells to the new surface water treatment plant; installation of overhead power lines to serve facilities in

Figure 2-2: Recharge Recovery Well Site with SCADA Tower

this and later phases; and construction of a new electrical substation. The SCADA system would also be completed in this phase (Figure 2-2). SCADA requires a radio and antenna at each diversion well and recharge-recovery well.

Phase III would continue with installation of additional recharge-recovery wells, as well as an unknown number of diversion wells. Pipelines to connect the wells to the rest of the system would be built, and the surface water treatment plant built in an earlier phase might be expanded to 60 MGD if deemed necessary.

Facilities in Phase IV would be similar to those constructed in Phase III, except that existing pipeline into the City might be rebuilt during this phase. By the end of construction of Phase IV in September 2011, total capacity of the City's water system would be 100 MGD.

Gravel access roads and other facilities required for operation would be constructed immediately next to the wells and pipelines. Wells, roads and facilities would be located in existing rights-of-way, along the edges of agricultural fields, or outside of existing riparian vegetation, to the greatest extent possible.

Table 2.1 describes the facilities to be built in Phases IIb, III, and IV of the Preferred Alternative.

No Action Alternative: 100 MGD ASR (60/40) without Federal Funding

Under this alternative, the City would proceed with construction and operation of the Equus Beds Division without Federal reimbursement of up to 25% of the total cost of the project, or $30 million, whichever is less. This alternative would have the same facilities built in the same sequence for the same construction and operation and maintenance costs as the Preferred Alternative. The only difference would be that no Federal funds would be used. The City would provide 100% of both construction and operation costs of the project. The Secretary of the Interior would not enter into a cooperative agreement, or other appropriate agreements with the City, and no Federal funds would be expended for development of the Equus Beds Division.

Table 2-1 Preferred Alternative Facilities, Phases IIb, III, and IV		
Facility	Description	Total System Capacity (MGD)
	PHASE IIb	
Recharge-recovery wells	26 recharge-recovery wells would be installed in this phase, 20 at existing sites, 6 at new sites	40
Pipelines	New 12-inch to 72-inch diameter pipelines would be built from the new surface water treatment plant to the recharge-recovery wells	
Overhead power lines	40 miles of new power lines would be built to serve facilities of this and future phases	
Substation	A new substation to serve water treatment plant and river intake constructed in earlier phases	
Process Control and SCADA	The PC/SCADA communications system would be completed	
	PHASE III	
Diversion wells	An unknown number of diversion wells would be installed along the Little Arkansas River	70
Recharge-recovery wells	27 existing wells would be re-drilled in Phases III and IV and 38 new wells drilled	
Pipelines	Water pipelines to serve the additional recharge-recovery wells would be built	
Surface water treatment plant	Water treatment plant built in Phase IIa might be expanded to 60 MGD if necessary	
	PHASE IV	
Diversion wells	An unknown number of diversion wells would be installed along the Little Arkansas River	100
Recharge-recovery wells	27 existing wells would be re-drilled in Phases III and IV and 38 new wells drilled	
Pipelines	Pipelines to serve the additional recharge-recovery wells would be built	

Last section of pipeline into City	The last section of pipeline into the City might be rebuilt during this phase	
Surface water treatment plant	Water treatment plant built in Phase IIa might be expanded to 60 MGD if necessary	

Alternatives Considered but Eliminated

100 MGD ASR (25/75)

Description

As with the City's Preferred Alternative, this alternative would entail creation of a second diversion in the Little Arkansas River near Sedgwick. Another 53 diversion wells would be drilled, rather than the 42 needed for the City's Preferred Alternative. This alternative would collect 75 MGD of surface water along with 25 MGD of diverted bank water during *above base flow* periods for aquifer recharge.

Reason for Elimination

The construction of 11 additional diversion wells and associated infrastructure would not be necessary for the City to meet its goals of: (1) effectively and economically supplying the City's year 2050 projected average and maximum daily demands; (2) enhancing protection of Equus Beds water quality; and (3) providing raw water treatable to drinking water standards with existing, conventional water treatment. Constructing more wells and associated infrastructure would force the City to buy additional property, negotiate for more easements, cause unnecessary impacts to land owners and the environment, and increase construction and maintenance costs.

100 MGD ASR (0/100)

Description

This alternative would require construction of 70 new diversion wells, rather than the 42 needed for the Preferred Alternative. All 100 MGD for aquifer recharge would come from bank-water diversion wells.

Reason for Elimination

The 100/0 Option would require the installation of 70 diversion wells along the Little Arkansas River, eliminating the need to divert surface water. The already-completed diversion structure at Sedgwick would be underutilized, if used at all, as 100% of the water would come from bank storage. Drilling and maintaining so many expensive wells, many on private property, would not be necessary for the City to meet its goals. Constructing extra wells and associated infrastructure would force the City to purchase additional property, negotiate for unnecessary easements, pay extra construction, equipment, and maintenance costs, and cause unnecessary impacts to the environment. Many of these environmental impacts would be to the ecologically sensitive riparian zone.

150 MGD ASR (60/90, 75/75 and 100/50 Options)

Description

All three options would have diverted 150 MGD of combined surface and diversion water for aquifer recharge during *above base flow* conditions. A total of 42, 53, or 70 diversion wells (the same number of wells as the corresponding 100 MGD options) would be needed, respectively.

Reason for Elimination

Engineering and hydrology studies, along with a demonstration project (Burns and McDonnell 1994), have shown that 100 MGD is enough water to supply the City's water needs and protect the Equus Beds aquifer through the year 2050. Additional costs of facilities, infrastructure, and the operation and maintenance associated with the 150 MGD ASR system would not be necessary. Constructing extra wells and associated infrastructure would also force the City to purchase more property, negotiate for additional easements, and cause further, unnecessary impacts to the environment.

The ILWSP without the ASR

Description

Reclamation planning studies for water projects include a discussion on the "*Future without the Project Condition.*" This discussion results in a reasonable prediction of what will happen in the absence of a project. While this EIS is not a planning report, Reclamation still needs to consider an alternative where ASR is not implemented.

A "no project" alternative would result in implementation of the ILWSP without the ASR component. The City would rely solely upon surface water and withdrawals from the aquifer from its current well fields. No surface water would be injected into the Equus Beds for storage and protection of water quality. Groundwater levels would continue to fall and saltwater would continue to seep into the aquifer. Since groundwater rights are greatly over-allocated in the Equus Beds region, the City would have to increase its dependence on non-firm surface water supplies in Cheney Reservoir and the Little Arkansas River. If the City wanted to increase its share of groundwater, it would be required to compete with agriculture for additional water rights.

Reason for Elimination

The City developed the ILWSP to protect itself against predicted water shortages and declining quality in its water supply. Implementation of the ILWSP without ASR would not provide additional protection to the Equus Beds by inhibiting saltwater intrusion from the Arkansas River and past oil field and salt mining activities. Water levels in the aquifer would not return to more natural levels and groundwater contributions to base flows in both the Little Arkansas and Arkansas rivers would not be restored. Water levels in Cheney Reservoir would drop as the City takes more water for M&I use. Cyanobacteria blooms would likely continue to threaten drinking water stored in the reservoir. This alternative would not meet the purpose, need, and evaluation criteria for protection of water quantity and quality in the Equus Beds, nor would it protect drinking waters stored in Cheney Reservoir.

Conservation Only

Description

This alternative would depend solely on water conservation to meet the project purpose and need. The City has employed an extensive conservation plan since 1991. Plan components include requirements for an inverted rate structure; main replacement; automated pumps; meter maintenance; leak detection; low-flow showerheads and faucets; low-flush toilets; lawn-watering restrictions; continuing to encourage industries to reduce water losses to cooling, processing, and irrigation; wastewater reuse, and continuing to operate the City’s water system to minimize water losses from over- pumping and from the treatment facilities. The conservation program, as described, would help meet the City’s average day water demands until the year 2016 (Burns and McDonnell 2003).

Reason for Elimination

Even with its stringent water conservation program, the City would be unable to supply the 2050 estimated shortages in average-day demand. In addition, this alternative would not protect the Equus Beds from saltwater intrusion from the Arkansas River and past oil field and salt mining activities. Aquifer water levels would not return to near historic-levels, so groundwater contributions to base flows in both the Arkansas and Little Arkansas rivers would not be restored. Competition for limited aquifer and surface water rights would continue.

Summary of Impacts

Table 2-2 summarizes impacts of both alternatives considered (the Preferred Alternative and the No Action Alternative.) Since the only difference between the Preferred (Action) and No Action alternatives would be a partial source of funding, the only measurable differences in expected impacts would be socioeconomic (including environmental justice), cumulative, and irreversible and irretrievable commitment of Federal resources.

Table 2-2 Summary of Impacts – Preferred Action Alternative (25% Federal Funding) vs. No Action Alternative (No Federal Funding)

	Preferred Alternative (ASR with Federal Funding)	**No Action Alternative** (ASR without Federal Funding)
Geology	Construction would remove topsoil, causing temporary changes in surface geology, except for construction of recharge basins, which would require excavation.	Same effects as for the Preferred Alternative.
Soils	Construction of facilities would cause localized, temporary disturbance of 1,700 acres, permanent disturbance of 266 acres.	Same effects as for the Preferred Alternative.
Land Use	Construction would permanently disturb about 65 acres of prime farmland. Some temporary disturbance would also occur.	Same effects as for the Preferred Alternative.
Surface Water Resources	Base flows in the Little Arkansas River would	Same effects as for the Preferred Alternative.

Table 2-2 Summary of Impacts – Preferred Action Alternative (25% Federal Funding) vs. No Action Alternative (No Federal Funding)

	Preferred Alternative (ASR with Federal Funding)	**No Action Alternative** (ASR without Federal Funding)
Surface Water Resources (continued)	increase slightly; significant flow reductions would occur at the confluence with the Arkansas; flow changes in the Arkansas, the Ninnescah system, and in Cheney Reservoir would be minor; discharges from Cheney would increase slightly.	
Surface Water Levels	Base flows would increase slightly in the Little Arkansas and Arkansas rivers; total flows would decrease slightly in both streams; water levels in Cheney Reservoir and the Ninnescah River system would rise slightly.	Same effects as for the Preferred Alternative.
Surface Water Quality	Water quality in the Little Arkansas River would improve slightly; changes in the Arkansas, Ninnescah system, and Cheney Reservoir would be immeasurable.	Same effects as for the Preferred Alternative.
Surface Water Rights	Surface water rights would not be affected.	Same effects as for the Preferred Alternative.

Table 2-2 Summary of Impacts – Preferred Action Alternative (25% Federal Funding) vs. No Action Alternative (No Federal Funding)		
	Preferred Alternative (ASR with Federal Funding)	**No Action Alternative** (ASR without Federal Funding)
Groundwater Levels	Groundwater levels would rise.	Same effects as for the Preferred Alternative.
Groundwater Quality	Rising groundwater levels would help protect the Equus Beds Aquifer against saltwater intrusion from the Arkansas River, oilfield brine, and salt mining.	Same effects as for the Preferred Alternative.
Groundwater Rights	Increasing groundwater storage and quality would help protect groundwater rights	Same effects as for the Preferred Alternative.
Air Quality	Construction would cause localized, short-term impacts; and minor, long-term impacts from continuing transportation and equipment operation.	Same effects as for the Preferred Alternative.
Noise	Construction could cause wildlife and livestock to temporarily leave affected areas; increased construction traffic on local roads could temporarily affect residents and wildlife.	Same effects as for the Preferred Alternative.

Table 2-2 Summary of Impacts – Preferred Action Alternative (25% Federal Funding) vs. No Action Alternative (No Federal Funding)

	Preferred Alternative (ASR with Federal Funding)	**No Action Alternative** (ASR without Federal Funding)
Esthetics	Project facilities would permanently affect local rural, agricultural landscape; construction would temporarily affect the area.	Same effects as for the Preferred Alternative.
Climate change	Carbon-based fuels would be expended during construction and operation of the system; storage of surface water underground would provide some protection from potential effects of climate change.	Same effects as for the Preferred Alternative.
Biological Resources	Construction on already-disturbed lands would cause some wildlife species to temporarily leave the affected area, but there would be little further fragmentation of habitat; should bald eagle nesting be discovered in the project area, all work in the vicinity would cease until after fledging; construction would be routed around wetlands where possible, with wetlands repaired or replaced where impacts are	Same effects as for the Preferred Alternative.

Table 2-2 Summary of Impacts – Preferred Action Alternative (25% Federal Funding) vs. No Action Alternative (No Federal Funding)		
	Preferred Alternative (ASR with Federal Funding)	**No Action Alternative** (ASR without Federal Funding)
Biological Resources (continued)	unavoidable. The project may affect, but is not likely to affect, three threatened or endangered species. There would be no impact on critical habitat.	
Socioeconomics	Federal funding would represent a positive impact on residents of the project area and would result in an overall, reduction in negative regional economic benefit of about $50 million.	Implementation of the project without Federal funding would represent a negative impact on residents of the project area and would result in about negative $75 million regional economic benefit.
Environmental Justice	Federal funding would help mitigate impacts of increased water bills to low income or minority households; resulting household water bills would be held near or below the EPA recommended payment threshold of 2.5% of total income.	Project implementation without Federal funding would result in water users having to pay for all construction and operating costs; water bills in low income or minority households would exceed the EPA recommended payment threshold of 2.5%.
Cultural Resources	Should any potential cultural sites be discovered, site protection and mitigation (including consultation with the SHPO) would be required before any disturbance is	Same effects as for the Preferred Alternative.

Table 2-2 Summary of Impacts – Preferred Action Alternative (25% Federal Funding) vs. No Action Alternative (No Federal Funding)		
	Preferred Alternative (ASR with Federal Funding)	**No Action Alternative** (ASR without Federal Funding)
Cultural Resources (continued)	allowed.	
Cumulative Impacts	Impacts of ASR—combined with those of the remainder of the ILWSP—would result in significant flow reductions at the confluence of the Little Arkansas with the Arkansas River; however, positive benefits to both surface and groundwater supplies as well as to poor and minority households would result; no further loss to wildlife habitat would be expected.	Impacts of ASR, and those of the remainder of the ILWSP, would result in significant flow reductions at the confluence of the Little Arkansas and the Arkansas; however, positive benefits to both surface and groundwater supplies would result; no further loss to wildlife habitat would be expected; and this alternative would result in negative economic impacts to low income or minority households.
Unavoidable Environmental Impacts	About 1,700 acres of land would be temporarily disturbed; about 266 acres would be permanently disturbed, including about 65 acres of prime farmland; localized soil erosion would occur during construction; sedimentation and turbidity in the Little Arkansas River could increase slightly during construction; air quality could decrease slightly during construction; noise levels could increase slightly during and after	About 1,700 acres of land would be temporarily disturbed; about 266 acres would be permanently disturbed, including about 65 acres of prime farmland; localized soil erosion would occur during construction; sedimentation and turbidity in the Little Arkansas River could increase slightly during construction; air quality could decrease slightly during construction; noise levels could increase slightly during and after

Table 2-2 Summary of Impacts – Preferred Action Alternative (25% Federal Funding) vs. No Action Alternative (No Federal Funding)

	Preferred Alternative (ASR with Federal Funding)	**No Action Alternative** (ASR without Federal Funding)
Unavoidable Environmental Impacts (continued)	construction; vehicular access to local residences could temporarily be disrupted; some esthetic impacts would occur; some economic impacts to low income and minority households would occur.	construction; vehicular access to local residences could temporarily be disrupted; some esthetic impacts would occur; significant economic impacts to low income and minority households would occur.
Irreversible and Irretrievable Commitment of Resources	Construction would result in an irreversible Federal funding commitment; energy, labor and materials expended would not be available for other uses; Federal funding would be discontinued on completion of the project, resulting in assumption of all O&M costs by the City.	The City would be responsible for the commitment of all resources for construction and operation of ASR; energy, labor and materials expended would be paid for by local consumers and not be available for other uses.
Short and Long Term Impacts	Construction would cause short-term impacts to land, water and other resources; system operation would cause long-term impacts; insertion of Federal dollars would result in net positive effects on the local economy and help minimize economic impacts to low income and minority households.	Construction would cause short-term impacts to land, water and other resources; system operation would cause long-term impacts; both short and long-term financial hardship could result on low income and minority households.

Chapter 3: Affected Environment

Introduction

The geographic area impacted by the Preferred (Action) and No Action Alternatives would fall within three Kansas counties – Sedgwick, Harvey, and Reno. Impacts to Sedgwick and Harvey County would be primarily due to construction and economic impacts to water customers. Smaller impacts would result from changes to the Bentley Reserve and Equus Beds well fields, which are not part of ASR. Potential economic impacts could extend into Reno and Kingman counties, along with possible project-related changes in water use and storage in Cheney Reservoir.

The Equus Beds aquifer lies beneath parts of Sedgwick, Harvey, Butler, McPherson, Marion, and Rice counties. Potential impacts to counties other than Sedgwick and Harvey would be primarily economic or indirect in nature. Construction of the part of the project analyzed in this EIS would be limited to northern Sedgwick and southern Harvey counties.

Setting

The project area includes the City of Wichita and surrounding metropolitan and rural areas in south-central Kansas. The Little Arkansas and Arkansas rivers enter the City from the north and northwest, respectively, joining in downtown Wichita. Cheney Reservoir lies on the North Fork of the Ninnescah River, approximately 24 miles west of the City, while the main stem of the Ninnescah flows to within 15 miles of the City to the southwest. It empties into the Arkansas River approximately 30 miles south of Wichita.

Agriculture and urban development have replaced most of the historic, native mixed-grass prairie. Most local land is used for agriculture, including crop, hay, pasture, and livestock production. Wichita is the largest and most populous metropolitan area in Kansas, with an estimated population of 344,000 (U.S. Bureau of the Census 2003). The Lower Arkansas River basin covers 11,500 square miles in 20 counties and has the second largest population (641,000) of any of the 12 major river basins in Kansas (Kansas Water Office 2008a). That population is expected to swell to 813,000 by 2040.

Local reservoirs, rivers, streams, and nearby areas are used for recreation, including water skiing, hiking, nature watching and other outdoor activities.

Topography

The local topography varies from extremely flat along major rivers and in lowland areas to gently rolling in upland areas. Most of the project area drains to the Arkansas River and its tributaries, including the Little Arkansas, Ninnescah and North Fork of the Ninnescah. Surface elevations range from approximately 1,200 feet above mean sea level (msl) along the river to 1,600 feet above msl in uplands.

Climate

Kansas winters are generally cold, with the most extreme conditions generally occurring December through February. Spring and fall seasons are short and transitional, while summers are hot, humid, and last for approximately six months. The average annual temperature in Wichita is 68.1 degrees Fahrenheit, but both daily and seasonal temperature variations can be severe. Extreme lows and highs range from -10 degrees to 108 degrees Fahrenheit. Severe weather, including extended periods of drought, tornadoes and thunderstorms, are not unusual, especially during spring and summer. Wichita's average annual precipitation is 29.33 inches (Slater and Hall 1996).

Geology

Local physiographic[1] regions include the Flint Hills, High Plains, Arkansas River Lowlands and the Wellington-McPherson Lowlands.

Limestone and shale underlie the Flint Hills, which contain numerous bands of chert and flint deposited in shallow seas 245 to 286 million years ago (KGS 1999).

Streams carried eroded material from the Rocky Mountains to form the High Plains region during the period ranging from approximately 1.6 to 66 million years ago. A mass of eroded sand and rock underlying the plains is known as the Ogallala Formation (KGS 1999). The portion of the formation within the project area is composed primarily of unconsolidated material.

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[1] Landforms are classified according to both their geologic structure and history (physiography.) Different structures and histories result in readily observable, distinct forms

The Arkansas River and Wellington-McPherson lowlands are characteristically similar to the High Plains. They consist of relatively flat plains comprised of alluvial sand, silt, and gravel deposited by streams and rivers. The Arkansas River Lowland was formed approximately 10 million years ago. The Wellington-McPherson Lowland was recently formed, between 1 and 2 million years ago. The Wellington-McPherson alluvium overlies the Hutchinson salt bed, one of the largest salt beds in the world (KGS 1999). The Equus Beds Aquifer is contained within unconsolidated alluvial materials and provides water for Wichita and surrounding communities. It is comprised of saturated sand, silt and gravel deposited during the Pliocene and Pleistocene Ages.

Soils

The USDA, Natural Resources Conservation Service (NRCS 1999) defines soil as, "a natural body comprised of solids (minerals and organic matter), liquid, and gases that occurs on the land surface and occupies space." Soils are characterized by layers. Layers are distinguishable from each other as a result of additions, losses, transfers, and transformations of energy and matter, or the ability to support rooted plants. A soil association is a group of soils geographically associated in a characteristic repeating pattern, generally consisting of one or more major soils and at least one minor soil. Each soil association has unique soil type(s), relief, and drainage (Burns & McDonnell 2003).

Soil associations found in the project area are described below. No construction would be planned outside Sedgwick and Harvey counties.

Sedgwick County

Approximately 82% of Sedgwick County is considered prime farmland comprised of four different soil associations (SCS 1979). Bottomlands adjacent to the Little Arkansas River and North Fork of the Ninnescah River are deep, nearly level and well drained. They consist of the alluvial Elandco-Canadian-Elandco association with a sandy subsurface (Burns & McDonnell 2003). These soils are used primarily for growing cultivated crops.

Shallow to deep, nearly level, moderately-poorly to excessively well-drained soils along the Arkansas River are of the Lesho-Lincoln-Canadian association. They also have a sandy subsurface and are used primarily for crop cultivation.

The Naron-Farnum-Carwile association covers approximately 9% of the county and is also primarily used for plant cultivation. These alluvial soils consist of deep, nearly level, poorly to well-drained soils with a loamy subsurface.

The Goessel-Tabler-Farnum soil association is found south of the town of Sedgwick and covers approximately another 9% of the county. They are deep, nearly level, gently sloping and moderately to well-drained alluvial soils with a clay- to loam-like subsoil. They are also primarily used for crop cultivation.

Harvey County

There are five soil associations found within Harvey County (SCS 1974), where approximately 72% of the land area is described as prime farmland.

The Farnum-Slickspots-Naron association is found in the southwestern part of the county. It consists of deep, nearly level to gently sloping, poorly to well-drained loams and fine sandy loams. These soils are used primarily to grow wheat and sorghum.

About 6% of the county lies within the Little Arkansas River floodplain. It consists of a mixture of deep, nearly level, well-drained silt and silty clay loams known as the Detroit-Hobbs association. The floodplain is used primarily for cultivation of wheat and sorghum.

Deep, nearly level to gently sloping, moderately well- to well-drained silt and silty clay loams form the Crete-Ladysmith association are found west of the Little Arkansas River. This association is found primarily along broad ridges and side slopes. It supports small native grass communities bordering large, cultivated areas.

The Carwile-Pratt association consists of deep, nearly level, poorly-drained, fine sandy loams and deep, well-drained, loamy fine sands. These soils are found on uplands in the western portion of the county. They are used primarily for crop cultivation but also support small areas of native grasses.

The Farnum-Hobbs-Geary association contains deep, nearly level to gently sloping soils. They are well-drained loams and silty loams found on both uplands and floodplains. The association is found primarily along streams in the eastern parts of the county. These soils are also primarily used for crop cultivation.

Reno County

Approximately 67% of the land in Reno County is classified as prime farmland. Most of Cheney Reservoir also lies in this county. Two soil associations are found along the reservoir – the Farnum-Shellabarger and Renfrow-Vernon associations (SCS 1966).

The Farnum-Shellabarger association consists of deep, brown, loamy soils which often overlie sandy/gravelly material on sloping, dissected plains. This association occupies a large area along the southern county boundary and is used primarily for crop cultivation.

Renfrow-Vernon soils consist of both deep and shallow, reddish soils over clayey white shale. The association is found primarily in the southeastern part of the county and consists of about 85% Renfrow -Vernon and 15% minor soils. The primary use is crop cultivation.

Kingman County

A small part of Cheney Reservoir lies in the northeastern corner of Kingman County, within the Shellabarger-Milan-Renfrow association. These gently sloping soils are used primarily for crop cultivation, but some small patches of native grasses remain. There are seven major soil types found in the remainder of the county, intermingled with a wide variety of minor soil types.

Farnum-Shellabarger soils are deep, nearly level to sloping, well drained soils on uplands with loamy subsoil. Nearly all of them are used for crop cultivation.

Albion-Shellabarger soils are deep, nearly level to strongly sloping, upland soils. They have a loamy subsoil. Approximately half of this acreage is used for growing crops, while the remainder is used as rangeland.

Blanket-Clark-Farnum soils are also upland soils that vary in slope and are deep and well-drained, with clayey and loamy subsoil. Like most of the soils in the project vicinity, most of this acreage is used for crop cultivation.

Pratt-Carwile soils are somewhat poorly drained, are found in uplands and have a sandy, loamy and clayey subsoil. Wheat is the main crop grown on these soils, but sorghum and alfalfa are also produced. Large areas in the southern part of the county are used as rangeland.

Quinlan-Nashville soils range from shallow to moderately deep and are found in gently to strongly sloping areas. They are well drained and lie above loamy subsoil. Crops are cultivated in approximately half of this area, and the remainder is used primarily as rangeland.

Renfrow-Owens soils are found on uplands and range from shallow to deep. They are well drained with predominantly clayey subsoil. Nearly all this acreage is used for crop cultivation.

Waldeck-Dillwyn-Plevna soils are deep, nearly level, somewhat poorly to poorly drained, with loamy and sandy subsoil. They are found in floodplains and along low terraces near streams. Most of these areas are used for rangeland, as they generally have poor potential for crop cultivation.

Land Use

Irrigation accounted for approximately 71% of all water pumped or diverted within the 11,500 square mile Lower Arkansas River basin during 1997 (KWO 2008). About 92% of that water came from groundwater sources, including the Equus Beds. The combined land area of Sedgwick, Harvey and Reno counties, where project construction and other localized impacts would occur, covers approximately 1.8 million acres. About 1.28 million acres are used for crop cultivation. The primary crops are wheat and corn, but sorghum and alfalfa are also common. Approximately 375,000 acres are used for pasture and livestock production. Important industries in the metropolitan and project areas include crude oil production, petroleum refining, military and private aircraft manufacturing, chemical manufacturing, milling, and grain storage.

The corner of Kingman County next to the project area includes part of Cheney Reservoir and associated Federal property. Cheney Reservoir covers approximately 9,600 surface acres and has about 67 miles of shoreline. Cheney State Park covers approximately 1,913 acres. Another 5,439 acres of land and 4,109 acres of water make up the Cheney Wildlife Management Area.

The Equus Beds Well Field occupies about 200 acres in northern Sedgwick and southern Harvey counties. Most of this area is made up of croplands, warm season pasture, and riparian woodlands. The Local Well Field consists of bank water reclamation wells and distribution lines alongside both the Little Arkansas and Arkansas rivers. The field lies entirely inside the Wichita city limits.

Surface Water Resources

Principal streams in the project area include the Arkansas, Little Arkansas, Ninnescah, and the North Fork of the Ninnescah. Both the Little Arkansas and Ninnescah rivers are tributaries of the Arkansas River, which originates on the eastern slopes of the Rocky Mountains in central Colorado. The Arkansas is impacted by extensive irrigation diversions on its way to Wichita. It often runs dry upstream near Great Bend, Kansas. Minimum recommended stream flows established for the Arkansas River at Kinsley and Great Bend, Kansas are only 2 and 3 cfs, respectively

(DWR 1-100.17, revised 11/29/94.) The river flows over a predominantly sandy bottom and has a drainage basin covering parts of Colorado, New Mexico, Kansas, Oklahoma, Texas, and Arkansas.

The Little Arkansas River flows through five Kansas counties over a generally clayey bottom. Sand replaces much of the clay before its confluence with the Arkansas in Wichita. There are no large reservoirs on the Little Arkansas, but flows are heavily influenced by irrigation diversions and groundwater withdrawals. Some floodwaters are diverted into the Little Arkansas and Chisholm Creek floodways near Valley Center and Wichita. These flows are discharged to the Arkansas River downstream from the Arkansas/Little Arkansas confluence.

The North Fork of the Ninnescah River flows over a predominantly sandy bottom through five Kansas counties. It joins with the Ninnescah River in Sedgwick County south of Wichita. The North Fork was dammed by Reclamation in 1964 approximately 15 miles upstream from its confluence with the Ninnescah to form Cheney Reservoir. The reservoir is used for water supply by the City and for fish and wildlife conservation, flood control, and recreation. Reclamation computed a "preliminary" firm yield of 52,600 acre feet per year for the reservoir in 1959. That figure was revised in 1960 to 42,900 acre feet. During a year with average precipitation and with the ILWSP in place, the City could operate the reservoir by withdrawing a maximum of 47 MGD (52,600 acre feet per year.) However, if this amount were pumped during a critical period, the reservoir would theoretically run out of water.

Surface Water Quantity

U.S. Geological Survey (USGS) stream flow records from 1922-1966 were used to create a Cheney Reservoir operations model. Stream discharges to the reservoir within the project area come primarily from direct runoff due to precipitation. This results in a highly variable discharge rate, which can change dramatically from day to day, season to season, and year to year. Low flow statistics provide a good indication of *base flow* conditions (groundwater discharge to the stream.) Overall minimum, mean, maximum, 7-day average low flow, and 2, 10, and 100 year flood flow data are provided in Table 3-1.

Table 3-1 Discharges of the Arkansas, Little Arkansas and North Fork of the Ninnecah

Statistic		Mean Daily Discharge (cfs)		
		Arkansas River @ Wichita	Little Arkansas River @ Valley Center	North Fork Ninnescah @ Cheney Dam
Overall Minimum		5	1	0
Overall Maximum		41,100	28,600	47,900
Mean (Average)		986	305	159
Percent of Time Discharge (cfs) Equaled or Exceeded	90%	101	20[b]	19
	50%	402	58	79
	10%	2,030	456	257
Floods	2-year	10,600	6,830	3,920
	10-year	27,500	19,900	20,700
	100-year	48,600	37,200	84,900
7-Day Average Low Flows	2-year	92.2	18.9	10.3
	10-year	29.4	8.6	5.4
	100-year	10.3	2.5	0.7

[a] Statistics based on estimated mean daily discharges, as derived from stream flow records for water years 1923-1996. Flood discharges estimated from analysis of recorded annual instantaneous peak discharges.

[b] Recommended minimum stream flow established in accordance with K.S.A. 82a-703, DWR-1-100.7 (revised 11/29/94).

Use of surface water for M&I supply increased 24% between 1990 and 2000 in both northeastern and south-central Kansas. Part of this increase was due to the City's decreasing dependence on the Equus Beds aquifer and increasing dependence on surface water from Cheney Reservoir. As a result, groundwater use from the Equus Beds decreased by 21%. Other municipal water supplies in the Lower Arkansas River Basin continued to come primarily from groundwater sources. Only the Kansas-Lower Republican, Solomon, and Upper Arkansas River Basins used significant amounts of surface water for irrigation (Kenny and Hansen 2004). The state reserves 37 cfs between Halstead and Sedgwick in the Little Arkansas River during spring (high irrigation) months for use by farmers.

Minimum desirable stream flows (MDS) are established by the Kansas Department of Health and Environment (KDHE) for various locations within the Arkansas River basin. These recommendations are listed in Table 3-2. Median monthly flows for the Little Arkansas and Arkansas rivers are found in Table 3-3.[2] Flows in the Arkansas River in Wichita are, on average, roughly three times those in the Little Arkansas, which in turn has about two times the flow of the North Fork of the Ninnescah River.

Table 3-2 Minimum Desirable Stream Flows (cfs) – Little Arkansas River

	Alta Mills	Halstead	Sedgwick	Valley Center
April – September	5[a]	57[b]	20[b]	20[b]
October – March	5[a]	20[b]	20[b]	20[b]

[a] Recommended minimum desirable stream flows (MDS) established in accordance with K.S.A. 82a-703, DWR-1-100.7 (revised 11/29/94)
[b] As required in permit to appropriate water, City of Wichita, File No. 46,578, issued by the Kansas Department of Agriculture, Division of Water Resources, Feb. 23, 2007
[c] The Kansas Department of Wildlife and Parks prefers higher flows during spawning seasons, which typically run from April through June, though specific numeric criteria have not been established (pers. comm., Eric Johnson, KDWP, 5/19/2008)

[2] The median flow in a series of measured flows is the flow measurement where 1/2 the flows are greater and 1/2 the flows are less. This differs from the average flow, which is calculated by dividing the sum of the measurements by the number of measurements

Table 3-3 Median Monthly Flows (cfs)[a]					
Month	Little Arkansas River		Arkansas River		
	Alta Mills	Valley Center	Hutchinson	Wichita	Arkansas City
January	23.3	53.8	124.9	249.9	571.1
February	26.0	61.1	169.4	327.1	645.5
March	31.0	70.4	207.2	387.7	801.0
April	35.0	76.4	216.8	459.7	947.1
May	45.5	107.6	273.5	573.4	1,198.2
June	57.0	129.4	405.1	825.1	1,515.8
July	31.5	75.6	248.4	504.5	959.6
August	22.7	54.7	166.5	321.6	659.7
September	21.6	53.5	150.0	293.2	555.5
October	18.7	49.6	117.6	226.9	520.6
November	26.0	58.8	149.6	306.0	634.2
December	24.5	58.4	142.3	287.8	595.8

[a] Statistics based on flows derived from USGS streamflow records for water years 1923-1996

Surface Water Quality

KDHE includes 2 of the 14 segments of the Little Arkansas River on its list of stream segments with water quality limitations. The project construction area falls inside one of these water quality limited segments. Constituents of concern in the project area include dissolved oxygen, chloride, fluoride, sulfate, total ammonia, chlordane and fecal coliform bacteria (KDHE 2001). River water quality can vary significantly with time and location. A summary of USGS water quality data in, above, and below the project area is found in Table 3-4.

Table 3-4 USGS Surface Water Quality Data Ranges (January 1998 – April 2008)				
Stations →	**Little Arkansas River**		**Arkansas River**	
Parameters ↓	07144100 Sedgwick (*project*)	07144200 Valley Center (*downstream*)	07143330 Hutchinson (*upstream*)	07144550 Derby (*downstream*)
Conductance (μmhos/cm^3)	54 – 1480	159 – 1,440	515 – 3751	152 – 4,430
Dissolved Oxygen (mg/l)	3.6 – 15.7 (43 – 127%)[a]	7.5 – 13.9 (89 – 151%)[a]	7.3 – 8.3	8.6 – 13.0 (97 – 118%)[a]
pH (std. units)	6.0 – 8.7	7.0 – 8.5	7.3 – 8.3	7.1 – 8.8
Hardness (mg/l)	16 – 380	130 – 320	*	270[b]
Calcium (mg/l)	4.7-160	38.6 – 101	*	73.9[b]
Magnesium (mg/l)	1 – 23	7.5 – 16.5	*	20.5[b]
Sodium (mg/l)	5.7 – 126	28.0 – 80.4	*	178[b]
Potassium (mg/l)	4.6 – 9.8	5.5 – 7.5	*	7.6[b]
Chloride (mg/l)	<5 – 305	29 – 87	*	236[b, d]
Sulfate (mg/l)	<5 – 80	28 – 67	*	131[b]
E. coli (colonies)	4 – 46,000	13 – 2,600	*	508[b]
Suspended Solids (mg/l)	4 – 1970	9 – 48	*	*
Atrazine (μg/l)	0.07 – 41[c]	*	*	*

[a] ( ) = percent saturation
[b] Only once sample analyzed
[c] Numeric aquatic life criteria for Atrazine in surface water are 170 (acute) & 3 (chronic) μg/ml
[d] EPA recommended secondary drinking water standard for chlorides is 250 mg/l
* Data not collected at this site

The discovery of pharmaceutical and antibiotic contaminants in surface and groundwater around the country has recently attracted scientific and public attention. The cities of McPherson and Newton discharge wastewater into the Little Arkansas River upstream from the proposed project site. Such discharges could potentially result in contamination. The USGS analyzed one water sample from the Little Arkansas River for a broad range of pharmaceuticals in 2003. A low level of caffeine was the only contaminant detected. Other pharmaceutical contaminants, if any, were present at non-detectable levels. Three samples (each) were collected from two Little Arkansas River sites (Sedgwick and Halstead) during 2008 and analyzed for a broad spectrum of antibiotics. None were detected. In addition, no antibiotics were discovered in samples collected from 10 Equus Beds index wells during 2008 (personal communication, A. Ziegler to C. Webster 9/24/08).

Salinity levels are periodically elevated in the Arkansas River. Otherwise, water in the main stem of the Arkansas tends to be moderately hard and acceptable for treatment. Chloride concentrations (representing salinity) can range up to 1,700 mg/l. EPA secondary drinking water standards recommend limiting chloride concentrations to 250 mg/l. Several natural and man-made salinity sources contribute to elevated chloride levels in the Arkansas River basin. These include historic oil field operations, salt mine operations, and naturally occurring buried salts.

Chloride concentrations in the Little Arkansas and North Fork of the Ninnescah rivers are much lower. These higher quality waters discharge to the salty Arkansas River and improve overall surface water quality.

Figure 3-1 ***Cyanobacteria bloom in Cheney Reservoir, 2003 (USGS Photo)***

Cyanobacteria contamination occasionally causes severe taste-and-odor episodes in Cheney Reservoir. The genus *Anabaena*, is the likely cause (USGS 2008c). Odor and taste problems occur when the bacteria produce the compound geosmin. The USGS monitors environmental variables, such as light, temperature, conductivity, and turbidity to predict cyanobacteria blooms. The City plans to use this data to aid in the management of the reservoir.

Atrazine (herbicide) is applied to local crops during the spring and fall to kill weeds. These applications typically coincide with intense rainfall. Atrazine concentrations in the Little Arkansas often exceed the Kansas chronic aquatic life criterion (3 mg/l) between March and July (Table 3-4). Runoff to the Little Arkansas that is used for Equus Beds recharge may have to be treated to remove atrazine during these months.

Groundwater Resources

The *Kansas Water Plan* (KWO 2008) lists "protecting and enhancing instream flows and stabilizing ground water depletion" as priority issues in the Little Arkansas River Basin. Groundwater is an important source of municipal, industrial, irrigation, domestic, and livestock water. The major water bearing formations in the project area include the Wellington Formation, Ninnescah Shale, Ogallala Formation, Lower Pleistocene Deposits, Illinoisan Terrace Deposits, Wisconsinan Terrace Deposits and Recent Alluvium, and the Equus Beds. The Equus Beds aquifer comprises the eastern-most part of the High Plains Aquifer in Kansas. The name (Equus) refers to a depositional area famous for its profusion of pre-historic American horse (equine) fossils. The formation underlies approximately 900,000 acres of land in Sedgwick, Harvey, Marion, McPherson, Rice, and Reno counties. It is comprised of sections of the Ogallala Formation, Lower Pleistocene deposits, Illinoisan, and Wisconsinan terrace deposits.

Groundwater Levels

There was little groundwater use in the project area before 1940. The Equus Beds were accessible from shallow, hand-dug wells. The City started developing the aquifer as a water source during the 1940s. Large agricultural tracts were then converted from dry farming to irrigated farmland. Annual water use increased until withdrawals from the aquifer exceeded natural recharge most years. Despite the fact that there tend to be fewer withdrawals and more recharges during wet years, overall declines in groundwater levels since 1940 have exceeded 50 feet in some areas. Figure 3-1 shows water level changes in the Equus Beds recorded between August 1940 and January 2008.

As groundwater levels fell, infiltration of salty (high-chloride) water from the Arkansas River increased. Contributions of high quality groundwater to the Little Arkansas River decreased at about the same rate. Arkansas River water infiltrated into the aquifer at a rate of less than eight cubic feet per minute (cfm) before 1940. The Equus Beds and Little Arkansas River were nearly in equilibrium or at nearly the same elevation (zero-storage deficit) at that time (Myers *et al.* 1996.) The Little Arkansas River benefited from about 38 cfs recharge from the aquifer during this period of equilibrium.

The current storage deficit in the aquifer is estimated at 200,000 acre-feet. This results in about 26 cfs infiltration (an increase of 18 cfs or 225%) to the aquifer from the Arkansas River, while groundwater recharge to the Little Arkansas River has declined to about 14 cfs (a decrease of approximately 24 cfs or 63%.)

Groundwater Quality

Groundwater quality varies considerably, depending on which geologic formation the water comes from. Water also tends to become more mineralized with depth (Burns & McDonnell 2003). Total dissolved solids (TDS) contents range from about 300 mg/l to 2,700 mg/l in the aquifer. TDS levels below 500 mg/l are usually considered suitable for domestic use, while levels above 1,000 mg/l generally give water an objectionable taste or odor. Although some salt contamination is naturally occurring, fresh water withdrawals may be altering the flow patterns of natural salt. Groundwater development north of the Arkansas River has lowered the water table. Meanwhile, saline water intruding from the river and other sources maintains its natural head. This leads to the potential for saltwater intrusion into the aquifer (Young *et al.* 2001.)

The only physical properties with regulatory criteria are TDS, pH and laboratory turbidity. During a baseline groundwater quality study of the Equus Beds from 1995-98 (Ziegler 1999), pH ranged from 4.4 to 8.6 standard units. Values below 7.0 are considered acidic, while pH values above 7.0 are considered basic. Some sample values fell outside EPA's (2004) Secondary Drinking Water Standard of 6.5 (slightly acidic) to 8.5 (slightly basic.)

Increasing salinity is one of the prime water quality issues in the heavily used aquifer. Chlorides from natural and man-made sources have degraded water quality in some areas. The saltier the water, the more difficult and expensive it is to treat to drinking water standards. Naturally occurring salt sources include a variety of deeper geologic formations. Man-made sources include brines from oil fields (primarily the Burrton Oil Field to the northwest) and salt-refining operations (primarily near Hutchinson to the west.) The highest groundwater chloride concentrations occur near the city of Burrton in Harvey County, but the plume in this vicinity is migrating southeast, down the groundwater gradient. Continued expansion of the plume would move saltier water into the project area. Groundwater chloride levels are also generally higher near the Arkansas River, where salty river water migrates into the aquifer.

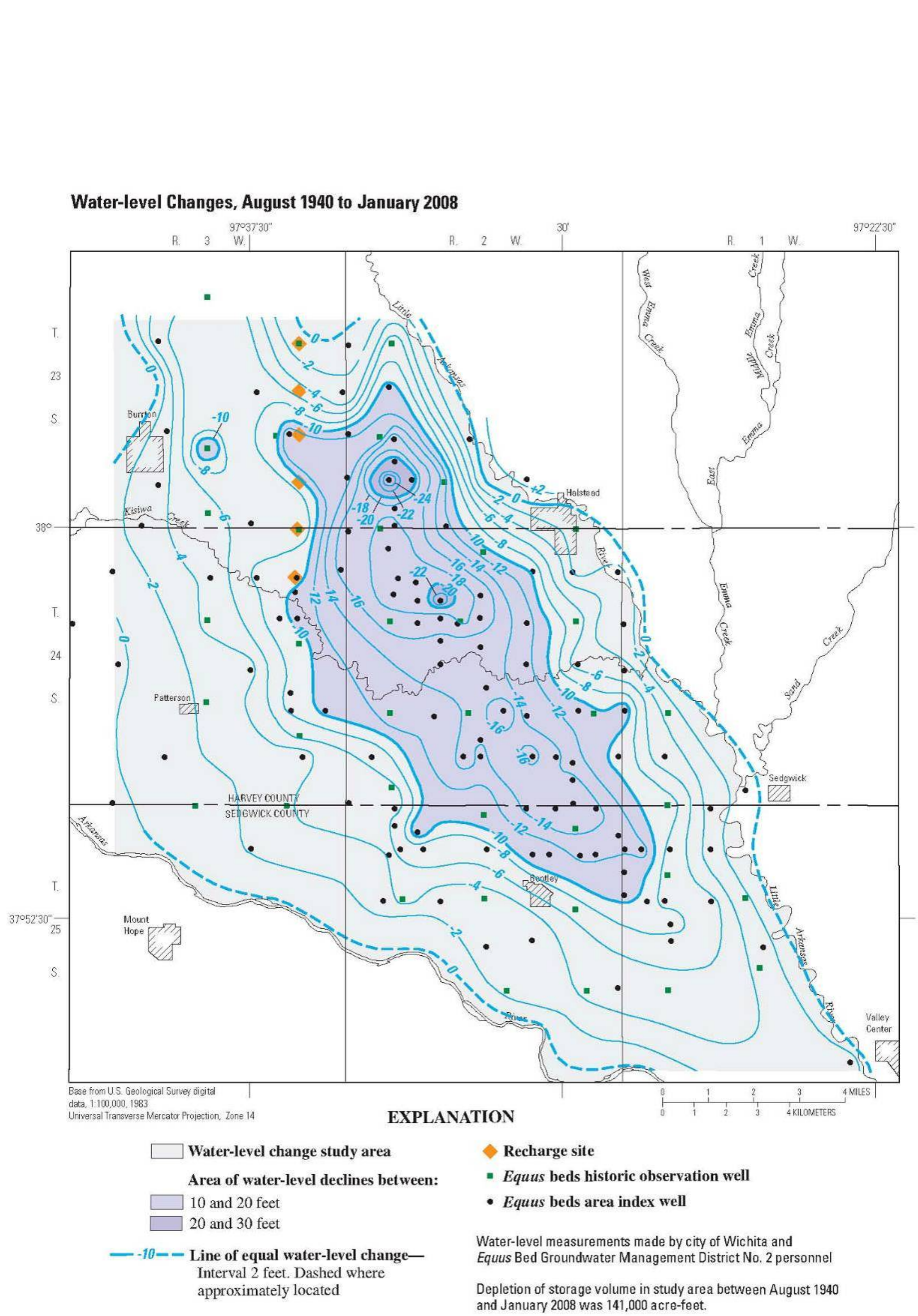

Figure 3-2 Equus Beds Water Storage (Figure courtesy of USGS)

Groundwater Rights

Area groundwater rights are significantly over-allocated. Before 1991, estimated safe groundwater yield from the Equus Beds was 50,240 acre-feet per year, based on recharge estimates of six inches per year. The City's water rights for the Equus Beds Well Field allow the use of 78 MGD (40,000 acre-feet per year.) The USGS subsequently reduced estimated recharge rates by nearly 47% (Hansen 1991) to 3.2 inches per year. The more recent estimate supports an actual annual safe yield of 29,900 acre-feet. Overall, the City has water rights for approximately 99,300 acre-feet per year from combined sources (Equus Beds Well Field, Local Well Field [pulling bank storage water from along the Little Arkansas and Arkansas rivers] and Cheney Reservoir.) These water rights should be sufficient for the City to meet water demand through 2016. However, over-allocation of water rights highlights threats to the aquifer that cannot be ignored.

Groundwater Management District No. 2 (GMD2) was created by the Kansas Legislature in 1974 to manage the aquifer's falling water table. This resulted in the closure of most areas in the City's well field to development of additional water rights. Despite GMD2 efforts to reverse water rights allocation trends, approximately 120,000 acre-feet per year of water rights had been allocated in the 175 square mile Equus Beds area by 2003.

Air Quality

Air pollution in the agricultural part of the project area consists primarily of dust from unpaved roads and farming activities. There are some emissions from agricultural vehicles and road traffic. Smoke from grassfires or stubble burning occasionally contributes, as does wind-blown dust, but these sources are temporary.

Urban air pollution comes from numerous sources, including motor vehicle traffic, industry, dry cleaners, paint shops, residential fireplaces, and print shops. Natural sources contribute as well (wildfires, wind blown dust, etc.) Prevailing southwest winds generally dilute urban air pollutants in the project area, helping to reduce emission concentrations. The Wichita/Sedgwick County metropolitan area has been designated as "In Attainment" for air toxins and criteria pollutants since 1989 (Wichita Environmental 2008).

Noise

Noise conditions vary from rural to suburban to urban areas. Background noise levels generally increase with increasing population density, activity, and development. The Equus Beds Well Field is located in rural Sedgwick and Harvey counties. The Bentley Reserve Field is located in rural Sedgwick County. The Local Well Field is located alongside the Little Arkansas River inside the Wichita City Limits. Cheney Reservoir is located in rural Reno and Kingman counties. Except for the Local Well Field, the project area lies primarily in rural areas where typical daytime and nighttime sound levels are 35 and 25 decibels (dB/A)[3], respectively (Burns & McDonnell 2003).

Esthetics

The landscape of south-central Kansas outside of the Wichita metropolitan area is composed primarily of nearly flat to rolling croplands and pastures along both uplands and lowlands. Lines or small groves of native trees k

Figure 3-3 Open landscape typical of rural south-central Kansas

[3] dB/A refers to the measurement of noise in "A-weighted" decibels." A-weighted measurements highlight frequencies from 3-6 kHz, to which the human ear is most sensitive

known as “hedge rows” or “wind breaks” are fairly common but disappearing. Many hedge rows have been removed to increase the acreage available for crop cultivation. Past climatic conditions and agricultural practices have resulted in riparian zones along streams and rivers that tend to be relatively narrow. This gives the region an open appearance. Much of the agricultural area is irrigated using center pivot systems and these systems, along with irrigation wells, scattered farm houses, barns, and related structures and equipment dot the landscape.

Biological Resources

Ecoregion

The proposed, extended project area of Harvey, Kingman, Marion, McPherson, Reno, Rice, and Sedgwick counties is located within two EPA Level III ecoregions; the Flint Hills and Central Great Plains (EPA 2008). The Great Bend Sand Prairie, Smoky Hills, and Wellington-McPherson Lowland are encompassed by the Central Great Plains Ecoregion. This ecoregion was once dominated by mixed-grass prairie with scattered low trees and shrubs, but has now been converted primarily to cropland and urban uses.

The Flint Hills is the largest intact tall-grass prairie remaining in the Great Plains. These hills mark the western edge of the tall-grass prairie, characterized by rolling hills composed of shale and cherty limestone, rocky soils, and by wet, humid summers. The rocky surface makes the area difficult to plow. As a result, much of the region remains open, preserving the grasslands while supporting very little cropland agriculture.

The Smoky Hills are an undulating to hilly loess plain with sandstone hills. The region is transitional, with a variable climate and natural vegetation ranging from tall-grass prairie in the east to mixed-grass prairie in the west. Land use consists primarily of cropland and grassland. Dry-land winter wheat is the principal crop.

The Great Bend Sand Prairie is characterized by undulating, rolling sand plains that include windblown dunes. This ecoregion supports native vegetation such as sand prairie bunchgrass. Center-pivot irrigation is more often used than in surrounding regions.

The Wellington-McPherson Lowland consists of flat, lowland topography, which separates it from the Great Bend Sand Prairie Ecoregion. Rich loess and river valley deposits support cropland agriculture comprised primarily of winter wheat and grain sorghum. The area is underlain by shale, gypsum, and salt from ancient Permian seas, and is known for the Hutchinson salt member and the alluvial Equus Beds Aquifer. The

McPherson wetlands, located in McPherson County, comprise a small part of this area.

Woody encroachment has occurred in these regions due to poor management and the absence of fire. Oak, cedar, and other woody species are now common where huge expanses of nearly treeless prairie once existed.

Wildlife

Grassland birds, mammals, reptiles and amphibians were common in the area before European settlement. The species composition of the area has varied slightly, but the increasing variety of habitat allows for a greater diversity of species since settlement and urbanization. Common species are described below.

Mammals

Many mammal species are present in Reno, Harvey, Kingman, and Sedgwick counties. All of these species may exist in the project area.

Small mammals include the following species:

- deer mouse (*Peromyscus maniculatus*)
- black-tailed jack rabbit (*Lepus californicus*)
- eastern cottontail rabbit (*Sylvilagus floridanus*)
- blacktail prairie dog (*Cynomys ludovicianus*)
- thirteen-lined ground squirrel (*Spermophilus tridecemlineatus*)
- eastern fox squirrel (*Sciurus niger*)
- marmot (*Marmota monax*)
- muskrat (*Ondatra zibethica*)
- mink (*Mustela vison*).

Larger mammals, often described as predatory, carnivorous, or omnivorous also reside in the area, including the following species:

- badger (*Taxidea taxus*)
- striped skunk (*Mephitis mephitis*)
- red fox (*Vulpes vulpes*)
- coyote (*Canis latrans*)
- raccoon (*Procyon lotor*)
- opossum (*Didelphis virginiana*).
- beaver (*Castor canadensis*).

Bat species found in the area include the little brown bat (*Myotis lucifigus*), big brown bat (*Eptesicus fuscus*), and red bat (*Lasiurus borealis*).

The two hoofed species in the area are the white-tailed deer (*Odocoileus virgininanus*) and mule deer (*O. hermionus*). The once wide-roaming, American bison (*Bison bison*) has nearly been eliminated from the project area. It now exists in the wild only in the Maxwell State Game Preserve in McPherson County.

Birds

Kansas lies along the central flyway, a migratory route for many species of birds. The state is also home to several resident species. Species listed below have been known to, or could occur in the project area.

Shore birds and other waterfowl that exist in or migrate through include the:

- great blue heron (*Ardea herodias*)
- snowy egret (*Egretta thula*)
- cattle egret (*Bubulcus ibis*)
- killdeer (*Charadrius vociferous*)
- red-winged blackbird (*Agelaius phoeniceus*)
- mallard (*Anas platyrhynchos*)
- northern shoveler (*Anas clypeata*)
- blue-winged teal (*Anas discors*).

Many birds subsist in grassland habitats, and some also do well in grassland-forest land edge habitats. These include the following species:

- American goldfinch (*Carduelis tristis*)
- American kestrel (*Falco sparverius*)
- northern harrier (*Circus cyaneus*)
- bobwhite quail (*Colinus virginianus*)
- eastern bluebird (*Sialia sialis*)
- dickcissel (*Spiza americana*)
- red-tailed hawk (*Buteo jamaicensis*)
- mourning dove (*Zenaida macroura*)
- eastern kingbird (*Tyrannus tyrannus*)
- northern cardinal (*Cardinalis cardinalis*)
- American robin (*Turdus migratorius*)
- eastern and western meadowlarks (*Sturnella magna* and *S. neglecta*)
- field sparrow (*Spizella pusilla*)
- ring-necked pheasant (*Phasianus colchicus*)
- lark bunting (*Calamospiza melanocorys*)
- horned lark (*Eremophila alpestris*)
- greater prairie-chicken (*Tympanuchus cupido*).

Birds common in forests include a variety of owls, hawks, and thrushes that often hunt in nearby grasslands. The following species are also found:

- red-headed woodpecker (*Melanerpes erythrocephalus*)
- common flicker (*Colaptes auratus*)
- downy woodpecker (*Picoides pubescens*)
- red-eyed vireo (*Vireo olivaceus*)
- wild turkey (*Meleagris gallopavo*).

Reptiles and Amphibians

Several reptile species occur in or near the project area. These include:

- prairie racerunner (*Cnemidophorus sexlineatus*)
- garter snake (*Thamnophis sirtalis*)
- plains garter snake (*Thamnophis radis*)
- brown snake (*Storeria dekayi*)
- prairie kingsnake (*Lampropeltis calligaster*)
- milk snake (*Lampropeltis triangulum*)
- bull snake (*Pituophis melanoleucus*)
- ringneck snake (*Diadophus punctatus*)
- eastern yellowbelly racer (*Coluber constrictor*)
- northern water snake (*Nerodia sipedon*)
- prairie rattlesnake (*Crotalus viridis*)
- great plains skink (*Eumeces obsoletus*)
- snapping turtle (*Chelydra serpentine*)
- ornate box turtle (*Terrapene ornata*)
- western painted turtle (*Chrysemys picta*)
- spiny softshell turtle (*Apalone spinifera*)
- smooth softshell turtle (*Apalone mutica*).

Amphibians common in the area include:

- tiger salamander (*Ambystoma tigrinum*)
- Woodhouse's toad (*Bufo woodhousei*)
- great plains toad (*Bufo cognatus*)
- plains leopard frog (*Rana blairi*)
- western chorus frog (*Pseudacris triseriata*)
- Blanchard's cricket frog (*Acris crepitans*)
- bullfrog (*Rana catesbeiana*).

Fish

An aquatic monitoring study was conducted as part of the Equus Beds Groundwater Recharge Demonstration Project, conducted from 1995 through 1997. This study established baseline fisheries data on the Arkansas and Little Arkansas rivers. Data was used to estimate biomass and abundance for fish species, and measure and record the habitat and food available to fish species.

Study results showed that aquatic communities in each river system are typical of sandy bottom streams in Kansas. The macroinvertebrate community is composed of various taxa suited for warm-water streams that have turbid water and shifting sand substrates. Most of the fish are forage species, such as:

- red shiners (*Cyprinella lutrensis*)
- sand shiners (*Notropis ludibundus*).

Game species, such as:

- channel catfish (*Ictalurus punctatus*)
- flathead catfish (*Pylodictis olivaris*)
- green sunfish (*Lepomis cyanellus*).

And introduced, rough fish species such as the common carp (*Cyprinus carpio*).

Other common species include:

- river carpsucker (*Carpoides carpio*)
- bluntnose minnow (*Pimephales notatus*)
- suckermouth minnow (*Phenacobius mirabilis*)
- mosquito fish (*Gambusia affinis*).

Fish species more common to the Little Arkansas River are:

- orange-spotted sunfish (*Lepomis humilis*)
- largemouth bass (*Micropterus salmoides*)
- white crappie (*Pomoxis annularis*)
- freshwater drum (*Aplodinotus grunniens*)
- slenderhead darter (*Percina phoxocephala*).

Fish collected less frequently on the Arkansas River system include:

- black buffalo (*Ictiobus niger*)
- emerald shiner (*Notropis atherinoides*)
- yellow bullhead (*Ameiurus natalis*)
- freckled madtom (*Noturus nocturnus*)
- speckled chub (*Extrarius aestivalis*)
- black bullhead (*Ameiurus melas*).

These lists are not all-inclusive and do not represent species missed during sampling.

Threatened, Endangered, or Candidate Species

Four Federally listed threatened or endangered species are identified by the U.S. Fish and Wildlife Service (FWS) for Reno, Kingman, Harvey, Rice, Marion, McPherson, and Sedgwick counties. Three of these occur or have occurred in the project area. These species are also considered threatened or endangered by the State of Kansas, as are 12 additional species. Each occurs or occurred in the past in the project area. Because of their declining populations, any impacts or potential impacts to these species are of concern.

State-Listed

The following species are identified by the Kansas Department of Wildlife and Parks (KDWP) as either threatened or endangered.

American burying beetle (*Nicrophorus americanus*) The American burying beetle is a large beetle listed by both the KDWP and FWS as endangered. However, it is not Federally-listed in any of the project counties.

This species exhibits wide habitat tolerance, though its natural habitat may be mature forests. Soil characteristics are important to the habitat suitability for American burying beetles, because they bury carrion. Extremely xeric[4], saturated, or loose and sandy soils are unsuitable for this practice.

Adults seek out and bury the carcasses of small animals such as mice and young birds. They then move them to suitable substrate, shave them, roll them into a ball, treat them with secretions, and bury them. The American burying beetles lay eggs next to these carcasses so that larvae may feed on the carcass. Adult American burying beetles may also catch and kill other insects.

Populations of American burying beetles are active from April through September. Adults are nocturnal, laying eggs most commonly in June and July. Larvae emerge in July and August (NatureServe 2007).

Arkansas River speckled chub (*Macrhybopsis tetranema*) The Arkansas River speckled chub is a minnow-like fish listed by the KDWP as endangered in the Arkansas River drainage. Critical habitat in the project area includes all of the Arkansas River in Kingman, Reno, Rice, and Sedgwick counties.

[4] Xeric refers to soils typical of dry or desert-like conditions, while saturated refers to soils that are soaked with moisture

This species inhabits the shallow channels of large, permanent flowing, sandy streams of the lower Arkansas River watershed. Its preferred habitat is a substrate of clean, fine sand. It avoids areas of calm water and silted stream bottoms. The breeding season runs from May to August when water temperatures exceed 70 degrees Fahrenheit. The diet of the Arkansas River speckled chub is not known, but probably consists of larval insects.

Bald eagle (*Haliaeetus leucocephalus*) The bald eagle occurs throughout North America and is listed as threatened by the KDWP. Bald eagle populations in the US, except the population in the Sonoran Desert of Arizona, have recovered and are no longer Federally-listed. Eagles remain protected under the Bald Eagle Protection Act (1940) and Migratory Bird Treaty Act (1918).

Habitat requirements are related to the bald eagle's food staple – fish. Bald eagles tend to nest close to large bodies of water including lakes, rivers, reservoirs, and oceans. Nesting typically occurs in large trees or along rocky cliffs. Bald eagles often return to the same nesting area year after year, and will often re-use the same nest. Roosting areas are usually located near water but may be located elsewhere.

Bald eagles migrate during winter in search of food sources.

Black-footed ferret (*Mustela nigripes*) The black-footed ferret is listed by both the FWS and Kansas as endangered. It is not designated as Federally-endangered in any of the project counties. This ferret is a small, weasel-like mammal, brownish colored above and whitish or yellowish below, with a dark mask around the eyes. Black-footed ferrets breed in March and early April and approximately three young are born in April, May, or June.

Black-footed ferrets are very secretive and rarely observed, except at night. They closely associate with prairie dogs and often use abandoned dens. Their range is limited to open habitat, including grasslands, steppe, and shrub steppe. They are carnivorous, feeding mostly on prairie dogs, but occasionally on ground squirrels, cottontail rabbits, and deer mice.

Captive breeding has helped in the restoration of this dwindling species, though the lack of suitable habitat and prey makes recovery difficult (NatureServe 2007.)

Eastern spotted skunk (*Spilogale putorius*) The eastern spotted skunk is a small mammal listed by KDWP as threatened. Critical habitat is found within Sedgwick County, but is in the Cowskin Creek and Big Slough drainage basins, outside of the project area.

This species prefers riparian habitat and uses fence rows, out buildings, hollow logs, and rock and brush piles as den sites. The eastern spotted skunk breeds in March and April, giving birth to a litter of 2 to 9 young in May or June. This species eats a variety of foods, including berries, carrion, seeds, fruits, birds, bird eggs, and mice. It is almost entirely nocturnal.

Eskimo curlew (*Numenius borealis*) The Eskimo curlew is a shorebird believed to be extinct. It remains on the KDWP endangered list, though the last confirmed sighting in Kansas occurred in 1902. It was once listed as endangered by the FWS, but due to the high likelihood of extinction, is no longer listed.

Flathead chub (*Platygobio gracilis*) The flathead chub is a small fish that only reaches 9 inches in length. It has a broad, wedge-shaped head, large mouth, and one small barbel on each side of the mouth. It is light greenish or brown in color on the dorsal side and plain silvery on the sides. This species once occurred in the main stems of the Missouri, Lower Kansas, Republican, Arkansas, and Cimarron rivers. The only recently documented populations in Kansas were found in the extreme upper reaches of the Arkansas River and in the South Fork of the Nemaha River. The flathead chub is still known to occur in out-of-state reaches of the Arkansas and Cimarron rivers, so it may still occur in Kansas during high flow periods. The species occurs from the Rio Grande to the Arctic Circle in small creeks and large rivers that have turbid, fluctuating water levels and unstable sand bottoms. This fish relies on summer floods to successfully spawn.

Flathead chubs feed on a wide variety of food, including aquatic insect larvae, terrestrial insects, berries, seeds, and other small fish.

The primary reason for the decline of flathead chubs is the impoundment of their habitat. Building dams and reservoirs has fragmented their habitat and made it unsuitable for their needs (Rahel and Thel 2004). KDWP lists it as threatened.

Flutedshell mussel (*Lasmigona costata*) The flutedshell mussel is listed by the KDWP as threatened. It is a tan to black, freshwater mussel with indistinct broad green rays. This species is an obligate riverine species that prefers clear water riffles with moderate current, and substrate of medium to small sized gravel. They historically occurred in eastern Kansas (KDWP 2004).

Longnose snake (*Rhinocheilus lecontei*) Longnose snakes are medium-sized snakes, reaching a length of 34 inches in Kansas. They are harmless and easy to recognize. Their upper bodies are yellowish-cream with 18-35 black blotches separated by pink or reddish interspaces. They have round pupils and a long pointed snout.

This species prefers open prairies, sandy regions and rocky areas in rugged canyons. It is a constrictor that feeds on lizards, insects, small mammals, and smaller snakes. Females lay one clutch of 4 to 9 eggs during June, which hatch in August or September (Collins and Collins 2008). The species is listed by KDWP as threatened due to habitat encroachment.

Peregrine falcon (*Falco peregrinus*) The peregrine falcon is listed by KDWP as threatened. It is a bird of prey with pointed wings, a narrow tail, and a quick wing-beat. Adults have slate-blue colored backs, bars and spots below, and a heavy black face pattern that appears as dark sideburns.

Peregrine falcons are uncommon transients and occasional winter residents in Kansas. They are native to both North and South America, living in many different habitat types. They often nest in cliffs, trees, or tall buildings and prey on other birds, small mammals, lizards, fishes, and insects. They nest in May or June and raise a clutch of 3 to 4 young.

Piping plover (*Charadrius melodus*) The piping plover is a shorebird listed by KDWP as threatened. It is also a Federally-listed threatened species in some areas, but not listed for any of the project counties. The Great Lakes population of piping plover maintains a far-reaching breeding area in the central portions of Canada and the United States. It exists as far north as Manitoba and Alberta. Piping plovers winter along the Gulf coast and adjacent barrier islands but may rarely be found on sandbars and barren flats within the project area during spring and fall migrations. They feed on invertebrates such as worms, insects, crustaceans, mollusks, beetles, and grasshoppers (USFWS 2008a).

Snowy plover (*Charadrius alexandrinus*) The snowy plover is listed by KDWP as threatened. It can be found along sparsely vegetated salt flats, sandbars, and beaches during spring and fall migrations. This species primarily nests in Kansas at Quivira National Wildlife Refuge, where there is designated critical habitat. It also nests occasionally at Cheyenne Bottoms Wildlife Area and along rivers and streams of southwest and central Kansas. The nest is scratched out as a depression in the sand and nesting occurs from mid-March through late summer. Incubation takes 24-28 days. The snowy plover feeds on insects and aquatic invertebrates picked from open flats.

Silver chub (*Macrhybopsis storeriana*) The silver chub is listed by the KDWP as endangered. It is a member of the minnow family and is typically found in deep waters of low gradient streams, rivers and lakes. This species prefers pools with clean sand and fine gravel but will move into riffle areas if necessary to avoid silty areas. Little is known about the spawning habits of the silver chub, but it may spawn in open water in May and June. This fish feeds near the bottom, finding food by sight or taste. Its natural range is mostly east of Kansas and includes the Ohio and Mississippi river basins (KDWP 2005).

Topeka shiner (*Notropis topeka*) The Topeka shiner is a minnow-like fish listed by the KDWP as threatened. The FWS lists it as endangered in some areas, though it is not Federally-listed in any of the project counties. The Topeka shiner prefers open pools near the headwaters of streams that maintain a stable water level due to weak springs or percolation through riffles. The water in these pools is usually clear, except for plankton blooms that develop during the summer. These fish spawn from late May to July and the young mature in one year. The maximum life span is 2 to 3 years. Their diet consists of insects and zooplankton.

State and Federally-Listed Species that may be found in the Project Area

These species are identified by both the FWS and KDWP as being threatened or endangered and potentially found within the project area.

Arkansas darter (*Etheostoma cragini*) The Arkansas darter is a small, geographically isolated fish found only in southeast Kansas, including parts of the Arkansas River basin. It is presently on the FWS candidate list, but the KDWP lists it as threatened. State-designated critical habitat for this species within the project area lies along the North Fork of the Ninnescah River, starting at the Reno-Stafford County line, and extends to its confluence with the South Fork of the Ninnescah River in Sedgwick County. Additional areas are found along numerous perennial, spring-fed reaches of named and unnamed streams south of the Arkansas River in Reno, Kingman, and Sedgwick counties.

The Arkansas darter prefers small prairie streams, seeps, and springs that are partially overgrown with watercress and other broad-leaved aquatic plants. It is usually found in shallow water with little current, as well as in areas with aquatic vegetation and exposed willow roots for cover. It is most common near the headwaters of small streams. Aquatic insects and other arthropods comprise most of its diet. This species breeds from March to May and lays eggs in sandy substrate.

Arkansas River shiner (*Notropis girardi*) The Arkansas River shiner is a small fish thought to be extinct in Kansas. It is listed by KDWP as endangered and FWS as threatened. There is state-designated critical habitat for this species in the project area, including all of the mainstem of the Arkansas River and portions of the mainstem Ninnescah and South Fork Ninnescah River.

The Arkansas River shiner prefers the protected, leeward side of sand ridges, formed by steady, shallow-water flow. It historically inhabited the main channels of wide, shallow, sandy bottomed rivers and larger streams of the Arkansas River basin. The species spawns from June to August when streams approach flood stage. Eggs drift near the surface in the swift current of open channels, develop and hatch within 3 to 4 days. Hatchlings swim to sheltered areas. The Arkansas River shiner feeds facing upstream and captures organisms washed out of shifting sand.

Interior least tern (*Sterna antillarum*) The interior least tern is listed as endangered by both the FWS and KDWP. This designation applies to populations throughout the contiguous United States, except for populations within 50 miles of the Texas Gulf Coast. The most current population data indicates that there are approximately 8,000 individuals (USFWS 2008.)

The interior least tern breeds along large rivers within the interior of the United States during summer months. It migrates south into Mexico, the Caribbean, and northern South America during the winter (Ridgely *et al.* 2003.) It arrives at breeding sites from April to early June and spends 4 to 5 months breeding, nesting, and brooding. Egg-laying begins in late May in nests constructed on un-vegetated sand or gravel bars within wide river channels, along salt flats, or on artificial habitats such as sand pits. Nests are shallow, inconspicuous depressions scratched out by adults and located in the open. Several nests may be located in the same area. They are susceptible to loss by inundation and predation.

The interior least tern feeds primarily on small fish, but also eats crustaceans, insects, mollusks, and worms. They usually forage near nesting sites. They are considered to be transients and occasional summer visitors in Kansas. However, the species has occasionally been known to breed on sandbars in the Arkansas River. There are other breeding populations in Kansas. The species is known to nest at Quivira National Wildlife Refuge in far western Reno County. The refuge has been designated as critical habitat.

Whooping crane (*Grus americana*) The whooping crane is a large bird listed by both KDWP and FWS as endangered. This species once ranged from the Arctic coast to central Mexico, and from Utah to New Jersey, South Carolina, and Florida. Today, a self-sustaining population breeds and nests at Wood Buffalo National Park in Canada and over-winters at Aransas National Wildlife Refuge in Texas. They migrate through the

Great Plains between these points, using rivers, lakes, and other water bodies for feeding and resting.

The whooping crane's diet consists of larval insects, frogs, rodents, small birds, berries, plant tubers, crayfish, and waste grains from harvested cropland. They nest in Canada beginning in late April and lay 1 to 3 eggs. Both parents participate in incubation and rearing of the young. Autumn migration to Texas begins in mid-September and lasts until mid-November. Whooping cranes roost in riverine habitat on isolated sandbars and in large, palustrine wetlands (dominated by trees, shrubs and emergent plants) while in migration, where they are safer from predators. One of the most famous, struggling American bird species, the total population of whooping cranes reached a low of 240 individuals during the mid-1990s (NatureServe 2007.)

Whooping cranes commonly roost at Quivira National Wildlife Refuge and Cheyenne Bottoms Wildlife Area while migrating through Kansas. FWS has designated Quivira National Wildlife Refuge, in far western Reno County, as critical habitat for this species.

Vegetation

Vegetation in the project area before European settlement consisted of mixed-grass prairies, wet meadows, emergent wetlands, and some riparian forests. Most of these communities have been converted to cropland, pasture, or shelter belts. Crops consist mostly of wheat, corn, soybeans, or sorghum (Burns & McDonnell 2003).

Mixed-grass prairies consist of grasses and shrubs of varying heights. Common species include:

- little bluestem (*Schizachyrium scoparium*)
- buffalograss (*Bouteloua dactyloides*)
- gamagrass (*Tripsacum dactyloides*)
- big bluestem (*Andropogon gerardii*)
- needlegrasses (*Acnatherum or Nassella* spp.).

Mixed-grass prairies have been historically maintained by fire, grazed by large herbivores (including American bison), and the plants had well-established, dense root systems.

Wet meadow communities typically hold a transitional zone between the prairie and lowland areas, and consist of a variety of plant species, such as:

- needlegrasses (*Acnatherum or Nassella* spp.)
- prairie cordgrass (*Spartina pectinata*)

- big bluestem (*Andropogon gerardii*)
- switchgrass (*Panicum virgatum*)
- rushes (*Juncus* spp.)
- sedges (*Carex* spp.).

The areas next to rivers and streams in the project area are dominated by thin bands of lowland riparian forest. Species in these forests include:

- cottonwood (*Populus deltoides*)
- willow (*Salix* spp.)
- catalpa (*Catalpa speciusa*)
- hackberry (*Celtis occidentalis*)
- elm (*Ulmus* spp.)
- maple (*Acer* spp.)

Non-Native Invasive Species

Non-native invasive species are plants and animals that are not part of the original flora and fauna of an area. They are considered undesirable for a variety of reasons. The Federal government has been directed by the Federal Noxious Weed Act of 1974 to prevent the spread, introduction, or continued existence of non-native, invasive species. Likewise, Kansas has laws preventing the spread and continued existence of species considered to be a nuisance.

One of the most invasive and destructive animal species is the zebra mussel (*Dreissena polymorpha*), which was discovered in El Dorado Reservoir (Butler County) in 2002. It was discovered in Cheney Reservoir in 2007 (Figures 3-4 and 3-5) and in Marion Reservoir in 2008. The presence of a related and equally undesirable invasive species, the quagga mussel (*Dreissena rostriformis bugensis*), has not yet been documented in Kansas. White perch and grass carp are also nuisances in Kansas, as are other species which have not been directly identified and targeted by the state or Federal government. Table 3-5 contains a list of state and Federally controlled invasive species known to be present in the area.

Figure 3-4   Invasive zebra mussels fouling El Dorado Reservoir, 2003 (USACE photo)

Figure 3-5   Zebra mussels clogging water pipe (USACE photo)

Table 3-5	Non-Native Invasive Species Documented in Project Area
Vegetation	Bull thistle (*Cirsium vulgare*)
	Bur ragweed, bursage (*Ambrosia grayi*)
	Canada thistle (*Cirsium arvense*)
	Field bindweed (*Convolvulus arvensis*)
	Hoary cress (*Lepidium draba*)
	Johnson grass (*Sorghum halepense*)
	Leafy spurge (*Euphorbia esula*)
	Multiflora rose (*Rosa multiflora*)
	Musk thistle (*Carduus nutans*)
	Pignut (*Hoffmannseggia glauca, H. densiflora*)
	Quackgrass (*Elymus repens, Agropyron repens*)
	Russian knapweed (*Acroptilon repens, Centaurea repens*)
	Sericea lespedeza (*Lespedeza cuneata*)
	Kudzu (*Pueraria lobata, P. Montana* var. *lobata*)
Animals	White perch (*Morone americana*)
	Common carp (*Cyprinus carpio*)
	Zebra mussel (*Dreissena polymorpha*)

Wetlands

Wetlands are areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, vegetation typically adapted for life in saturated soil conditions. There are a variety of wetland types, including swamps, marshes, bogs, and similar areas. Wetlands are important areas for the support of wildlife and plant diversity. They provide habitat for a wide variety of fish, wildlife, and plants, enhance water quality by filtering pollutants and sediment from runoff, prevent erosion, and store flood waters. For these reasons, wetlands are classified as special aquatic sites. They are afforded protection by the Federal Clean Water Act (CWA). Section 404 of the CWA gives the USACE the authority to regulate such wetlands and other waters. Wetlands are considered jurisdictional. In other words, only a local USACE office may make an official determination on what is considered a wetland.

The project area has dozens of small wetlands of many different types (the larger, McPherson Wetlands are found in McPherson County, well outside of the area where construction impacts would occur.) Small, local wetlands are broadly categorized as riverine, lacustrine, or palustrine habitats. They include freshwater emergent wetlands and freshwater forested/shrub wetlands. Although not considered actual wetlands, small, low-lying areas that collect water during wet periods, known as "vernal pools," occur throughout the area. Vernal pools can be considered to be important breeding or survival habitat for certain species. Most vernal pools in the area lie within or alongside cultivated areas.

Riverine habitats are those existing in and along rivers and streams. Most local riverine habitat consists of slow-flowing perennial streams with a sand and mud substrate, though some small streams flow only intermittently. Vegetation consists primarily of submerged aquatic plants. Riverine systems exist within rivers and streams throughout the project area.

Lacustrine systems include wetlands and deep water habitats found in a topographic depression or dammed river. The total area of a lacustrine system is usually more than 20 acres, of which less than 30% is covered with trees, shrubs, persistent emergents, emergent mosses or lichens. This type of wetland generally surrounds lakes and reservoirs, including Cheney Reservoir.

Palustrine habitats are wetlands dominated by trees, shrubs, emergent plants, mosses or lichens, and any other similar water bodies less than 20 acres in size and less than 6.6 feet deep. This wetland type includes natural and man-made ponds and wetland features adjacent or near to riverine and lacustrine systems.

Prime and Unique Farmlands

There has been a substantial and continuing decrease in the amount of open farmland within the project area over the last century. Urbanization has converted many acres of productive farmland to non-agricultural use. Prime and unique farmlands are defined as those that require a relatively small level of cost and effort to produce high-quality food and fiber crops. They are protected from unnecessary and irreversible conversion to non-agricultural use by the Farmland Protection Policy Act (7 USC 4201 *et seq*.) Federal agencies are required to identify the potential effects of government projects on prime and unique farmlands and prevent negative impacts where practical. As described in the "Soils" section of this chapter, a large percentage of the project area is considered to be prime farmland. These prime farmlands are identified by soil type, along with current and former uses.

Visual Resources

Visual character is defined by topography, vegetation, and land use. Each of these attributes contributes to the esthetic quality of an area.

The project area is located on flat to gently rolling ground in a rural setting. Area vegetation consists primarily of row crops and pastures. Scattered across the landscape are center-pivot irrigation systems, wells, and other structures. These include farmhouses, barns, sheds, grain and silage elevators, oilfield batteries and tanks, and oilfield pump jacks.

The Little Arkansas River consists of a braided channel with sand bars, forested islands and numerous bends, enclosed by a riparian zone consisting of trees and shrubs that varies from a few feet to more than 500 feet wide. Riparian zones average less than 300 feet wide and are often much narrower.

Figure 3-6 Little Arkansas above Wichita at a flow of about 58 cfs

Cheney Reservoir lies in a rural setting with scattered houses, trees, campgrounds, and other recreational facilities surrounding it. The communities of Wichita, Sedgwick, Halstead, Bentley, Burrton, Valley Center, and others break up the primarily agricultural/grassland area, but less than 3% of the total area is considered residential. Large buildings and elevated highways dot the landscape in the Wichita vicinity, where much of the area is heavily urbanized.

Wild and Scenic Rivers

Wild and Scenic Rivers are those rivers designated by the National Wild and Scenic Rivers Act (16 USC 1271-1287). They are rivers that are free of dams or other human structures, or that have ecological importance, or that have important recreational values. The act requires that these rivers be considered during planning and development to prevent negative impacts.

None of the rivers in the project area, nor any in Kansas, are designated as Wild and Scenic Rivers.

Socioeconomics

Social and Economic Conditions

Social and economic conditions within the Equus Beds region of influence are indicated by certain factors. These include:

- Existing population(s) and expected changes
- Educational levels and availability
- Income levels
- Values of agricultural and nonagricultural production
- Recreational types and availability, and
- Local employment.

Each indicator must be placed in context before the magnitude of its impacts can be measured. The economies of Butler, Harvey, Kingman, Marion, McPherson, Reno, Rice, and Sedgwick counties could be directly impacted by ASR construction or operation. Therefore, existing social and economic conditions will be reviewed for these counties.

Wichita is the largest city and center of economic activity in the region. The City is tied closely to aircraft manufacturing, which is the largest economic sector. Additional important sectors include other manufacturing types, health care, petroleum production and refining, government, and agriculture. Wichita State University, the University of Kansas Medical School, smaller colleges, McConnell Air Force Base, and the Kansas Air National Guard also contribute to the economy and impact social and economic conditions.

Each social or economic indicator discussed in this document uses data from various governmental and non-governmental sources. Data sources are identified where needed in the discussion.

Current conditions of economic indicators in the region are described. These indicators include:

- Population
- Education
- Median household and *per capita* income

- Poverty rates
- Home ownership
- Earnings
- Agricultural acreage and value of production
- Labor force and unemployment
- Small area and municipality economies
- Recreation, and
- Other measures of economic activity.

Population

Two population trends have dominated within both Kansas and the project area over the past 40 years. First, rural counties have lost population, sometimes more than 10% per decade. Second, urban counties (including Sedgwick) have gained population at an even greater rate (KWO 2008). The Bureau of the Census estimated a 2007 population of 695,049 for the eight-county economic impact area. This is a 3.4% increase over the 2000 Census of 672,359, and a 14.6% increase over the 1990 Census of 606,717. Most growth in Kansas since 1990 occurred in Sedgwick County (including Wichita.) Sedgwick County accounted for 81.9%% of total growth in the region. Population throughout the region, outside of Sedgwick County, grew between 1990 and 2000, but declined slightly thereafter. About 24.4% of the population in Kansas' 105 counties lived in the eight-county impact area in 1990. That percentage increased to 25.0% by 2007. Estimated 1990, 2000, and 2007 populations for the impacted region, individual counties, and the State of Kansas are provided in Table 3-6.

Table 3-6 Population of Regional Counties

County	2007 Estimates	2000 Census	1990 Census
Butler	63,045	59,482	50,580
Harvey	33,493	32,869	31,028
Kingman	7,826	8,673	8,292
Marion	12,238	13,361	12,888
McPherson	29,196	29,554	27,268
Reno	63,145	64,790	62,389
Rice	10,080	10,761	10,610
Sedgwick	476,026	452,869	403,662
Total	**695,049**	**672,359**	**606,717**
Kansas	2,775,997	2,688,418	2,477,574

Source: U.S. Bureau of the Census

Population growth (Table 3-7) is projected through 2025 for the economic impact area, based upon the 2000 Census. The most rapid growth is expected in Butler County. Most growth, overall, is anticipated in Sedgwick, Butler, and Harvey Counties. These three counties constitute the Wichita Metropolitan Statistical Area, or MSA, as defined by the

Bureau of the Census. Negative population growth is projected for the more rural Kingman, Marion, McPherson, Reno, and Rice counties.

Table 3-7 Population Projections for Economic Impact Area, 2000-2025

County	**2000 Census**	**2010**	**2015**	**2020**	**2025**	**% Change 2000-2025**
Butler	59,484	74,565	79,925	83,312	86,046	45
Harvey	32,869	34,538	35,338	36,311	37,417	14
Kingman	8,673	8,360	8,249	8,152	8,076	-7
Marion	13,361	13,269	13,051	12,899	12,786	-4
McPherson	29,554	29,573	29,348	29,117	28,863	-2
Reno	64,790	57,877	55,877	54,982	54,455	-16
Rice	10,761	10,241	10,101	10,023	9,942	-8
Sedgwick	452,869	481,730	497,998	515,403	531,939	17
Total	**672,361**	**710,153**	**729,887**	**750,199**	**769,524**	**14**
Kansas	2,688,824	2,818,880	2,880,017	2,936,670	2,988,382	11

Source: U.S. Bureau of the Census, 2000 Census

The most striking population growth reported in the project area between 1990 and 2007 was for Hispanics of all races. Comparisons of total and Hispanic population growth in the eight-county area are presented in Table 3-8. Total growth in the region was 14.6%, while the Hispanic population grew 165.5%, Percentages of Hispanic population residing in the various counties within the project area are provided in Table 3-9.

Table 3-8 Total & Hispanic Population Growth within the ASR Impact Area				
County	**Growth – Total Population**		**Growth – Hispanic Population**	
	1990-2000	1990-2007	1990-2000	1990-2007
Butler	17.6%	24.6%	80.1%	123.9%
Harvey	5.9%	7.8%	62.1%	98.4%
Kingman	4.6%	-5.6%	62.3%	109.1%
Marion	3.7%	-5.0%	117.8%	153.4%
McPherson	8.4%	7.1%	76.3%	137.8%
Reno	3.8%	1.2%	47.7%	62.0%
Rice	1.4%	-5.0%	116.5%	192.8%
Sedgwick	12.2%	17.9%	108.8%	188.7%
Total	**10.8%**	**14.6%**	**97.5%**	**165.5%**

Education

Education is one indicator of the skill level of the labor force. It is a measure of the attractiveness of an area to businesses and industries considering expansion or relocation. Educational attainment in impacted counties, the region, the state, and the United States is provided in Table 3-10.

Table 3-9 Hispanics – Percent of Total Population within the ASR Impact Area			
County	1990	2000	2007
Butler	1.47%	2.25%	2.63%
Harvey	5.21%	7.97%	9.58%
Kingman	0.93%	1.44%	2.06%
Marion	0.92%	1.92%	2.44%
McPherson	1.19%	1.94%	2.65%
Reno	3.97%	5.65%	6.36%
Rice	2.63%	5.61%	8.11%
Sedgwick	4.32%	8.04%	10.57%
Total	**3.80%**	**6.78%**	**8.81%**

The percentage of adults 25 years of age or older with at least a high school education in each of the eight counties ranges from 82.7% to 87.3%. The regional average is 85.1%. This compares to 86.0% for the state and 80.4% for the nation.

The percentage of the population with a Bachelor's degree or higher level of education ranges from 17.3% to 25.4% for counties in the region. The regional average is 23.5%. This compares to 25.8% with Bachelor's degrees or higher statewide and 24.4% nationally.

Educational attainment in Wichita and the rest of the region impacted by the project is comparable to state and slightly above national levels. This attainment translates into a skilled workforce. The potential for attracting well paying jobs to the region in the future appears to be good.

Table 3-10 Educational Attainment in Kansas

Percentage of Persons Age 25 and Over – 2000

County	**High School Graduate or Higher**	**Bachelor's Degree or Higher**
Butler	87.3	20.4
Harvey	85.3	23.0
Kingman	84.7	17.8
Marion	84.4	17.9
McPherson	85.9	22.2
Reno	82.7	17.3
Rice	83.4	17.5
Sedgwick	85.1	25.4
Region	85.1	23.5
Kansas	**86.0**	**25.8**
United States	**80.4**	**24.4**

Source: U.S. Bureau of the Census,2000 Census of Population and Housing

Median Household and Per Capita Income, Poverty Rates, and Home Ownership

Table 3-11 presents median household income, *per capita* income, poverty rate, and home ownership rates for counties potentially impacted by the project. Figures for Kansas and the United States are also provided.

Estimated 2005 median household[5] income in project-impacted counties ranged from $37,176 to $49,091. Estimated 2005 *per capita*[6] income in the same counties ranged from $22,176 to $34,703. Kansas ($32,866) and U.S. ($34,471) *per capita* incomes were near the upper end of this range.

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[5] Household income is the sum of money earned during the calendar year by all household members who are 15 years of age and older

[6] *Per capita* income is the mean income computed for every man, woman, and child in a geographic area. It is derived by dividing the total income of all people 15 years old and over in a geographic area by the total population in that area

Table 3-11 Income, Poverty Rate, and Home Ownership Rate				
County	**2005 Median Household Income[1]**	**2005 *Per Capita* Income[2]**	**2005 Persons Below Poverty[3] Level**	**2000 Home Ownership Rate[4]**
Butler	$49,091	$30,228	9.4%	77.7%
Harvey	$44,032	$29,977	8.2%	71.9%
Kingman	$41,511	$27,137	12.4%	77.8%
Marion	$38,153	$23,336	9.5%	79.9%
McPherson	$46,236	$31,890	9.3%	74.0%
Reno	$39,790	$27,109	13.1%	70.7%
Rice	$37,176	$22,176	13.8%	76.6%
Sedgwick	$43,340	$34,703	13.1%	66.2%
Kansas	**$42,861**	**$32,866**	**11.7%**	**69.2%**
United States	**$46,242**	**$34,471**	**13.3%**	**66.2%**

[1] *U.S. Bureau of the Census, Housing and Household Economic Statistics Division*
[2] *U.S. Bureau of Economic Analysis, Local Area Personal Income*
[3] *U.S. Bureau of the Census, Small Area Income and Poverty Estimates*
[4] U.S. Bureau of the Census, Census of Population and Housing

There were large differences in both household and *per capita* income among counties in the region. This was especially true for median household income. Higher incomes were more common near the City and along Interstate corridors I-135 and I-35.

There was a large variation in the number of persons below the poverty level[7] in project impacted counties in 2005. The results presented no discernable pattern. Poverty rates were highest in Rice, Sedgwick, Reno, and Kingman counties. Rates in these four counties exceeded the state average, while the Rice county rate exceeded both state and national averages. Poverty rates in Butler, Harvey, Marion, and McPherson counties fell well below state and national averages.

[7] Families and persons are classified as below poverty level if their total family income or unrelated individual income is less than the poverty threshold specified for the applicable family size, age of householder, and number of related children under the age of 18.

Home ownership rate is computed by dividing the number of owner-occupied housing units by the number of occupied housing units or households. With the exception of Sedgwick County, home ownership rate in the area is relatively high compared to rates throughout both Kansas and the United States.

Earnings

Major industry groups in the region, based upon total earnings, include construction, manufacturing, wholesale trade, retail trade, health care, social assistance services, and government and government enterprises. Earning patterns indicate that a wide range of worker skills and education are both needed and available in the area.

The largest segment[8] of earnings is in manufacturing, which accounts for over 30% of estimated total earnings. This is due, in large part, to the presence of aircraft manufacturing. Wichita has a number of aircraft manufacturers and styles itself, "The Aircraft Capital of the World." Aircraft manufacturers include the Cessna Aircraft Company, Spirit AeroSystems, Hawker Beechcraft, Boeing Integrated Defense Systems, and Bombardier Learjet. These companies generally pay well and employ more than 34,000 people. Other goods manufactured in the Wichita area include HVAC (air conditioning and heating) systems, agricultural equipment, and recreation products.

Labor Force and Unemployment

Approximately 67% of the total regional workforce is located in Sedgwick County (Bureau of Labor Statistics 2006). Sedgwick and Butler counties had the highest unemployment rates (4.7%) in 2006. Unemployment rates in the remaining six, project impacted counties ranged from 3.4 to 4.6%. Rates in all counties except Marion, Kingman, and McPherson counties (where unemployment rates were low), approximated state and national averages. Table 3-12 summarizes regional, state and national civilian labor force estimates.

[8] Large segments are defined as sectors that account for 5% or more of total earnings in the area, based upon U.S. Bureau of Labor estimates

Table 3-12 Civilian Labor Force Estimates				
County	**Labor Force**	**Employed**	**Unemployed**	**Unemployment Rate**
Butler	32,110	30,606	1,504	4.7%
Harvey	18,223	17,409	814	4.5%
Kingman	4,333	4,165	168	3.9%
Marion	6,739	6,461	278	4.1%
McPherson	17,842	17,242	600	3.4%
Reno	33,107	31,589	1,518	4.6%
Rice	5,431	5,193	238	4.4%
Sedgwick	245,576	234,097	11,479	4.7%
Total	**363,361**	**346,762**	**16,599**	**4.6%**
Kansas	**1,466,009**	**1,400,172**	**65,837**	**4.5%**
United States	**151,100,848**	**144,113,800**	**6,987,048**	**4.6%**
Source: U.S. Department of Labor, Bureau of Labor Statistics				

Agricultural Acreage and Production Value

Agriculture constitutes an important aspect of the regional economy, both in terms of direct income and employment effects on other support and processing industries. The 2002 Census of Agriculture showed that around 9.5% of all Kansas agricultural land lies within the eight-county, project Economic Impact Area (EIA). Farmers in the EIA produce about 8% of the total value of Kansas farm products. Table 3-13 summarizes agricultural data in the impact area and in Kansas. Information includes the number of acres of agricultural land, number of farms, and compares agricultural production within the EIA to production throughout the state.

Table 3-13 Agricultural Acres, Farms, and Product Values					
County	**Total Agricultural Land (Acres)**	**Farm Product Values (millions)**	**Number of Farms**	**Average Farm Size (Acres)**	**Average Product Value (by Farm)**
Butler	701,202	$116.42	1,309	536	$88,939
Harvey	351,724	$60.30	832	423	$72,475
Kingman	555,799	$51.79	837	664	$61,879
Marion	588,427	$81.29	996	591	$81,618
McPherson	574,875	$99.43	1,161	495	$85,640
Reno	735,132	$111.67	1,570	468	$71,127
Rice	416,224	$105.79	500	832	$211,575
Sedgwick	533,871	$75.42	1,355	394	$55,664
Total	**4,457,254**	**$702.11**	**8,560**	**521**	**$82,023**
Kansas	**47,227,944**	**$8,746.24**	**64,414**	**733**	**$135,782**

Source: Census of Agriculture 2002

Recreation

Recreation is an important part of the regional economy. Wichita maintains several museums, 97 public parks, and sporting facilities. Other facilities include amphitheaters, child play areas, basketball courts, picnic areas, fishing ponds, recreation centers, swimming pools, hiking trails, and tennis courts, among others. Popular outdoor activities include hunting, fishing, camping, nature watching, boating, and others. There are fee-based public and private recreational sources in the City and nearby that include professional sports arenas, zoos, amusement parks, paintball facilities, bowling alleys, raceways, golf courses, miniature golf courses, and lakes. In addition, there are three state parks, two major USACE reservoirs (El Dorado and Marion), Cheney Reservoir, as well as several smaller outdoor recreation areas.

El Dorado State Park

El Dorado State Park is located in Butler County, about 35 miles northeast of Wichita. The dam at El Dorado Reservoir was completed by USACE in June 1981. The lake consists of approximately 8,000 surface acres, with 4,500 acres of nearby park lands and 3,500 acres of wildlife area. KDWP manages reservoir recreation, fish, and wildlife resources, including four primary campgrounds and the largest state park in Kansas.

The lake provides many opportunities for water-oriented activities, such as camping, picnicking, swimming, skiing, fishing, boating, hunting, and nature watching. The state park reported 722,755 visitor days during

2006. This number comprises almost 12% of all visitor days in the Kansas State Park System.

Cheney State Park

Cheney Dam and Reservoir is a Reclamation facility located about 6 miles north of Cheney and 24 miles west of Wichita. The dam lies at the common intersection of the boundaries of Kingman, Reno, and Sedgwick counties. The reservoir lies in all three counties and provides a variety of recreational uses, along with fish and wildlife benefits to south-central Kansas.

Many species of sport fish common in Kansas are caught in Cheney Reservoir. The adjacent park provides excellent camping, boating, swimming, and picnicking facilities. The park is administered by KDWP, as are 1,900 acres of nearby land and over 5,400 surface acres of water. In addition, there are over 5,200 acres of land and 4,100 acres of water reserved for conservation and management of migratory birds and other wildlife. There were an estimated 490,837 visits to Cheney State Park during 2006. This represents about 8% of all visitor days recorded that year in the Kansas State Park System.

Marion Reservoir

Marion Dam and Reservoir, completed by USACE in 1968, encompasses 6,200 acres of water surrounded by another 6,000 acres of public lands. The dam lies between the communities of Marion and Hillsboro in Marion County. Four well-equipped campgrounds and 171 campsites surround the lake. Marion Reservoir supports one of the best walleye fisheries in Kansas. It attracted 78,700 park visits during 2006.

Sand Hills State Park

Sand Hills State Park, located near Hutchinson in Reno County, is a 1,123 acre natural area that has been preserved for its picturesque sand dunes, grasslands, wetlands, and woodlands. Popular activities include hiking, nature watching, and horseback riding. There were an estimated 27,787 visits to the park during 2006.

Maxwell State Game Refuge

This 2,254 acre wildlife refuge and state park located in McPherson County is managed by KDWP. It supports about 50 head of elk and the largest herd of wild, American bison in Kansas (150-200 head.) It also contains a 46 acre fishing lake surrounded by 260 acres of public use area. More than 150 species of birds have been identified along 1.5 miles of hiking trails.

Environmental Justice

An evaluation of environmental justice is mandated by Executive Order 12898 (*Environmental Justice*, February 11, 1994) for Federal actions that affect the environment. “Environmental justice” implies that no group of people, regardless of race, ethnicity, socioeconomic status, or community, bear a disproportionate share of negative impacts from a project. It is evaluated by determining the percentage of impact to one group compared to another. Should the percentage of total impacts on a specific group be greater than the proportion of the total population represented by that group, impacts would be considered to be unfairly distributed.

Demographic data from various sources were used to evaluate environmental justice. The locations of different groups of people in the ASR project impact area were derived from data provided by the Bureau of the Census, individual counties, municipalities, and local school districts. Current conditions were generally estimated using data from the Bureau of the Census.

Evaluating environmental justice concerns requires an understanding of several factors. Among the most important would be, (1) where the project impacts would be likely to occur, and (2) where affected groups would be located. Identifying the location of specific groups can be difficult when nonpermanent residents, such as migrant workers, temporarily use an affected area. Migrant demographic data is limited throughout the nation. Census data do not account for all nonpermanent residents, because some cannot be contacted and others may not want to be found or counted. In addition, difficulty contacting persons residing in sparsely populated, rural areas results in a tendency to undercount local populations. Despite these challenges, Census data are typically the most complete and comparable demographic and economic data available.

Income data for the impacted region and the state are summarized in the previous section in this chapter. Data indicate that median household income is much lower in Rice, Reno, and Marion counties than in many areas of Kansas. *Per capita* income is lower than average for the same counties, plus Kingman and Harvey counties.

Poverty rates show a different pattern. Both income and poverty rates in Sedgwick County are relatively high, indicating a higher disparity between the wealthiest and poorest individuals. In comparison, poverty rates outside of Sedgwick County are relatively low. Any action having a disproportionate, adverse effect on counties or parts of counties listed as having low incomes or high poverty rates could raise environmental justice issues.

Bureau of the Census data are available for race and Hispanic origin (2006). These data are presented in Table 3-14. Distribution of population by race is similar for each of the project area counties, except Sedgwick and Harvey. Blacks and Hispanics make up a relatively high percentage of the total population in the urbanized Wichita area. Hispanics make up a relatively high percentage of the population in Rice and Reno Counties.

Table 3-14 Race and Ethnic Origin – 2006 Percentages

County	**White**	**Black or African American**	**American Indian**	**Asian**	**Pacific Islander**	**Two or more races**	**Hispanic or Latino**
Butler	95.33	1.53	1.00	0.57	0.03	1.56	2.54
Harvey	95.22	1.86	0.58	0.67	0.04	1.63	9.33
Kingman	96.89	0.33	0.78	0.45	0.16	1.39	2.07
McPherson	96.82	1.07	0.39	0.32	0.07	1.33	2.18
Marion	97.66	0.49	0.67	0.19	0.02	0.98	2.16
Reno	94.27	2.97	0.67	0.80	0.04	1.26	6.40
Rice	96.10	1.36	0.85	0.67	0.04	0.98	7.54
Sedgwick	83.55	9.42	1.08	3.82	0.09	2.05	10.28
Total	**87.34**	**6.99**	**0.97**	**2.79**	**0.08**	**1.84**	**8.54**
Kansas	**89.08**	**5.95**	**0.99**	**2.20**	**0.07**	**1.71**	**8.59**

Sources: U.S. Bureau of the Census 2000; American FactFinder, 2006 Population Estimates, Tables T3 & T4

As noted in Table 3-6, Hispanic population throughout the project area grew by 165.5% from 1990 through 2007. By comparison, the Hispanic population in urbanized Sedgwick County (Wichita) grew 188.7%. Such population increases within a single ethnic group are considered substantial, especially when compared to an overall population growth of 14.6% for the same area over the same time period. Ethnic population changes of this magnitude would need to be addressed during the environmental justice review.

Cultural Resources

The project cuts through three physiographic regions within the Central Great Plains – the Flint Hills, the Arkansas River Lowland, and the Wellington-McPherson Lowland. The history of human occupation within this area can be divided into six broad time periods, or stages, based upon differences in the way people interacted with their environment. These periods, ranging from earliest to latest, include the Paleo-Indian, Archaic, Early Ceramic, Middle Ceramic, Late Ceramic, and Historic. Development within cultures, along with the influx of new ideas and materials from neighboring regions, resulted in adaptations in settlement patterns, cultural materials and subsistence economics. Particular artifacts, house types, and exploitation of different plant and animal species characterized each period.

Paleo-Indian Period (10,000 – 6,000 BC)

This period began near the end of the last Ice Age. People were typically highly mobile and traveled in small bands. They hunted now-extinct, large, Ice Age animals and foraged for berries, seeds, roots, small game, clams, and other locally available plants and animals. The primary hunting tool was a spear tipped with a large, leaf-shaped, chipped-stone projectile point. Archeologists have divided this period into three stages, based primarily upon the shape of the projectile points. The Llano stage ranged from approximately 10,000 – 9,000 BC, the Folsom stage from 9,000 – 8,000 BC, and the Plano stage from approximately 8,000 – 6,000 BC.

The earliest, well-documented evidence of human activity in the Central Great Plains was attributed to the Llano stage (10,000 – 9,000 BC). The culture was identified by a distinctive projectile point with a centrally flaked flute, known as a "Clovis" point. It is the earliest projectile point known in America. It was often found near the remains of mammoth and other large Ice Age mammals. Though Clovis points have been found in Kansas, none closely associated with animal remains have been discovered (Logan 1998). According to Brown and Simmons (1987), other artifacts found that relate to the hunting and butchering of large animals include:

- cylindrical bone and ivory fore-shafts with projectile points
- scrapers
- knives
- cobble choppers
- gravers
- bifaces, and
- hammerstones.

The Folsom stage (9,000 – 8,000 BC) was characterized by the presence of a different style of projectile point. Archeologists know it as the "Folsom" point. The Folsom point had an extended central flute and was associated with now-extinct bison. The bison replaced the mammoth as the primary source of food and raw materials. Folsom points have been found throughout Kansas, although they appear to be concentrated primarily in the northeast and southwest corners of the state (Brown and Simmons 1987). Leaf-shaped points collected at the Twelve-Mile Creek site (14LO2) in Scott County (west-central Kansas) have not definitively been identified as Folsom. However, this site produced several skeletons of extinct bison and may represent the only excavated Folsom complex in the state (O'Brien 1984).

The Plano stage (8,000 – 6,000 BC) was characterized by a variety of chipped projectile points and knife forms. Before 7,000 BC, the most widely-hunted animals included now-extinct forms of bison, horse, and camel. Modern bison were associated with sites dated to 7,000 BC and later. A group of Paleo-Indian cultures were represented by various, characteristically chipped stone projectiles and knife forms. Cultures documented in Kansas include the Plainview, Hell Gap, Meserve/Dalton, Milnesand, Midland, Agate Basin, Scottsbluff, and Eden. The newer, leaf-shaped projectile points are variable in design but are characterized by parallel flaking along the tool edges. These, more recent points lack the central flute typical of Clovis and Folsom types.

Six, well-documented Paleo-Indian sites have been excavated in Kansas. They include the Tim Adrian, DB, Norton Bone Bed, Laird, Sutter (scattered around the state), and an unnamed site in Sedgwick County. Excavated Plano sites are scarce in Kansas. Most information comes from nearby states. Site 14SG515, located near Wichita, is a possible Cody complex. It contains Scottsbluff and Eden points, along with a Cody knife (Brown and Simmons 1987). The absence of other known sites in the project area does not preclude their existence. It has been suggested that the absence of known sites may be primarily related to two factors:

- a lack of intensive surveys in the western 2/3 of the state, and
- difficulty locating sites in the eastern 1/3 of the state, due to their burial beneath other soil deposits (Brown and Simmons 1987).

Wheat (1978) defined four types of human behavior that would result in distinctive archeological sites that may be present in Kansas, including:

- mass kill sites
- butchering sites
- long-term campsites, and
- short-term campsites.

The presence of projectile points and recorded mastodon, mammoth, and bison remains in Harvey and Sedgwick counties indicates the potential for additional Paleo-Indian sites. The probability is high that additional bison jump and animal trap sites are present, particularly in western Kansas (Brown and Simmons 1987).

Archaic Period (6,000 BC to AD 1)

Many large Ice Age animals went extinct during the Pleistocene, approximately 8,000 to 9,000 years ago. Hunter-gatherer groups learned to depend more upon modern bison, elk and deer as dietary staples (Hofman 1996). Plants became more important in the diet as the economy switched from dependence upon one type of large game, to reliance upon a wide variety of smaller game and other foods (Logan 1998). Human populations remained nomadic, but focused more on seasonal exploitation of resources in certain areas as they became available. Pit houses and new processing-storage technologies appeared in upland hunting and processing camps (bison kill areas.) Seed processing also led to more widespread use of grinding slabs. The manufacture of ceramic objects began around 5,500 BC. Increased numbers and specialized types of chipped-stone tools appeared and the *atlatl*, or throwing stick, became common.

There are a limited number of excavated Archaic sites scattered throughout Kansas. The only clearly defined Archaic site near the project area is found in the Flint Hills. Six cultural complexes or phases have been defined for the Flint Hills. They include the:

- Logan Creek complex
- Munkers Creek phase
- Nebo Hill phase
- Chelsea phase
- El Dorado phase, and
- Walnut phase.

Early Ceramic Period (AD 1 to 1000)

The Early Ceramic Period, or Plains Woodland, is equivalent to the Woodland stage farther east in the United States. Populations trended toward sedentism during this period.[9] They intensified horticultural activity, expanded regional networks and made ceremonial activities and mortuary practices more elaborate (Griffin 1967). Technological changes became especially important, especially the adoption of bow and arrow weaponry and the widespread use of ceramic pottery for storage and cooking. Ceramics of this stage are typically described as thick, stone-tempered and with cord-marked exteriors (Montet-White 1968; Farnsworth and Asch 1986; Adair 1996).

Expanded use of small, short duration camps next to specific environmental locales suggests increased use of seasonally specialized extraction camps to exploit locally abundant resources (Roper 1979; Emerson and Fortier 1986; Seeman 1986). Several Plains Woodland sites have been recorded (many unofficially) within the Little Arkansas River

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9 Sedentism refers to a tendency to settle down and spend less time traveling or wandering.

valley inside the project area. Though most of the eight Plains Woodland cultural manifestations found in Kansas are poorly understood, Keith complex sites have been located between the Little Arkansas and Platte rivers (Johnson and Johnson 1998). Ceramics collected at these locations are unique. The vessels are conical in shape and generally have very thick, cord-marked walls. Projectile points discovered range in size and shape from large, dart points typically associated with *atlatls*, to small, corner-notched arrow points. Keith complex sites are usually located on ridges and terraces overlooking rivers and streams.

Greenwood and Butler phase sites are found along the eastern edge of the project area. The Butler phase site in El Dorado Reservoir dates to between A.D. 200-800 (Grosser 1970, 1973). Greenwood phase sites are found throughout the Flint Hills and Osage Cuestas (Witty 1980). Reviews of cultural materials from these two phases suggest they are connected. They are typically characterized by limestone-tempered, Verdigris[10] type pottery.

Some sites have characteristics typical of both Keith and Greenwood/Butler phases, yet may be unique enough to be considered as distinct cultural manifestations. These sites are typically found on terraces or sand dunes along the Little Arkansas River, or on ridges overlooking small playa lakes. Ceramics are typically sand-tempered, conical, and made from locally available sandy clays. Chipped stone tools include *atlatl* dart points and notched arrow points made from river cobbles and upland quartzite. A few of these tools have been identified as originating in the Flint Hills.

Middle Ceramic Period (AD 1000-1500)

Kansas sites attributed to the Middle Ceramic Period are typically grouped under the Central Plains Tradition or Plains Village Tradition. The Middle Ceramic Period is probably the best understood prehistoric stage in the area. Until recently, some of the studied sites were thought to contain several contemporaneous houses but recent work on the Solomon River phase of north-central Kansas shows that these people lived in broadly scattered homesteads rather than villages (Latham 1996; Blakeslee 1999).

Sites attributed to the Smoky Hill phase are found in the north and northeastern parts of the project area. Smoky Hill people generally resided in semi-rectangular earth lodges on terraces along rivers and streams. These swidden (slash and burn) foragers exploited nearly every edible plant and animal available (Logan 1998; Blakeslee 1999). Ceramics associated with this stage include globular bowls and jars, with exteriors generally cord-marked. They were tempered with sand or grit.

[10] Verdigris refers to a green patina on the pottery resulting from the weathering of copper in the clay

Pratt Complex sites are typically found in the Arkansas River lowlands. These people were likely associated with the Southern Plains Village Tradition (Brosowske and Bevitt 2006). Bluff Creek Complex sites have been found south of the project area, but little is known about this complex.

A few Middle Ceramic sites have been recorded in the project area and it is likely that other sites lie undetected. Recorded sites are most often found along small material scatters on terraces of the Little Arkansas, Saline, Smoky Hill and Solomon rivers and their tributaries.

Late Ceramic Period (AD 1500-1800)

The Late Ceramic Period is often associated with the appearance of Euro-American trade goods. A wide variety of iron, copper, brass, and glass objects and stone gunflints begin to appear. Groups associated with this period include the Wichita, Kansa, Pawnee, and other nations. Prominent village sites of the Great Bend aspect are found along the upper Little Arkansas River in Rice and McPherson counties. Other village concentrations, including wood-framed, grass-covered houses, arbors and subsurface storage pits are found in Marion and Cowley counties. Camp and other special purpose sites have been recorded in the project area. Light to moderate scatter, including chipped stone, pottery, and faunal debris[11] are usually associated with these sites. The preferred Pawnee Nation bison hunting area was located along the northern edge of the project area. Recent work has identified Great Bend aspect hunting camps nearby (Latham 1996). Sites associated with the White Rock phase, a western Oneota component, are also found.

Euro-American sites started to appear during this period, beginning with Coronado's expedition through the Central Great Plains in 1541. French trappers and explorers arrived around 1740. They left evidence of hunting camps, trails, refuse piles, discarded weapons and armament, etc.

Historic Period (Post-1800)

Euro-American sites did not appear in numbers until after AD 1800. This effectively established the beginning of the Historic Period. The Wichita, Cheyenne, Commanche, Kiowa, Kiowa Apache, and other nations were still in the area. However, most archeological sites attributed to this period are representative of Euro-American settlement. Sites are typically represented by a wide variety of agricultural settlements and implements, bridges and fords, civic sites, artifact scatters, historic trails, cemeteries, and other materials. Sites of historic military Forts Ellsworth and Harker are located near the project area, as are a number of historic trails (Santa Fe, Chisholm, etc.) Euro-American settlement increased when Kansas achieved territorial status in 1854. Potawatomi, Kickapoo, and other

[11] "Faunal debris" refers to animal remains associated with archeological sites

Indian nations were moved to reservations and later to Oklahoma. Euro-American settlement increased dramatically following the granting of state status in 1861. Another settlement boom occurred in 1865 at the end of the Civil War. The "cowboy era" arrived during the 1870s, along with the railroad and a booming cattle business.

Recorded Sites and Types of Sites

As of August 8, 2002, there were 59 recorded archeological sites in Harvey County, 32 in Reno County, and 123 in Sedgwick County. Although helpful in determining the likelihood of finding additional sites in the area, these numbers do not provide concrete evidence.

The project area includes a variety of specific site types, including lithic quarries/collection stations, rock shelters, tipi rings, stone alignments, earthen construction, human burial areas, and rock art sites.

Lithic Quarries/Collection Stations

Little systematic excavation of quarry sites has occurred in Kansas. However, several sites have been recorded near the project area in the Flint Hills. Chert or flint outcrops in the Flint Hills were commonly used by native peoples for the manufacture of chipped stone implements. Only one of these sites has been documented on the periphery of the project area, but additional sites are possible. Four quarry sites are found near the project area in Butler County (Brown and Simmons 1987).

Rock Shelters

No rock shelter sites have been reported within the project area. Several sites have been recorded in southeast and north-central Kansas (Brown and Simmons 1987). The potential for locating sites of this type depends on the location of suitable rock outcrops, large enough to be used for shelter.

Tipi Rings, Stone Alignments, and Earthen Construction

` The location of tipi rings, stone alignments, and native inhabitant earthen construction is rare in Kansas. This is probably due to extensive farm cultivation throughout the state. These structures may have been common, before Euro-American settlement. Sites may still occur in arid or other regions less subject to cultivation.

Earthen "council circles" have been recorded in McPherson County (Paint Creek or Udden site, 14MP1) and at the Sharps Creek or Swenson site (14MP301). These sites consist of low central mounds, 20-30 meters in diameter, surrounded by a shallow ditch or series of oblong depressions. According to Brown and Simmons (1987), maximum relief of the features ranges from 44 to 88 centimeters (17.3 to 34.6 inches.)

Human Burial Areas
Areas set aside for human remains (i.e. mounds and ossuaries) are usually attributed to the Late Archaic and Ceramic periods. A number of these sites have been recorded near the project area and several of these sites have been excavated. Numerous additional instances of fragmentary human bone remains have also been recorded. There is one burial site located near the project area in Reno County (Brown and Simmons 1987). Larger burial sites tend to be associated with large village sites located along the banks of major rivers and tributaries.

Rock Art Sites
Many rock art sites have been recorded in Kansas. Most have been found along the eastern edge of the Smoky Hills region. Smaller numbers of sites have been located in the southeast corner and south-central parts of the state. Site distribution appears to coincide with the distribution of suitable rock outcrops. All recorded sites include petroglyphs (figures cut into the rock) and one site includes a pictograph (figures painted on the rock.) Nearly all the artwork is considered to be a part of the pan-Plains incised rock art tradition dating from just before European contact. No rock art sites have been recorded within the project area (Brown and Simmons 1987).

Habitation Sites
Cultural deposits at habitation sites are often linked to seasonal occupation and may include subsurface features. Evidence may include organic staining of the soil and/or the presence of a diversity of tool classes. Site size can range from moderate to extensive and may include numerous landforms. Two types of habitation sites may be found within the project area, including:

Residential Base or Village Residential bases or villages served as the hub from which foraging parties originated. Most processing, manufacturing, and maintenance activities occurred there. Village archeological sites tend to be large and contain a high density of widely varied tools and other artifacts.

Field Camp Foragers tended to set up temporary operational centers while away from the village. Individual sites have been differentiated according to the nature of the resources collected and the size of the social group supplied. Subsurface features may be present.

Lithic Scatters/Task Specific Sites These short-term occupation sites are generally related to the procurement of a limited number of locally available resources and/or the reduction of raw lithic materials (shaping stones into tools.) Subsurface features, structures, and organic staining are not generally found at these small sites. The density and diversity of cultural debris is limited. Artifacts are often restricted to task-specific tools. Lithic scatters often fall below the threshold of visibility, even with excellent survey conditions. Isolated finds may be associated with lithic scatters. These sites are often found in rugged terrain, where only a small area is suitable for habitation, such as on small benches and ridge spurs. Types of sites include preliminary food processing, lithic procurement, and/or reduction, and artifact scatter sites.

Bison Kill Sites These task-specific sites are unique enough to be treated separately. They range in size and are generally associated with favorable terrain for animal impoundments or jumps. Impoundments could be used as naturally occurring traps. They would include steep-walled ravines, draws, or arroyos and other areas where animals could become trapped or bogged down. Jump sites are generally found at the base of steep to moderately steep ravines and canyons where the herd could be driven over the edge. Most recorded kill sites are found buried in sediments. None have been recorded within the project area.

Sacred, Specialized Ceremonial, or Mortuary Sites Cemeteries, cairns, mounds, petroglyph, and pictograph sites are included in this type. They may or may not be spatially separated from habitation sites. Sacred sites are often archeologically difficult to recognize. The *Handbook of American Indian Religious Freedom* indicates that sacred sites include places where:

- ancestors arose from the earth
- the clan received its identity
- ancestors were buried
- people received revelation
- a culture hero left ritual objects for the people
- people made pilgrimages and vision quests
- gods dwelled, or where
- animals, plants, minerals, or waters with special powers were found.

Additional types of sacred sites were listed by Sundstrom (1996), which included:

- places frequented by the spirits of one's ancestors
- places where esteemed members of a group died or were buried
- places where ceremonies were held in the past, and
- places recognized as sacred by other groups.

Archeologists categorize sites as either general or specific. Sites were often associated with springs, round stones (especially in areas at some distance from streams or other water sources), fossil outcrops, or places where rock art or stone effigies were present (Sundstrom 1996).

Chapter 4: Environmental Consequences

The affected area encompasses the communities, land, water, and air-sheds that might be affected by the project. The boundaries of the affected area for each resource extend to where impacts can be reasonably measured and have meaning. Watershed boundaries are used for the analysis of hydrological conditions. For geological, soil, and cultural resources the affected area includes those parts within or in close proximity to the *footprint* impact of the project's construction sites. Human resource impacts are measured within local land divisions, typically counties because of the data sets. For environmental justice issues, zip codes are used to distinguish certain locales of interest. Boundaries for climate change have less meaning, but water basins boundaries add meaning. The term "project area" can be used interchangeably with "affected area" in the discussion in this chapter.

Direct environmental impacts (Phase IIb, III, and IV) would be limited to the immediate areas surrounding the pipeline, Surface Water Treatment Plant (SWTP), recharge basins, the Little Arkansas and Arkansas rivers, and the Equus Beds, Bentley Reserve, and Expanded Local well fields in Harvey and Sedgwick counties. Environmental impacts could include impacts to water levels in Cheney Reservoir and possible changes in spillway releases and resulting flows in the North Fork of the Ninnescah River.

Impacts (including indirect ones) are discussed for the Harvey, Sedgwick, Reno, Marion, and Kingman county region, with an affordability analysis included, for the **Preferred Alternative** (100 MGD ASR [60/40] with Federal funding) and the **No Action Alternative** (100 MGD ASR [60/40] without Federal funding.) Little or no direct or indirect impact to environmental, human, economic, or cultural resources is expected outside of the project area and surrounding counties.

Since the alternatives are identical except for their funding, the impacts would be identical also, except for "Socioeconomics" and "Environmental Justice." A *baseline* was needed to compare impacts. It was decided that this baseline would be provided by considering a **No Project Condition**, even though this condition would be impossible to obtain, as portions of the ILWSP are already being implemented.

Setting

Construction of a surface water diversion structure and intake, water pre-treatment plant, pipeline, wells, settling basins, access roads, power lines, SCADA, and other infrastructure would cause physical impacts on the landscape. As with the case of many construction projects, many of these impacts would be short-term or intermittent. These include noise and air impacts from machinery, staging areas that are disturbed while stockpiling materials, and active excavation corridors for laying pipelines and cables.

The project area covers approximately 150 square miles. Within that area an estimated 266 acres would be physically impacted on a long-term basis, including 65 acres of prime farmland (Table 4-1). Another 1,700 acres would be disturbed on a temporary basis. The project would be completed over a period of about 40 years, during which there would be alternating periods of intense construction activity and inactivity.

Geology

Construction could cause localized, permanent changes to geological resources. For example, the removal of topsoil in recharge basins would expose porous sands and conglomerates. Minor, permanent changes could occur to surficial geology due to the construction of roads, overhead power lines, runoff control features, the SWTP, a recharge basin, and other facilities. These minor impacts (either permanent or temporary) would not measurably affect natural geologic processes or project area geology. Overall, geological impacts would not be considered to be of concern.

Mitigation - Geology

No mitigation for impacts to geology is required. Construction of the surface water diversion structure, water intake, pipeline, recharge basins, well fields, SWTP, electric power lines, SCADA system, and ancillary structures would result in some disturbance to soils and prime farmlands (Table 4-1). Erosion could occur in areas where bare soil has been exposed, where water is temporarily discharged during well tests, and where wheeled or tracked vehicles are operated. Construction traffic could compact some soils.

Table 4-1 Projected Impacts to Soils and Prime Farmlands			
Alternative	**Temporary (acres)**	**Permanent (acres)**	**Prime Farmland (acres)**
100 MGD (60/40 Option) with Federal Funding	1,700	266	65
100 MGD 60/40 Option w/o Federal Funding	1,700	266	65

Sedgwick County

Approximately 82% of Sedgwick County is listed as prime farmland (SCS 1979). Wichita and its surrounding metropolitan area cover more than 10% of the county area. The total acreage to be disturbed by the project (Table 4-1) would be less than 0.01% of the total area, and more than 72% of that disturbance would be temporary in nature (trenching, equipment and materials storage, staging, soil stockpiling, temporary erosion control, etc.) Construction in the Equus Beds Well Field (northern Sedgwick and southern Harvey counties) and Local Well Field (Sedgwick County) would temporarily disturb about 900–1200 acres. The access road, and diversion and recharge well heads would permanently impact approximately 200 acres, including 40 acres of prime farmland. Expansion of the Local Well Field would temporarily disturb approximately 17 acres inside the Wichita city limits, and the well heads would permanently disturb another 10 acres. Expansion of the Local Well Field is considered to be a separate component from ASR in the ILWSP

Harvey County

Approximately 72% of the land area in Harvey County is prime farmland. As with Sedgwick County, only small areas of prime farmland would be disturbed by construction and most impact would be temporary.

Reno County

Approximately 67% of the land in Reno County is prime farmland. Most of Cheney Reservoir also lies in this county. However, actual construction is slated to occur only within northern Sedgwick and southern Harvey counties. No direct impact to prime farmlands in Reno County is expected.

Kingman County

A small part of Cheney Reservoir lies in the northeastern corner of Kingman County, but, as with Reno County, no impact to prime farmlands is expected, as no project-related construction is planned in this area. Permanent, detrimental impacts to soils in the project area are not expected.

Mitigation – Soil Disturbance

Construction would, to the extent practicable, occur along existing rights-of-way and next to, or in place of, pre-existing facilities, minimizing impact to prime farmlands and undisturbed soils. In addition, most disturbances on prime farmland would be for pipeline construction. Soil would be replaced once the pipeline is installed, resulting in only temporary impacts. The proposed SWTP is designed to use a mechanical oxidation system (hydrogen peroxide,) rather than an oxidation lagoon system. This would minimize the SWTP footprint.

Soil loss would be minimized and mitigated by implementation of erosion and sedimentation control plans. Best Management Practices (BMPs) would be used, possibly including silt fences, silt traps, sedimentation basins, and reshaping and reseeding. Water discharged during well-testing would be collected and piped to the nearest waterway to prevent local erosion. Since more than 5 acres of land would be disturbed by construction, a National Pollutant Discharge Elimination System (NPDES) permit would be required. It would be obtained from KDHE and would include a specific plan to prevent and control erosion from storm water runoff and subsequent downstream water quality degradation.

Land Use

The City, with an estimated metropolitan population of 460,000, occupies more than 10% of Sedgwick County and smaller parts of Butler and Harvey counties. A 21% increase in population (60,000 persons) is projected for Sedgwick County, including Wichita, by 2030 (GMD2 1995). This growth, along with related growth of business, industry, and infrastructure, would occur whether or not the project is implemented. Implementation would not dictate whether growth is contiguous and compact, or scattered and of low-density. Though increasing the available water supply would tend to enhance the rate of conversion of agricultural lands into residential and business developments, changes in land use would not generally be considered as substantial or adverse. Restoration of water levels in the aquifer would benefit agricultural irrigators and all other water users.

The combined land area of Sedgwick, Harvey and Reno counties is approximately 1.8 million acres, with approximately 1.28 million acres used for crop cultivation, primarily wheat and corn. Nearly all of that cultivated acreage could be considered prime farmland. Approximately another 375,000 acres are used for pasture and livestock production. The small part of Kingman County within the project area includes part of Cheney Reservoir and nearby lands. Cheney Reservoir covers approximately 9,600 surface acres and has about 67 miles of shoreline. Cheney State Park encompasses approximately 1,913 acres, while another 5,439 acres of land and 4,109 acres of water make up the Cheney Wildlife Management Area.

The Equus Beds Well Field occupies approximately 1,200 acres within Sedgwick and Harvey counties, where most of the land is made up of croplands, warm season pasture and riparian[1] woodlands. The Expanded Local Well Field covers only about 10 acres and lies completely inside the Wichita city limits.

Small areas and rights-of-way needed for permanent structures, including the surface water intake, pipeline, recharge basin, SWTP, overhead power lines, SCADA towers, wells and roadways would cause minor impacts on future land use. Most of the construction would involve pipelines, which would impact land use only temporarily. Approximately 12 miles of the new pipeline would be installed along existing pipeline right-of-way. About 29 acres would be permanently impacted by construction of the SWTP and another 200 acres changed by installation of well heads, roads, and a recharge basin.

Mitigation – Land Use

To the maximum extent practicable, all construction would replace existing structures, occur on already-disturbed land next to existing structures, or along existing roads and rights-of-way. Care would be taken to minimize the foot print whenever construction is required in riparian or other sensitive areas. Roads and rights-of-way would run parallel to or along the edges of, rather than through riparian zones, prime farmland and other sensitive ecosystems whenever possible. For these reasons, no mitigation would be necessary for changes in land use. Approximately 266 acres, including about 65 acres of prime farmland, would be permanently disturbed. The farmlands disturbed would not be available for crop production. Lands would be physically altered by the project and dedicated to other uses (roads, well sites, and recharge basins.)

Water Resources

Key concerns about water are related to changes in water levels in the Little Arkansas, Arkansas, and Ninnescah and North Fork-Ninnescah rivers, Equus Beds aquifer, and Cheney Reservoir. These changes are in turn related to concerns about water quantities (including water rights) and quality, aquatic resources, wildlife, and other topics addressed in this EIS. To have an understanding how the project would affect water resources, a hydrology model was developed and used to estimate the changes. Model results were used in estimating the effects on biological resources.

Modeling Hydrology

The Reservoir Network (RESNET) computer model was used to evaluate potential hydrologic impacts of Wichita's ILWSP (including the ASR.) Modeling required data from all aspects of the ILWSP, as impacts to surface and ground water in the area would not be mutually exclusive. Model details are found in Appendix A, but the following general data sets were used:

[1] *Riparian* – pertaining to the banks of a river or stream, and the plant and animal communities found there

- Historical mean daily stream discharge at selected points within the project area
- Historical monthly reservoir evaporation rates
- Available storage and other physical data for Cheney Reservoir
- Available storage, natural recharge and other parameters for the Equus Beds aquifer
- Wichita's current and projected water demands
- Agricultural irrigation demands in the Equus Beds Well Field area
- Minimum Kansas desirable stream flow requirements
- Supply capability and other operating parameters for all current and potential water supply sources, and
- The preferred allocation order for each water supply source.

RESNET then performed a daily simulation of reservoirs and streams as a circulating network. Impacts to ground waters were simulated. A daily water balance was calculated for ILWSP over an 85-year period (for water years 1923 – 2007.) In cases where the entire 85 years of data were not available (i.e., data from Cheney Reservoir), data were simulated using available historical data.

Three alternatives were modeled, based on date, water demand, and comparison of a project compared to no project, as follows:

- **Current** – This alternative used year 2000 average-day demand data to simulate current City water requirements, based on ASR construction through Phase I
- **No Project** – Same as "Current," except average-day raw-water demands were projected through the year 2050
- **ILWSP 100** – This alternative projected average-day demands and included development of the following components, projected through the year 2050, including:
    - The capture of 40 MGD of induced filtration surface water and 60 MGD of direct diversion surface water from the Little Arkansas River (ASR)
    - Redevelopment of the Bentley Reserve Well Field, and
    - Expansion of the Local Well Field.

The model considered both municipal and agricultural demands on the aquifer.[2] RESNET simulated aquifer operations in the same way it would a surface water reservoir. A USGS MODFLOW groundwater flow model was used to create a table used by RESNET to relate aquifer elevation, aquifer storage deficit, and aquifer gains and losses to the Arkansas and Little Arkansas rivers. Table 4-2 lists total gains and losses for the Equus Beds as a function of water

[2] Details on the development of water demands can be found in section 1.5 of Appendix A

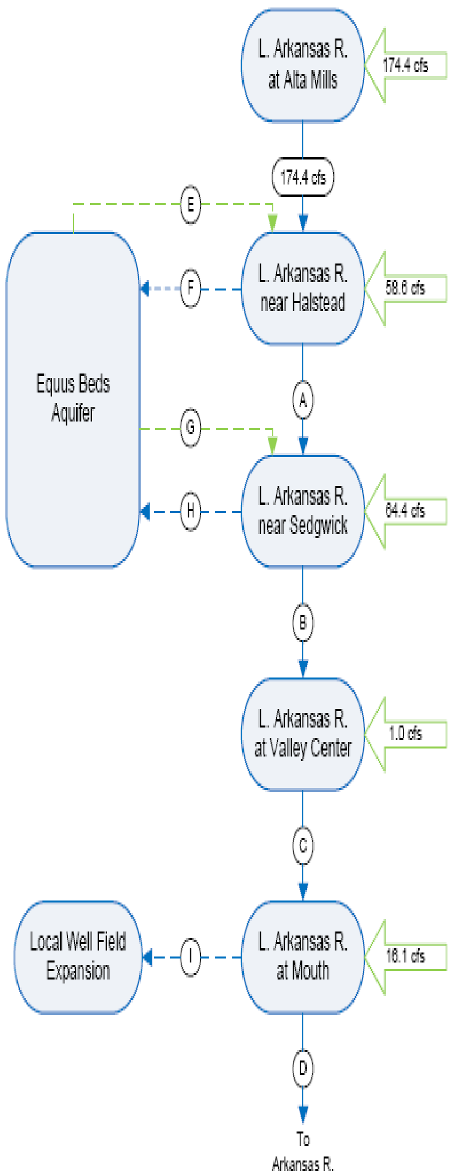
table level. The table is a product of simulated stream flux derived from the groundwater flow model and a review of the distribution of recent baseflow gains in the Arkansas and Little Arkansas rivers next to the project area. The final two columns in Table 4-2 show the resulting distribution of aquifer losses. Results indicate that the aquifer contributes water to both rivers once elevations reach 1,389 feet (storage deficit of 63,500 acre-feet.) Aquifer gains and losses were simulated to the Arkansas River near Maize, Little Arkansas River near Halstead, and the Little Arkansas River near Sedgwick.

Table 4-2 Equus Beds Storage Deficit Gains-Loss Data

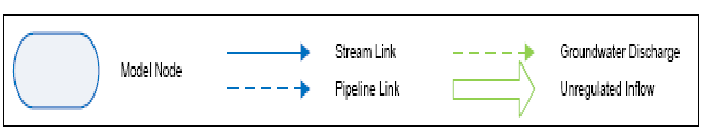
Index Well 886 Elevation (ft. NGVD[3])	Storage Deficit (acre-ft.)	Net Equus Beds Loss Rates (cfs)	
		To Arkansas River	To Little Arkansas River
1,342	429,700	-116.6	6.6
1,360	289,400	-72.8	10.8
1,366	242,700	-58.3	12.3
1,370	211,500	-50.5	12.5
1,375	172,600	-38.7	13.7
1,380	133,600	-24.1	15.1
1,385	94,700	-11.1	17.1
1,389	63,500	0.6	19.4
1,390	55,700	4.1	20.0
1,395	16,800	20.6	23.4
1,396	9,000	24.8	24.2
1,402	0	41.8	28.2

[3] NGVD = National Geodetic Vertical Datum

Water Balance for Little Arkansas River



Schematic Location	Description	Average Flow for Alternative (cfs)		
		Current	No Project	ILWSP
A	Flow in Little Arkansas River below Halstead	238.5	236.8	222.9
B	Flow in Little Arkansas River below Sedgwick	310.9	306.7	278.1
C	Flow in Little Arkansas River below Valley Center	311.9	307.7	279.2
D	Flow in Little Arkansas River at Mouth	328.0	323.8	258.1
E	Groundwater discharge from Equus Beds to Little Arkansas River above Halstead	5.4	3.7	6.0
F	Recharge to Equus Beds from diversion wells along Little Arkansas River	0.0	0.0	16.3
G	Groundwater discharge from Equus Beds to Little Arkansas River between Halstead and Sedgwick	8.0	5.5	9.1
H	Total recharge from Little Arkansas River to Equus Beds through diversion wells between Halstead and Sedgwick and surface intake near Sedgwick	0.0	0.0	18.2
I	Diversions from Little Arkansas River to Local Well Field expansion	0.0	0.0	39.2



Notes:

- Current alternative assumes no project with approximate current water demands (70.4 million gallons per day [MGD] average).
- No-project alternative is same as Current except with projected year 2050 demands (111.6 MGD average).
- ILWSP alternative assumed year 2050 water demands with 100-MGD diversion system from Little Arkansas River for recharge of Equus Beds aquifer.
- All stated values are average flows, in cubic feet per second, over the entire 85-year simulation period (10/1/1922-9/30/2007).
- Flows may not balance exactly because of rounding.

Figure 4-1 Water Balance for the Little Arkansas River

Surface Water Resources

Principal streams in the project area include the Arkansas, Little Arkansas, Ninnescah and the North Fork of the Ninnescah. Both the Little Arkansas and Ninnescah are tributaries of the Arkansas River. Cheney Reservoir lies on the North Fork of the Ninnescah and stores water for the support of fish and wildlife, recreation, and drinking water supply.

Zebra mussels (*Dreissena polymorpha*), originally thought to originate in the Black or Caspian seas of Europe, are confirmed invaders of Cheney Reservoir (Jeffrey Tompkins, pers. comm. 5/30/2008) as well as El Dorado and Marion reservoirs. These fingernail-sized, rapidly reproducing mollusks have created serious, economically devastating problems in water supply systems around the country by clogging up intakes, filters, pumps, etc. There are no known effective predators of this species in America, and no known means of extermination. This leaves expensive chemical application along with labor-intensive manual removal of infestations in water systems as the only, temporary treatment options. The presence of this species could impact the City's future reliance on public water supplies from the reservoir.

Cyanobacteria (*Anabaena*) blooms occasionally cause severe taste and odor problems in Cheney Reservoir. The USGS monitors environmental variables such as light, temperature, conductivity, and turbidity to predict blooms, which can impact use of reservoir water for drinking water.

Minimum desirable stream flows (MDS) established by the Kansas Department of Health and Environment (KDHE) for locations within the Little Arkansas River are found in Table 3-2. Minimum allowable flows were established primarily for the purpose of protecting irrigation water rights, but also to protect vegetation, fish, and wildlife. The Kansas Department of Wildlife and Parks (KDWP) prefers higher flows, especially during spawning seasons, to protect aquatic life (60 cfs from May through June, 34 cfs during the remaining months.) No minimum desirable stream flow standards have been formally established for the protection of spawning aquatic species (Eric Johnson, personal communication, May 19, 2008). Impacts to "Surface Water Resources" are specified below under "Surface Water Levels" and "Surface Water Quality."

Surface Water Levels

Impacts to water surface elevations and flow depths would closely mirror changes in flow. Therefore, flow and elevation are considered together in this section.

Little Arkansas River

Halstead

The project should result in approximately 3 cfs increase in median flow at Halstead for ten months each year by 2050. However, median flows from May through June (typically high flow months) should decrease up to 12 cfs. Should the project not be completed, median flows would be expected to range from about 26 cfs in October to a high of 90 cfs in June. This compares to 28 - 78

Figure 4-2 Little Arkansas River near Halstead

cfs with the project. Average daily flows at Halstead (in Harvey County) above 1,000 cfs would occur approximately 4% of the time, with or without the project, and average daily flows above 300 cfs would occur about 10% of the time, in comparison to 11% without the project. Changes in the flow regime due to diversion would be more apparent during flows between 80 and 200 cfs (Figure 4-3.)

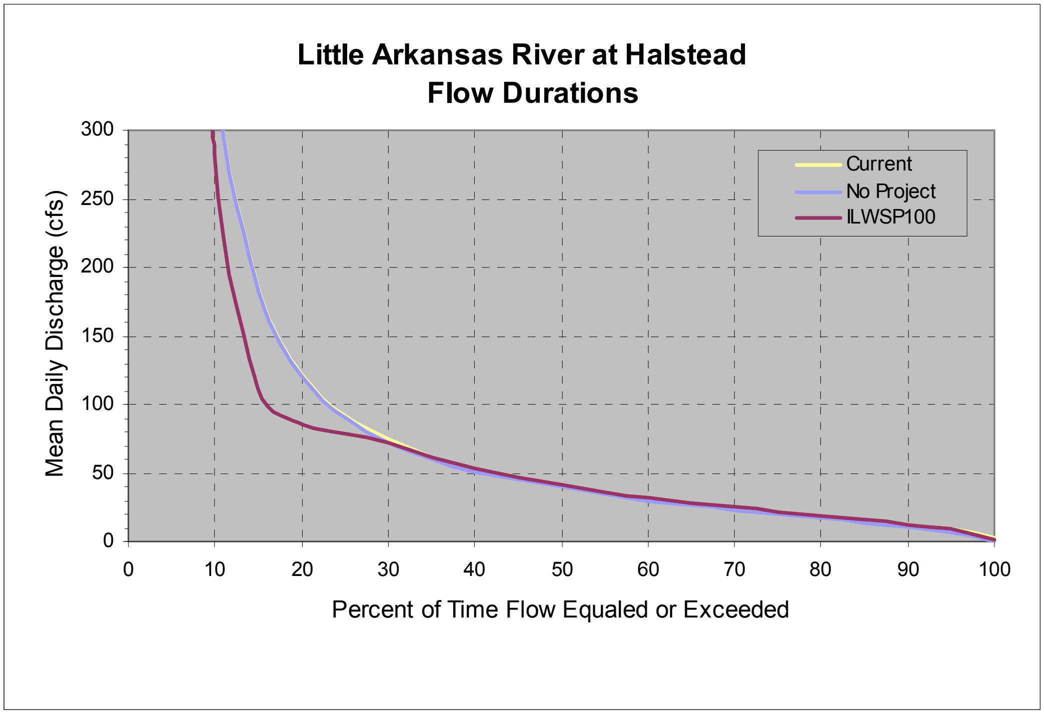


Figure 4-3 Flow durations for the Little Arkansas River at Halstead

Sedgwick

Median flows at Sedgwick should increase about 2-6 cfs from July through April, but decrease by 15-35 cfs during May and June. Monthly median flows for these two months are currently about 94 and 117 cfs, respectively. Based on these results, base flows would increase and median monthly flows would continue to exceed the lower limit recommendations from KDHE and KDWP (Table 4-3). Greater median flows during low-flow periods should benefit both riparian and aquatic habitats, including vegetation, fish, and wildlife. The predicted increase would be due to additional groundwater recharge of the stream resulting from rising aquifer levels. Water would be diverted from the river more frequently and at higher rates during May and June when flows are typically the highest. Changes in the flow regime due to diversion would be more apparent during flows between 80 and 300 cfs (see Figure 4-4.)

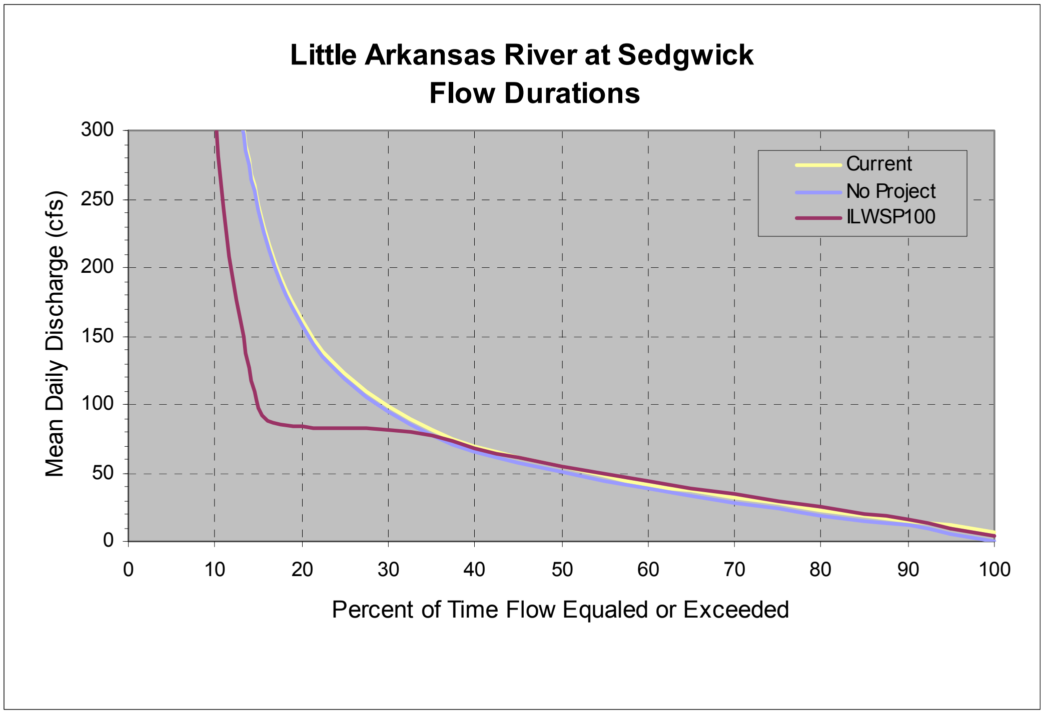


Figure 4-4 Flow durations for the Little Arkansas River at Sedgwick

Valley Center

The project should result in median flow increases of 6-7 cfs at Valley Center (in Sedgwick County) during all months except May and June. Flows would decrease by about 16-36 cfs during this two-month period. Average daily flows over 1,000 cfs would still occur approximately 5% of the time, and average daily flows above 300 cfs would continue approximately 10% of the time. Since these larger, high energy flows would change little and high energy flows have the most influence on stream morphology,[4] load transport,[5] and often on aquatic species reproduction, impacts to these natural processes should be minimal. Kansas established a year-round MDS of 20 cfs at this location. All simulated median monthly flows with the project would exceed the MDS (Figure 4-5). Project implementation would increase the probability of stream flows exceeding the Kansas MDS (78-92%), as compared to conditions without the project (68-92%.) The KDWP has no official, current MDS recommendations for protection of habitat but has indicated in the past that it would prefer minimum flow values at this site of 60 cfs in April, May, and June, when many species reproduce. KDWP recommends minimum flows of 34 cfs for the remaining months. Again, project implementation should result in greater frequency in meeting KDWP flow recommendations (56-77% with project compared to 51-74% without project.)

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[4] Stream morphology is the field of science dealing with changes of stream form and cross-section due to sedimentation and erosion processes

[5] High energy flows can pick up and carry much more sediment, debris and other particles than lower energy flows

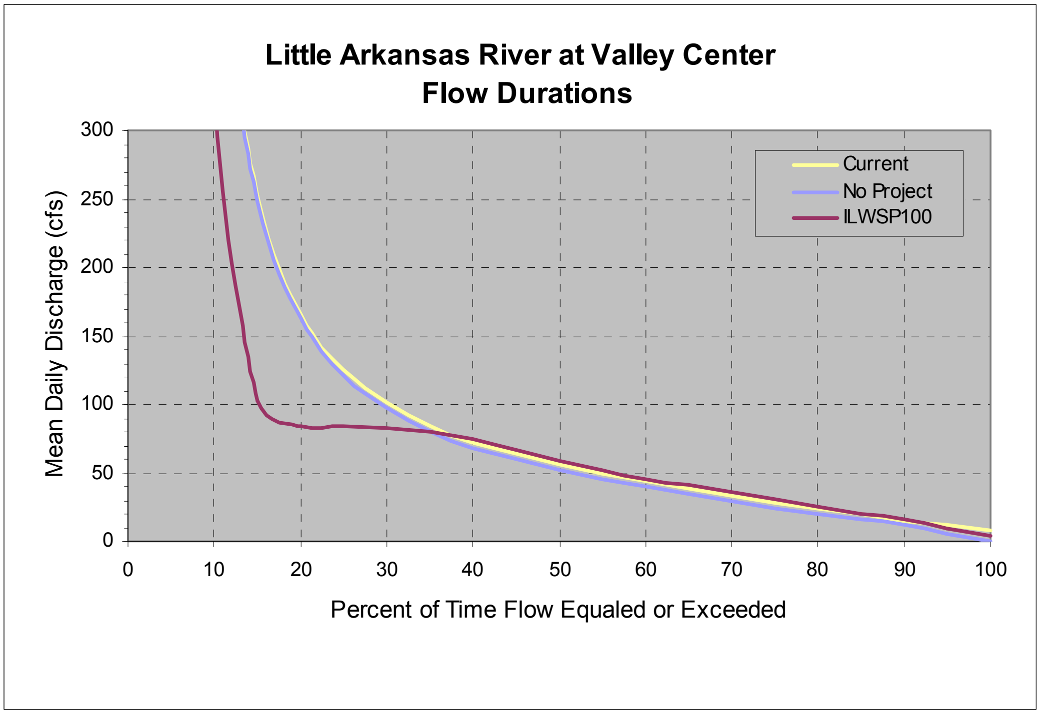

Figure 4-5 Flow durations for the Little Arkansas River at Valley Center

Project-related increases in *base flow* in the Little Arkansas at Valley Center should eventually raise flow elevations in the river about 0.05 feet during most months. Slight declines in elevation from April through June would be likely (as stated above) when diversions would be highest. These greater diversions for aquifer recharge could lower water levels by as much as 0.2 feet (2.4 inches) about 25% of the time. Data on the number of days per year (1995-2005) when base flow was exceeded are provided in Table 4-3. Modeled monthly base flow summaries are charted in Appendix A.

Table 4-3 Number of Days per Year when Base Flows were exceeded (2005 Permit Requirements)*

	Year										
Little Arkansas River @	1995	1996	1997	1998	1999	2000	2001	2001	2003	2004	2005
Halstead	114	130	270	199	349	228	168	99	151	151	144
Sedgwick	210	180	318	301	365	290	226	143	218	258	239

** Based on USGS recorded flows*

No diversions would occur during low flows and changes to flow during moderate periods would impact aquatic ecosystems less than changes during high or low "outlier" flows. Negative impacts resulting from surface diversions would be partially offset by the benefits of increased *base flow*. Changes in the flow regime due to diversion would be more apparent during flows between 80 and 300 cfs (Figure 4-5.)

Little Arkansas at Mouth

The most pronounced flow changes would occur just upstream of the confluence of the Little Arkansas with the Arkansas River in Wichita. The Expanded Local Well Field (not part of the project) could divert up to 45 MGD (70 cfs) from the Little Arkansas River in this area. Again, no diversions would occur when river flows fall below 20 cfs, the MDS established by KDHE. However, pumping from

Figure 4-6 Little Arkansas flows into the Arkansas River at Wichita

the Expanded Local Well Field and from upstream would typically cause monthly, median flows at the mouth to drop to about 20 cfs. Water would be diverted from diversion (infiltration) wells approximately 90% of the time, or for all flows above the MDS. Median monthly flows currently range from about 17-106 cfs. Simulated daily flow durations indicate that discharge to the Arkansas River from this location would decrease markedly about 80% of the time. The Expanded Local Well Field lies between the Arkansas and Little Arkansas rivers, near their confluence in an urban, extensively developed area. Natural habitat within the City has been reduced by floodway diversions, multiple low-head dams, bulkheads, and other channel modifications. Most of the river banks through downtown have been rip-rapped, built upon, or otherwise modified. (Figure 4-6.) There is a low-head dam at the mouth of the Little Arkansas, a second dam about 500 meters upstream, and additional dams constructed upstream from there. As a result, water flows from pool to pool and water elevation in this short stream segment would be maintained, despite the drop in median flow. Likewise, periodic high and flood flows would not be expected to decrease in frequency. These flows would effectively maintain the scour and build effects needed to maintain sandbars and other riverine habitat. As a result, changes resulting from the project should not cumulatively impact natural habitats.

During periods of maximum diversion, flows and water levels would drop, but the amount of drop would be limited by the MDS and by the low-head dams (Figure 4-7.) Project facilities would continue to be developed through the year 2050 (Phase IV), which would assure incremental change in streamflow. Extended implementation would also result in incremental increases in *base flow* as the aquifer level increases. The rate at which the Equus Beds is recharged would depend on climatic conditions and the rate at which construction is completed.

Mitigation – Little Arkansas River, Surface Water Levels
Regaining the natural operating balance between the aquifer and the Little Arkansas River is one of the primary objectives of the project. Overall median flows would decrease, as more water would be diverted from the river when flows reach or exceed moderate levels. However, *base flows* would be protected and likely increased. Significant flow reductions would occur only in the short, pooled reach near the mouth of the stream, primarily during periods of moderate flow. Low-head dams and other modifications to both stream and banks have resulted in an urban, rather than a natural environment near the confluence. Water is pooled in this area, maintaining relatively stable water levels, rather than flowing naturally through. Mitigation for any changes in water surface level or flow is not necessary in this locale.

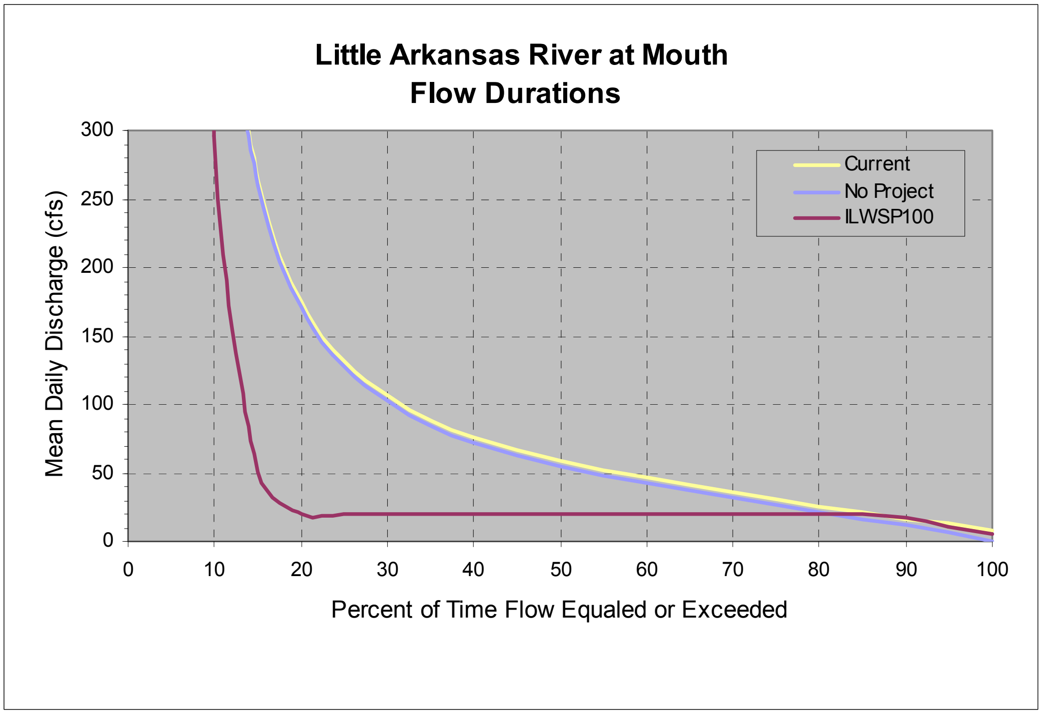

Figure 4-7   Flow durations for the Little Arkansas River at the mouth

Arkansas River

Wichita

The nearest USGS gauging station in the Arkansas River downstream from the Little Arkansas and the project area is approximately 3.7 miles below the confluence with the Little Arkansas. Flows at this site are influenced by groundwater discharges to the Little Arkansas and by withdrawals from both the Arkansas River upstream and from the Little Arkansas. These discharges and diversions include:

- Induced infiltration from the Arkansas River resulting from redevelopment of the Bentley Reserve Well Field
- Induced infiltration from the Little Arkansas and Arkansas rivers resulting from operation of the Expanded Local Well Field
- Diversions from the Little Arkansas for recharge of the Equus Beds aquifer (the Aquifer Storage and Recharge Phases of the ILWSP)
- Changes in the amount of groundwater discharge from the Equus Beds to the Little Arkansas and Arkansas rivers
- Upstream irrigation and water rights withdrawals from the Little Arkansas and Arkansas rivers.

Figure 4-8 Arkansas River downstream from confluence with Little Arkansas

Median monthly flows below the confluence with the Little Arkansas River currently range from about 206 to 765 cfs. During these typically higher flows, impacts from diversions upstream or in the Little Arkansas would be largely buffered. The net or overall effect would be reduced. Simulated flow duration curves indicate that during low flow periods, project flows would be slightly higher than those predicted without the project. Conversely, the project would result in slightly reduced flows during higher flow periods. Overall, water surface elevations with the project would be expected to vary less than 0.1 feet (1.2 inches) from those without the project. Estimated flow durations are estimated in Figure 4-9.

Modeled monthly base flow summaries are charted in Appendix A. Flows in the Arkansas River near the mouth of the Little Arkansas should be minor, as the Little Arkansas contributes only a small part of the total river flow. Impacts to sediment load transport and channel morphology would also be considered minor, as these processes occur primarily during high and flood flows. The percent of time that flows exceed 1500 cfs should drop slightly, from about 14% to 13%, with the project.

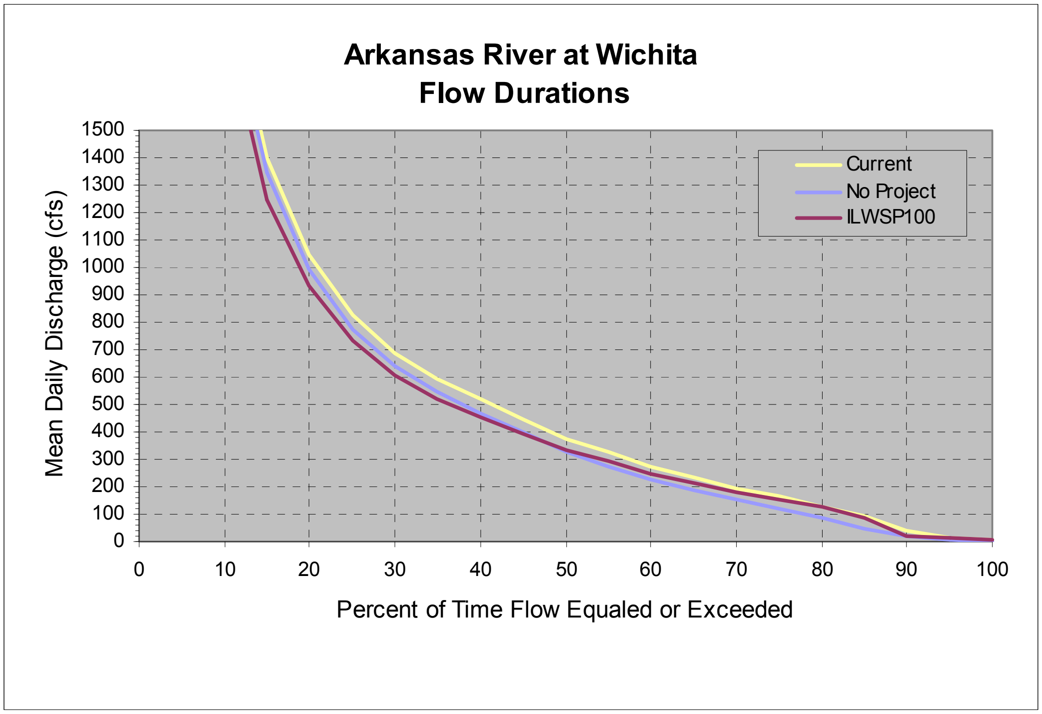

Figure 4-9 Flow durations for the Arkansas River at Wichita

Arkansas City

The USGS gauging station on the Arkansas River at Arkansas City lies about 24 miles downstream from the confluence with the Ninnescah, near the Kansas-Oklahoma state line. Discharge at this site would reflect net downstream impacts from the ILWSP (including the project) as it lies below both the confluence of the Arkansas with the Little Arkansas and with the Ninnescah. Due to the distance downstream and the relatively small predicted changes to overall flow, no adverse impacts on water resources are expected. Simulated median monthly flows suggest that peak flows in June could be 36 cfs less with the project than without it. That would be equal to about a 2% reduction in median flow. Annual median flows would drop by only about 1.2 cfs or about 0.15%. Estimated flow frequencies are provided in Figure 4-10.

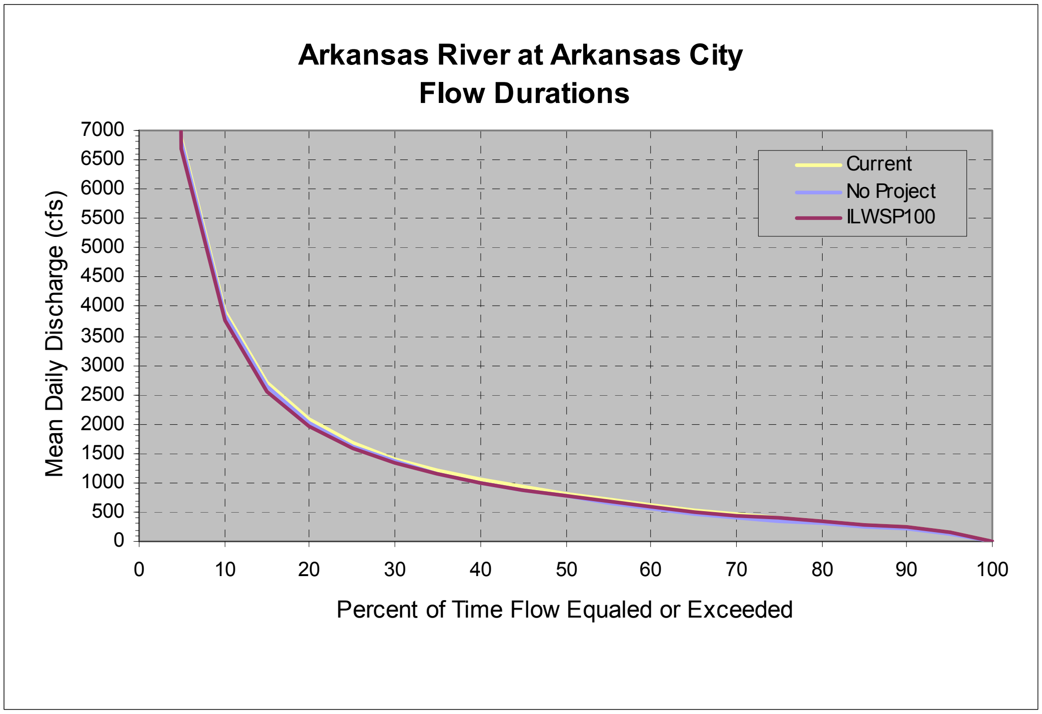

Figure 4-10 Simulated flow durations on the Arkansas River at Arkansas City

Mitigation – Arkansas River, Surface Water Levels
Changes in flow in the Arkansas River downstream from the project area considered to be inconsequential. As a result, net impacts to the river and ecosystem would likely be immeasurable. No mitigation would be necessary.

Cheney Reservoir

The project should result in more City reliance upon water from the Equus Beds and less dependence upon water from Cheney Reservoir. Increased use of the Expanded Local and Bentley Reserve Well fields (through the ILWSP) would also reduce the City's reliance on the reservoir. RESNET modeling predicts that increased use of Equus Beds water would result in a 1.5 to 3.0 foot overall increase in pool elevation at Cheney (Figure 4-11.) Should the project not be completed, municipal demands on Cheney during drought periods could deplete the usable water supply. Since Reclamation would not be assuming ownership of the project, the contract between them and the City would not be affected in the long-term.

Mitigation – Cheney Reservoir, Surface Water Levels
No mitigation would be necessary.

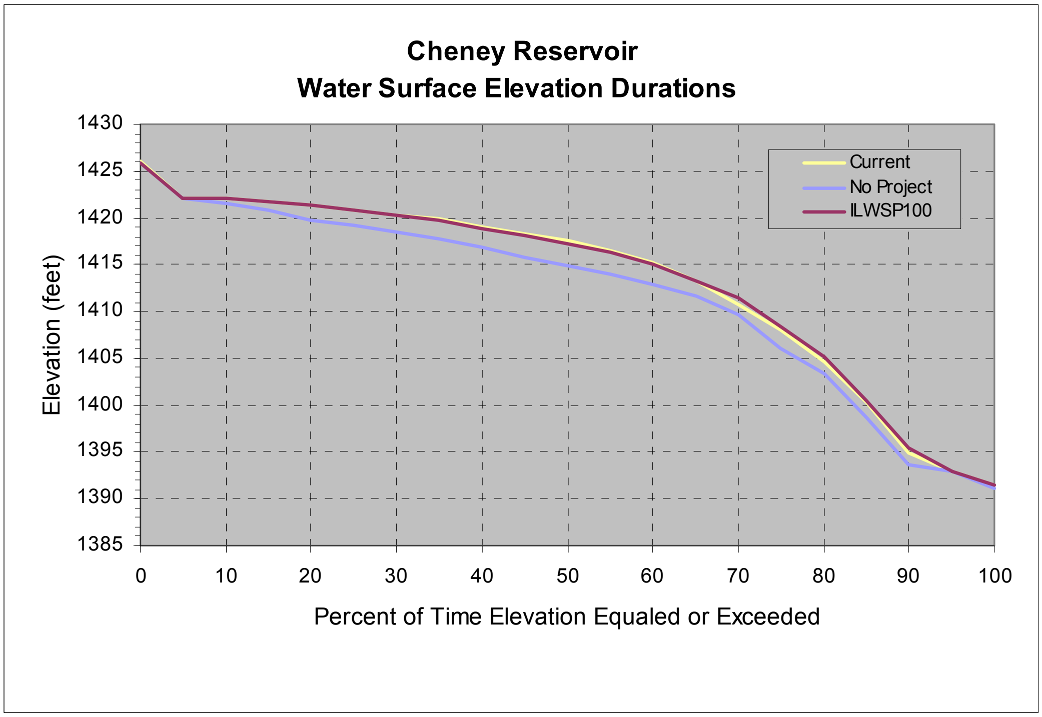

Figure 4-11 Surface water elevations for Cheney Reservoir

North Fork of the Ninnescah River

There are no minimum release requirements for Cheney Reservoir. Releases generally occur only after significant runoff events and when the conservation pool is full (elevation 1421.6 feet). Releases and spills from the reservoir into the North Fork would likely decrease without the project, as Wichita would be forced to take more water from conservation storage. The project should result in lower municipal demand on the reservoir, and thus higher average water levels in the reservoir. This could result in an increase in the number and volume of water releases from the dam (Figures 4-12 and 4-13), resulting in similarly modest, higher average flows in the river. Higher water levels should benefit water rights holders as well as both aquatic and riparian communities downstream.

Mitigation – North Fork of the Ninnescah River, Surface Water Levels
No mitigation would be necessary.

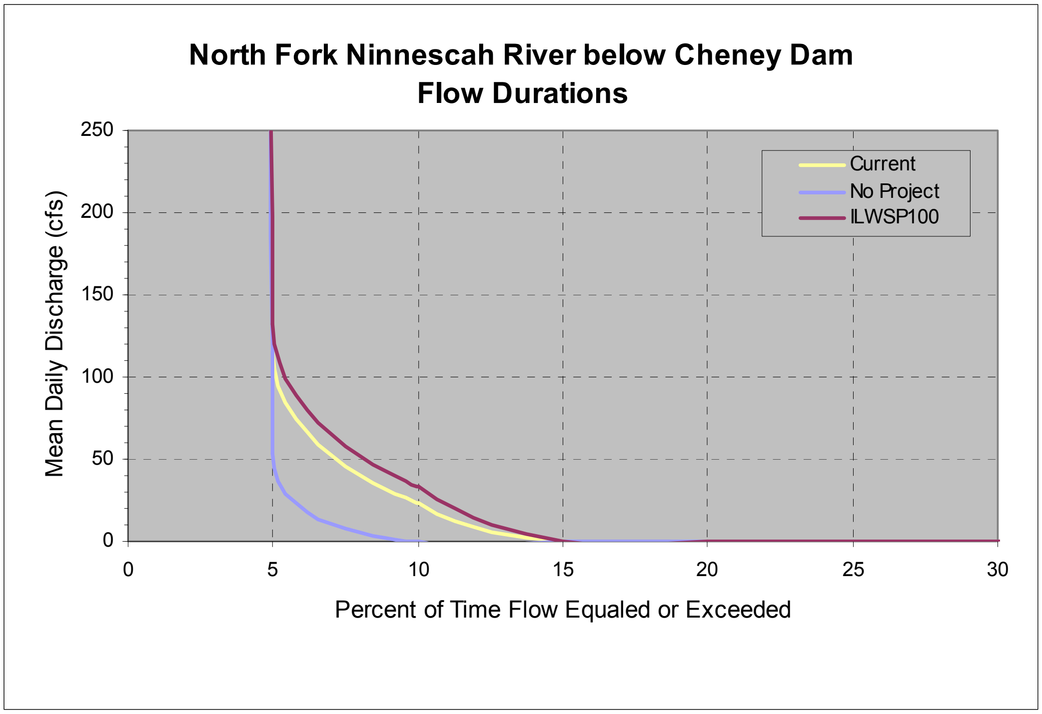

Figure 4-12 Flow durations for North Fork Ninnescah below Cheney Dam

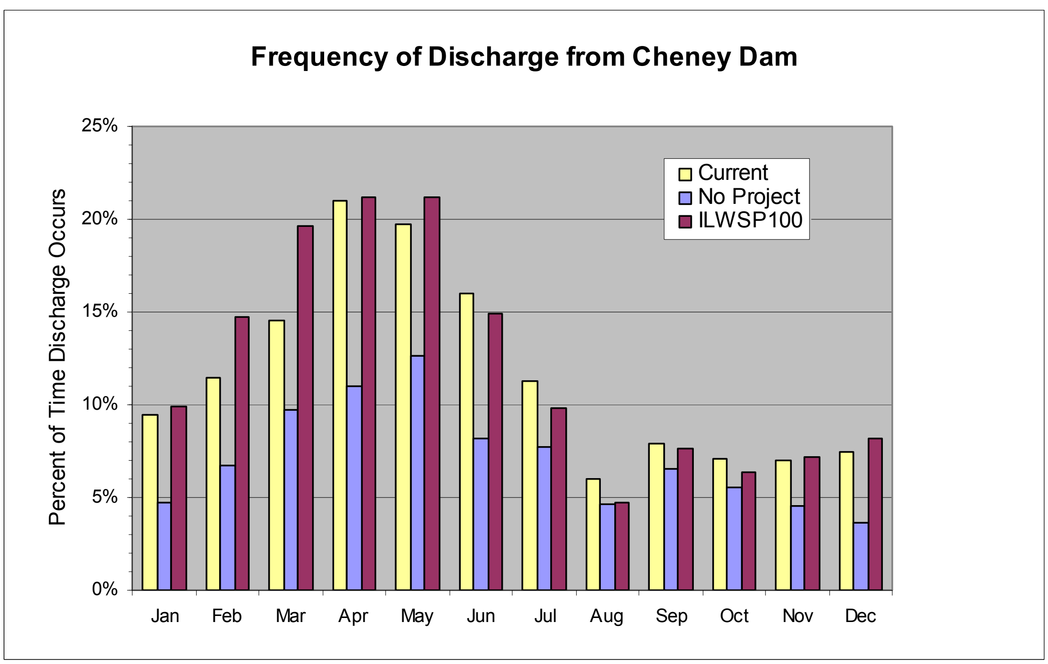

Figure 4-13 Discharge frequency from Cheney Dam

Ninnescah River near Peck

Simulated project impacts to the Ninnescah River below its confluence with the North Fork would be insignificant compared to total stream discharge. Spills from Cheney Reservoir make up only a tiny part of total streamflow. The project could result in overall flow increases of up to 9 cfs in comparison to no project (Figure 4-14).

The established MDSs at this location based on month are:

- 100 cfs from November through May
- 70 cfs in June
- 30 cfs from July through September, and
- 50 cfs in October.

The percentage of time that MDS values could be met would vary slightly, whether or not the project is implemented.

Mitigation – Ninnescah River near Peck, Surface Water Levels
No mitigation is necessary.

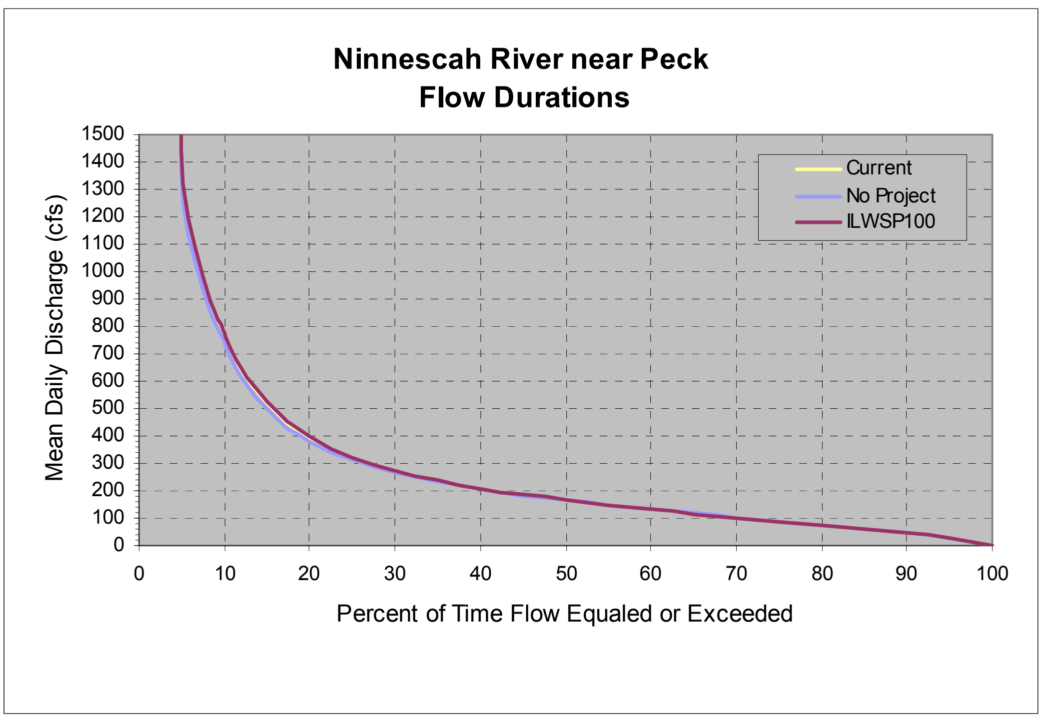

Figure 4-14 Flow durations in the Ninnescah River near Peck

Surface Water Quality

A variety of factors influence water quality in and around the project area, including season, amount of sunlight or shade, flow rate, water depth, precipitation, temperature, aquatic/riparian community health, and agricultural, industrial and domestic activities. Given these factors, surface water quality can vary considerably with both time and location. The project would impact some of these contributing factors, water depth and flow rate, for example, but this impact should be minimal. In addition, eventual higher quality groundwater discharges contributing to *base flow* should improve water quality in the Little Arkansas, which discharges to the Arkansas River.

Little Arkansas River

KDHE includes Little Arkansas River segments 1 (headwaters[6]) and 14 (upstream of the confluence with the Arkansas River in Wichita) on its list of streams with water quality impairments. The constituents of concern for segment 14 (project area) include chlordane, dissolved oxygen, oxygen demand, nutrients, and sediments (KDHE 2001). Atrazine levels in water may be elevated during the spring and summer when most herbicides are applied. Identification of seasonal trends is important because high stream flows, which tend to be seasonal, have a substantial effect on chemical loads (Christensen *et al*. 2000). Chemical concentrations are often reduced during periods of high flow, while sediment and solids loads increase.

In general, the Little Arkansas is a "gaining" stream within the project area, as indicated by higher water levels in the surrounding aquifer than in the stream (Myers *et al.* 1996; Aucott *et al*. 1998). Gaining streams are partially replenished from groundwater sources. A relatively large amount of local annual precipitation (approximately 20%) recharges the Equus Beds aquifer and moves down gradient. Percolation through sands and soils removes some contaminants, resulting in higher quality water in the aquifer than on the surface. Groundwater not intercepted by pumping ultimately discharges to the Little Arkansas and lower reaches of the Arkansas River. The single exception along the Little Arkansas is near Halstead, where a small dam causes higher surface water elevations upstream than in the aquifer, resulting in a reverse flow (the stream recharges the aquifer.)

The quality of water in the aquifer can often exceed that of the river. Seasonal environmental fluctuations, evaporation rates, changes in human or livestock activities, flow rates and groundwater levels can directly impact surface waters. Therefore, surface water quality can be beneficially impacted by groundwater discharges. Injecting pre-treated water into the aquifer, or allowing it to infiltrate through sands from recharge basins should increase aquifer storage. It should also raise water table levels, limit salt water intrusion, limit evaporation, and help enhance water quality. In addition, pre-treating water to reduce atrazine has been

[6] Headwaters refer to waters located near the origin or beginning of a stream

shown to effectively reduce concentrations to near-baseline levels (Ziegler *et al*. 1999). Simply diverting water through a diversion well located next to the stream removed about 75% of the atrazine, probably through sorption to aquifer sediment (Schmidt *et al.* 2007). This filtration process also removed or reduced the concentration of other potential contaminants (that is, chlorides, suspended solids, bacteria, etc.) Some suspended solids filter out as water flows through the stream bottom to bank storage wells. These solids tend to re-suspend in the stream during high flows, which temporarily increases suspended solids concentrations in the water column. Suspended sediments are scoured from the bottom during high flow events anyway, so little additional impact would be expected.

The overall effect would be increased gain of higher quality water in the Little Arkansas from Equus Beds discharges. Provided that polluting influences remain the same, long-term improvements in Little Arkansas River water quality would be expected.

Mitigation – Little Arkansas River, Water Quality
The project is intended to improve long-term water quality in the Little Arkansas River. No mitigation is necessary.

Arkansas River

Water quality impacts to the Arkansas River should result primarily from changes in the quantity and quality of water received from the Little Arkansas. While diversions from the Little Arkansas would occur only when flows are above *base flow*, these diversions would nevertheless reduce the quantity of better quality water available for dilution of the saltier Arkansas River. This impact would be somewhat reduced once the aquifer elevation exceeds 1389 ft. Flow simulations indicate that the Equus Beds would then start contributing to *base flow* in the Arkansas as well as the Little Arkansas. Water entering the stream from the aquifer would be of generally higher quality, but of insufficient quantity to measurably improve mainstem water quality.

Long-term impacts to the Arkansas River downstream of the confluence with the Little Arkansas should result in an overall average decrease in flow of about 2%. Improvements in the quality of Little Arkansas discharges and to Arkansas River recharge from a rising aquifer should partially mitigate this minor reduction in flow. Total dissolved solids (TDS), total suspended sediment (TSS), and chloride concentrations would likely increase slightly in the mainstem. Such increases would be expected to be insignificant.

Mitigation – Arkansas River, Water Quality
Predicted changes in water quality in the Arkansas River are less discernable in comparison to the water quality improvements expected in the Equus Beds and Little Arkansas River. No changes in designated stream uses would result, as salinity of the Arkansas River is periodically too high for use as an irrigation or drinking water source. No mitigation is necessary.

Cheney Reservoir

Cheney Reservoir lies on the North Fork of the Ninnescah River, which is outside the immediate construction area. No direct impact on reservoir water quality would be expected. As aquifer levels rise and groundwater quality improves, more drinking water should be diverted from the Equus Beds aquifer and less from the reservoir, resulting in higher reservoir water levels (provided there are no significant changes in local climate or other surface water uses.) Rising water levels would be expected to have neutral to positive effects on water quality.

Mitigation – Cheney Reservoir, Water Quality
Water quality impacts of higher water levels in Cheney Reservoir are not known at this time, but should not cause any degradation of water quality. Mitigation is not necessary.

North Fork of the Ninnescah River

Increased releases from Cheney Reservoir due to the project should provide a net, positive benefit to water quality in the North Fork of the Ninnescah River and to nearby riparian zones. Increased flows should increase dissolved oxygen levels for support of fish and wildlife and provide additional water to local ecosystems and water rights holders.

Mitigation – North Fork of the Ninnescah River, Water Quality
No mitigation is necessary.

Surface Water Rights

Little Arkansas River

The City would not divert water from the Little Arkansas River unless flow exceeds MDS requirements (20 cfs during the winter and 57 cfs during irrigation season) at Halstead. No additional water rights would be needed by the City. There should be no impact to existing water rights.

Mitigation – Little Arkansas River, Surface Water Rights
No mitigation is necessary.

Arkansas River

Flows in the Arkansas River downstream from the confluence with the Little Arkansas would decrease slightly with the project, especially during periods of moderate to high flow. The KDA lists only one water rights permit (industrial) within the City on the Arkansas below the confluence with the Little Arkansas. State records indicate that this diversion is not currently active (KGS 2008). The next diversion point is located more than 11 miles downstream, near the city of Derby.

Mitigation – Arkansas River, Surface Water Rights
The modest decrease in flow during high energy river flows, when plenty of water is available, would not impact existing surface water rights. No mitigation is necessary.

Cheney Reservoir

The project should make more water available for withdrawal from the Equus Beds. This should ultimately result in less reliance by the City upon waters diverted from Cheney Reservoir. Reservoir water rights holders would benefit.

Mitigation – Surface Water Rights in Cheney Reservoir
No mitigation is necessary.

North Fork of the Ninnescah River

The project would result in decreased City dependence upon water diverted from Cheney Reservoir. As a result, more water should be available for release from Cheney Dam, benefiting downstream water rights holders.

Mitigation – North Fork of the Ninnescah River, Surface Water Rights
No mitigation is necessary.

Groundwater Resources

The Equus Beds is an important source of municipal, industrial, irrigation, domestic and livestock water. There are 1,620 non-domestic wells withdrawing an average of 157,000 acre-feet (51.2 billion gallons) of water from the aquifer each year. Industrial use comprises approximately 15% of the total, while irrigation takes another 50% and municipalities use 34%. All other uses account for about 1% (GMD2 1995). The Kansas legislature created GMD2 in 1972 to manage and protect the heavily used aquifer. Once representatives were selected and the district boundaries approved in 1974, management of the Equus Beds was based on two fundamental principles: 1) the Aquifer Safe-Yield Principle, which limits withdrawals to annual recharge, and 2) the Groundwater Quality Principle, which seeks to maintain naturally occurring water quality.

Groundwater Levels

The City, irrigators, and others would continue to rely on the Equus Beds as a prime water source, with or without the project. Should the project not be developed, continuing over-allocation of water rights would result in further water level drops in the aquifer. Water quality would continue to degrade also, as more high-chloride Arkansas River water and brines from salt-mining and oil field production would seep into and spread in the aquifer.

In general, the project would increase the volume of water stored within the Equus Beds. Increasing storage would result in a corresponding increase in aquifer elevation. The rate at which the Equus Beds could be recharged after a drought would improve dramatically. Due to changing climatic conditions, it is not possible to accurately estimate the time needed to replenish current storage deficits; however, both the 100 MGD ASR (60/40) Preferred and No Action (partial Federal financing versus 100% local financing) alternatives should result in an estimated net recharge rate of 12,700 acre-feet/year (Burns &McDonnell 2003.) With a current deficit of 250,000 acre-feet, initial replenishment should take an estimated 21 years, given the current information on precipitation, temperature, and water use. Once the aquifer is replenished, modeling suggests that water storage could be maintained within 100,000 acre-feet of pre-aquifer development conditions.

The USGS studied groundwater level impacts at artificial recharge sites near Halstead and Sedgwick during 1997-98 (Ziegler *et al.* 1999). River levels near Halstead were nearly always higher than water levels in the adjacent aquifer, due to a downstream, low-head dam. This indicated that, contrary to other segments of the Little Arkansas, the segment running through Halstead tends to recharge the aquifer. In addition, approximately 307 million gallons of water were artificially recharged through a well at the Halstead site. Water levels in shallow monitoring wells showed little or no change, while water levels in deep wells rose during extended periods of artificial recharge. Water levels receded once artificial recharge stopped, most likely due to distribution of locally recharged water throughout a wider area within the aquifer. Regardless, these notable changes in water level in the deep wells verified that artificial recharge rates were sufficient to benefit the aquifer.

Only approximately 37 million gallons of water were artificially recharged at the Sedgwick site. The entire recharge was done through recharge basins rather than through recharge recovery wells. All four monitoring wells showed increases in water levels while recharge was occurring, but when recharge ceased, water levels dropped within two months.

The volume of water recharged at either site during the study was inadequate to accurately predict long-term water level impacts. The spread of recharge waters throughout the aquifer over time and distance (moving away from the recharge point) likely limited the ability to monitor long-term effects over such a short time period. However, RESNET modeling indicates that raising the water table would increase hydraulic gradients from the aquifer to the Little Arkansas River. This would result in an increase in river *base flows*. Raising the water table would also result in a general reduction of hydraulic gradients from the Arkansas River to the aquifer, resulting in decreased infiltration of river water with higher chloride concentrations. RESNET predicts an overall, potential decrease of about 50 cfs by 2050, should the project be fully implemented. In addition, once aquifer levels reach 1389 feet, the aquifer could begin recharging the Arkansas, though volumes would be too small to impact overall water quality in the river. Discharge from the aquifer to the smaller Little Arkansas would be expected to increase by 4 cfs or greater.

Mitigation – Groundwater Levels
One of the primary purposes of the project is to increase water levels in the aquifer to more natural levels. This should help protect against saltwater intrusion and increase groundwater gains to both the Little Arkansas and Arkansas rivers. More ground water would be protected from evaporation and become available for agricultural, municipal and industrial use. No mitigation for rising groundwater levels is necessary.

Groundwater Quality

Water quality in the aquifer varies considerably, depending upon which geologic formation the water comes from. Water tends to become more mineralized with depth (Burns & McDonnell 2003). Total dissolved solids (TDS) content ranges from 300 mg/l to 2,700 mg/l. Oil field brine (saltwater) contamination has made some groundwater unsuitable for use in parts of western Harvey County. Chloride concentrations in contaminated areas range from 500 mg/l to 8,000 mg/l. Before saltwater contamination, chloride concentrations were less than 150 mg/l (GMD2 1995). The EPA Secondary Maximum Contaminant Level (SMCL) is 250 mg/l.

The project should provide some water quality relief in both shallow and deeper areas. This would be accomplished by:

1) injecting relatively high quality water from the Little Arkansas River during high flows
2) reducing the hydraulic gradient between the Arkansas River and the aquifer, thereby reducing infiltration rates of high chloride water, and
3) inserting freshwater between salty and higher quality water areas.

Salinity increase in the aquifer is undesirable and is a key water management issue. Adding freshwater is expected to dilute high chloride waters and help impede the rate of water quality degradation by changing the hydraulic gradient.

The USGS collected more than 4,000 water samples from the Little Arkansas River, diverted source water, and monitoring wells near the recharge areas between 1995 and 2000. Researchers found four possible contaminants of concern (COCs). COCs are defined as contaminants with concentrations greater than 20% of drinking water standards (Ziegler *et al*. 2001). COCs in the Equus Beds include chloride, arsenic, total coliform bacteria, and atrazine. Data indicate that mixing shallow groundwater near the stream with surface water dilutes overall concentrations of atrazine. Powder Activated Carbon (PAC) could be used to remove additional amounts during primary herbicide application season (May through June).

The USGS used chloride as a tracer during artificial recharge studies from 1995 through 2004. Researchers noted that Total Organic Carbon (TOC) concentrations from water taken from shallow monitoring wells alongside the Little Arkansas River near Halstead were diluted by 20% compared to water collected directly from the river. Diverting stream water through a diversion well at Halstead removed approximately 75% of the atrazine and diluted other chemical concentrations as well (Schmidt *et al.* 2007). Clay, organic matter, and other particles in the soil appeared to filter out many constituents. These results demonstrated potentially effective bank water collection and filtration which could enhance water quality protection of the alluvial aquifer.

Schmidt, *et al.* (2007) examined the geochemical effects of induced stream-water recharge on the Equus Beds during a pilot demonstration project from April 1995 through May 2002. The authors concluded that water level declines in the aquifer may accelerate migration of saltwater from both the Burrton oil field and the Arkansas River. Data indicated that water levels and chemistry in the shallow part of the aquifer next to the Little Arkansas River were constantly recharged. As a result, groundwater chemistry was similar to that of the Little Arkansas River. Data suggest that artificial recharge from the Little Arkansas during high flow would not only augment the City's underground water supply, it would replenish the aquifer with fresh rather than saltwater (Appendix A).

Water samples from the Halstead recharge site showed short-term, beneficial physicochemical impacts from artificial recharge. Chloride concentrations (median concentration of 60 mg/l) in diverted source water at the Halstead site were lower than in samples of fresh water. The USGS attributes this to the fact that diversion water was collected during high flow periods when chloride concentrations were lower. Chloride concentrations in shallow monitoring wells approximated chloride concentrations in recharge water shortly after recharge. Once recharge ceased, chloride levels rebounded to greater than pre-recharge concentrations.

The quality of pre-treated surface water diverted at the Sedgwick site was also improved over the quality of raw river water (Ziegler *et al.* 1999). Diverted surface water was treated before pumping into recharge basins (no recharge recovery wells were used at Sedgwick) and most physical properties – like turbidity and suspended solids – improved substantially. A polymer was used to remove turbidity before recharge. Concentrations of constituents like dissolved solids, bacteria, and organic compounds were lower in treated recharge water than in the river. Median chloride concentration in the treated diversion water was 62 mg/l, well below EPA's SMCL.

Given these findings, USGS researchers point out that the volume and period of artificial recharge (especially at the Sedgwick site) have been inadequate to determine long-term water quality impacts. About 744 million gallons of water had been artificially recharged at Halstead by January 2001. Approximately 136 million gallons had been recharged near Sedgwick. Artificial recharge during the Equus Beds Groundwater Demonstration Project was equivalent to less than 3% of the water pumped for municipal use (USGS 2008). Some increases in chloride and atrazine concentrations in well water were noted during the trial, though concentrations remained considerably less than standards established by the EPA.

Mitigation – Groundwater Quality
One of the intended purposes of the project is to protect and enhance groundwater quality. Water quality monitoring would continue and mitigation measures; that is, additional treatment to reduce atrazine, turbidity, chloride or bacteria levels (chlorination followed by dechlorination) would be instituted, as needed.

Groundwater Rights

Area groundwater rights are significantly over-allocated in relation to groundwater recharge values. Prior to 1990, estimated safe groundwater yield per year was 50,240 acre-feet, based on recharge estimates of 6 inches/year. The USGS subsequently revised estimated recharge rates to 3.2 inches/year (Hansen 1991). The more recent estimate supports an actual safe yield of 29,900 acre-feet/year. The City's water rights for the Equus Beds Well Field alone allow use of 40,000 acre-feet (78 MGD) per year.

Groundwater Management District No. 2 was created in 1974 to manage the aquifer's falling water table. This resulted in the closure of most areas in the City's well field to development of additional water rights. Regardless, a total of approximately 120,000 acre-feet/year of water rights had already been allocated in the 175 square mile Equus Beds area by 2003. Should the project be implemented, the amount of water in storage and available for recovery would be reviewed and certified annually by GMD2. The City has obtained additional water rights for withdrawals from the Bentley Reserve and Expanded Local well fields (Table 4-4). However, poor water quality in the Bentley Reserve Well Field already limits both agricultural and municipal use.

Table 4-4 Projected Water Recovery and Diversion Rates

Area	Annual Quantity (ac-ft)	Max. Diversion Rate (MGD)
Bentley Reserve Well Field	5,000	10
Expanded Local Well Field	35,000	45
Source Water Diversion (Surface)	100,000	100
Storage Recovery Rights	Depends upon volume stored	126

The project would benefit current water rights holders in three ways: 1) higher groundwater levels would reduce pumping costs, 2) reduced migration of high chloride water from the Arkansas River and the Burrton oil field would help protect groundwater quality, and 3) more water would become available for use.

Mitigation – Groundwater Rights
The project would help protect existing groundwater rights by increasing water storage and improving water quality in the Equus Beds. The KDWR and GMD2 are developing regulations and permitting requirements to ensure that existing water rights would not be negatively impacted. No further mitigation would be necessary.

Air Quality

The Wichita/Sedgwick County area has been designated as "In Attainment" for air toxins and criteria pollutants since 1989 (USEPA 2008). Air pollutant criteria are provided in Table 4-5. The project would add only minor sources of air pollutants and contaminants. Well-head pumps and other equipment would be electrically powered, placing additional modest demands on electric utilities. Backup generators would be used only when utilities fail. As a result, neither the "Prevention of Significant Deterioration" (PSD) increments nor significant impact levels for criteria pollutants would be exceeded in the long-term. Fugitive dust (PM_{10}) from excavations or vehicle traffic over dirt roads could exceed PSD levels during construction. Likewise, short-term emissions from construction equipment could increase NO_X (nitrogen dioxide produced by high temperature combustion), CO (carbon monoxide) and SO_2 levels. Actual increases would depend upon the type and amount of construction equipment being used, but pollutants would only result in short-term impacts to ambient air quality.

Mitigation – Air Quality
No mitigation is necessary.

Table 4-5 Air Pollutant Criteria			
Pollutant	**Averaging Period**	**Significance Criteria ($\mu g/m^3$)**	**Secondary[a] Criteria**
SO_2[b]	Annual	20	
	24-hour	91	
	3-hour	512	1300 $\mu g/m^3$
PM_{10}[c]	Annual	17	
	24-hour	30	150 $\mu g/m^3$
$PM_{2.5}$[d]	Annual		15 $\mu g/m^3$
	24-hour		35 $\mu g/m^3$
NO_2[e]	Annual	25	0.053 ppm[f]

Source: *www.epa.gov/air/criteria.html*
[a] Secondary criteria were established by the EPA to protect public welfare
[b] Sulfur dioxide
[c] Particulate matter less than 10 micrometers in diameter
[d] Particulate matter less than 2.5 micrometers in diameter
[e] Nitrogen dioxide
[f] ppm = parts per million by volume

Noise

Background noise levels generally decrease with decreasing population density. The Equus Beds Well Field, Bentley Reserve Well Field and most proposed pumping, pipeline, pre-treatment and recharge facilities would be located in sparsely populated areas of rural Sedgwick and Harvey counties. The Expanded Local Well Field is located inside the Wichita city limits, but within a fenced, undeveloped area on City property.

Noise-generating project facilities would be widely dispersed and operations would not produce a sufficient increase in noise level to impact the public. Most pumps would either be electric submersibles or operate inside enclosed buildings. No facilities would be scheduled for construction within several hundred feet of existing residences or other public structures. Upon completion of construction, increased operational or maintenance traffic would be intermittent and generate noise comparable to that generated by existing agricultural activities.

Noise during construction would result from construction of wells, increased traffic to and from construction sites and operation of construction equipment. No blasting would occur. If an estimated 3 dB/A increase in noise resulted during construction, the incremental increase could impact a residence or occupied area situated within 600 feet. Should construction noise become a concern, planners could work with residents to develop a mitigation plan. If well construction should occur too near a residence or other occupied structure or populated area, noise mitigation devices, like special mufflers, etc., could be required. Wildlife, livestock, and other sensitive noise receptors could be temporarily impacted as well.

Mitigation – Noise
If necessary, communication with local residents during construction could be important to mitigate possible noise impacts. Wildlife and livestock would likely temporarily vacate heavy construction areas. No further noise mitigation is necessary.

Esthetics

A rural, open, level to rolling agricultural area with scattered trees and farmhouses is typical outside of metropolitan areas in south-central Kansas. The project would not require installation of huge facilities that would block the horizon or interfere with the overall view. Scattered grain elevators, outbuildings, and farm equipment would likely be more intrusive to the passing observer than project facilities. The SWTP, surface water intake, well-heads and overhead power lines would perhaps contribute the most to change in the observable landscape. The size of the SWTP would be minimized by the use of mechanical oxidative technology, rather than oxidation lagoons. Most of the other facilities would be constructed underground. Recharge basins would be located on City property inside locked fences and landscaping would be used to make them as unobtrusive as possible.

Construction and well-drilling equipment would temporarily impact local esthetics. All wastes and by-products generated during construction would be properly handled and disposed. All ground disturbances not specifically resulting in the construction of above-ground facilities would be repaired, reseeded, replanted, or returned to original condition and use. Horizontal drilling would be used to install stream pipeline crossings underground.

Mitigation – Esthetics
No further mitigation is necessary.

Climate Change

U.S. Department of the Interior, Secretarial Order 3226 (2001), *Evaluating Climate Change Impacts in Management Planning*, states that, “Each bureau and office of the Department will consider and analyze potential climate change impacts when undertaking long-range planning exercises, when setting priorities for scientific research and investigations, when developing multi-year management plans, and/or when making major decisions regarding the potential utilization of resources under the Department’s purview. Departmental activities covered by this Order include, but are not limited to, programmatic and long-term environmental reviews undertaken by the Department…"

Weather, something that changes every day or week, but when averaged over a long period of years, is called climate. The World Meteorological Organization and the United Nations Environment Program established the Intergovernmental Panel on Climate Change (IPCC) in 1988. The IPCC predicts that the earth's climate is changing due to atmospheric buildup of greenhouse gases (GHG). These gases include carbon dioxide, methane, nitrous oxide, and chlorofluorocarbons (IPCC 2007). Uncertainty exists about exactly how the earth's climate will respond to enhanced concentrations of GHG. However, observations indicate that detectable climatic changes will occur. Most models predict increases in overall temperature and changes in rainfall, evaporation, groundwater recharge rates, soil moisture, and runoff patterns. Based on this information, it is likely that historic and future (that is, year 2050) hydroclimatic[7] conditions in the proposed project area will differ.

Council on Environmental Quality (CEQ) 1997 draft guidance on climate change requires Federal agencies to determine whether and to what extent (1) their actions may affect climate change, and (2) climate change may affect their actions. The CEQ asserts that the first question is perhaps better answered at the Federal program level. Project-level (local) emissions are likely to be of such insignificance that predicting impacts to climate may not be possible. This approach recognizes that individual projects such as the City's proposed ASR may increase GHG by only marginal amounts, compared to emissions emitted by the state, county, City, or even the utility providing power to the project.

Westar Energy supplies electricity to about 664,000 customers. It is the largest electrical utility in Kansas and would provide electricity for ASR. Demand for electricity in the state increases approximately 1.5% annually (Westar Energy 2007) and peak demand is expected to increase from 4,836 MW[8] in 2007 to 5,648 MW in 2018. ASR would be responsible for only a tiny fraction of this increase. The magnitude of CO_2 emissions generated by ASR would pale in comparison to those generated by the City, county, state, country, or utility. This point illustrates the need to focus on Federal actions at the program level, not the project level, in order to disclose meaningful information about the impacts of Federal actions on climate change.

Kansas does not currently regulate CO_2 emissions. Westar signed an agreement with the State of Kansas during February 2008 to voluntarily reduce its carbon emissions. The company proposes to complete its first round of carbon measurements sometime in 2009. As a result, figures comparing ASR carbon emissions to those produced by Westar as a whole are not yet available.

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[7] Hydroclimatic refers to conditions of precipitation, flood, drought, evaporation, evapotranspiration, and related water-cycle phenomena

[8] MW refers to 1 megawatt of energy, which equals 1 million watts

Westar proposes to increase its percentage of natural gas electrical generation from 6% in 2007 to about 10% or 11% by 2017 (Westar Energy 2007). Some methane recycled from decomposing landfills is used in its natural gas plants. Gas-fired plants generate only about 40% as much CO_2 as coal plants (Westar Energy 2007). In addition, the company reports that efficiency at its Wolf Creek nuclear power plant has increased from about 74% in 1985 to 91% today. This has allowed Westar to increase peak generating capacity to 1,200 MW from the original 1,150 MW while keeping the generation of nuclear waste at a constant level. Nuclear energy generates almost no GHG. Westar has requested a 20 year permit extension (until 2045) for its Wolf Creek operations.

Westar also plans to invest in wind energy and expects to operate three wind farms in Kansas by the end of this year, generating nearly 300MW of emission-free energy. In addition, Westar recently agreed to abide by Leadership in Energy and Environmental Design Standards (LEEDS). Referred to as "Green Building Rating," LEEDS requires state-of-the-art, energy-efficient and environmentally-sound construction. Westar attempts to increase both operational and environmental efficiency as demand increases.

The second question posed by CEQ is difficult to answer. It requires an evaluation of the potential impacts of climate change on the project. To do this, global information must be downscaled to a water basin or local scale. Although climatic change may be considered to be reasonably foreseeable, especially at the continental or global level, there is no widely-accepted methodology for transforming variations in global temperature or precipitation into incremental, quantifiable changes. Global climatic changes could lead to a variety of impacts on a local scale. Precipitation could increase on one side of a county and decrease on the other. Average temperatures could go down over one time period, and up during the next.

Current climate modeling focuses on *global* hydroclimatic changes. Changes recorded across large areas would be easier to average over time. This could lead to significant differences between global, continental, regional, and local conditions over a specified time period. As an example, overall precipitation could decrease significantly for Sedgwick County by 2050. On the other hand, there would likely be "wet" years, where annual precipitation greatly exceeds the average. The range of change from global influences could mask observation of impacts from small actions. The project's actions can not be differentiated for these reasons.

Numerous "downscaling" techniques have emerged to reconcile global climate change data with local data (Giorgi *et al.*. 1994; Semenov and Barrow 1997; Conway and Jones 1998; Prudhomme *et al.*. 2002; Wurbs *et al.*. 2005). Although few downscaling attempts have been made in Kansas, some insight can be gained from conclusions drawn by University of Kansas scientists (Feddema *et al.* 2008) and from studies conducted in Texas. Spatial downscaling was used to evaluate the impacts of climate change on Water Availability Modeling (WAM) estimates for the Brazos River Basin (Wurbs *et al.* 2005). The study concluded that using Global Circulation Models to predict local climatic changes does not necessarily result in accurate predictions. Muttiah and Wurbs (2002) conducted a similar study on the San Jacinto River Basin. They concluded that their downscaling methods provided only a general framework for evaluating impacts of climate change on water resources management. They also concluded that several different, alternative models could be used to make climate impact predictions. Different models could produce different results.

Feddema *et al.* (2008) provided the most comprehensive projections for climate change in Kansas. They based their projections upon a variety of models and evidence that the level of atmospheric GHG has grown significantly over the past 200 years. Their projections are based on IPCC A1B (middle-of-the-road) GHG emissions levels. Most of the increase in levels can be attributed to fossil fuel burning. According to the authors, about 40% of burned carbon ends up in the atmosphere, while the rest is absorbed by the ocean and land surfaces. As a result, atmospheric carbon dioxide concentrations have risen by 1/3 compared to pre-industrial conditions. Methane levels rose about 300% during the same period. Temperature records show an average increase in global temperature of 1˚ F over the past century. Most of this change has occurred over the past 20 years. Some Kansas farmers are now delaying winter wheat planting by as much as three weeks, compared to 30 years ago. Feddema and his associates conclude that global climate change will lead to stronger, but less frequent, local convective systems (for example thunderstorms) in the mid-latitudes (including Kansas.) This would result in longer dry periods between storms. Less frequent, higher intensity rainfall would likely mean more runoff, more intense floods, and less water storage in soil during dry periods.

The authors suggest that the number of "growing degree days"[9] will increase over the next several decades. This should enhance crop maturation and productivity. However, this prediction comes with a caveat. Increasing the number of "growing degree days" would mean an increase in a crop's need for water, which is estimated as potential evapotranspiration. Model projections show a significant increase in both temperature and evapotranspiration in Kansas' future. As a result, simulations of water deficit, or irrigation water need within the state are projected to increase by 2-8 inches by 2050, depending on location. Soil moisture levels are concurrently projected to decrease, especially during summer months, which would negatively impact river flows, reservoir supplies, and groundwater recharge (Feddema *et al.* 2008). These same authors project that average climate values for south-central Kansas (including the project area) would change between 2000 and 2050, as follows:

[9] Increasing average annual temperatures should result in more days each year when warm conditions stimulate plant (crop) growth

- temperature would increase about 4° F
- potential evapotranspiration would increase about 5 inches per year, and
- precipitation levels would remain relatively stable.

The following consequences would likely result:

- there would be a seasonal redistribution of precipitation.
- precipitation events would likely be more severe
- there would be longer dry spells between precipitation events, and
- moisture deficits (the difference between potential and actual evapotranspiration) would increase.

Based on these results, Feddema and associates project that water demand will exceed water supply in south-central Kansas by 2050.

No single downscaling technique has gained wide acceptance among scientists, so the authors based their results on a variety of models, including the:

- Community Climate System Model (CCSM), National Center for Atmospheric Research
- Canadian Climate Center model, and the
- U.K. Hadley Center model.

Models more suitable to downscaling global-scale climate results into local-scale hydrologic variables are being and will continue to be developed. Reclamation funded one such study during 2008 and more are being planned. Better predictions of future climate change at the basin and local level are needed in order to accurately revise input data sets for the RESNET model used to evaluate impacts of water projects like ASR.

Though accurate, quantitative evaluation of climate change for the small project area may not be possible at this time, conclusions drawn by Feddema and associates highlight general trends. As a result, protecting water supplies in the project area is of high concern. Storing surface waters underground may make them less susceptible to changes in long or short-term hydroclimatic conditions. Raising the water level in the aquifer to near historical levels, as intended, would result in higher base flows in both the Little Arkansas and Arkansas rivers. Increased base flows would help offset projected impacts to river levels caused by climate change.

Mitigation – Climate Change

To the extent practicable, environmentally friendly and energy efficient procedures and equipment would be used both during construction and operational phases of the project. Diversion of surface water, which would be exposed to climatic change, for storage underground should help protect it.

Biological Resources

Wildlife

Most impacts to wildlife would be temporary, occurring only during short periods of intense construction. Increased human and mechanical activity would cause some species to temporarily vacate. Small areas would be permanently altered to construct a recharge basin, SWTP, service roads, power lines, fence enclosures, and install well-heads, pumps, and other small structures. Most permanent construction would occur underground. Native and introduced vegetation are either interspersed between large cultivated fields or residential areas or line the banks of streams (riparian zones) or croplands (hedge rows.) There would be little further fragmentation of the environment.

Mitigation – Wildlife

To the extent practicable, environmentally friendly procedures and equipment would be used both during construction and operational phases. Most construction would occur along existing rights-of-way or on land already cleared for agriculture or municipal use. Care would be taken to avoid riparian zones, hedge rows, and other areas needed by wildlife whenever possible. No other mitigation is needed.

Endangered, Threatened, and Candidate Species

Several Federal or State-listed species (such as the piping plover, snowy plover, interior least tern, and whooping crane) migrate through or around the project area. Most of these species would be present only during early spring and late fall months, when ASR would operate at reduced capacity. A few species (like the interior least tern) occasionally breed on isolated sandbars in the Arkansas River and migrating whooping cranes may occasionally rest there as well. Recent development in downtown Wichita has created some suitable habitat for nesting of the least tern in the Arkansas River. However, there is no designated critical habitat in the project area. Construction would occur along the Little Arkansas rather than the mainstem. Project completion would lead to only slight impact to Arkansas River flow. There would be no measurable impact on the Arkansas River or to its sandbars due to periodic construction. Mostly seasonal, high and flood flows would continue to scour river bottoms and maintain sandbars. Mammal and reptile species could move out of the way during construction and re-inhabit most areas once construction is complete.

Though no longer on the endangered or threatened list, the bald eagle is protected by the Migratory Bird Treaty Act (MBTA) and Bald Eagle Protection Act (BEPA). BEPA does not allow disturbance of nesting sites.

There are no known endangered, threatened, or candidate aquatic species in the Little Arkansas River. The Arkansas River shiner has historically inhabited the main channels of wide, shallow, sandy bottomed rivers in the Arkansas River basin, but there are no known populations in the project area.

Mitigation – Endangered, Threatened, and Candidate Species
To the extent practicable, environmentally friendly procedures and equipment would be used both during construction and operational phases. Should bald eagle nesting be discovered anywhere in the project area, all construction in the immediate vicinity would cease until after fledging. No other mitigation is needed.

Non-Native Species

Most project construction would occur on already disturbed land. Standardized construction methodology designed to limit the transfer or introduction of non-native species would be used. Certified weed-free seed would be used to re-establish vegetation where removed or damaged. Several introduced plant and animal species exist in Kansas. Zebra mussels are found in Cheney, Marion, and El Dorado reservoirs. None of these reservoirs are located within or hydraulically connected to the construction area. Salt cedar, purple loosestrife, and several other introduced plant species are also present, but redistribution of non-native species into new habitats through construction would not be likely.

Mitigation – Non-Native Species
No additional mitigation is necessary.

Critical Habitat

There is no federally designated critical habitat in the project area. There is state-designated critical habitat in the North Fork Ninnescah for the Arkansas River speckled chub and some habitat designated for other species along the Arkansas River. Conditions would not be expected to change enough to have a measurable impact on habitats in these stream reaches.

Mitigation – Critical Habitat
No mitigation for impacts to critical habitat is needed.

Wetlands

Wetlands in or near the project area are small and scattered. The City has taken steps to protect existing wetlands by locating pipelines within roadways, when necessary.

Mitigation – Wetlands
Construction would be routed around wetlands to the maximum extent practicable. Where practical options are unavailable or inadequate to avoid impacts, wetlands repair and or replacement would become necessary. No other mitigation is needed.

Socioeconomics

Two possible funding alternatives were investigated for the portion of this project eligible for Federal funding (Phases IIb, III, and IV.) The first (the Preferred Alternative) would involve Federal funding of up to 25% of the project cost (Federal-local cost sharing.) The second (the No Action Alternative) would require the City to fund 100% of the project. The City has already completed Phase I and is working on Phase IIa without Federal funds. City officials have stated their decision to complete the project, with or without Federal dollars. Therefore, investigating the socioeconomic impacts of both alternatives is imperative. Consumer affordability, regional economic impacts, and environmental justice issues were evaluated for each alternative. Results along with the analytical details and discussions of the economic analyses are found in Appendices B and C.

Water supply projects that reduce the potential for current and/or future water shortages generally benefit a local economy. Water availability can influence commercial output levels, production costs, the number and types of businesses locating in an area, and even labor availability. Should some funding for the project come from sources outside the project region, these funds would positively influence regional economic activity. Outside funding would reduce the amount of local funds needed to build the project and lessen the adverse impact of project costs on household spending by reducing the percentage of consumer income required to "pay the water bill."

Regional economic impacts from construction and operation of water supply facilities stem from capital, labor, energy, and other expenditures. Such spending generally leads to both long and short-term, positive changes in local output, and increased employment. However, if a project is totally self-financed, the net difference in regional economic impacts could be negative. Affordability or financial feasibility refers to the ability of households, businesses, and other water users to pay project costs.

The project could be considered "financially feasible" if local water users have the resources to pay all construction and operating costs. Monthly user fees, retirement of debt incurred during project construction, tax assessments, or other funding methods could be used to pay for the project. The project would be large and costly (the entire ILWSP would cost more than $500 million.) If costs are greater than the community's ability to pay, imposing all costs on consumers would result in financial hardship. Clearly, distributing costs (that is, through government cost-sharing) could make the project more affordable for area consumers.

Economic and other impacts from a project like ASR are not necessarily evenly spread throughout a community. Lower income families could end up paying a higher, or unaffordable, percentage of household income for project benefits.

Construction could impact one neighborhood or group more than another as a result of the pipeline layout, location of treatment plants, or the location of other project features. For that reason, environmental justice becomes a concern. The intent of environmental justice is to ensure that no single group of people bears a disproportionate share of negative impacts.

Methods

The socioeconomic analysis for the project includes a regional impact analysis (RIA) and an affordability analysis. The RIA requires economic modeling using IMPLAN to capture the spin-off effects of project expenditures. These impacts include one-time impacts from initial construction expenditures and recurring impacts from annual operation.

The affordability analysis is based on a household budgeting approach. Water bills (as a percentage of household income) in the project area are compared to water bills paid in others parts of Kansas. Environmental justice is addressed by comparing the potential increase in water bills (with project completion) to income in different sub-areas of the region.

IMPLAN

Regional impacts of projected expenditures for ASR construction, operation, and maintenance were analyzed using the *Impact Analysis for Planning Model* (IMPLAN). IMPLAN uses the Department of Commerce national input-output model to estimate flows of commodities used and produced by industry. Social accounts[10] are converted into input/output accounts. Multipliers[11] are applied for each industry in the area. The model considers percentages of expenditures in each category that either remain in or flow out of the region. This requires the use of estimated changes in expenditures for goods and services.[12]

Regional impact analysis (RIA) measures changes in the distribution of regional economic activity as a result of an alternative. In this case, the alternative is construction of the ASR (with or without Federal funding,) and the region includes the Wichita metropolitan area and surrounding counties. For the purposes of this analysis, economically impacted counties would be assumed to include Butler, Harvey, Kingman, Marion, McPherson, Reno, Rice, and Sedgwick.

Flows of money into, out of, or through the selected counties would have both social and economic impacts. The size of the impact area is both expanded and limited by the outward flow of goods, services, and payments. Economic impacts within the region would include:

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[10] Social Accounts track monetary flows between industries and institutions

[11] Multipliers represent the effect of a dollar spent in a region as it moves from one individual to another. A dollar spent by one individual becomes income for another, who then spends a portion of that dollar in the region, which becomes someone else's income

[12] Goods and services values used in the model cover project construction, operation, maintenance and repair activities

- Changes in industry output
- Value added
- Employee compensation, and
- Employment.

Industry output is a measure of the value of total industry production. It is directly comparable to Gross Regional Product (GRP). "Value added" represents payments made to workers, interest payments, profits, and indirect business taxes. Employee compensation refers to wages and benefits paid to workers. Employment is measured as the combination of full and part-time jobs.

IMPLAN considers the following types of facilities associated with water projects:

- Intake facilities
- Wells
- Water lines
- Buildings, and
- Instrumentation.

Activities associated with these facilities (and therefore considered in IMPLAN) include:

- Water treatment
- Facility repair
- Pumping, and
- Storage.

Estimated costs for each activity are sorted into the following categories:

- Materials
- Equipment
- Fuel, and
- Labor.

Affordability Analysis

Several acts and laws are intended to protect water resources and assure clean public water supplies. These include:

- The Safe Drinking Water Act (SDWA)
- The Clean Water Act (CWA)
- The Toxic Substances Control Act (TSCA)
- The Asbestos Hazard Emergency Response Act (AHERA)
- The Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), and

- The Resource Conservation and Recovery Act (RCRA).

However, from the public point of view, assuring the affordability of a water supply could be as important as protecting the source itself. The EPA includes "affordability determination" on its list of guidelines for assessing the legal compliance of water supply projects. The use of Federal grants or credit assistance requires an affordability assessment. This assessment requires knowledge of financial responsibility, establishment of penalties and fines, and setting of standards.

"Ability to pay" can be defined as the maximum amount households can pay for water, considering both incoming and outgoing dollars (income and household expenses.) There is no universally accepted method for measuring payment capability or affordability for domestic water supplies. The most common technique has involved calculating the cost of water as a percentage of median household income. Total annual user charges are divided by median annual income and compared to a predetermined threshold value of water utility affordability. This threshold is determined by analyzing household income information, payments for water service, and payments for other goods and services. Affordability criteria are often used with other measures to describe general socioeconomic conditions, including poverty and unemployment rates.

The EPA (1980) looked at the consumer cost for complying with Federal drinking water regulations. Agency economists concluded that annual household water service costs ranging from 1.5% to 2.5%[13] of median annual income raised questions about affordability. Rates over 2.5% of median household income were labeled "unaffordable." The EPA published a follow-up affordability study in 1993. The agency then revised its estimated unable-to-afford threshold to 2.0%.[14] Finally, it was decided that, on average, any increase in annual household user charge greater than 1.0% of median income would require additional financial resources to make it affordable. Study results indicated that a 25% increase in consumer water rates would, in many cases, cause financial hardship. As a result, 1996 SDWA amendments authorized small, public water systems to use less extensive (therefore less expensive) water treatment technology – if the most effective technology is not considered to be "affordable."

The EPA then defined the total affordability level for combined water supply and wastewater treatment as 4% of median household income. This figure was later amended to 4.5%, to allow 2.5% for drinking water supply and 2.0% for wastewater treatment. This 4.5% threshold does *not* apply to each and every household, however. The threshold does not recognize differences in income

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[13] These rates correspond to average water bill rate increases of 100% (questionable affordability) to 200% (considered unaffordable)

[14] The EPA affordability threshold is not a true measure of *affordability*. It is, instead, a measure of fee increases considered acceptable by lending institutions

distribution. Some households can afford to pay more, while others can only afford to pay less.

Confusing the issue even further, the Department of Housing and Urban Development (HUD) established an affordability threshold for water and sewer payments, respectively, of 1.3% and 1.4% (total of 2.7%) of annual median income (EPA 2006). An independent study by the National Consumer Law Center (NCLC 1991) supported an affordability threshold for combined water and sewer bills of 2.0%. The United States Department of Agriculture, Rural Development Act (USDA-RDA) set grant eligibility at 0.5% of median annual income, if annual income in the region is less than 80% of the state median. In other words, any project resulting in a water bill cost increase of less than 0.5% of median household income would not be eligible for Federal funding. Should median household income in a project area fall between 80% and 100% of the state median, the eligible cost-increase threshold would be 1.0%.

None of the thresholds discussed above necessarily represent a maximum payment per household that can be made for water supplies. Accounting for all household expenses in every household would be extremely difficult. Affordability thresholds are based on a variety of factors, some of which can only be estimated. These factors include:

- Current water rates
- Current household income
- Costs of alternate water supplies, and
- Other financial considerations.

It is apparent that different Federal agencies use different affordability thresholds for determining the economic impacts of water supply projects. In order to simplify this analysis, meet NEPA requirements for keeping documents concise and to the point, and come up with a single planning threshold, the commonly used EPA threshold (2.5%) was selected for use in this investigation.

Finally, using simple cost to income ratio to determine affordability within individual households ignores other important factors. The ratio would apply to "average" households only.

According to Piper and Martin (1999), a study assessing the financial and economic feasibility of rural water system improvements could provide a relatively simple framework for estimating the average ability of water users to pay for improvements. The method adequately accounts for differences in household income and expenses. Affordability analysis assumes that the highest observed water payments made within a region represent an upper limit in the ability to pay. The process involves five steps:

(1) Evaluating water cost data for users *outside* the impact area
(2) Gathering household income, housing cost, tax payment, utility cost, insurance payment, and other household expense data *outside* the study area, but *within* the same region
(3) Calculating residual household income (income less payments for housing, taxes, utilities other than water, etc.)
(4) Calculating the cost paid for water per $1,000 of residual income by users *outside* the area but *within* the same region, and
(5) Applying *ability-to-pay* factors[15] to the residual income of households *within* the study area.

Measurable variations in household income, household expenses, and other costs of living must be accounted for. In regions with lower housing costs but equivalent median incomes, the percentage of income available for water payments would be greater.

Higher income households would be expected to use more water and have higher water bills than lower income households. Since water is a necessity, poorer families would be expected to spend a greater part of their household income on it. Therefore, estimating the variation in the percentage of total income spent by households making different levels of income would better represent average household ability to pay for water supplies.

Household Payment Capability within the Region

Data from the report, *Kansas Municipal Water Use 2006* (Kansas Water Office 2008) were used to estimate water use and cost in Kansas, both inside and outside the Equus Beds project area. Average housing costs for individual municipalities were derived from the 2000 Census. Percentage of households owning a home (1) with a mortgage, (2) without a mortgage, and (3) households with renters, were calculated along with average costs for each category of home. This information was used to derive a weighted,[16] average housing cost. Average household expenditures were calculated, based upon U.S. Department of Health and Human Services (DHHS 2008) data. The DHHS estimated average health costs in Kansas to be about $4,089 annually. Average annual costs for food were estimated to be $5,366. Average transportation ($8,166) and insurance costs ($3,630) for the Midwest region were obtained from the *2000 Consumer Expenditure Survey* (U.S. Bureau of the Census 2008).

Median household income data for each municipality was also gathered from the 2000 Census. The estimated representative household expenditures discussed above were subtracted from median annual household income to estimate residual

[15] *Ability-to-pay* factors compare dollars spent on water service to dollars remaining once other household bills have been paid
[16] The weighted housing cost is based on the percentage of households that fit a certain category and the housing cost for that category. The percentage of housing fitting a category is multiplied by the cost for that category, then the result for all categories are summed to derive a weighted housing cost for each municipality

(leftover) income for all municipalities inside and outside the study region. Water cost was then divided by residual income to estimate payment capability factors. These factors were then separated into a mean factor, a median factor, the factor that separated the highest 10% of municipalities from the other 90%, and the factor that separated the highest 25% from the other 75%.

For comparison purposes, different categories of payment capability factors are provided in Table 4-6. Payment capability factors are used to indicate the amount of variation in water bills as a percentage of income, both within the study area and throughout Kansas. Payment capability factors estimated for households outside the study area are applied to estimate total payment capability. Outside-of-area factors are used primarily for two reasons. First, these factors represent a wide range of actual payments made under a variety of economic conditions. Therefore, it is likely that the high end of this range would be closer to the maximum amount households *can* pay for water within the smaller study (sub) area. Second, comparing study area factors to data collected only from within that same area would imply that the highest *current* household water bill is the most that can be afforded. For this reason, outside comparison is required.

Table 4-6 Payment Capability Factors[17]

Measure[18]	**Kansas**	**Kansas outside study area**	**Study Area**
Average	.05118	.05983	.04032
Median	.04015	.04212	.03079
Highest 10%	.13088	.13596	.05604
Highest 25%	.05530	.07062	.04367

Results indicate that the highest 10% payment capability throughout Kansas is about 13.1%; the highest 10% for Kansas municipalities and rural water suppliers outside the study area is 13.6%; and the highest 10% for municipalities and rural water suppliers within the study area is 5.6%. The higher payment capability factors calculated outside the study area support the use of these factors to estimate payment capability. The top 10% factor is used to represent the maximum amount of residual income that can be spent on water, because that represents a payment near the observed maximum. This factor is used to account for potential outlying municipalities with unusual circumstances. Therefore, the payment capability factor used to estimate payment capability throughout the study area is 13.6% of residual household income.

The factors presented in Table 4-6 can be converted to percentages of median household income and compared to the EPA threshold of 2.5% of median household income. This would be done to evaluate consistency between the two measures. The top 10% factor of 13.6% of residual income (outside the study

[17] "Payment capability factors" are used to estimate the percent of residual household income needed to pay the water bill

[18] Payment capabilities are calculated for households with average and median incomes, as well as for poorer households, where greater percentages of residual (leftover) income are needed to pay the water bill (top 10% and 25% refer to households with the highest water bills compared to residual income)

area) is the equivalent of about 2.6% of median family income. This figure exceeds the EPA threshold of 2.5%, but is fairly consistent.

Payment capability within the Equus Beds study area was estimated by applying the top 10% factor of 13.6% to residual income data for Wichita. The City is the dominant municipality in the study region and represents most payment capability. The residual annual household income within Wichita was estimated to be $7,275. Applying the top 10% factor (13.6%) resulted in a payment capability of $990 per connection per year ($83 per month.) Residential and commercial customers were combined to calculate payment affordability.

Total payment capability over a 50 year period (2000 – 2050) was used to evaluate project affordability. There were an estimated 110,000 residential and 12,000 commercial water customers in Wichita during 2000 (Burns and McDonnell 2003). Totals are projected to increase to 164,200 residential and 15,000 commercial customers by 2050.

Total construction cost for the project was estimated at $236.52 million. The annual equivalent construction cost ($12.71 billion) was estimated using the current water plan formulation rate of 4.875 percent[19] over a 50 year period. Annual operation and maintenance (O&M) costs were estimated to be $5.82 million. Assuming that all project costs (construction and O&M) would be paid by consumers, annual costs over the 50 year period would be $18.53 million. Dividing this total by the number of expected customers in 2050 would result in an annual cost per customer of $103.50. Average cost per customer over the entire 50 year period would be $124.50.

The average Wichita household currently pays about $342 per year in water bills (Kansas Water Office 2008). When costs associated with project construction, operation, and maintenance are added together ($124.50 + $342.00), the average annual cost per household comes to about $467. This total is much lower than the total estimated maximum payment capability of $990. These results indicate that construction, operation and maintenance costs could be paid by water users. In other words, the *average* household would find the project to be affordable.

Regional Economic Impacts

In most cases, calculating increases in commercial activity attributable to expanded or improved water supplies is very difficult. However, changes in water rates could either negatively or positively impact the composition of goods and services. One such impact would be on the numbers and types of businesses locating in an area. This could lead to increased commercial activity. However,

[19] The plan formulation rate is used to discount future benefits and computing costs, or otherwise convert benefits and costs to a common time basis. The basis for the rate is the average yield during the preceding fiscal year on United States interest-bearing, marketable securities. At the time the computation was made, terms of 15 years or more remained to maturity. However, the rate cannot be raised or lowered more than one-quarter of 1 percent for any year

estimating increases in commercial activity associated with water improvement projects is difficult. Costs of building, operating, and maintaining the proposed project have to be known before general, regional economic impacts can be calculated. Total expenditures would lead to a change in final demand[20] for goods and services throughout the project area. Construction costs would represent a one-time infusion of funds, while project O&M would result in benefits to the local economy over a longer term.

Project construction cost estimates were obtained from R.W. Beck, Inc. (Personal communication 6/13/08) and broken down into the following three categories:

- materials
- labor and
- equipment.

Breaking costs down was necessary to improve the accuracy of impact estimates. However, two questions had to be answered before any accurate estimate of overall impact could be made. First, would all or only part of the money originate inside the region? Second, if all funding originated inside the region, but the project did not continue to completion, would those funds flow outside the region?

Money coming from any source, whether inside or outside the area, would impact the regional economy. Spending that originates inside the area, however, would result primarily in a redistribution of income and output, rather than an increase in regional economic activity.

Regional Purchase Coefficients (RPCs[21]) were used in this analysis to address sources of funding. The ASR could generate net positive regional economic benefits, regardless of whether or not the source of funds comes from within. However, calculating that benefit would be difficult, as the analysis would require specific data on consumer spending patterns that generally do not exist. For the purposes of this evaluation, funds coming from outside the region that would be used to pay for project related costs would be assumed to be spent within the region.

Project-related labor costs were treated as household expenditures. To further simplify the evaluation, it was assumed that all labor costs would be translated into household income. Equipment costs were split into fuel and non-fuel categories. Fuel costs went into the model as direct fuel expenditures, while non-fuel equipment costs were sorted by equipment type. Estimated project construction costs are provided in Table 4-7.

[20] Estimated change in final demand for goods and services within the project area would be equal to the change in local spending directly attributable to the project

[21] RPCs are ratios provided within the MPLAN model that represent trade flows and the portion of regional demands purchased from local producers

Table 4-7 Construction Costs by Category Used to Estimate Regional Impacts

Construction Feature	Total Cost	Materials Cost	Labor Cost	Equipment (Non-Fuel)	Equipment (Fuel)
Recharge/Recovery Wells at Existing Sites					
Recharge/Recovery Well	$3,109,000	$1,119,882	$552,239	$949,796	$487,083
Control Building	$1,536,000	$926,417	$551,906	$32,827	$24,850
Piping & Valving	$995,000	$696,500	$248,750	$35,048	$14,702
Monitor Wells (1 shallow & 1 deep)	$124,000	$41,100	$19,991	$39426	$23,482
SCADA	$311,000	$248,037	$62,963	$0	$0
Electrical & Instrumentation	$1,710,000	$1,561,864	$108,686	$19,409	$20,040
Site Work, Access & Fence	$622,000	$450,511	$83,839	$53,703	$33,947
Subtotal	**$8,407,000**	**$5,044,312**	**$1,628,374**	**$1,130,209**	**$604,105**
Recharge/Recovery Wells at New Sites					
Recharge Well	$1,473,000	$530,584	$261,643	$450,000	$230,773
Control Building	$727,000	$438,480	$261,221	$15,537	$11,762
Piping & Valving	$515,000	$360,500	$128,750	$18,140	$7,610
Monitor Wells (1 shallow & 1 deep)	$59,000	$19,556	$9,512	$18,759	$11,173
SCADA	$147,000	$117,239	$29,761	$0	$0
Electrical & Instrumentation	$810,000	$739,831	$51,483	$6,346	$12,340
Land	$91,000	$65,911	$12,266	$7,857	$4,966
Site Work, Access & Fence	$368,000	$0	$0	$0	$0
Subtotal	**$4,190,000**	**$2,272,100**	**$754,635**	**$516,640**	**$278,624**
Waterlines					
12” DIP	$489,000	$234,958	$157,282	$62,962	$33,797
16” DIP	$966,000	$506,481	$289,200	$109,570	$60,749
20” DIP	$491,000	$258,677	$147,981	$53,846	$30,495
24” DIP	$1,562,000	$908,549	$417,391	$150,220	$85,840
30” DIP	$1,023,000	$698,413	$194,800	$91,502	$38,286
36” DIP	$7,822,000	$5,252,988	$1,505,749	$750,579	$312,684
42” DIP	$2,139,000	$1,432,504	$416,315	$205,040	$85,141
48” DIP	$3,007,000	$1,987,709	$599,134	$297,117	$123,039
66” PCCP	$33,857,000	$25,393,341	$4,950,675	$2,480,456	$1,032,528
Subtotal	**$51,356,000**	**$36,673,620**	**$8,678,528**	**$4,201,293**	**$1,802,559**
Computer & Radio Systems					
Power Lines	$4,909,000	$3,681,750	$981,800	$75,764	$169,686
Transmission Lines	$6,620,000	$4,288,543	$1,544,428	$492,438	$294,590
Service Drop	$119,000	$106,856	$9,143	$1,502	$1,499
Subtotal	**$6,739,000**	**$4,395,399**	**$1,553,572**	**$493,940**	**$296,089**
Surface Water Treatment (Membrane – 30 MGD)	$59,600,000	$41,720,000	$11,920,000	$3,874,000	$2,086,000
Sedgwick Surface Water Intake (60 MGD)	$4,935,000	$3,454,500	$987,000	$320,775	$172,725
Substation	$4,908,000	$3,435,600	$981,600	$319,020	$171,780
Standpipe	$505,000	$353,500	$101,000	$32,825	$17,675
Raw Project Cost	**$145,549,000**	**$101,287,000**	**$27,656,000**	**$10,992,000**	**$5,614,000**
Contingency @ 30%	**$43,664,700**	**$30,386,100**	**$8,296,900**	**$3,297,700**	**$1,684,000**
Admin, Legal, Planning	**$47,303,400**	**$21,002,700**	**$26,300,700**	**$0**	**$0**
TOTAL COSTS	$236,517,100	$152,675,800	$62,253,600	$14,289,700	$7,298,000

Data from Burns & McDonnell (2000, 2003) were used to estimate regional impacts from annual operation and maintenance. O&M costs were divided into material, labor, equipment, fuel, and power costs. Estimates were based on results calculated for a regional water supply project in South Dakota, Iowa, and Minnesota (Reclamation 1993). Cost percentages applied to each category of O&M are provided in Table 4-8. Actual O&M cost estimates are presented in Table 4-9.

Table 4-8 Percentage of Costs Attributed to Each O&M Category

Activity	Material	Labor	Power	Equipment	Fuel
Treatment	17.5%	32.5%	38.0%	9.0%	3.0%
Wells	26.0%	26.0%	0	35.0%	3.0%
Waterlines	63.0%	26.0%	0	11.0%	0

Table 4-9 O&M Costs by Category Used to Estimate Regional Impacts

Construction Feature	Total	Materials	Labor	Equipment (Non-Fuel)	Equipment (Fuel)	Power
Capture Flow from Little Arkansas River						
Surface Water Intake	$147,200	$38,400	$53,150	$51,250	$4,400	$0
Recharge-water Treatment	$2,300,000	$404,800	$747,500	$209,300	$69,000	$869,400
Equus Beds Aquifer Recharge						
Recharge (vertical wells)	$290,950	$75,900	$105,000	$101,300	$8,750	$0
Recharge (recovery wells)	$539,350	$140,750	$194,650	$187,750	$16,200	$0
Surface Water Recharge	$263,350	$68,700	$95,050	$91,700	$7,900	$0
Waterlines	$17,250	$10,850	$4,500	$1,900	$0	$0
Powerlines	$11,500	$7,250	$3,000	$1,250	$0	$0
SCADA	$79,350	$49,950	$20,700	$8,700	$0	$0
Expansion of Local Well Field						
Horizontal Collector Wells	$46,000	$12,000	$16,600	$16,000	$1,400	$0
Vertical Wells	$14,950	$3,900	$5,400	$5,200	$450	$0
Waterlines & Powerlines	$2,300	$1,450	$600	$250	$0	$0
Development of Bentley Well Field						
Vertical Wells	$26,000	$6,800	$9,400	$9,050	$750	$0
Raw Water Treatment & Delivery Improvements						
Pipeline	$6,900	$1,800	$2,500	$2,400	$200	$0
Treatment Plant (Phase I)	$747,500	$130,800	$244,800	$67,300	$22,400	$282,200
Treatment Plant (Phase II)	$1,322,500	$231,450	$433,100	$119,000	$39,700	$499,250
TOTAL COSTS	$5,815,100	$1,184,800	$1,935,950	$872,350	$171,150	$1,650,850

Construction of a water supply project (ASR) should generate positive regional economic impacts. However, the net economic effect would depend upon the relative proportions of local and outside (in this case, Federal) funding. Should all funding come from within the region, local (including household) expenditures normally reserved for other goods and services would be used to pay for the project. Should different demand sectors within the region have different rates of leakage,[22] a resultant change in final demand would produce changes in both income and economic output.

Estimated construction-related economic impacts, based on 100% funding from outside sources (Federal funding), are presented in Table 4-10. It should be noted that direct economic benefits to the local region would be limited to periods of construction.

Table 4-10 Regional Economic Benefits – 100% Outside Funding

Expenditure Category	**Cost of Feature (millions)**	**Impact Category**			
		Value Added (millions)	Employee Compensation (millions)	Employment (total)	Output (millions)
Recharge/Recovery wells	$4.582	$1.796	$0.861	27.5	$5.963
Control Building	$2.263	$1.744	$1.045	32.1	$3.585
Piping & Valving	$1.510	$0.621	$0.316	8.8	$2.126
Monitor Wells	$0.183	$0.050	$0.023	0.8	$0.218
SCADA	$0.458	$0.107	$0.064	1.6	$0.556
Electrical & Instruments	$2.520	$0.409	$0.266	6.7	$2.895
Site Work, Access & Fence	$0.990	$0.256	$0.123	3.9	$1.169
Land	$0.091	$0.047	$0.011	0.6	$0.115
Waterlines	$51.356	$7.664	$3.753	112.2	$21.004
Computer, Radio Systems	$4.909	$0.897	$0.456	13.2	$5.671
Powerlines	$6.739	$1.472	$0.750	22.0	$7.975
Surface Water Treatment	$59.600	$26.987	$15.171	462.8	$80.550
Water Intake	$4.935	$1.484	$0.734	21.4	$6.172
Substation	$4.908	$3.713	$2.287	71.9	$7.624
Standpipe	$0.505	$0.123	$0.063	1.8	$0.604
Admin, Planning, Legal & Management	$47.303	$22.004	$12.512	338.7	$62.961
Contingency	$43.665	$20.812	$11.531	337.8	$62.756
TOTAL	$236.52	$90.186	$49.966	1,463.8	$271.994

[22] Leakages of money from within to outside the region occur as a result of spending on goods and services produced outside

For the purposes of this analysis, predicted regional economic impacts were compared for various cost share scenarios, including zero share (no Federal funding), 30%, 50%, and 70% cost share, and project construction using 100% Federal funding. Results are presented in Table 4-11.

Table 4-11 Regional Economic Impact Based on Percent of Federal Funding (Construction)

Portion of Federal Funding	Impact Category			
	Value Added (millions)	Employee Compensation (millions)	Employment (total)	Output (millions)
0% Federal Funding	-$75.6	-$33.2	-901	-$110.5
30% Federal Cost Share	-$25.9	-$8.2	-192	+$4.2
50% Federal Cost Share	+$7.3	+$8.4	+281	+$80.7
70% Federal Cost Share	+$40.5	+$25.0	+754	+$157.2
100% Federal Funding	+$90.2	+$50.0	+1,464	+$271.9

Results indicate that a 50% Federal cost share would be necessary before the project could generate net positive economic benefits for the region. Compared to 50% Federal funding, paying for the project locally would cost the region about 900 jobs and more than $110 million in reduced economic output.

O&M expenditures were analyzed using a similar approach. Unlike construction spending, O&M spending would impact the area economy throughout the operating existence of the project. Results are presented in Table 4-12.

Table 4-12 Regional Economic Impact Based on Percent of Federal Funding (Operation & Maintenance)

Portion of Federal Funding	Impact Category			
	Value Added (thousands)	Employee Compensation (thousands)	Employment (total)	Output (thousands)
0% Federal Funding	-$2,229.4	-$1,143.1	-53.4	-$4,084.6
50% Federal Cost Share	-$1,114.7	-$571.6	-26.7	-$2,047.3
100% Federal Funding	+$2,233.3	+$869.1	+21.9	+$6930.8

Mitigation – Socioeconomics

Both impact and affordability analyses indicate that the project without Federal cost sharing as proposed in the No Action Alternative would result in negative regional economic impacts. Providing Federal funding equal to 50% of total project construction, operation and maintenance costs would result in positive regional impacts. The Reclamation Preferred Action (25% Federal funding) would largely alleviate negative impacts, but would not result in positive regional economic benefits. It would, at least, make ASR more "affordable," especially to low income families." Outside funding would result in an overall, positive benefit to customers.

Environmental Justice

Evaluating environmental justice requires both an understanding of where project impacts are or would be likely to occur, and where potentially affected groups are located. Demographics from the U.S. Bureau of the Census, counties, municipalities, and local school districts were used to identify and locate potentially affected groups in the project area.

The primary environmental justice issue associated with the project would be the effect of increased water payments on low income or minority households. Income, race, and ethnic data were collected from the U.S. Bureau of the Census by zip code within the metropolitan area. There were 13 zip codes with median household incomes less than the median for the entire study area, and at least one category of minority population greater than the average (see Table 4-13). Zip codes 67210, 67214, and 67219 had environmental justice issues of particular concern. Average water cost per customer, both with and without the project, were compared to median household incomes within these zip codes. Results were then compared to the affordability thresholds. Water costs per consumer were calculated for each of the 17 zip codes where median income was less than the regional average, or the percentage of minority population was greater than the average. These results were calculated by dividing water cost by household income. They are provided in Table 4-13.

Environmental justice is evaluated in this document based on the comparison of physical and economic impacts among groups. The primary environmental justice issue associated with ASR is the effect of increased water payments on low income or minority households. Income, race and ethnic data for the City were collected from the U.S. Bureau of the Census by zip code. There were 13 zip codes with median household incomes less than the median for the entire study area, and at least one category of minority population greater than the average (see Table 4-13). Zip codes 67210, 67214, and 67219 had environmental justice issues of particular concern. Average water cost per customer, both with and without the project, were compared to median household incomes within these zip codes. Results were then compared to the established EPA threshold (2.5%) and the threshold established during the regional payment capability analysis (3.46%). Water costs per consumer were calculated for each of the 17 zip codes where median income was less than the regional average, or percentage of minority population was greater than the average. These results were calculated by dividing water cost by household income. They are provided in Table 4-13.

Table 4-13 Household Income, Race & Ethnicity within Wichita

Zip Code	Median Household Income	Black	American Indian	Hispanic
67037	$60,066	0.75%	0.53%	2.33%
67038	*$36,719	0.44%	**6.65%	1.92%
67050	$51,328	0.17%	0.28%	2.00%
67060	$48,463	0.45%	0.90%	2.49%
67101	$52,000	0.82%	0.66%	2.33%
67108	$46,464	0.70%	0.30%	0.30%
67202	*$17,384	**19.62%	0.85%	6.50%
67203	*$34,345	5.60%	**1.34%	**16.84%
67204	*$41,181	3.13%	**1.26%	**21.93%
67205	$75,070	0.43%	**1.28%	3.01%
67206	$64,258	4.14%	0.55%	1.17%
67207	$43,251	**11.02%	0.89%	5.28%
67208	*$34,291	**29.80%	1.01%	3.77%
67209	$56,033	1.83%	0.79%	4.54%
67210	*$36,657	**10.86%	**1.47%	**18.46%
67211	*$29,794	7.96%	**1.52%	**12.51%
67212	$52,022	2.38%	0.88%	5.04%
67213	*$28,541	6.20%	**2.29%	**12.15%
67214	*$21,119	**54.98%	**1.32%	**17.85%
67215	$59,028	1.02%	1.07%	2.92%
67216	*$36,691	7.93%	**1.53%	8.02%
67217	*$39,874	4.72%	**1.45%	6.71%
67218	*$32,153	**10.25%	0.99%	**11.28%
67219	*$34,594	**30.43%	**1.38%	**9.29%
67220	$50,972	**25.92%	0.76%	3.52%
67226	$67,206	6.35%	0.11%	3.51%
67230	$93,593	2.76%	**1.61%	1.82%
67235	$80,472	1.58%	0%	4.90%
Area Average	**$43,459**	**10.12%**	**1.16%**	**8.78%**
Kansas Average	**$40,628**	**5.60%**	**0.92%**	**6.93%**

* = Median household income is less than for entire study area
** = percentage of minority population is greater than for the entire study area

Data in Table 4-14 indicate that current average household water payment income percentages fall below both affordability thresholds, except for zip code 67202. Federal cost sharing equal to 26% would help keep average household water payments in all zip codes under the EPA threshold.

Additional environmental justice concerns could include potential neighborhood impacts associated with construction and operation of facilities. Any adverse impacts related to changes in the physical environment in neighborhoods that have a high percentage of low income or minority households would need to be addressed under environmental justice.

Reclamation and EPA staff conducted a project site visit in August 2008 to evaluate environmental justice concerns. There appeared to be no environmental justice issues related to the location of diversion wells, water treatment plants, recharge-recovery wells, recharge basins, pipelines, power lines, or other ASR facilities. EPA investigators expressed some concern related to potential negative impacts of decreased streamflow in the Little Arkansas River downstream. Concern was based on possible subsistence activities of a growing Hispanic population located downstream from the project area. It was decided that, as long as stream flow is maintained at an adequate level to protect the local ecosystem, there should be no adverse environmental justice impacts.

Table 4-14 Water Cost per Consumer as a Percentage of Household Income, Present versus Future Condition, if ASR Costs are Paid entirely from Local Funds*

	Current Household Income Percentage	**Predicted Household Income Percentage**
Zip Code	@ $341.82 per Customer	@ $467.00 Per Customer
67038	0.93%	1.27%
67202	1.97%	**2.69%
67203	1.00%	1.36%
67204	0.83%	1.13%
67205	0.46%	0.62%
67207	0.79%	1.08%
67208	1.00%	1.36%
67210	0.93%	1.27%
67211	1.15%	1.57%
67213	1.20%	1.64%
67214	1.62%	2.21%***
67216	0.93%	1.27%
67217	0.86%	1.17%
67218	1.06%	1.45%
67219	0.99%	1.35%
67220	0.67%	0.92%
67230	0.37%	0.50%

* Income percentages are for each of the 17 zip codes where either the average income is less than the area average, or the minority population is greater than the area average

** Exceeds EPA payment threshold of 2.5%

*** Approaches EPA payment threshold of 2.5%

Mitigation – Environmental Justice
Providing Federal funding for approximately 25% of the ASR would largely mitigate predicted impacts to low income or minority households. Resulting increases in average household water bills would be held below or near the EPA recommended payment threshold of 2.5% for all areas in the region. Hydrology data indicate that base flows would go up slightly in the Little Arkansas River downstream from the project site, though seasonal flows could drop significantly near the confluence of the Little Arkansas with the mainstem. This area is located well below the EPA's geographic area of concern. Negative impacts to possible subsistence fishing would be unlikely. No mitigation should be necessary.

Cultural Resources

The affected area for cultural resources is in northern Sedgwick and southern Harvey counties. Neither county has been intensively inventoried for cultural resources. Even so, Sedgwick County has 145 recorded archeological sites, while Harvey County has 65. Most of these sites are prehistoric, though some are historic sites. Sedgwick County has 87 sites listed in the *National Register of Historic Places (NRHP).* Harvey County has 21 sites in the NRHP. All but one of the known NRHP sites in the two counties are located in urban areas and none lie within the project area.

Parts of the project area were inventoried for archeological resources by the City before Phase I of the ILWSP. No potential NRHP sites were impacted during that construction. However, pipelines would be buried in some terraces along the Arkansas and Little Arkansas rivers during upcoming phases. There is a high probability of discovery of more archeological sites along these terraces.

Once project excavation and construction locations are defined and mapped, the City must comply with the Antiquities Code of Kansas (74-5403) as well as to the requirements of the National Historic Preservation Act (NHPA). A qualified archeologist must survey all proposed construction areas before any ground disturbance occurs. Any discovered historic properties would be inventoried and appropriate steps taken to protect all sites potentially eligible for listing on the NRHP.

The City must consult with the Kansas State Historic Preservation Office (SHPO) on ground-disturbing activities likely to produce archeological sites before proceeding. Copies of any/all permits and/or concurrence letters from the SHPO must be provided to Reclamation.

Mitigation – Cultural Resources
Should potential historic properties be discovered that may be impacted by the project, design changes or mitigation would become necessary. Site protection would be required before any ground disturbance occurs. Preferred protection measures would involve project redesign to avoid the sites altogether. Should

mitigation become necessary, appropriate measures would be determined beforehand in consultation with the SHPO.

Cumulative Impacts Summary

Regulations implementing both NEPA and ESA require the consideration of cumulative effects. NEPA requires that cumulative effects analysis consider the incremental impact of the proposed action, when added to other past, present, and reasonably foreseeable future actions, whether or not those actions are Federal. ESA requires analysis of impacts from non-Federal actions only. In this instance, the City already completed Phase I and started construction on Phase IIa before seeking Federal funds. Impacts from the entire ASR project are discussed in this document, including already completed parts of the project. Federal actions that have already undergone FWS consultation or that have already been completed are considered to be part of the environmental baseline. The environmental impacts of prior ASR activities were discussed in the City's environmental document (Burns & McDonnell 2003) but are also reviewed here. This ensures that the environmental impacts of the cost-shared part of the project (Phases IIb, III and IV) are considered within the context of the entire project.

Water Resources

Flows in the Arkansas River basin have been altered by dams and depletions due to withdrawals since post-1800 Euro-American settlement. Several low-head dams currently exist on the Little Arkansas. Withdrawals have been primarily for irrigation, but municipal and industrial water needs have been on an increasing trend. Population and industrial growth in the region have resulted in increased water quality concerns. Both overall flow and water quality have been reduced, resulting in elevated fish and wildlife, water quality and water quantity concerns. Certain segments of the Little Arkansas River are currently listed by the State as water quality impacted.

Ground and surface waters have been depleted for municipal, industrial, and agricultural use and increased use of agricultural chemicals (that is, atrazine and others) have resulted in threats to water quality. There is no measurable indication showing the future trend of impacts on water quality, but projected growth in the Wichita metropolitan area and potential future climate change could compound problems.

Overuse of surface water has resulted in increased use of groundwater as the other source for irrigation, municipal and industrial supply, recreation, and other activities. This has resulted in drops in the aquifer level of up to 50 feet since the 1930s. Equus Beds Groundwater Management District No. 2 was created to manage groundwater use in the region for this reason. The district has limited allocation of water resources to present levels, so no new irrigation permits are being issued. The City has also reduced its reliance on water from the Equus

Beds in favor of increased use of surface water from Cheney Reservoir. These actions have resulted in some rebound in groundwater levels. The purpose of ASR is to further increase groundwater levels by injecting water collected from the Little Arkansas River during periods of high flow. The intent would be to restore groundwater levels to near-historic levels. Beneficial impacts to both ground and surface water quantity and quality would be expected.

ASR is just one part of the City's ILWSP. As a result of the ILWSP, withdrawals from Cheney Reservoir during normal and wet weather periods would continue to increase. Most of these withdrawals would occur during periods when reservoir storage is nominal or above. This could result in slightly lower overall reservoir levels, especially during periods of high precipitation (that is, spring months). It could also result in slightly lower discharge rates to the North Fork of the Ninnescah River downstream during the same periods.

The Bentley Reserve Well Field would also be reactivated. Its high-chloride water would be blended with low-chloride water from other sources to provide water of acceptable quality. Use of Wichita's Expanded Local Well Field near the confluence of the Arkansas and Little Arkansas rivers would be expanded. Water produced here comes from bank storage areas and aquifers located alongside both rivers. Using water from the Arkansas River sometimes results in elevated chloride levels in the aquifer. Lower-quality water from the Arkansas could also be blended to produce a final product with higher quality water.

The City has included in its ILWSP an effort for public conservation, protection and water-use education. These programs, while not expected to solve the key issues for water management, should contribute to an overall positive impact on ground and surface water resources and conditions.

Oil and salt production within the Arkansas River basin have impacted water quality in both the river and aquifer. Regulatory changes and improvements in production technology over the last century have helped reduce surface and ground water impacts from oilfield brines and mining. Contaminants remaining in the environment will pose a future challenge. In combination with the project, these programs should reduce impacts that contribute to ground water quality problems. Monitoring will provide a better view on how the conservation and mitigation measures are working.

Biological Resources

Urbanization, suburbanization, and advances in agricultural and livestock production have impacted the distribution and quality of riparian areas, wetlands, and vernal pools. Riparian areas along area streams have generally diminished to narrow belts alongside the stream. Most wetlands and vernal pools have been filled or otherwise converted into settlement or agricultural production areas.

The project in conjunction with other Federal and non-Federal actions would not contribute to further destruction of habitat, including habitat considered critical to propagation and protection of threatened or endangered species. No measurable impacts to critical habitat, threatened, endangered, or candidate species would be expected. Little further fragmentation of habitat would result. Improvements to ground and surface water quality, quantity, and habitat should result. The intent of the project is to improve and protect both ground and surface water resources.

Mitigation: Cumulative Impacts
No mitigation for cumulative impacts is necessary.

Unavoidable Environmental Impacts

Preferred Alternative: 100 MGD ASR (60/40) with Federal Funding

- Approximately 1,700 acres of land would be temporarily disturbed
- Approximately 266 acres of land (including about 65 acres of prime farmland) would be permanently disturbed (altered and dedicated to the project)
- Localized soil erosion would temporarily increase in construction areas
- Sedimentation and turbidity in the Little Arkansas River would increase during transmission line, access road, surface water intake, and other construction
- Air quality would decrease in local areas during construction
- Noise levels would increase in local areas during construction. Some minor noise level increases would be expected in areas of operating equipment
- Wildlife would be displaced during expansion of the Phase II SWTP
- Vehicular access to residences and businesses could be temporarily disrupted during construction
- Some industrial visual impact on the rural landscape would result for the life of the project.

No Action Alternative: 100 MGD ASR (60/40) without Federal Funding

- Approximately 1,700 acres of land would be temporarily disturbed
- Approximately 266 acres of land (including about 65 acres of prime farmland) would be permanently disturbed (altered and dedicated to the project)
- Localized soil erosion would temporarily increase in construction areas
- Sedimentation and turbidity in the Little Arkansas River would increase during transmission line, access road, surface water intake, and other construction
- Air quality would decrease in local areas during construction
- Noise levels would increase in local areas during construction. Some minor noise level increases would be expected in areas of operating equipment
- Wildlife would be displaced during expansion of the Phase II SWTP
- Vehicular access to residences and businesses could be temporarily disrupted during construction
- Some industrial visual impact on the rural landscape would result for the life of the project.

Irreversible and Irretrievable Commitment of Resources

Construction and operation would result in a permanent funding commitment. Funding would be for conducting impact analysis, paying for manpower, purchasing building materials and supplies, and construction. Materials would include borrow material, steel, concrete, piping, radio and computer equipment, transmission equipment, and other items. Energy expended on the project would not be available for other uses. Petroleum-based products, such as gasoline, diesel fuel, lubricants, and plastics would be consumed during construction.

Expenditure of Federal resources would be discontinued upon completion of the cost-sharing. The City would assume all O&M costs.

Short Term Uses/Long Term Productivity

Short term negative impacts can be counterbalanced by long term positive impacts. The short term negative impacts to soils, water quality, air quality, noise, and visual aspects of the project would be offset by the long term beneficial impact of the City having an assured M&I water supply through the year 2050. Farmers and others using water from the aquifer would also benefit.

Human Health and Safety

Water quality analysis indicates no resulting project-related health hazards to the public. Regulated toxins (COCs) are under the limits established for human health. Filtering river water through sandy banks or water treatment plants would reduce existing contaminant levels. Underground water storage would help protect water quality, limit evaporation, and conserve it in the face of possible climate change. In addition, aquifer storage would help protect the City's water supply from potential biological problems like the cyanobacteria blooms increasingly impacting Cheney Reservoir. Localized increases in noise or air pollution would also be insignificant.

There are no resultant, unusual hazards to public safety. Public hazards commonly associated with construction projects would be managed through standard safety practices.

Chapter 5: Consultation and Coordination

Public Involvement

NEPA requires Federal agencies to involve the public when taking actions such as construction, funding, or permitting. Public involvement provides an opportunity for interested individuals, officials, and organizations to participate in the EIS process.

This chapter documents Reclamation's consultation and coordination activities during preparation of the Environmental Impact Statement. Public involvement is described, including the public scoping and review processes.

Scoping Notice

"Scoping" before and during the EIS process is designed to help determine issues and alternatives to be analyzed.

Reclamation announced its intention to prepare an EIS in a Notice of Intent (NOI) published in the *Federal Register* on Friday, February 29, 2008. An information release (*Equus Beds Aquifer Recharge and Recovery Project, Environmental Impact Scoping Document*) announcing the NOI was mailed to approximately 156 parties. Recipients included Federal, Tribal, State, and local officials, agency representatives, public interest groups, conservation organizations, legal organizations, chambers of commerce, news media, and other interested parties.

Almost no public comment resulted from the scoping notice or information release. One local mayor asked if the proposed alternative would be equivalent to the ASR as originally proposed by Burns and McDonnell in 2003. The Sierra Club expressed concerns about protecting the aquifer from increased concentrations of atrazine, arsenic, and pharmaceuticals. Other concerns from the Sierra Club included impacts of the project on growth in the Wichita area and requests to address concerns already raised during development of the City's 2003 document by Burns and McDonnell.

Public Scoping Meetings

The City has been holding public information and scoping meetings on its ILWSP since 1997. Members of the public, government agencies, other organizations, and individuals have also been kept informed through tours, press releases, monthly and annual progress reports, project reports, public education projects, television ads, and formal agency consultations.

Three public scoping meetings concerning ILWSP were held during 1997 (October 20, 21, and 22) in Wichita, Cheney (Sedgwick County,) and Halstead (Harvey County.) The City announced these meetings to the public in the following local publications:

- The Ark Valley News
- The Harvey County Independent
- The Times-Sentinel, and
- The Wichita Eagle.

A total of 36 people attended the three meetings. All were asked to listen, view displays, and provide input. The public was also asked to submit written comments by mail or fax.

Three similar meetings were held for cooperating and interested government agencies in 1997 (October 21, November 5, and November 6). Representatives from Reclamation, EPA, USGS, FWS, KDWP, the Kansas Corporation Commission, the Kansas Department of Agriculture Division of Water Resources, KDHE, KWO, GMD2, and the Sedgwick County Conservation District attended. All were asked to listen, view displays, and provide input. They were also asked to submit written comments by mail or fax.

Issues raised included water quantity, water quality, water rights, vegetation, wetlands, and impacts on specific Federal and state threatened, endangered, or species of concern. Local farmers expressed concerns that the project would negatively impact their ability to irrigate. These concerns and comments were used to tailor the environmental analysis.

Since publication of the Burns and McDonnell report in 2003, a total of eleven public information meetings, along with poster displays, have been held in Sedgwick, Harvey, and Reno counties. A total of 349 people attended at least one of these events. Reclamation participated in two of most recent ones. The first was conducted in Halstead on May 14, 2008. The USGS and several Kansas agencies (including KDHE, KDA, KCC, and KWO) provided displays. No comments or questions were received. The second was again conducted in Halstead on May 26, 2009. Fewer than 15 persons attended this final event and no public comments were received.

In addition, informational materials have been provided to local libraries, chambers of commerce, and county and city councils. The City reports no substantive public comments on the project since publication of the 2003 report.

Public Hearings

Public hearings were held in 2004 by the Kansas Department of Agriculture, Department of Water Resources (50 attendees) and GMD2 (70 attendees.) No concerns were expressed during either hearing.

Figure 5-1 Public Involvement Meeting at Halstead High School, May 14, 2008.

One additional public hearing could be scheduled in Halstead (center of the project area) to provide information about the EIS, if public comment received during the 60-day review period indicates a hearing is warranted. The City and its contractors would participate in and help publicize this hearing. Comments would be noted and reserved for response in the final EIS.

Website

A public involvement website, (www.usbr.gov/gp/otao/equus), was created by Reclamation and announced to the public during February 2008. The announcement was made simultaneously with the release of the information pamphlet, *Equus Beds Aquifer Recharge and Recovery Project, Environmental Impact Scoping Document.* The web site provides additional project and contact information.

Cooperating Agencies

As the lead agency responsible for the preparation of this EIS, Reclamation invited 11 outside Federal, state, and other agencies with relevant expertise or jurisdiction to participate in the NEPA process.

Officials from two agencies signed memoranda of agreement (MOAs), signifying their agency's intents to participate as cooperating partners. Those agencies included the:

- U.S. Environmental Protection Agency, and the
- U.S. Fish and Wildlife Service.

Officials from the remaining nine agencies notified Reclamation that their agencies chose to participate on a consulting basis only. Those agencies included the:

- City of Wichita
- Kansas Department of Agriculture
- Kansas Department of Health and Environment
- Kansas Department of Wildlife and Parks
- Kansas Water Office
- Groundwater Management District No. 2
- Natural Resource Conservation Commission
- U.S. Army Corps of Engineers, and the
- U.S. Geological Survey.

The Kansas Historical Society, Kansas Geological Survey, and Wichita State University provided information and assistance as needed.

List of Preparers

Table 5-1 Bureau of Reclamation ASR EIS Technical Team

Name	Experience/Expertise	Title	Contribution
Collins Balcombe	B.A. Zoology, M.S. Wildlife & Fisheries, 5 years NEPA/ESA experience	Special Projects Director	Writing, editing, & technical review
Bob Blasing	B.S. Anthropology & Geography, M.S. Anthropology, 23 years archeology experience	Archeologist	Cultural resources, writing, editing, data interpretation & technical review
Ben Claggett	B.S. Mechanical Engineering, 5 years project	Equus Beds Federal Funding	Program development &

Table 5-1 Bureau of Reclamation ASR EIS Technical Team

Name	Experience/Expertise	Title	Contribution
	management experience	Program Manager	oversight
Robert G. Harris	B.A. English, M.A. English, 30 years technical writing & instruction experience	Technical Writer	Editing
Ashley Ladd	B.S. Wildlife Management & Research, 2 years NEPA/ESA experience	Natural Resource Specialist	ESA, FWCA, writing, editing, data verification & technical review
Vernon LaFontaine	B.S. Range & Wildlife Habitat Management, 28 years experience in wildlife management, ecosystem planning & environmental analysis	Natural Resource Specialist	Technical review, editing, & data verification
Roger Otstot	B.A. Economics, M.A. Agricultural Economics, 12 years economics experience	Economist	Socioeconomics, writing, editing, & data verification
Mark Phillips	B.S. Geology, 29 years experience in geohydrologic studies/modeling, river system studies/modeling, water conservation & GIS	Geologist	Hydrology, data interpretation & verification, & technical review
Steven Piper	B.S. Economics, M.S. Agricultural & Natural Resource Economics, Ph.D. Environmental Economics, 23 years economic analysis, including natural resource, regional impact, & water	Economist	Socioeconomics, writing, editing, & data verification

Table 5-1 Bureau of Reclamation ASR EIS Technical Team

Name	Experience/Expertise	Title	Contribution
	supply experience		
Charles F. Webster	B.S. Biology, M.S. Marine Biology, 28 years environmental analysis, 17 years NEPA/ESA, & 7 years environmental teaching experience, 37 peer-reviewed environmental publications	ASR EIS Team Leader, Environmental Protection Specialist	ASR EIS project coordination, writing, editing, data interpretation, & technical review

Table 5-2 Environmental Protection Agency ASR EIS Technical Team

Name	Experience/Expertise	Title	Contribution
Debbie M. Bishop	B.S. Social Science & Environmental Science, M.P.A. Urban Administration & Planning, 8 years Environmental Justice experience	Environmental Protection Specialist	Environmental Justice, writing & editing
Kristina Kasper	Environmental Justice & GIS	Environmental Justice Intern	Environmental Justice, GIS/mapping & writing
Althea Moses	B.S. Civil Engineering	Environmental Justice Program Manager	Environmental Justice, editing & consultation

Table 5-3 City of Wichita ASR EIS Technical Team (including contractors)

Name	Experience/Expertise	Title	Contribution
Deb Ary (Wichita)	Project Management	Superintendent of Production and Pumping, Project Manager	Project Management
Jerry Blain (Wichita)	Project Management	Former Superintendent of Production and Pumping, Project Manager	Project Management
Gene Foster (Burns & McDonnell)	Hydrology & modeling	Hydrology Modeler	Hydrology
Pat Higgins (Burns & McDonnell)	Geology, hydrology & modeling	Geohydrologist	Hydrology
Tom Jacobs (R.W. Beck)	Program Management Team	Program Manger	Project Management
Jeff Klein (Burns & McDonnell)	Project Management	Project Engineer	Project Management
Lynn Moore (Professional Engineering Consultants)	Program Management Team	Program Manager	Project Management
Mike Schomaker (Professional	Program Management Team	Program Manager	Project Management

Table 5-3 City of Wichita ASR EIS Technical Team (including contractors)

Name	Experience/Expertise	Title	Contribution
Engineering Consultants)			
Dave Stous (Burns & McDonnell)	Geology & Hydrology	Geohydrologist	Hydrology
David Warren (Wichita)	Project Management	Director of Water Utilities	Project Director

Environmental Compliance

Environmental Protection Agency Consultation

EPA Region 7 agreed to serve as a cooperating agency in the production of this EIS. Final signatures on the MOA between Reclamation (lead agency) and EPA were obtained on August 21, 2008. EPA and Reclamation conducted a joint project site visit on August 18, 2008. The purpose of the visit was to 1) familiarize EPA personnel with the project area, and 2) investigate potential project impacts on Environmental Justice in the Wichita Metropolitan Area. EPA investigators were particularly concerned about a rapidly growing Hispanic population alongside the Little Arkansas River, downstream from the project site. Information collected during the site visit adequately answered investigator's questions about potential impacts to families depending upon subsistence fishing (Appendix C). EPA Environmental Justice specialists provided input and completed an independent Environmental Justice investigation.

Clean Water Act (CWA, Section 404)

Section 404 of the CWA is administered by the U.S. Army Corps of Engineers (USACE), with oversight from the Environmental Protection Agency (EPA). Section 404 regulates the placement of dredged or fill materials into water bodies, including wetlands. An individual Section 404 permit would be required for any action on the Little Arkansas River or in wetlands that causes more than minimal adverse impacts. The City is constructing a surface water intake on the Little Arkansas River during Phase IIa. It is a 66 MGD structure; however, it will only be operated at 33 MGD until the addition of more pumps during Phases III or IV. No further construction of intakes would occur during the project.

Endangered Species Act (ESA)

ESA requires consultation with the U.S. Fish and Wildlife Service for actions that may affect Federally-listed threatened or endangered plant, fish or wildlife species. Should the biological assessment for the project conclude that there are no effects to threatened or endangered species, or critical habitat, the action could be implemented without consultation. Should it be determined that the Proposed Action may affect threatened or endangered species or habitat critical to their survival, formal consultation would be required.

Farmland Protection Policy Act (FPPA)

The U.S. Natural Resources Conservation Service (NRCS) is responsible for this enforcing this Act. The lead Federal agency (Reclamation) is required to consult with NRCS to ensure that impacts to prime or unique farmlands are considered.

Fish and Wildlife Coordination Act (FWCA)

FWCA, as amended in 1964, requires Federal agencies to consider the effect of any water-related project on fish and wildlife resources. The Federal agency (Reclamation) is required to consult with the USFWS to ensure that any project-related losses of fish and wildlife resources are mitigated. Consultations with state fish and wildlife agencies would also be required.

National Historic Preservation Act (NHPA)

NHPA establishes the protection of historic properties as national policy. It requires cooperation with states, tribes, local governments, and the general public. Historic properties are those buildings, structures, sites, objects, and districts, or properties of traditional religious and cultural importance to Native Americans, determined to be eligible for inclusion in the National Register of Historic Places (NRHP). Section 106 requires Federal agencies to provide the Advisory Council on Historic Preservation the opportunity to comment. Consultations are also required with the State Historic Preservation Office (SHPO), affected tribes, and the general public.

Distribution List

Federal Agencies/Contacts

Army Corps of Engineers, Kansas City District
Army Corps of Engineers, Tulsa District
Environmental Protection Agency, Region 7
Fish & Wildlife Service, Kansas Ecological Services
Natural Resources Conservation Service
U.S. House of Representatives – Kansas 1st District
U.S. House of Representatives – Kansas 4th District

U.S. Senators (2)

State Agencies/Contacts

Kansas Advisory Council for Environmental Education
Kansas Association of Conservation Districts
Kansas Biological Survey
Kansas Corporation Commission
Kansas Department of Agriculture –Division of Water Resources
Kansas Department of Health & Environment
Kansas Department of Wildlife & Parks
Kansas Geological Survey
Kansas House of Representatives – District 74
Kansas House of Representatives – District 80
Kansas House of Representatives – District 83
Kansas House of Representatives – District 84
Kansas House of Representatives – District 85
Kansas House of Representatives – District 86
Kansas House of Representatives – District 87
Kansas House of Representatives – District 88
Kansas House of Representatives – District 89
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Kansas House of Representatives – District 91
Kansas House of Representatives – District 92
Kansas House of Representatives – District 93
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Kansas House of Representatives – District 99
Kansas House of Representatives – District 100
Kansas House of Representatives – District 101
Kansas House of Representatives – District 102
Kansas House of Representatives – District 103
Kansas Natural Resource Council
Kansas Senate District 25
Kansas Senate District 26
Kansas Senate District 27
Kansas Senate District 28
Kansas Senate District 29
Kansas Senate District 30
Kansas Senate District 31
Kansas Senate District 34
Kansas State Historical Society
Kansas State University, Office of Extension Forestry
Kansas Water Office

City/County Governments

City of Andale
City of Burrton
City of Cheney
City of Colwich
City of Derby
City of Garden Plain
City of Goddard
City of Halstead
City of Haven
City of Hutchinson
City of Maize
City of Mt. Hope
City of Newton
City of Sedgwick
City of Valley Center
City of Wichita
Harvey County Commission
Reno County Commission
Sedgwick County Commissioner – 1st District
Sedgwick County Commissioner – 2nd District
Sedgwick County Commissioner – 3rd District
Sedgwick County Commissioner – 4th District
Sedgwick County Commissioner – 5th District
Wichita Water Utilities

Organizations/Businesses

American Fisheries Society, Kansas Chapter
Equus Beds Groundwater Management District No. 2
National Audubon Society
Ninnescah Yacht Club
Sedgwick County Conservation District
Sierra Club, Southwind Group
The Nature Conservancy
Wichita Area Chamber of Commerce
Wichita State University, Center for Economic Development
Wildlife Society, Kansas Chapter

Libraries

Wichita Public Library
Halstead Public Library
Hutchinson Public Library
Newton Public Library
Valley Center Public Library

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Appendix A - Hydrology

Hydrologic Operations Model

Burns & McDonnell's (B&M) Reservoir Network (RESNET) computer simulation model was used to evaluate potential hydrologic impacts for the Integrated Local Water Supply (ILWS) system. The model performs a daily simulation of reservoirs and streams as a circulating network and uses least-cost optimizing procedures to arrive at an optimized solution. The model is based on the Microsoft ACCESS database application and utilizes the database to contain the model input data, output data, and other modeling and solution control parameters and functions.

The operations model calculates a daily water balance for the ILWS system during the 85-year model simulation period (water years [WY] 1923–2007). The model requires the following general data sets for operation:

- Historical mean daily stream discharge at selected points within the project area
- Historical monthly reservoir evaporation rates
- Available storage and other physical data for Cheney Reservoir
- Available storage, natural recharge and other parameters for the Equus Beds aquifer
- City's current and projected water demands
- Irrigation demands for agriculture in the Equus Beds Well Field area
- Minimum desirable streamflow requirements
- Supply capability and other operating parameters for all current and potential water supply sources
- Preferred allocation order for each water supply source

B&M previously utilized the model (based on WY 1923-1996) to evaluate impacts by the ILWS system alternatives for Wichita's 2003 Environmental Impact Statement (EIS)[1]. Appendix C from the 2003 EIS describes the general construct and operations of the model. Reclamation reviewed the 2003 EIS and requested additional documentation from B&M regarding key components of the model. The request for additional information included:

- Details regarding the structure, operations, and data comprising the RESNET database model, and development of executable version of the model for Reclamation (included as Attachment A).
- Supporting documentation for the development of the aquifer-stream gain-loss table (included as Attachment B).
- Details on the development of historic streamflow discharge for RESNET model nodes (included as Attachment C).
- Details on the development of historic evaporation from Cheney Reservoir (included as Attachment D).

This additional requested information is presented as Attachments A-D of this Hydrology Appendix.

<u>Scenarios Evaluated</u>
Three alternatives were simulated by the model for the purposes of the current EIS:

[1] Final Environmental Impact Statement for Integrated Local Water Supply Plan, Wichita, Kansas; prepared by City of Wichita, Department of Water and Sewer; 2003

- Current – This alternative simulates what might be considered the current level-of-development on the supply system. It utilizes the year 2000 raw water demands for the City of Wichita and assumes no components of the ILWS project are in place (including those of phase 1 already built).

- No-Project – This alternative is same as Current above, except the City of Wichita raw water demands are projected to year 2050.

- ILWSP100 – This alternative includes the following proposed components of the ILWS and uses City of Wichita raw water demands projected to year 2050:
    - Aquifer storage and recovery (ASR) project features to capture 60 MGD (million gallons per day) of induced infiltration groundwater and 40 MGD of direct diversion of surface water from Little Arkansas River (ASR)
    - Redevelopment of the Bentley Reserve Well Field
    - Expansion of the Local Well Field

<u>Model Operational Period-of-Record -</u>
A product of the above review process of the 2003 version of the model was the extension of the modeling period by 11 years by B&M to include more current information. The current modeling period now covers an 85-year period and extends from water years 1923 through 2007. The model utilizes historic recorded and estimated daily streamflows and climatological data for that period. The use of this historic sequence for evaluating the proposed system is premised on the assumption that the past historic climatologic sequence will repeat itself in the future. This period includes significant drought events occurring during the 1930's and 1950's.

<u>Model System Network -</u>
A diagram displaying the model network is shown if Figure 1 of Attachment A. The model is comprised of 20 nodes at which daily demands and flows are calculated. Two of the nodes represent system storage: Cheney Reservoir and the Equus Beds Aquifer. Model nodes are connected together by various links representing stream connections, aquifer-stream interactions (accretions and infiltration to and from stream and aquifer), or diversion delivery pipelines. More detailed information on model structure, node connectivity, and decision parameters can be found in Attachment D.

<u>Model Inflows -</u>
Inflows to model stream nodes, and flow gains (unregulated flow) between stream nodes were derived from historic U.S. Geological Survey (USGS) recorded flows at various stations in the basin. Results from the groundwater/surface water interaction analyses in Attachment B were used to adjust unregulated flow in the model to eliminate 'double accounting' of model calculated return flows (see Section 6 – Attachment C).

For nodes where recorded discharge data were incomplete for the entire modeling period, regression analyses and drainage area ratios were used to estimate missing data. See Attachment C for further details on generation of model flow data.

<u>Model Demands –</u>
The model utilizes two primary demands to be applied to the water supply system:
- City of Wichita raw water demands.
- Agricultural diversions from Equus Beds Aquifer.

For the 'Current' modeling scenario, City of Wichita's demands are based on year 2000 average-day demand. For the 'No Project' and 'ILWSP100' alternatives, the demand is based on Wichita's year 2050 average day demand. More details on the development of demands can be found in section 1.5.1 of Attachment A of this Appendix, and in Appendix C of the 2003 EIS.

The agricultural demand from the aquifer is based on an average annual value of 26,500 acre-feet which is distributed evenly over the growing season of mid-May through mid-September (Sect. 1.5.6, Attachment A).

Cheney Reservoir -
Current area-capacity-elevation data are used by the model to calculate pool elevation and reservoir surface area for a given storage volume in Cheney Reservoir. Section 1.3.1 and Table 8 of Attachment A displays the various reservoir allocations used.

The model calculates a daily reservoir evaporation volume based on the simulated surface area and the historic daily evaporation rate. The daily evaporation rate was derived from recorded monthly pan evaporation at Cheney, when that data were available. For months when actual pan evaporation data were not recorded, the evaporation rate was estimated by B&M using their ETCALC model. Monthly evaporation was evenly distributed over month into daily evaporation. See Attachment D for additional details on calculation of reservoir evaporation rates.

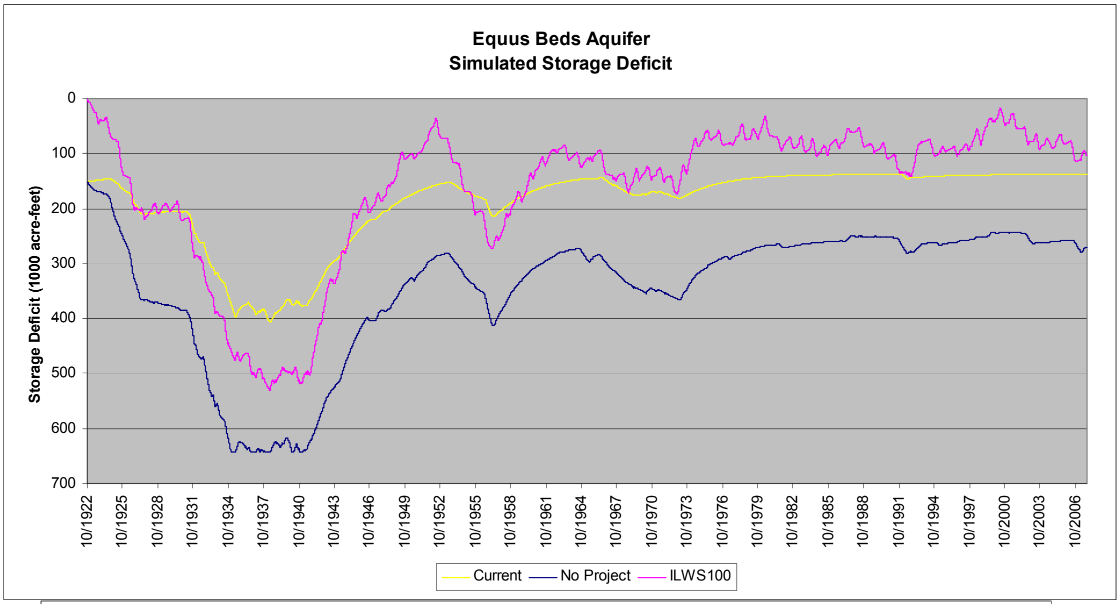
Equus Beds Aquifer -
The model operates the Equus Beds Aquifer similar to how a surface-water reservoir is operated. The USGS MODFLOW groundwater flow model was utilized by B&M to define a table that relates aquifer elevation, aquifer storage deficit, and aquifer gains and losses to the Arkansas and Little Arkansas Rivers (see Table A-1 in Attachment B). With additional model evaluation, the distribution of MODFLOW derived gain/losses to model nodes were modified as indicated in Table 9, Attachment A. The model simulates aquifer gains/losses to the following river nodes: Arkansas River near Maize, Little Arkansas River near Halstead, and Little Arkansas River near Sedgwick.

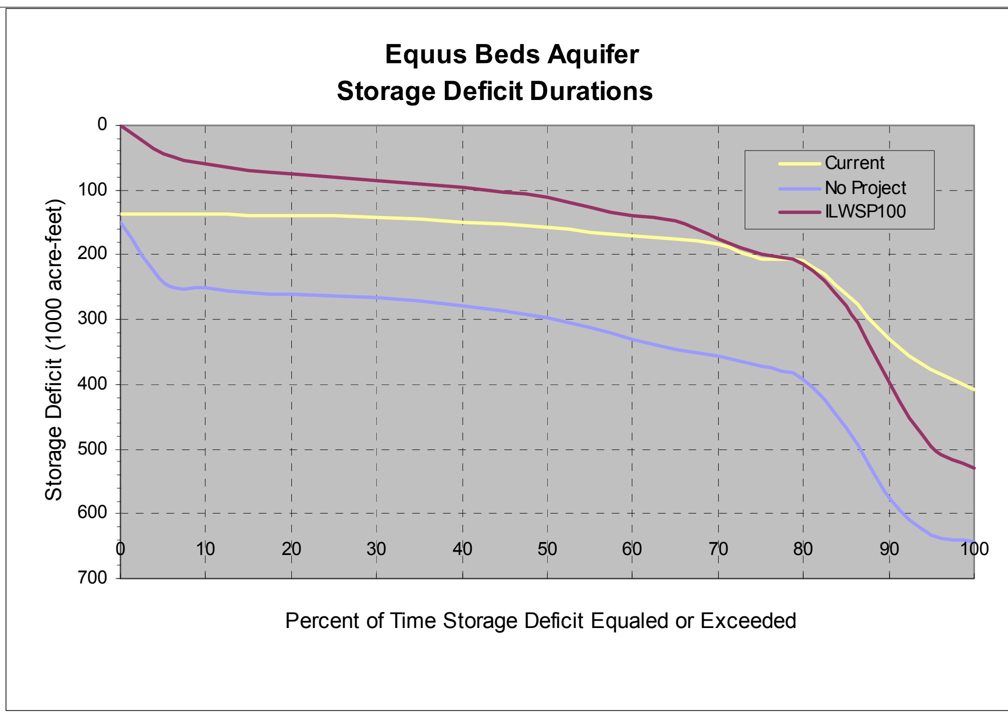
Model Simulation Results

Following is a discussion of simulation results for the three scenarios defined above. It primarily focuses on quantifying the impact differences between the future (year 2050 demands) with and without the preferred ASR 100 MGD project scenario. The inclusion of the ‘current’ scenario (no project implemented and year 2000 Wichita demands) in various charts is to illustrate the differences that will occur between now and the future planning horizon of year 2050, whether or not the project is implemented. The discussion is categorized by the hydrologic system potentially being impacted.

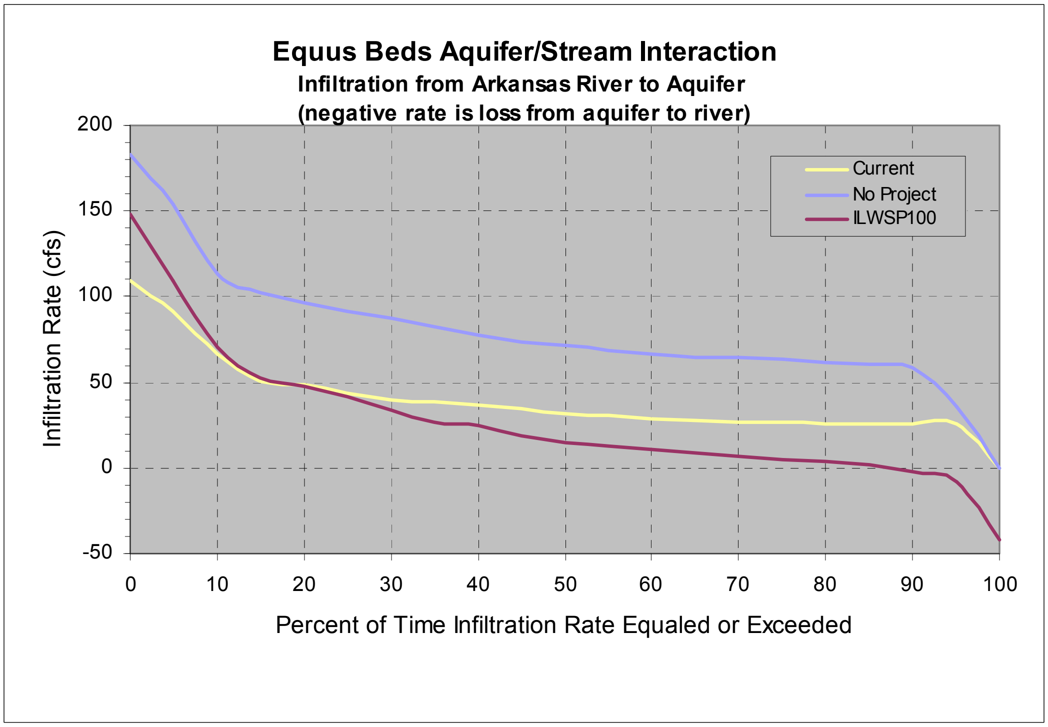
Equus Beds Aquifer -
In general, the ASR component of this project will increase the volume of water in storage within the Equus Beds aquifer available for later withdrawal. Increasing the aquifer storage volume will result in a corresponding increase in the elevation of the aquifer water table. This increases the hydraulic gradients from the aquifer to the Little Arkansas River, resulting in a potential increase in base-flow accretions to that river. It also results in a general reduction of hydraulic gradients from the Arkansas River into the aquifer, resulting in decreased infiltration from the Arkansas River to the aquifer.

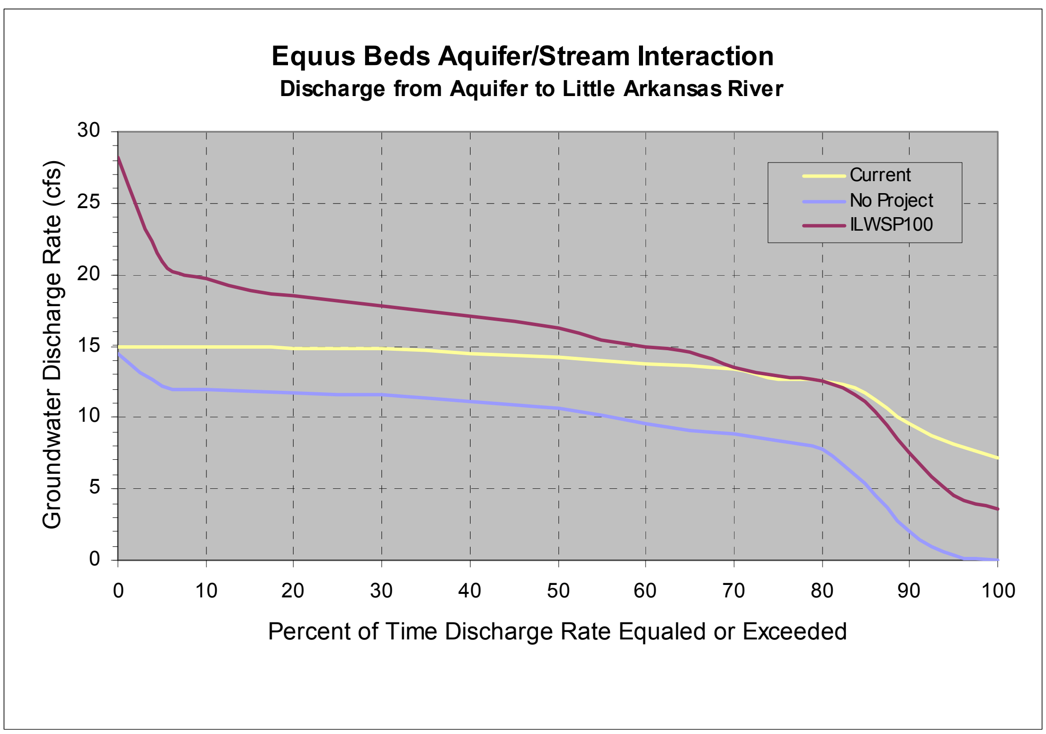
The following chart shows simulated aquifer storage deficit and monthly median water table elevations. Without implementation of the project, increasing demands will decrease aquifer storage from current conditions. With the project, aquifer storage will generally increase to levels above current conditions, with the exception of drought periods. It is estimated that for 70 percent of the time, aquifer levels will be greater than current conditions with the project in place.





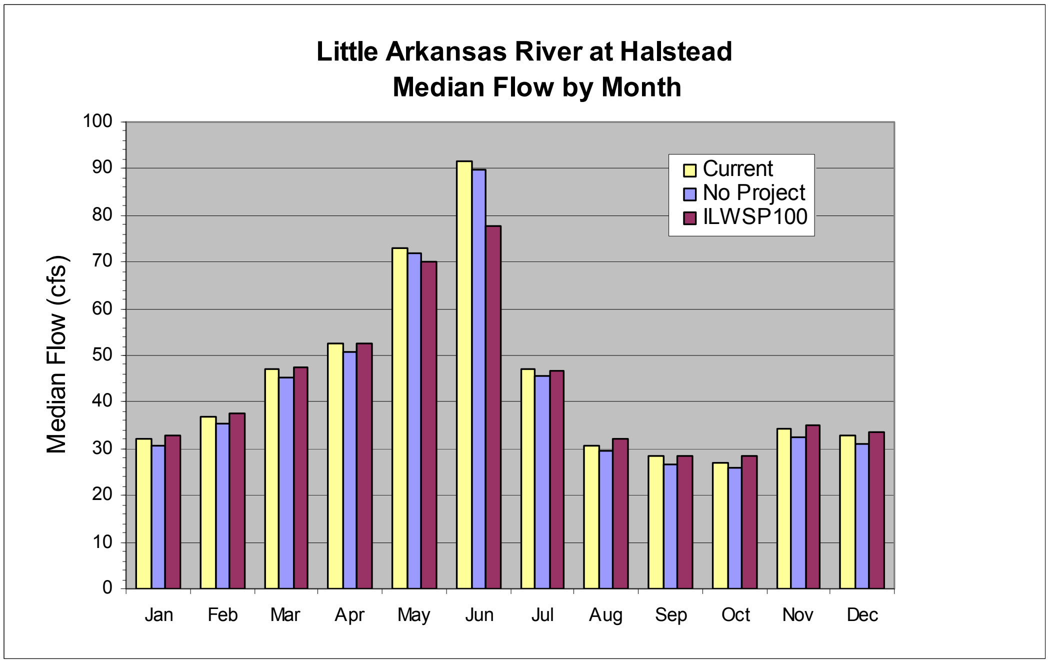
With an increase in aquifer storage, there is an associated decrease in infiltration from the Arkansas River to the aquifer, and an increase in discharge from the aquifer to the Little Arkansas River. Infiltration from the Arkansas River to the aquifer will generally decrease by about 50 cubic feet per second (cfs) for a majority of the time, as compared to without project. This will help reduce the influx of higher saline water from the Arkansas River to the aquifer. Discharge from the aquifer to the Little Arkansas River is anticipated to increase 4 cfs or greater as compared to without project conditions.



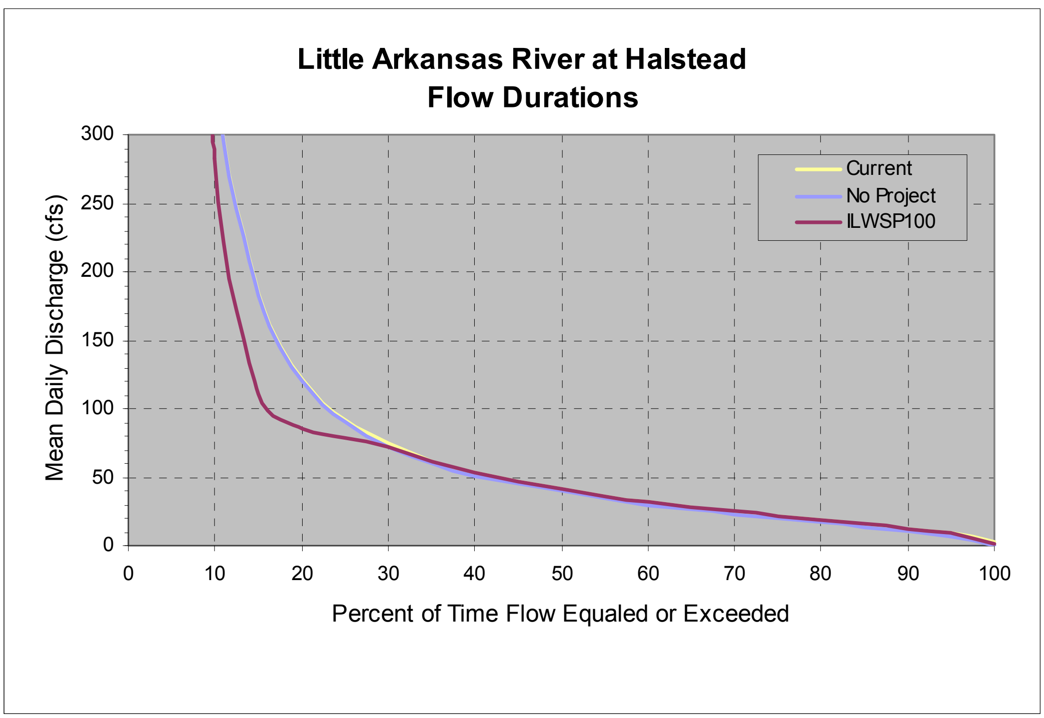


Little Arkansas River at Halstead –

Project features impacting this site are the ASR induced infiltration wells installed above this location. These wells will provide approximately half of the total ASR project diversion capacity. Recharge to the aquifer in the area above Halstead by the ASR component will result in a general increase in the aquifer water table and a corresponding increase in baseflow accretions to the stream above this location. With the project, median discharge at Halstead is anticipated to increase from 1 to 3 cfs for all months, except May and June, when there will be declines up to 12 cfs. May and June are generally the highest flow periods and it will be during these times that the greatest diversions to the infiltration wells will occur.

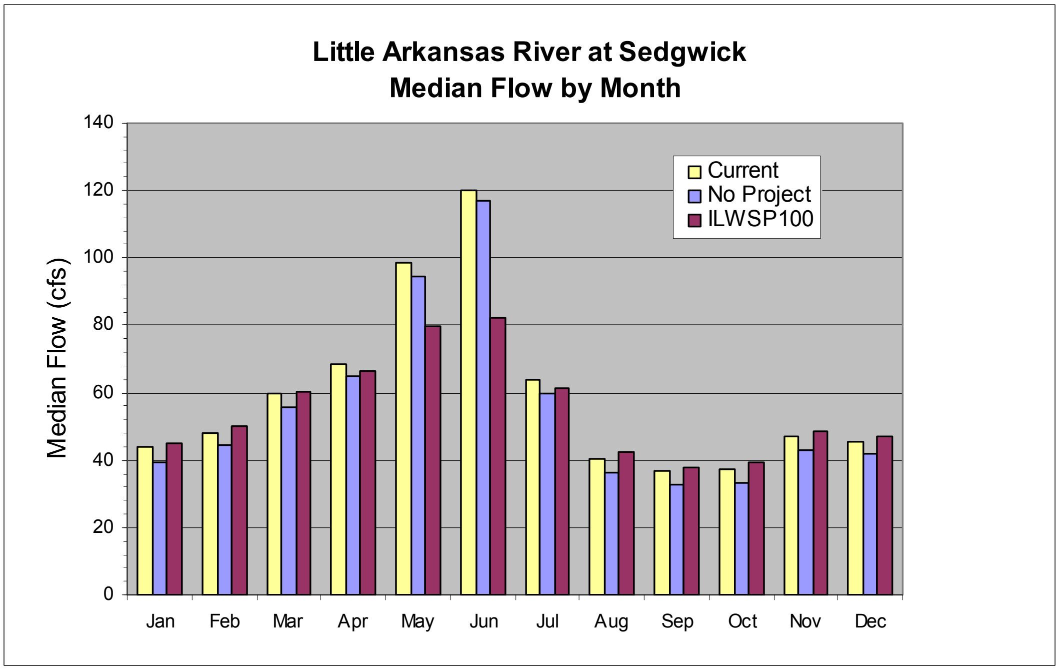


Little Arkansas River at Halstead Median Flow by Month (cfs)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
No Project	30.5	35.3	45.1	50.6	71.8	89.7	45.6	29.6	26.7	25.9	32.6	31.1
ILWSP100	33.0	37.7	47.4	52.6	70.0	77.8	46.6	32.1	28.5	28.4	35.0	33.4
Difference	2.5	2.3	2.3	2.0	-1.8	-11.8	1.0	2.4	1.8	2.5	2.3	2.3

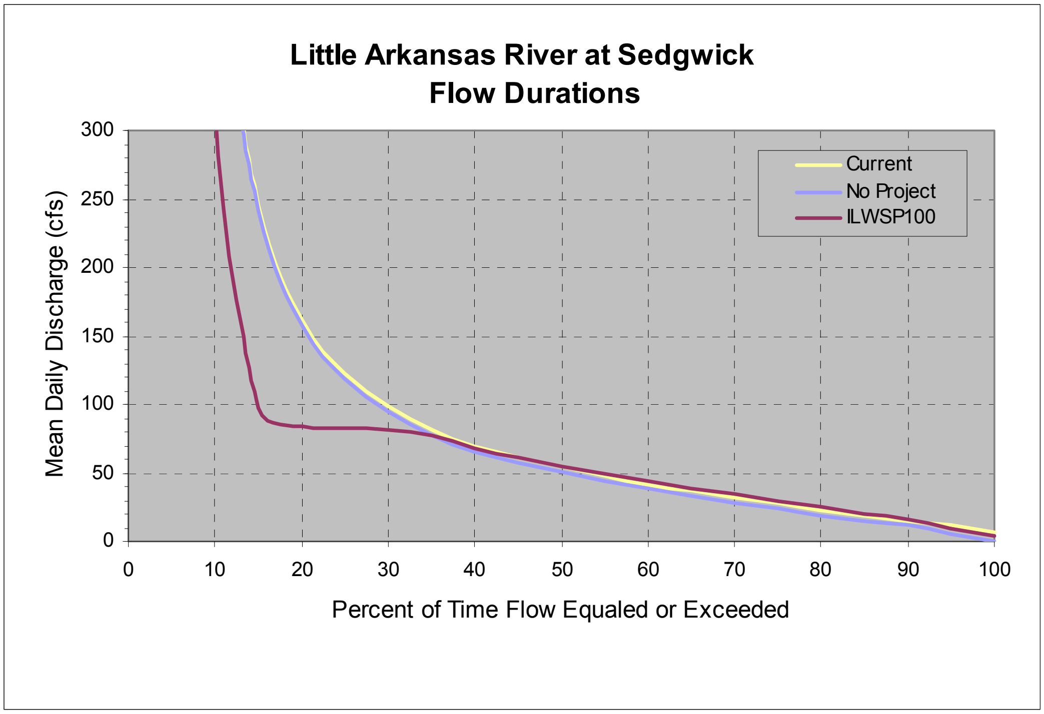


Little Arkansas River at Sedgwick -

The other half of the ASR infiltration well diversion capacity is to be installed between the Halstead and Sedgwick nodes. Sedgwick is also the location for the ASR surface water diversion site. Similar to impacts at the Halstead node, the increased recharge to the aquifer above Sedgwick will generally result in slightly higher aquifer discharge to the Little Arkansas. Median flow in the stream is expected to increase 2 to 6 cfs for all months, except May and June, when greater diversions will result in median flow declines of 15 to 35 cfs.



Little Arkansas River at Sedgwick												
Median Flow by Month (cfs)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
No Project	39.3	44.2	55.8	64.7	94.4	116.9	59.7	36.4	32.5	33.4	43.0	41.7
ILWSP100	45.2	49.9	60.0	66.5	79.7	82.1	61.4	42.2	37.6	39.4	48.3	47.1
Difference	5.8	5.6	4.3	1.8	-14.7	-34.8	1.7	5.8	5.1	6.0	5.3	5.3

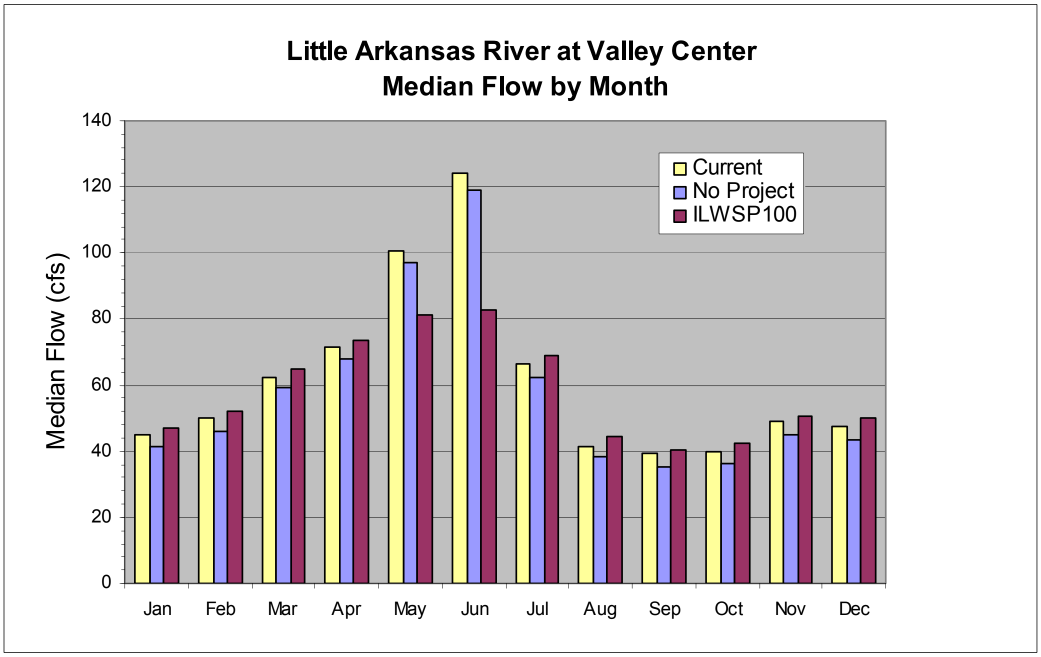


Little Arkansas River at Valley Center –
For all months except May and June, median flows at this location will increase 6 to 7 cfs with implementation of the project. This reflects the increased groundwater contributions to the Little Arkansas River above this location from increased aquifer storage. May and June exhibit a lower median flow than without project due to greater diversions occurring during those months. The simulated flow frequency curves indicate that, at lower flows, streamflow discharge will be generally slightly higher with the project than without.

Median water surface elevations are anticipated to be about the same with project as compared to without project for all months, except May and June, when there will be declines of about 0.1 - 0.2 feet.

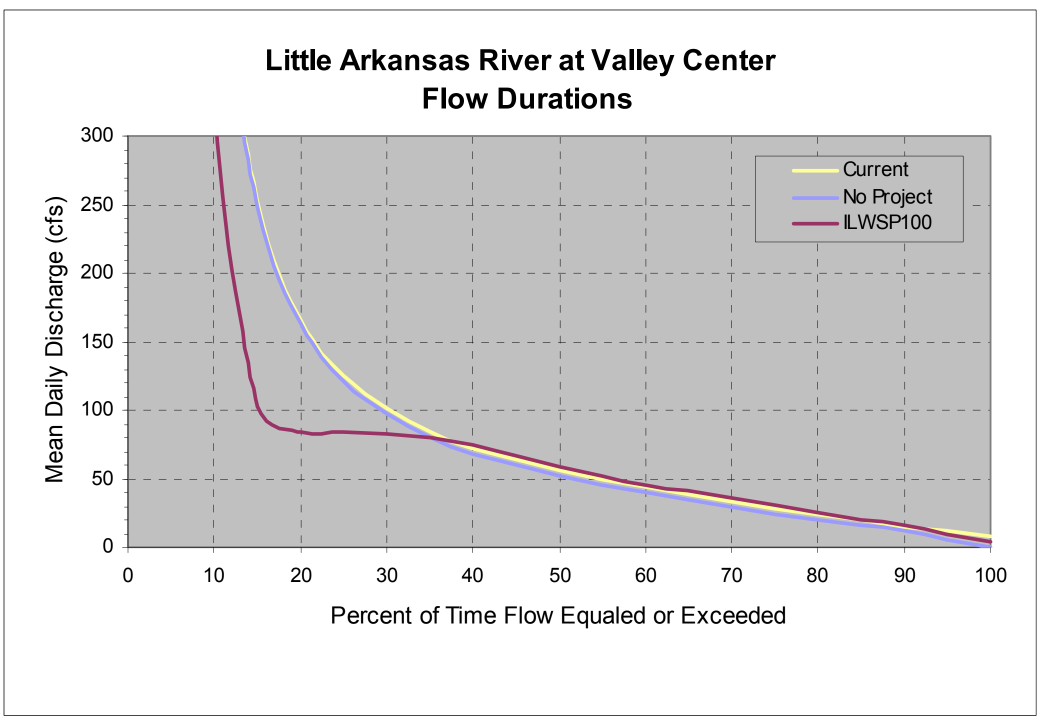
Kansas has established a minimum desirable streamflow (MDS) of 20 cfs for all months at this location. Simulated median monthly flows with the project in place are greater than the MDS. Simulated daily discharge with the project is anticipated to exceed this MDS 74 percent to 92 percent of the time, depending on month. Implementation of the project will increase the probability of streamflows meeting or exceeding the MDS as compared to without project.

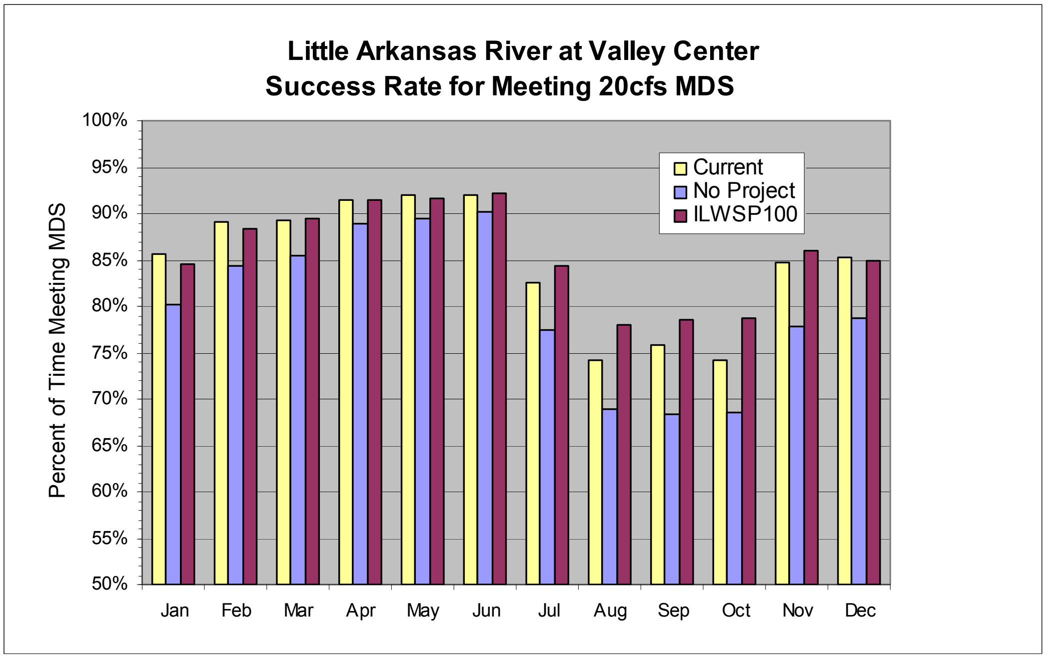
The Kansas Department of Wildlife and Parks (KDWP) has recommended higher minimum flow values of 60 cfs in April, May, and June; and 34 cfs for the remaining months. The success rates for meeting those flows with the project in place will be greater than those without the project, varying from 51 percent in December to 74 percent in June.

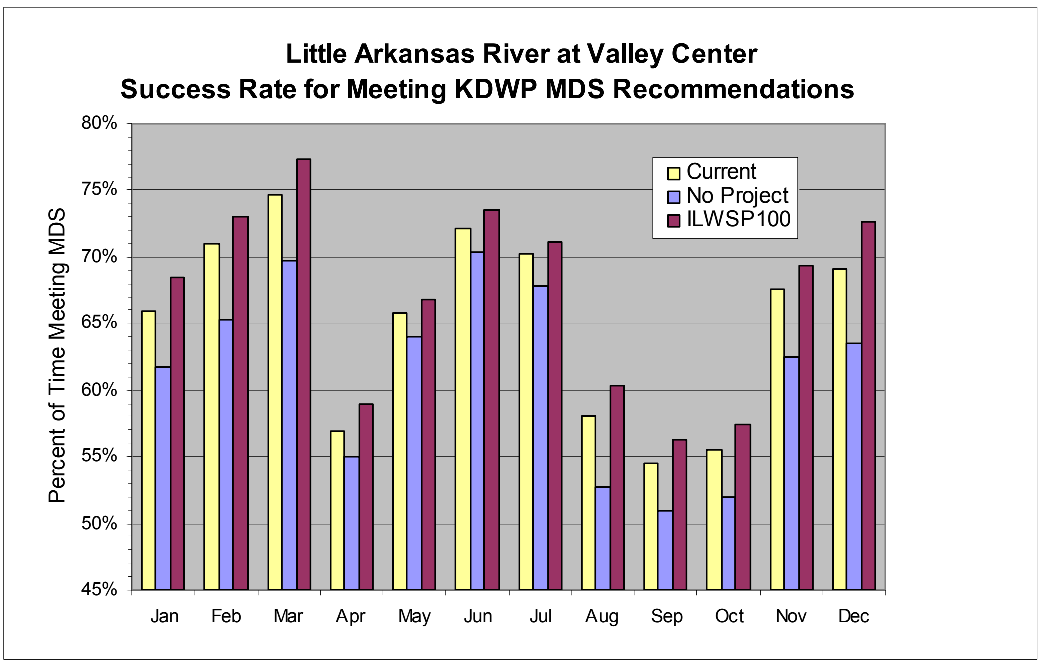


Little Arkansas River at Valley Center
Median Flow by Month (cfs)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
No Project	41.2	45.9	59.0	67.8	97.0	119.0	62.4	38.2	35.1	36.5	44.9	43.5
ILWSP100	47.2	52.2	64.8	73.7	81.3	82.7	68.8	44.2	40.6	42.3	50.8	50.1
Difference	6.0	6.3	5.7	5.9	-15.6	-36.3	6.4	6.0	5.5	5.8	5.9	6.6




Little Arkansas River at Valley Center
Success Rate for Meeting 20cfs MDS
Percent of Time Meeting MDS
100%
95%
90%
85%
80%
75%
70%
65%
60%
55%
50%
Current
No Project
ILWSP100
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec


Little Arkansas River at Valley Center
Success Rate for Meeting KDWP MDS Recommendations
Percent of Time Meeting MDS
80%
75%
70%
65%
60%
55%
50%
45%
Current
No Project
ILWSP100
Jan
Feb
Mar
Apr
May
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Aug
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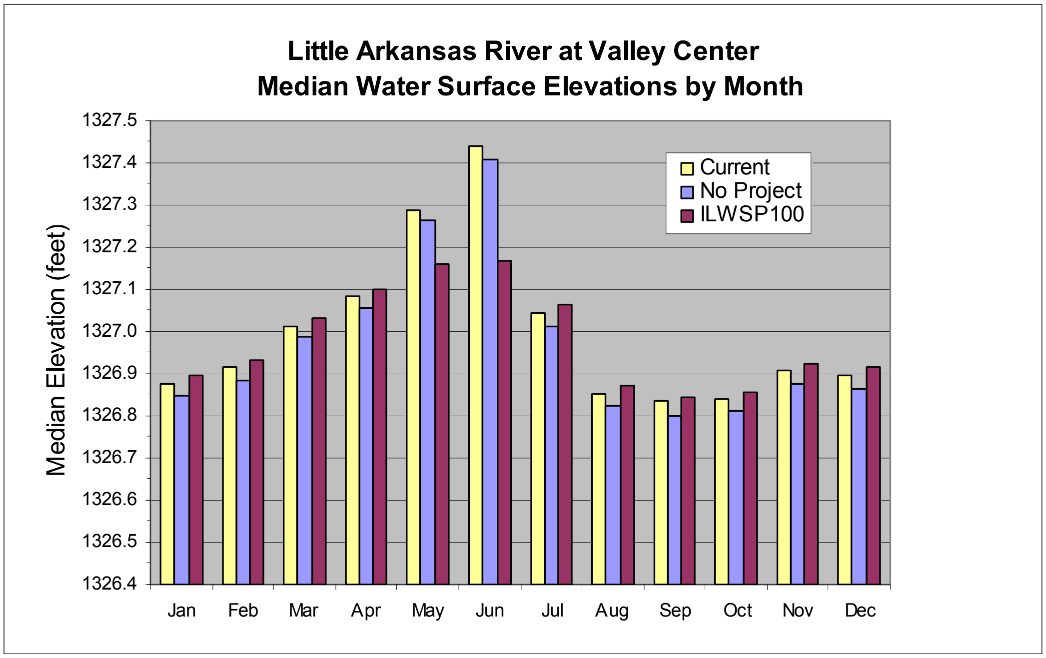
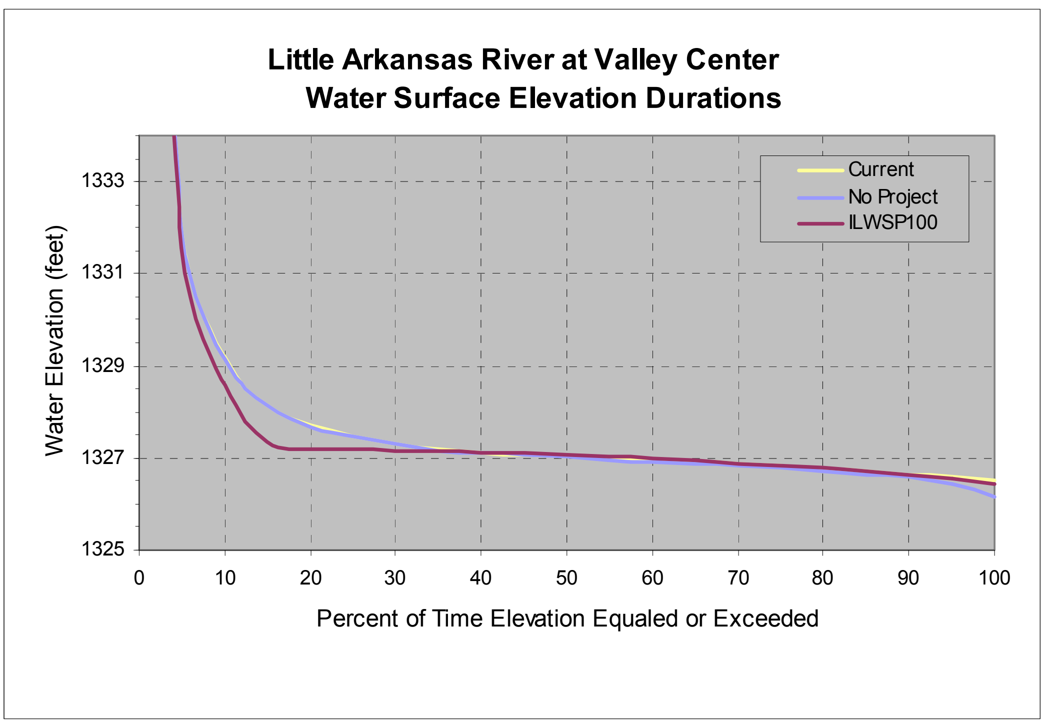
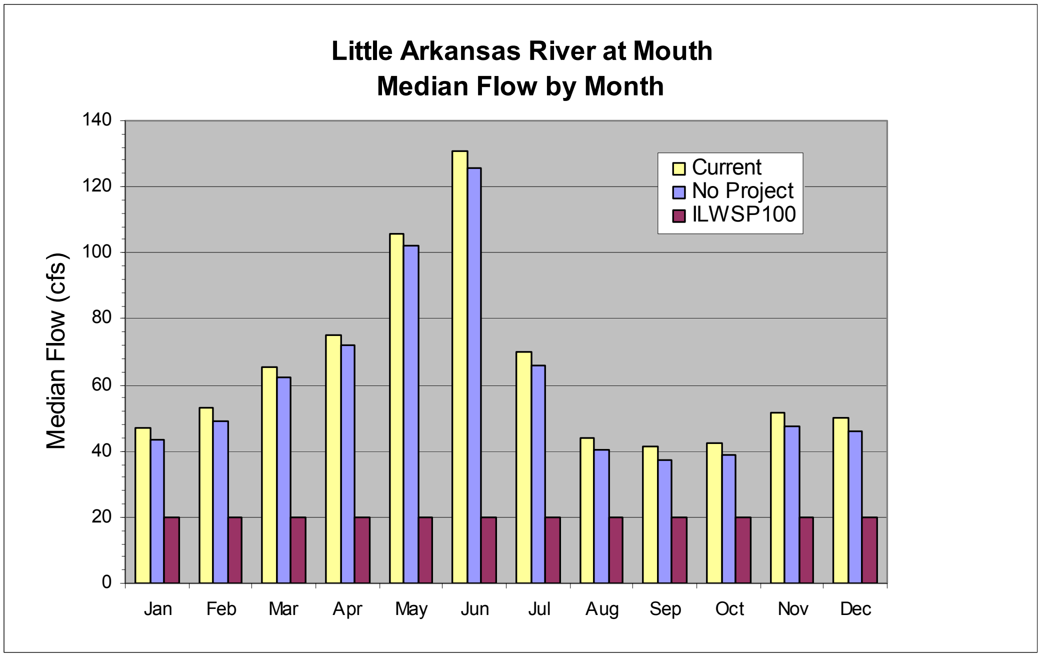


Little Arkansas River at Valley Center												
Median Water Surface Elevation by Month (feet)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
No Project	1326.8	1326.9	1327.0	1327.1	1327.3	1327.4	1327.0	1326.8	1326.8	1326.8	1326.9	1326.9
ILWSP100	1326.9	1326.9	1327.0	1327.1	1327.2	1327.2	1327.1	1326.9	1326.8	1326.9	1326.9	1326.9
Difference	0.0	0.0	0.0	0.0	-0.1	-0.2	0.0	0.0	0.0	0.0	0.0	0.1

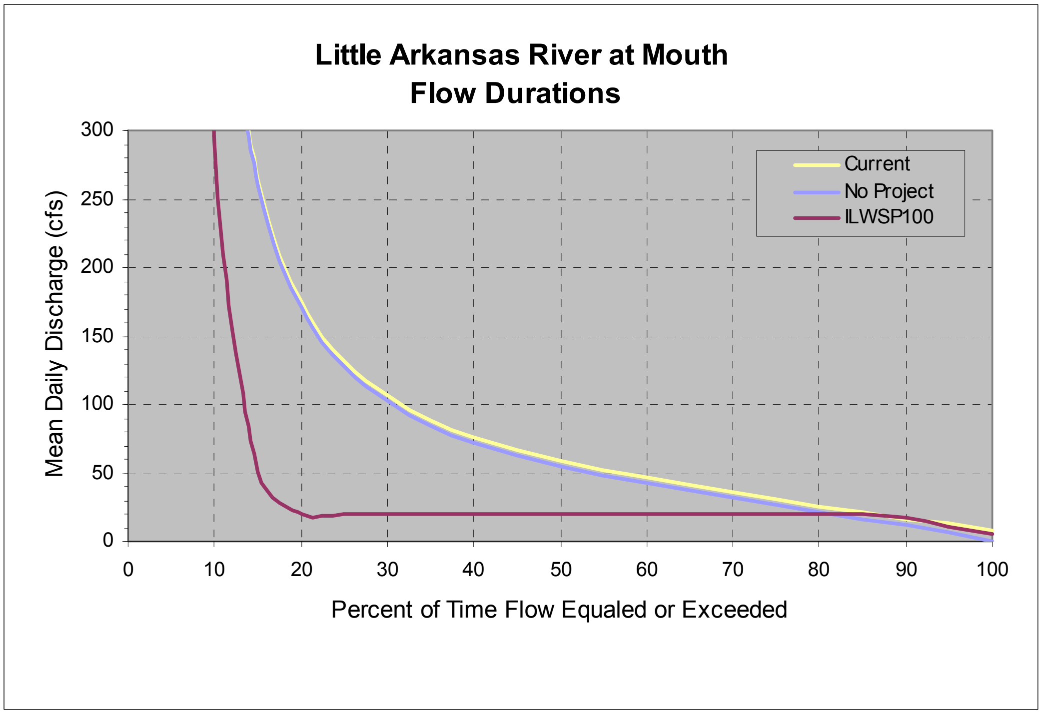


Little Arkansas River at Mouth –

The most significant changes to flows affected by the ILWSP are those occurring at the mouth of the Little Arkansas River. In addition to ASR diversion impacts occurring further upstream, the expansion of the Local Well Field will have the most significant impact on streamflow at this location. The expansion is proposed to divert up to 45 MGD (about 70 cfs) from the Little Arkansas River. Those diversions will be limited to those periods when flow in the river at this location is above 20 cfs. Therefore, with the project in place, the median monthly discharge for all months is anticipated to be 20 cfs. This results in reductions of monthly median discharge ranging from 17 to 106 cfs versus no-project conditions. Simulated daily flow durations indicate that for 80 percent of the time, discharge at this location will be significantly less than without project.



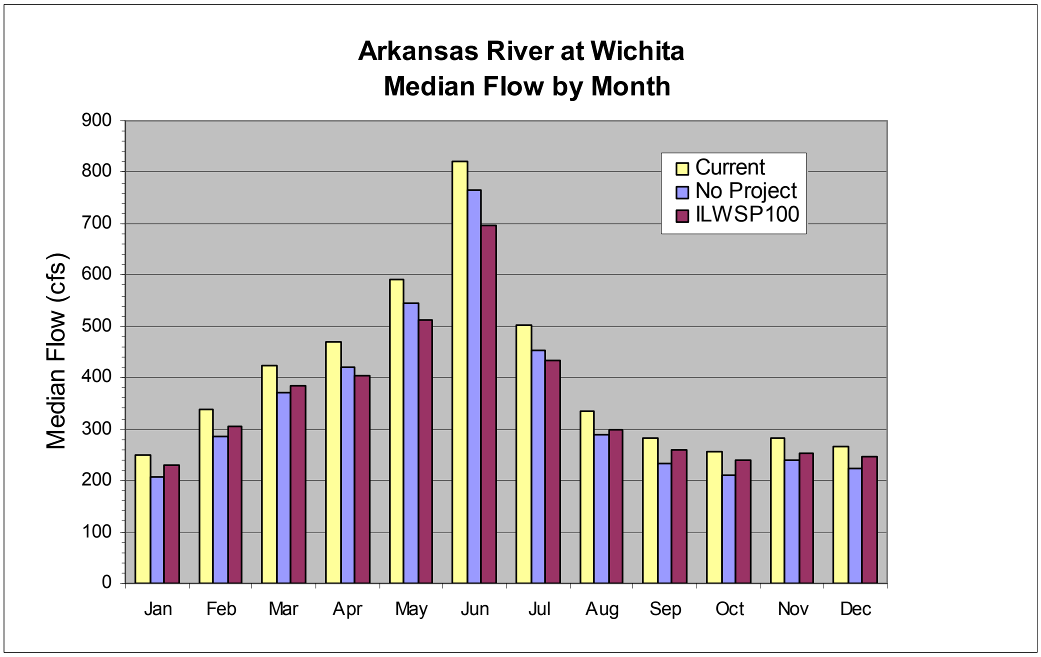
Little Arkansas River at Mouth												
Median Flow by Month (cfs)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
No Project	43.5	48.9	62.4	71.9	102.1	125.9	65.8	40.3	37.1	38.8	47.5	46.0
ILWSP100	20.0	20.0	20.0	20.0	20.0	20.1	20.0	20.0	20.0	20.0	20.0	20.0
Difference	-23.5	-28.8	-42.4	-51.9	-82.1	-105.8	-45.8	-20.3	-17.1	-18.8	-27.5	-26.0



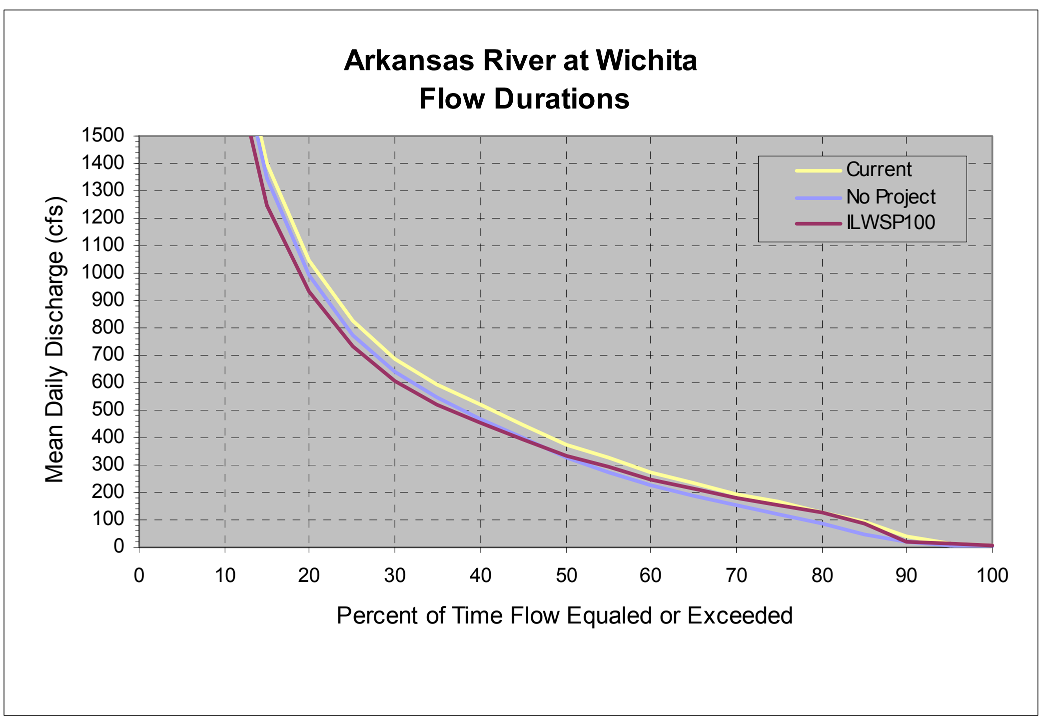
Arkansas River at Wichita -
This location represents the USGS streamflow gauging station located just downstream from the confluence of the Arkansas and Little Arkansas Rivers. Therefore, impacts to stream discharge at this location are a culmination of several ILWSP impacts to the Little Arkansas and Arkansas Rivers. These impacts include:

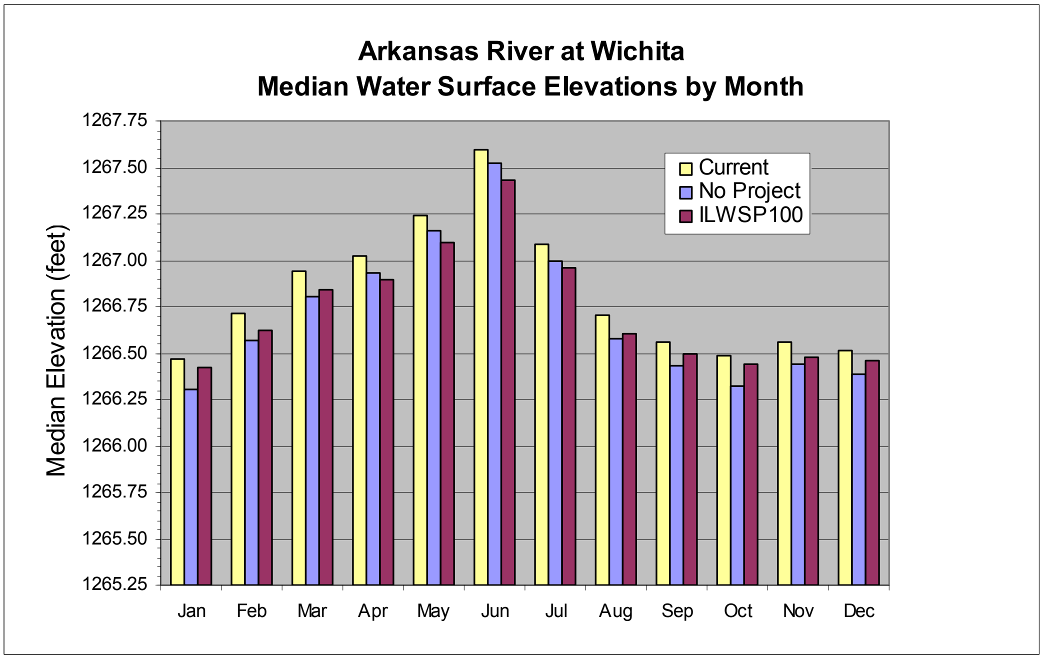
- Induced infiltration from the Arkansas River resulting from redevelopment of the Bentley Reserve Well Field.
- Changes in stream/aquifer interaction rates between the Equus Beds Aquifer and the Little Arkansas and Arkansas Rivers.
- Induced infiltration from the Arkansas River resulting from operation of the existing Local Well Field.
- Diversions from the Little Arkansas River for recharge of Equus Beds Aquifer.
- Induced infiltration from the Little Arkansas due to operation of the expanded Local Well Field.

With relatively greater discharge at this location, the impacts from diversions are a smaller percentage of overall discharge. Simulated flow duration curves indicate that during lower flow periods, flows with the project will be generally higher than without project. Conversely, during higher discharge periods, flows with the project will be generally lower than without project. Water surface elevations are anticipated to only vary within approximately 0.1 feet from without project conditions to with project.

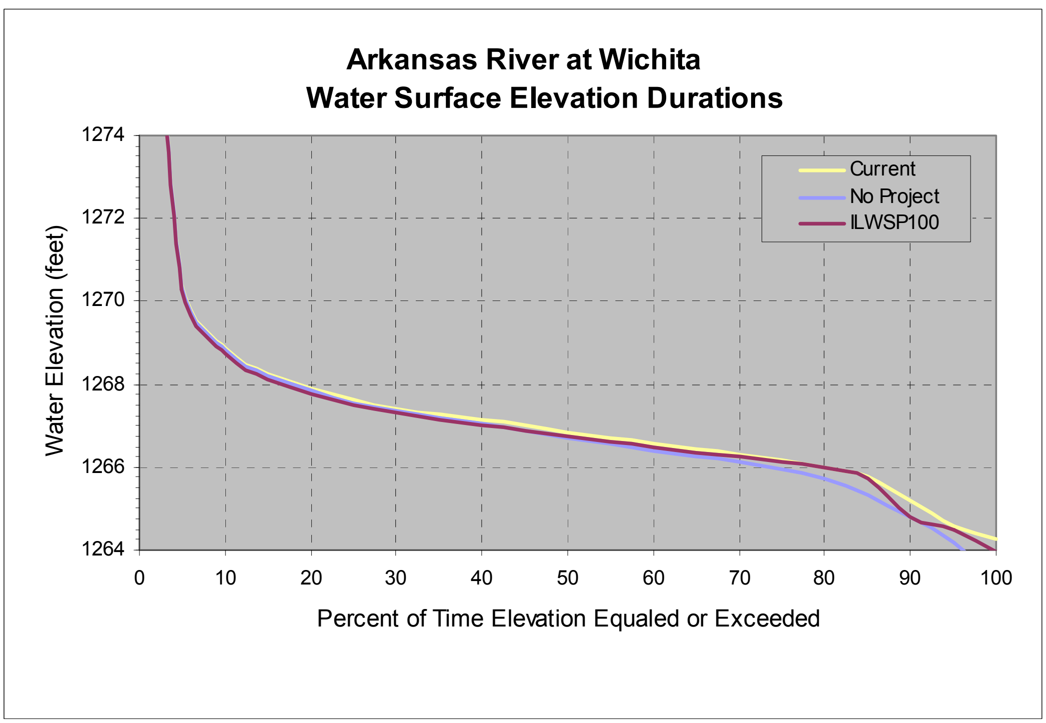


Arkansas River at Wichita												
Median Flow by Month (cfs)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
No Project	205.5	286.8	372.0	419.5	544.2	764.7	454.5	288.9	234.6	209.8	238.1	223.4
ILWSP100	231.4	306.8	385.9	405.1	511.0	697.0	434.9	299.7	258.8	240.0	252.6	247.5
Difference	25.9	20.0	13.9	-14.3	-33.2	-67.7	-19.6	10.8	24.1	30.2	14.4	24.1



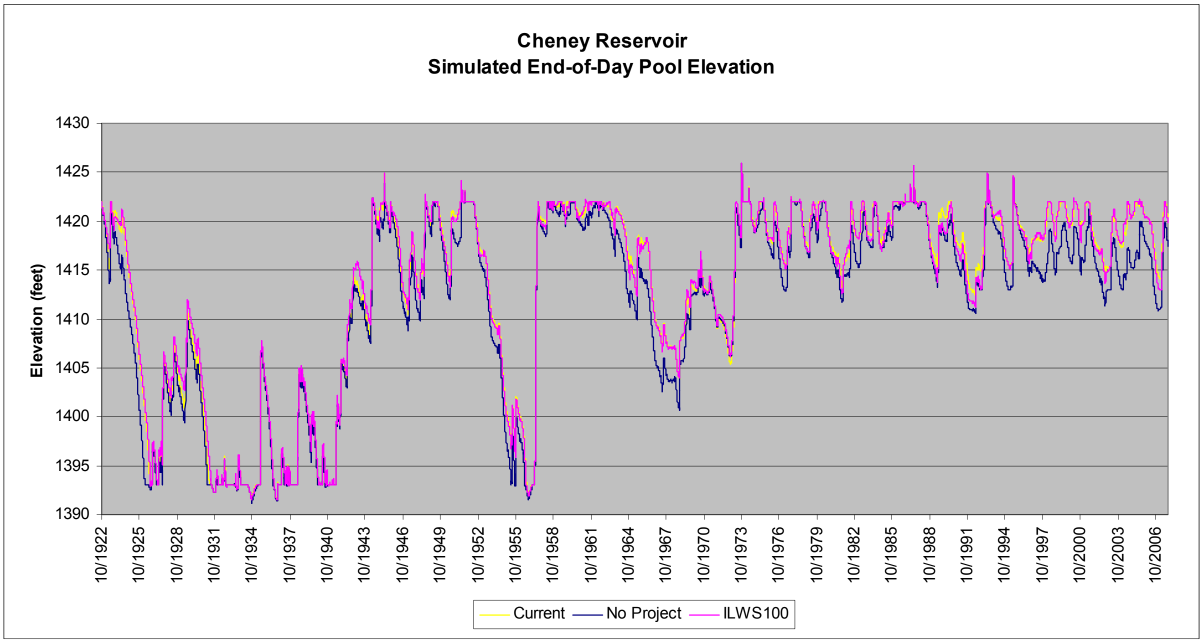


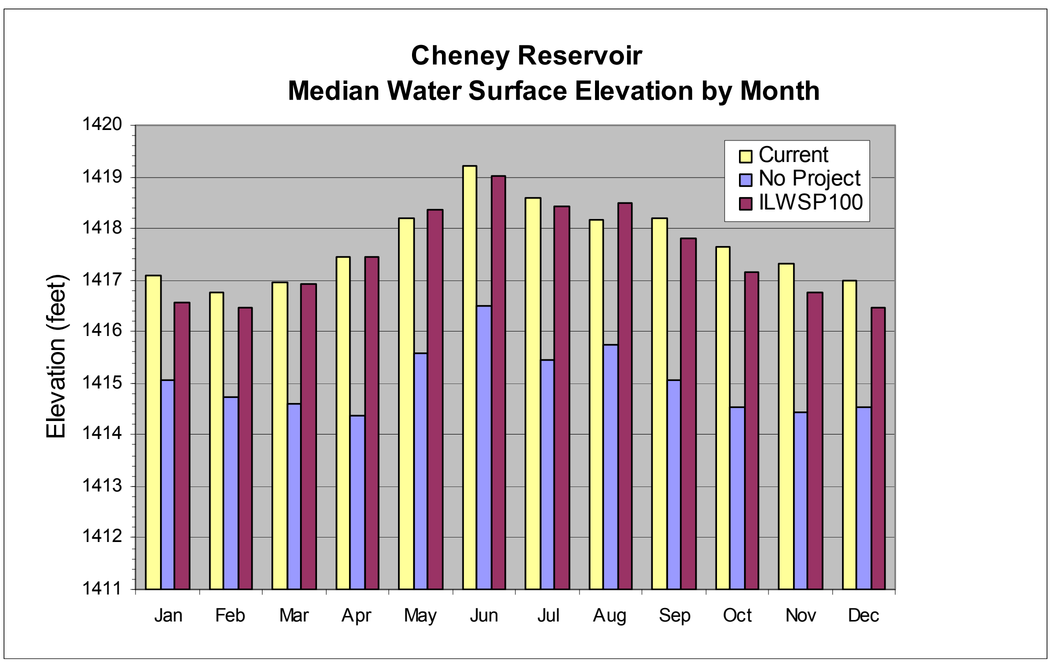
Arkansas River at Wichita												
Median Water Surface Elevation by Month (feet)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
No Project	1266.3	1266.6	1266.8	1266.9	1267.2	1267.5	1267.0	1266.6	1266.4	1266.3	1266.4	1266.4
ILWSP100	1266.4	1266.6	1266.8	1266.9	1267.1	1267.4	1267.0	1266.6	1266.5	1266.4	1266.5	1266.5
Difference	0.1	0.1	0.0	0.0	-0.1	-0.1	0.0	0.0	0.1	0.1	0.0	0.1



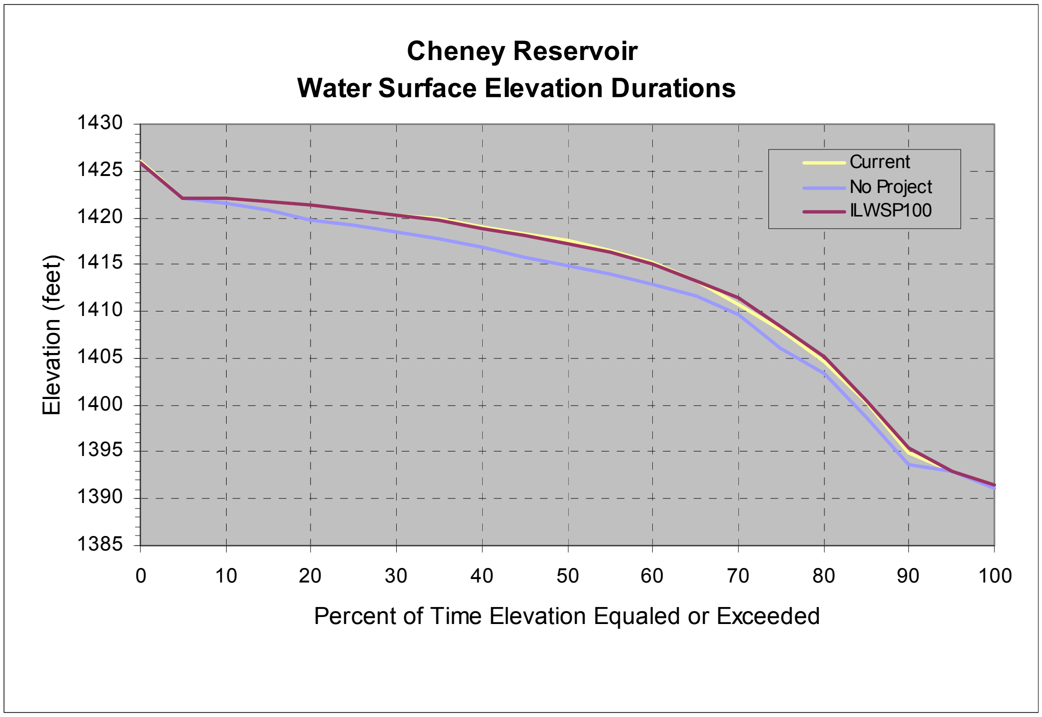
Cheney Reservoir -

The primary purpose of Cheney Reservoir is to provide a supply of water to Wichita. Without the project, increasing future demands will incur the operation of the reservoir at lower elevations. During drought periods, the demands on the reservoir will deplete the usable supply. With project implementation, there will be, generally, less of a demand on the reservoir as more of the demand can be shifted to aquifer storage. This will result in higher pool elevations of 1.5 to 3 feet over no-project conditions.

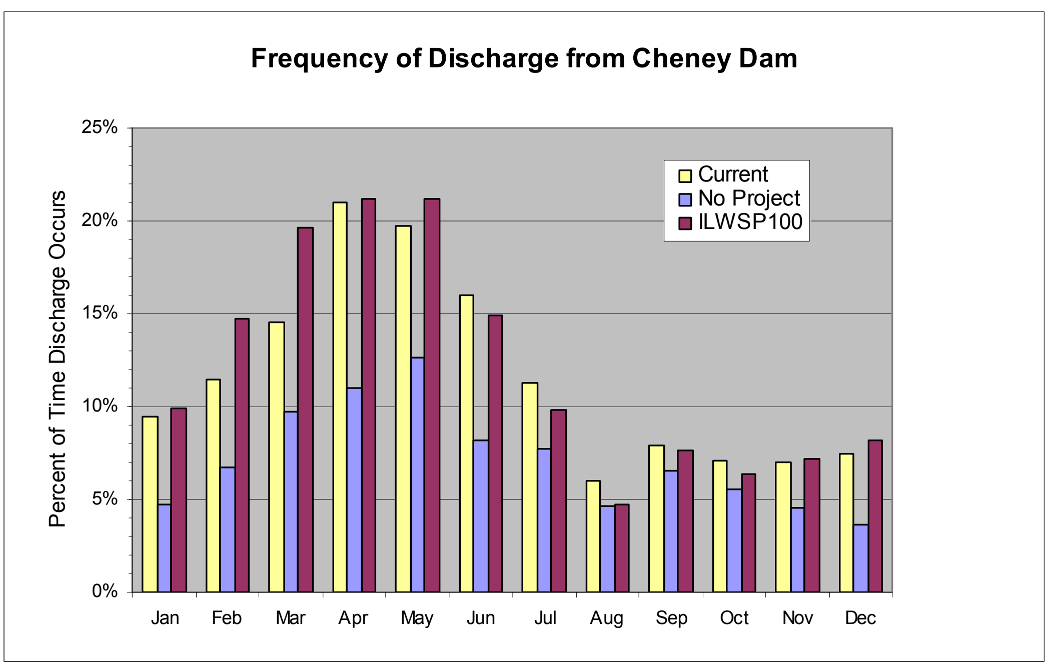


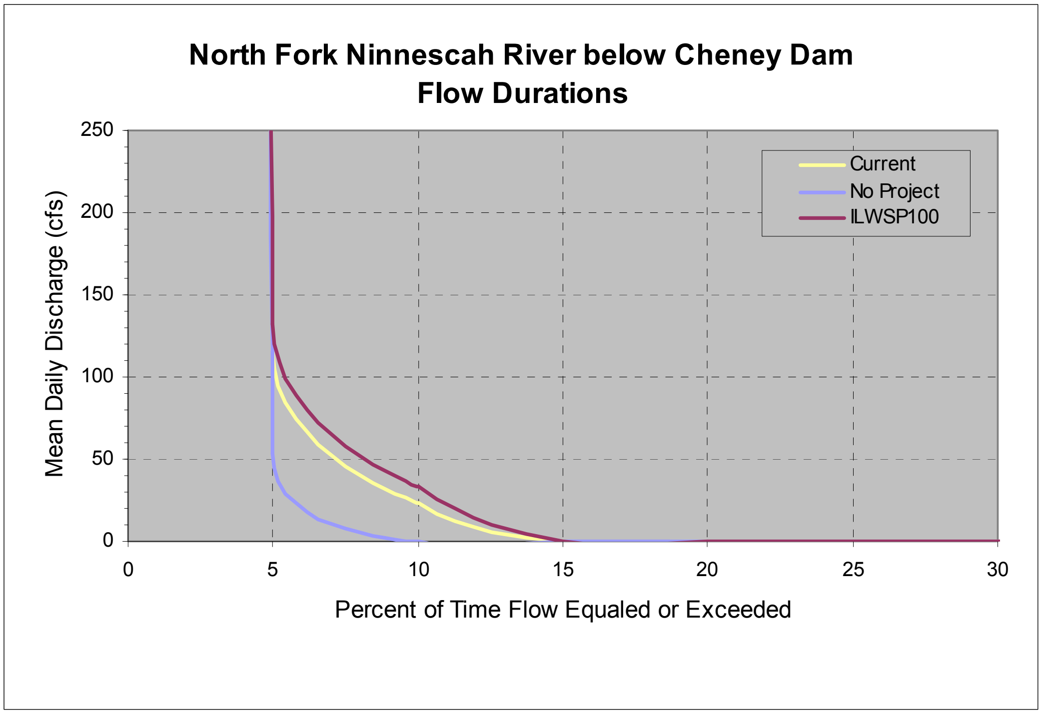


Cheney Reservoir												
Median Pool Elevation by Month (feet)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
No Project	1415.1	1414.7	1414.6	1414.4	1415.6	1416.5	1415.5	1415.8	1415.1	1414.5	1414.4	1414.5
ILWSP100	1416.6	1416.5	1416.9	1417.4	1418.4	1419.0	1418.4	1418.5	1417.8	1417.1	1416.8	1416.5
Difference	1.5	1.8	2.3	3.1	2.8	2.5	3.0	2.7	2.8	2.6	2.3	1.9



<u>North Fork Ninnescah River below Cheney Reservoir -</u>
There are no minimum release requirements from Cheney Reservoir. Therefore, releases generally only occur after significant runoff events and when the conservation pool in the reservoir is full (elevation 1421.6 feet). Without the implementation of the project, releases and spills from Cheney Reservoir will occur less frequently since Wichita will be utilizing more of the conservation storage in the reservoir. Will the project in place, there will be less demand on Cheney, resulting in greater storage in the reservoir and more frequent release events to the North Fork Ninnescah River.



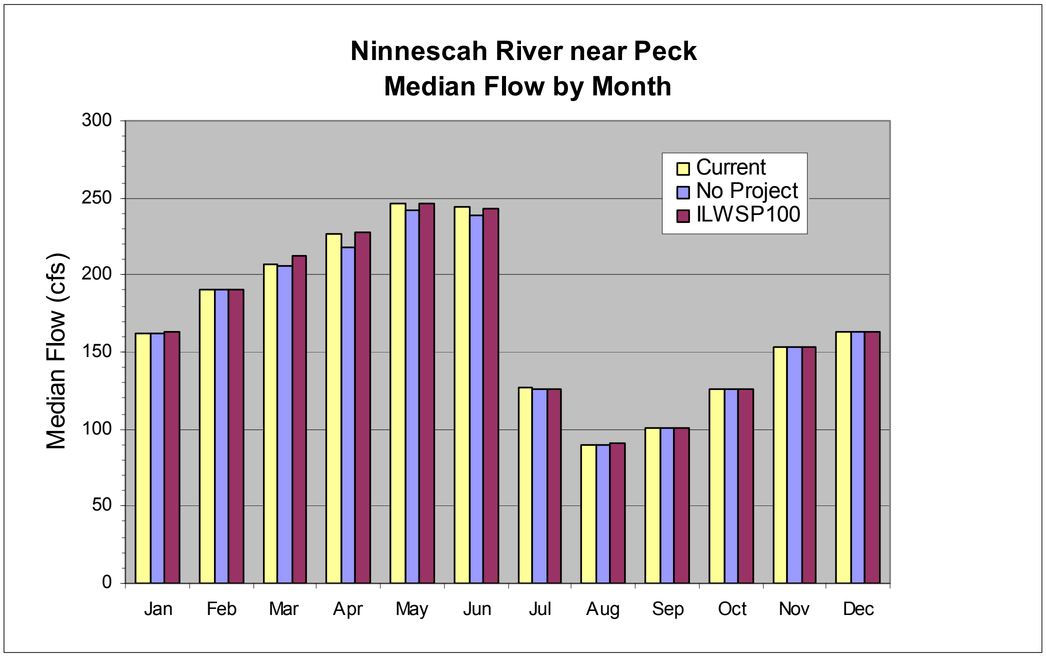


<u>Ninnescah River near Peck -</u>
Project impacts to stream discharge at this location are those produced by changes in releases from Cheney Reservoir. The releases from Cheney make up only a small portion of the total stream discharge at this location. Therefore, project impacts are relatively small compared to total discharge. Implementation of the project may result in increases in discharge of up to 9 cfs created by increasing spills from the reservoir over no-project conditions. But for a majority of the time, discharge would be about the same as without project.

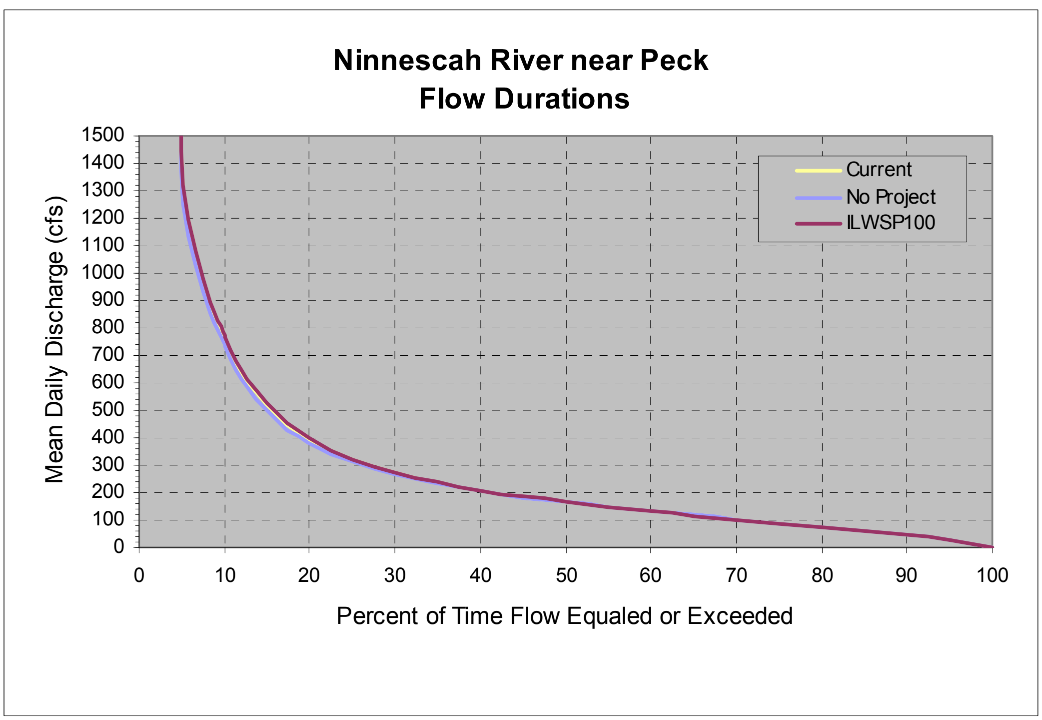
The KWO has established the MDS at this location to be:

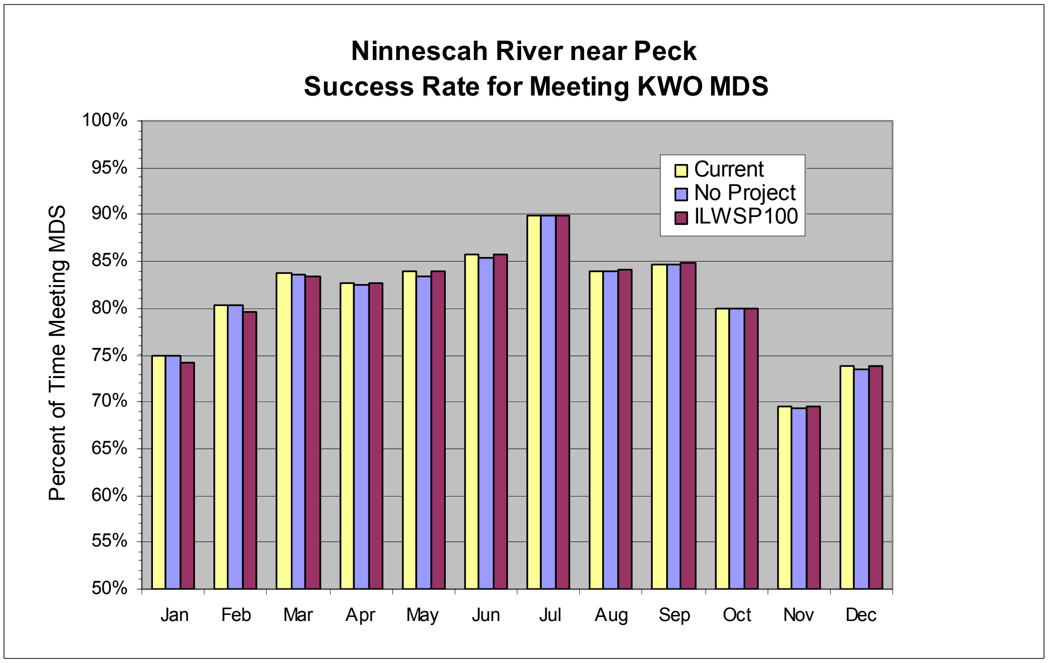
- 100 cfs in November through May
- 70 cfs in June
- 30 cfs in July through September
- 50 cfs in October

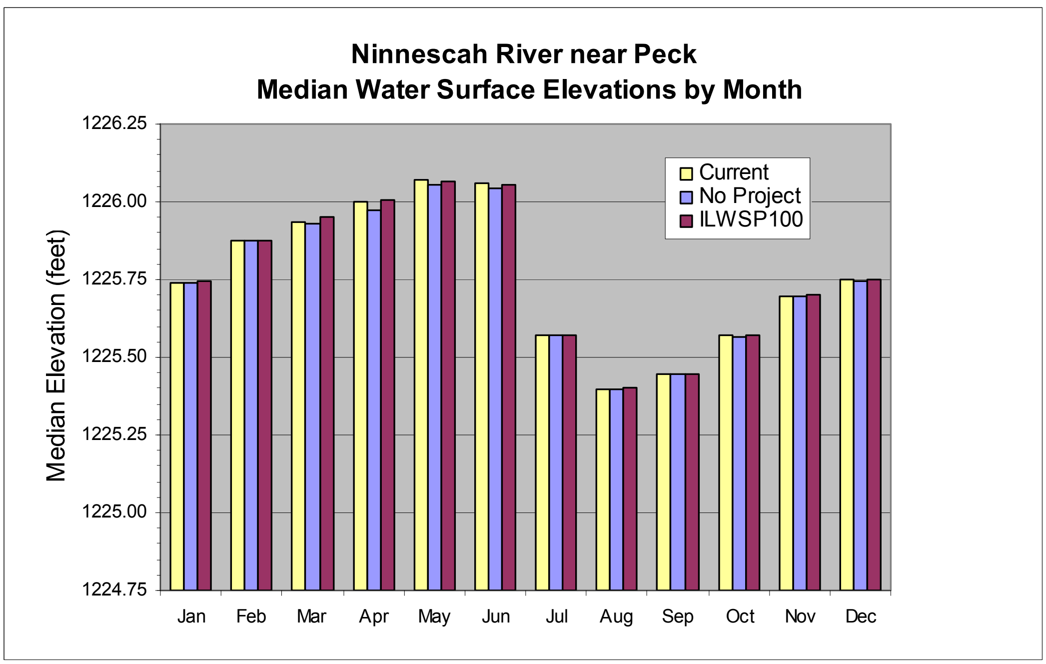
The percentage of time that these MDS values will be met will vary little between with or without project conditions.



Ninnescah River near Peck												
Median Flow by Month (cfs)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
No Project	161.7	190.0	206.1	218.4	241.5	238.5	126.2	90.1	100.4	125.7	153.2	163.4
ILWSP100	162.6	190.8	212.3	227.2	245.9	242.7	126.4	90.7	100.5	126.1	153.7	163.7
Difference	0.9	0.9	6.2	8.8	4.4	4.2	0.2	0.6	0.2	0.4	0.5	0.3

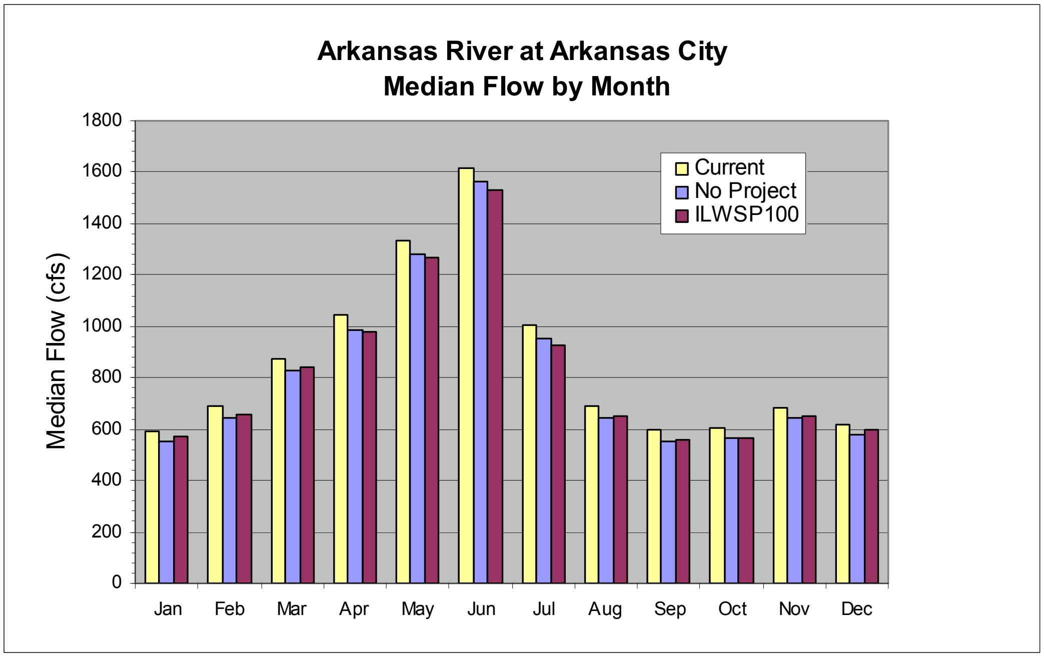




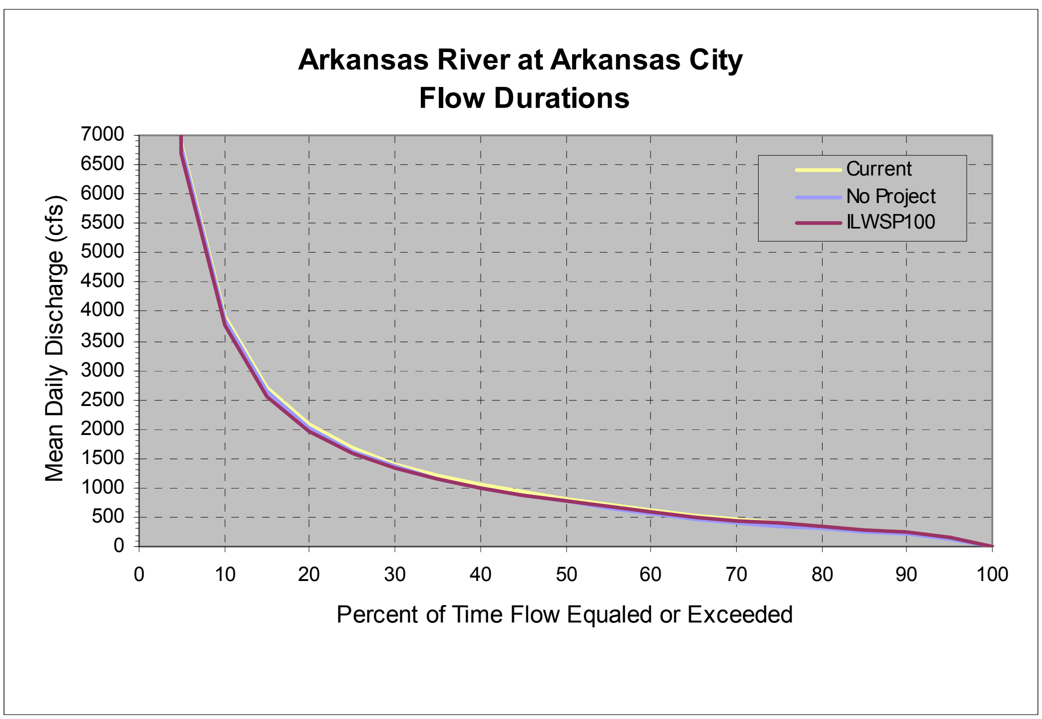


Arkansas River at Arkansas City -
This station is located near the Kansas- Oklahoma state line, approximately 24 miles downstream from the confluence of the Ninnescah and Arkansas Rivers. Discharge at this location would reflect the net impacts from the total ILWS project.

Due to its distance from the project area, and the intervening streamflow gains, the effects of the project on total discharge at this location are relatively small. Simulated median monthly flows suggest that during the peak flow month of June, discharge at this location could be 36 cfs less with implementation of project versus without project. This is approximately 2 percent of the median discharge for that month.



Arkansas River at Arkansas City Median Flow by Month (cfs)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
No Project	551.8	646.4	827.1	986.2	1284.1	1564.2	952.1	642.9	552.3	562.3	641.0	577.1
ILWSP100	572.6	659.6	841.6	978.9	1267.3	1528.5	927.1	650.0	561.0	567.8	648.7	598.3
Difference	20.8	13.2	14.5	-7.3	-16.7	-35.7	-25.1	7.2	8.7	5.5	7.7	21.2



Attachment A

Supplemental Information on RESNET Operations Model

OPERATIONS MODEL

This appendix documents the computer model that has been developed to simulate operation of the City of Wichita's Integrated Local Water Supply (ILWS) Plan. This operations model was used initially to help with the conceptual design of the ILWS system; it was later used to quantify potential hydrologic impacts for the project's environmental impact statement (EIS).

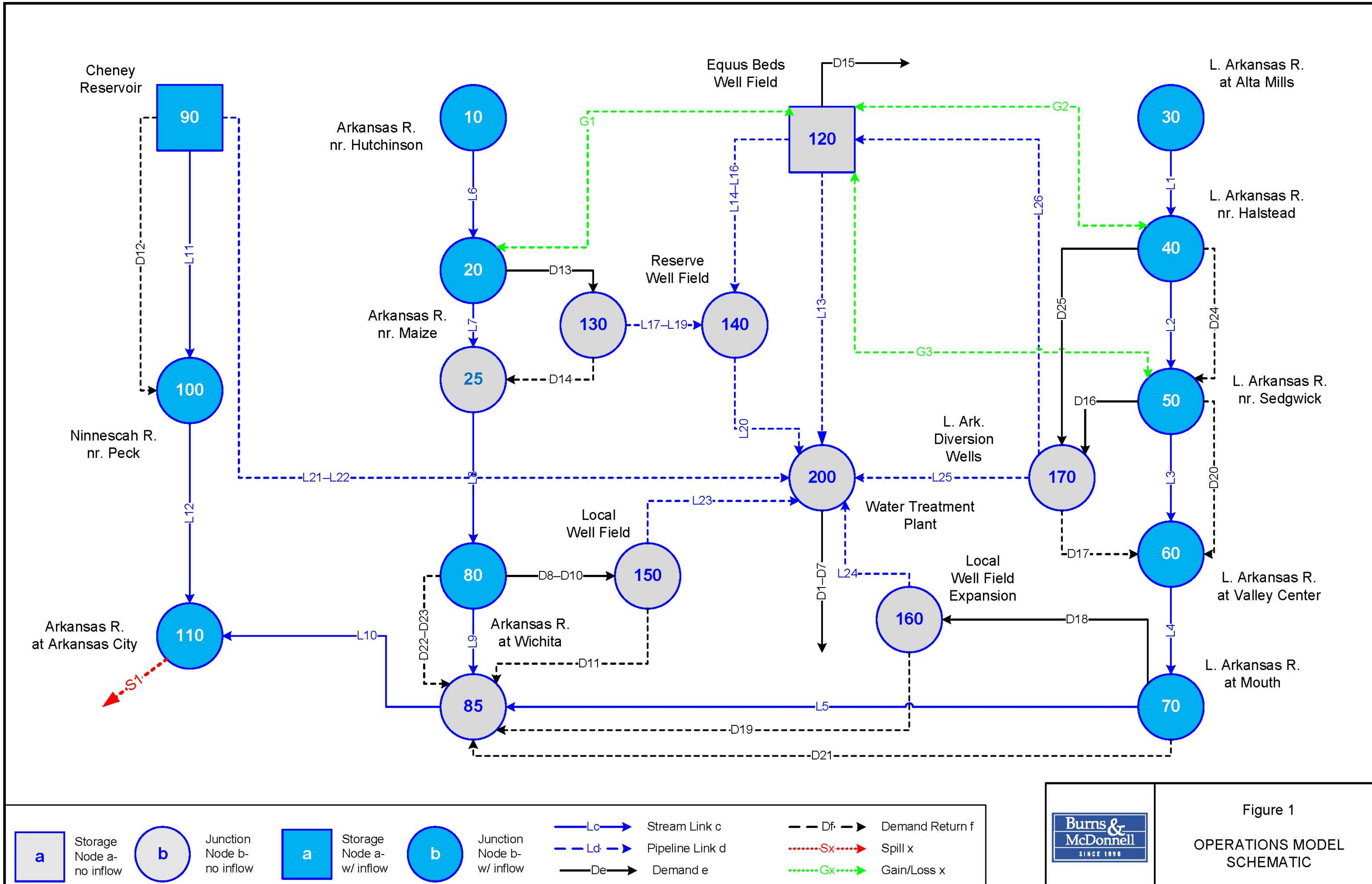
The operations model for the ILWS system was developed using Burns & McDonnell's Reservoir Network (RESNET) simulation model (Foster, 1989). This computer model represents the stream/reservoir system being simulated as a circulating network. This network representation allows the RESNET model to efficiently determine an optimum solution for each daily time step using least-cost network optimization techniques. This architecture makes it possible for RESNET to simulate systems of virtually unlimited complexity. The optimum network solution determined by the model each day represents a water balance for the ILWS system. This process is repeated for each day during the 85-year model simulation period (water years [WY] 1923–2007). Discussed below are the model's setup and input data, operating assumptions, and output data.

1 Model Setup and Input Data

The ILWS operations model uses the following types of hydrologic data:

- Historical mean daily stream discharge estimates at selected points within the project area
- Historical monthly reservoir evaporation rates
- Available storage and other physical data for Cheney Reservoir and the Equus Beds Aquifer
- City's current and projected water demands
- Irrigation demands for agriculture in the Equus Beds Well Field area
- Minimum desirable streamflow requirements
- Supply capability, operating parameters, and preferred allocation order for all current and potential water supply sources

These input data and operating assumptions are discussed in later sections. The ILWS system is represented in the operations model as a network of nodes with connecting links. A schematic of the overall operations model network is shown in Figure 1. Each of the components of the ILWS model is described further below.


Cheney Reservoir
90
Arkansas R. nr. Hutchinson
10
Equus Beds Well Field
120
D15
L. Arkansas R. at Alta Mills
30
G1
G2
L6
L14–L16
L26
L1
D12
L11
20
D13
Reserve Well Field
L. Arkansas R. nr. Halstead
40
Arkansas R. nr. Maize
130
L17–L19
140
L13
D25
D24
L7
L2
G3
25
D14
100
L. Arkansas R. nr. Sedgwick
50
D16
L20
L. Ark. Diversion Wells
Ninnescah R. nr. Peck
L21–L22
L8
200
L25
170
L3
D20
L23
Water Treatment Plant
Local Well Field
L12
D17
60
80
D8–D10
150
D1–D7
L24
Local Well Field Expansion
L. Arkansas R. at Valley Center
160
D18
Arkansas R. at Arkansas City
110
L10
D22–D23
L9
Arkansas R. at Wichita
L4
L. Arkansas R. at Mouth
D11
S1
85
L5
70
D19
D21
a
Storage Node a- no inflow
b
Junction Node b- no inflow
a
Storage Node a- w/ inflow
b
Junction Node b- w/ inflow
Lc
Stream Link c
Ld
Pipeline Link d
De
Demand e
Df
Demand Return f
Sx
Spill x
Gx
Gain/Loss x
Burns & McDonnell SINCE 1898
Figure 1
OPERATIONS MODEL SCHEMATIC

The RESNET model utilizes a Microsoft Access database file for storage of all model input and output data. The individual data tables used by the model are listed below in alphabetical order along with a brief description of their contents.

- tblRnAreaCapacity — Elevation-area-storage-leakage rate data for each model reservoir
- tblRnDemand — Input data for each model demand
- tblRnDemandData — Annual distribution data for applicable demands
- tblRnDemandOperations — Daily demand volumes and other related output data
- tlbRnDischargeSummary — Daily discharge below selected stream nodes
- tblRnError — RESNET error messages
- tblRnEvapData — Daily net evaporation data for applicable reservoirs
- tblRnEvapStation — Station identification for evaporation data in tblRnEvapData table
- tblRnFlowData — Daily unregulated inflow data for applicable model nodes
- tblRnFlowStation — Station identification for flow data in tblRnFlowData
- tblRnGageRating — Rating table data for stream nodes located at USGS gages
- tblRnImport — Data for each model import
- tblRnImportData — Annual distribution data for applicable imports
- tblRnLink — Input data for each model link
- tblRnLinkOperations — Daily link flow rates and other related output data
- tblRnModel — Base data that identifies each unique model alternative
- tblRnNetworkArcDump — Dump of network arc data when RESNET cannot find a feasible solution
- tblRnNetworkNodeDump — Dump of network node data when RESNET cannot find a feasible solution
- tblRnNode — Input data for each model node
- tblRnNodeOperations — Daily water balance for each node
- tblRnReservoir — Input data for each model reservoir
- tblRnReservoirLevel — Level/priority data for each model reservoir
- tblRnReservoirOperations — Daily storage and related output data for each reservoir
- tblRnSpill — Input data for each model spill node
- tblRnStorageSummary — Daily end-of-day storage in Cheney Reservoir and Equus Beds aquifer
- tblRnSupplySummary — Daily summary of each supply source's contribution toward meeting City's raw water demand
- tblRnWSElevSummary — Estimates of mean daily water surface elevations at four stream nodes plus daily end-of-day pool elevation and area for Cheney Reservoir

1.1 Model Data

Each unique ILWS alternative is represented by a single record in the model table (tblRnModel). The fields in this table are described below. In Table 1 and similar tables that follow, spaces have been added to the field names to improve readability.

Table 1: Data Fields in Model Table (tblRnModel)

Field Name	Description
ID	Unique record identifier assigned by system. This field contains the model ID that is used to identify each alternative model run.
Name	Short descriptive name for each alternative model run

Description	Description of model run
Start Date	Start date for model run (mm/dd/yyyy)
End Date	End date for model run (mm/dd/yyyy)
No Decimals	Requested precision for model results. The RESNET model uses acre-feet as its base volumetric unit so if this value is one the model will estimate volumes to nearest one tenth of an acre-foot.
Save Operations	True/false flag that indicates if detailed daily output data should be stored
No Zones	Should be zero for all ILWS model runs
Failure Probability	Not used by ILWS model
Primary Dmd Shortages	Number of days during simulation period with shortage in any primary demand
Source Model ID	Used for model cloning only

1.2 Model Nodes

The majority of the model nodes used in the operations model represent locations on project area streams, which include the Arkansas, Little Arkansas, North Fork Ninnescah and Ninnescah rivers. The remainder of the model nodes represent off-stream features, such as well fields, treatment plants and pipeline junctions. Each of these nodes is listed in Table 2.

Table 2: ILWS Model Nodes

Node Nos.	Name	Description	Unregulated Inflow?
10	Arkansas R. near Hutchinson	Located at USGS stream gage of same name. In model domain, most upstream node on Arkansas River.	Yes
20	Arkansas R. near Maize	Located at USGS stream gage of same name. Assumed supply source for Reserve Well Field and gains/losses to Equus Beds aquifer.	Yes
25	Arkansas R. below Maize	Located immediately downstream of Node No. 20	No
30	L. Arkansas R. at Alta Mills	Located at USGS stream gage of same name. In model domain, most upstream node on Little Arkansas River.	Yes
40	L. Arkansas R. near Halstead	Located at approximate position of Phase 1 intake. Assumed supply source for half of recharge diversion wells.	Yes
50	L. Arkansas R. near Sedgwick	Located at USGS stream gage of same name. Assumed supply source of surface water intake and balance of recharge diversion wells.	Yes
60	L. Arkansas R. at Valley Center	Located at USGS stream gage of same name.	Yes
70	L. Arkansas R. at Mouth	Located at mouth of Little Arkansas River.	Yes

80	Arkansas R. at Wichita	Located at USGS stream gage of same name. Assumed supply source for existing Local (E&S) Well Field.	Yes
85	Arkansas R. below Wichita	Located immediately downstream of Node No. 80	No
90	Cheney Reservoir	A storage node located on the North Fork Ninnescah River at Cheney Dam.	Yes
100	Ninnescah R. near Peck	Located at USGS stream gage of same name.	Yes
110	Arkansas R. at Arkansas City	Located at USGS stream gage of same name. Most downstream node in model domain.	Yes
120	Equus Beds Aquifer/Well Field	Storage node that represents Equus Beds Aquifer.	No
130	Reserve Well Field	Node that represents the total supply available from the Bentley Reserve Well Field. This well field is modeled as a direct surface water diversion (that is, aquifer storage is ignored and pumping is assumed to induce immediate and equal infiltration from the Arkansas River).	No
140	Reserve Well Field Junction	Junction node for supplies from Equus and Reserve Well Fields.	No
150	Local Well Field	Located along Arkansas River in downtown Wichita. This node represents the combined supply available from the existing Local (E&S) Well Fields. This well field is modeled like a direct, surface water diversion from the Arkansas River.	No
160	Local Well Field Expansion	Located along the Little Arkansas River in downtown Wichita. This node represents the combined supply available from the proposed Local Well Field Expansion. This well field is modeled as a direct, surface water diversion from the Little Arkansas River.	No
170	L. Arkansas R. Intake/Diversion Wells	Located along the Little Arkansas River. This node represents the combined supply available for aquifer recharge from the proposed surface intake and alluvial diversion wells. Pumping at the diversion wells is assumed to induce immediate infiltration from the Little Arkansas River.	No
200	Water Treatment Plant	Located at Wichita's main water treatment plant near the confluence of the Arkansas and Little Arkansas rivers. All raw water supplied to the City is assumed to flow through this node.	No

As noted in Table 2, slightly more than half of these nodes have unregulated inflow. These nodes are shown in blue in Figure 1. Unregulated inflow is surface runoff that enters tributary stream(s) above a node but below any upstream nodes. The methodology used to estimate unregulated inflow is described in a separate appendix (Burns & McDonnell, 2008c).

The node data for each model run is stored in an Access table named tblRnNode. The data fields in this table are listed in Table 3.

1.3 Model Storage Nodes

Two of the nodes in the operations model are storage nodes, or reservoirs: Cheney Reservoir (Node No. 90) and Equus Beds Aquifer (Node No. 120). Unlike non-storage nodes, these nodes have the ability to retain water from one time step to the next. In RESNET, a reservoir's storage is divided into levels with each level having a defined storage priority. Levels with the highest priority are filled first when water is available and used last when water from storage is required to meet demands. These priorities define the unit benefit of having water stored in each level. The defined reservoir levels for Cheney Reservoir and the Equus Beds Aquifer are listed in Table 4.

Table 3: Data Fields in Node Table (tblRnNode)

Field Name	Description
ID	Unique record identifier assigned by system. This field contains the node IDs that are used to identify the nodes in each alternative model run.
Model ID	Identifier (ID) for corresponding model in Model table (tblRnModel)
Number	Node number. Used as shorthand identifier for each node only.
Name	Short node name
Description	Description of node
Flow Station ID	If this node has unregulated inflow, the applicable flow station ID. Otherwise, this field will be null.
Source Node ID	Used for cloning only

Table 4: ILWS Reservoir Storage Levels

Level No.	Cheney Reservoir		Equus Beds Aquifer	
	Storage (acre-feet)	Storage Priority	Storage Deficit (acre-feet)	Storage Priority
1	1,140	999	-643,000	999
2	2,000	990	-200,000	770
3	4,000	980	-114,000	760
4	8,000	960	-103,200	750
5	10,000	950	-92,400	740
6	15,476	900	-81,600	730
7	24,817	750	-70,800	720
8	37,170	725	-60,000	710
9	53,265	700	-50,000	700
10	73,356	675	-41667	675
11	97,645	650	-33,333	650
12	125,842	350	-25,000	625

13	152,222	300	-16,667	500
14	170,575	100	-8,333	575
15	247,931	1	0	550

When both reservoirs are relatively full, water will be withdrawn from Cheney Reservoir first because it has a lower storage priority (for example, level 12 has a priority of only 350 for Cheney Reservoir but 625 for the Equus Beds Aquifer). This bias attempts to preserve the water stored in the Equus Beds because this water is relatively more expensive. However, once both reservoirs are drawn down further during a prolonged dry period, the storage priorities are coordinated so that both are drawn down at about the same rate.

There are three Access tables that apply to each model reservoir. The data fields for these tables are described in Tables 5, 6 and 7.

Table 5: Data Fields in Reservoir Table (tblRnReservoir)

Field Name	Description
ID	Unique record identifier assigned by system. This field contains the reservoir IDs that are used to identify the reservoirs in each alternative model run.
Node ID	ID for corresponding node in Node table (tblRnNode)
Initial Storage	Initial storage in the reservoir at start of model run (acre-feet)
Evap Station ID	If this reservoir has evaporation losses, the corresponding evaporation station ID in tblRnEvapStation
Loss Node ID 1	For leaky reservoir, the first loss node ID. Null if not applicable.
Loss Node ID 2	For leaky reservoir, the second loss node ID. Null if not applicable
Loss Node ID 3	For leaky reservoir, the third loss node ID. Null if not applicable
BOC Storage	Reservoir storage at bottom of conservation pool (acre-feet). Not used for ILWS operations model
TOC Storage	Reservoir storage at top of conservation pool (acre-feet). Not used for ILWS operations model
Base Water Right	Base annual water right (acre-feet). Applicable for Equus Beds only.
Max Recharge	Maximum value for recharge credit account (acre-feet). Applicable for Equus Beds only.
Initial Recharge	Initial value of recharge credit account (acre-feet). Applicable for Equus Beds only.
Min Storage	Output field that reports minimum reservoir storage during model run (acre-feet)
Source Reservoir ID	Used for model cloning only.

Table 6: Data Fields in Reservoir Area-Capacity Table (tblRnAreaCapacity)

Field Name	Description

ID	Unique record identifier assigned by system.
Reservoir ID	ID for corresponding reservoir in Reservoir table (tblRnReservoir)
Elevation	Reference pool or aquifer elevation for current reservoir (feet NGVD)
Area	Reservoir pool area for current reservoir at specified elevation (acres)
Storage	Reservoir storage for current reservoir at specified elevation (acre-feet)
Loss Rate 1	Reservoir loss rate to loss node 1 (acre-feet/day)
Loss Rate 2	Reservoir loss rate to loss node 2 (acre-feet/day)
Loss Rate 3	Reservoir loss rate to loss node 3 (acre-feet/day)

Table 7: Data Fields in Reservoir Level Table (tblRnReservoirLevel)

Field Name	Description
ID	Unique record identifier assigned by system.
Reservoir ID	ID for corresponding reservoir in Reservoir table (tblRnReservoir)
Level Num	Sequential level number. Used only for more convenient reference
Level Volume	Storage volume for current reservoir at top of specified level (acre-feet)
Priority	Storage priority for specified level

Additional data for the two system reservoirs are described in the following sections.

1.3.1 Cheney Reservoir

Cheney Reservoir is located on the North Fork Ninnescah River near Cheney, Kansas. This reservoir has the following defined storage pools:

- Dead pool: 979 acre-feet between elevation 1,367 and 1,378.5 feet NGVD
- Fish & wildlife pool: 14,310 acre-feet between elevation 1,378.5 and 1,392.9 feet NGVD
- Conservation pool: 151,800 acre-feet between elevation 1,392.9 and 1,421.6 feet NGVD
- Flood pool: 80,860 acre-feet between elevation 1,421.6 and 1,429 feet
- Surcharge pool: 451,347 acre-feet between elevation 1,429 and 1,453.4 feet NGVD

Table 8 lists the elevation-area-storage data for Cheney Reservoir.

Table 8: Cheney Reservoir Elevation-Area-Storage Data

Pool Elevation (feet NGVD)	Pool Area (acres)	Pool Storage (acre-feet)
1,367	0	0
1,370	14	13
1,375	107	272
1,380	445	1,545
1,385	808	4,535

1,390	1,504	10,241
1,395	2,333	19,793
1,400	3,291	33,761
1,405	4,530	53,265
1,410	5,785	78,987
1,415	7,293	111,602
1,420	8,976	152,222
1,425	10,788	201,557
1,430	12,835	260,557
1,435	14,949	330,019
1,440	17,466	411,058
1,445	20,631	506,303
1,450	23,387	616,350

As a conventional surface reservoir, Cheney Reservoir is also subject to evaporation losses. The estimated net evaporation rates from Cheney Reservoir are described in a separate appendix (Burns & McDonnell, 2008a). These rates account for the net evaporation losses each day (gross evaporation loss less direct precipitation gain).

1.3.2 Equus Beds Aquifer

The Equus Beds aquifer is modeled similar to a surface water reservoir except it does not have evaporation losses. Natural aquifer recharge was estimated to be 3.2 inches per year by the U.S. Geological Survey. This natural recharge is represented in the operations model as an import to this node (No. 120) of 18,800 acre-feet/year.

The interaction between the Equus Beds aquifer and local streams was evaluated in the MODFLOW groundwater model. Generally, aquifers receive their recharge from precipitation and streams serve as aquifer drains. The outflow from aquifers supports the baseflow in these streams. The Equus Beds aquifer has two streams that are major components of the hydrogeological system. The Arkansas River is generally parallel to the pre-development groundwater flow gradient so the interaction between the aquifer and this river was relatively minor. In contrast, the Little Arkansas River is at the down-gradient edge of the Equus Beds aquifer and generally perpendicular to the predominant groundwater flow direction. Changes in the aquifer groundwater level impact the differential head between the aquifer and streams and can result in significant changes in the volume of flow between the aquifer and streams.

The water budget summary feature in MODFLOW provides an accounting of the total water flow from aquifer to stream and stream to aquifer. These total aquifer-stream interaction flows are discussed in the accompanying groundwater appendix (Burns & McDonnell, 2008b) and repeated in Table 9.

Table 9: Equus Beds Storage Deficit-Gain-Loss Data

Index Well 886 Elevation (feet NGVD)	Storage Deficit (acre-feet)	Total Gain from Rivers (cfs)	Total Loss to Rivers (cfs)	Net Equus Beds Loss Rates (cfs)	
				To Arkansas River	To Little Arkansas River
1,342	429,700	133	23	-116.6	6.6
1,360	289,400	100	38	-72.8	10.8
1,366	242,700	89	43	-58.3	12.3
1,370	211,500	82	44	-50.5	12.5
1,375	172,600	73	48	-38.7	13.7
1,380	133,600	62	53	-24.1	15.1
1,385	94,700	54	60	-11.1	17.1
1,389	63,500	48	68	0.6	19.4
1,390	55,700	46	70	4.1	20.0
1,395	16,800	38	82	20.6	23.4
1,396	9,000	36	85	24.8	24.2
1,402	0	29	99	41.8	28.2

Table 9 lists the total gain and loss data for the Equus Beds aquifer as a function of water level. Initially, it was assumed that all aquifer gains come from the Arkansas River and all losses accrue to the Little Arkansas River but subsequent analyses proved this assumption to be too simplistic. In the ILWS plan and operations model the Arkansas and Little Arkansas rivers are treated as two distinct sources. Therefore, the flow between the aquifer and Arkansas River must be differentiated from the flow between the aquifer and Little Arkansas River. These flows were differentiated through an analysis that is described in the Streamflow Appendix (Burns & McDonnell, 2008c). The last two columns in Table 9 show the resulting distribution of these aquifer losses.

With recognition of this aquifer interaction, the RESNET model was customized for development of the ILWS system operations model by adding the ability to model a leaky reservoir. Leakage rates are entered into the model for each destination node as a function of reservoir storage. These reservoir leakage or loss rates can be negative, indicating an actual gain.

1.4 Model Links

The nodes described above are interconnected in the operations model by a series of model links. These links, which are listed in Table 10, represent both natural stream reaches, and pipelines and other man-made conveyance facilities. These stream and pipeline links are shown respectively as solid or dashed blue lines in Figure 1. Each model link has only one origin node and one terminal node. The flow in these links can travel in only one direction from their origin node to their terminal node. Each link also has a specified minimum and maximum flow rate, expressed in acre-feet/day. Generally, the minimum flow rate for these links is zero but the maximum flow rate is dependent on the link type; natural streams are assigned an arbitrarily large flow rate and pipelines are assigned maximum flow rates based on their flow capacity. The RESNET model uses a least-cost algorithm to find the best solution in each time step. Therefore, each link also has an assigned unit flow cost, which is expressed in arbitrary cost units per acre-foot.

Table 10: ILWS Model Links

Link No.	Origin→ Terminal Node Nos.	Description	Minimum Flow Rate (ac-ft/day)	Maximum Flow Rate (ac-ft/day)	Unit Cost/ ac-ft
L1	30→40	L Arkansas R: Alta Mills–Halstead	0	1,000,000	0
L2	40→50	L Arkansas R: Halstead–Sedgwick	0	1,000,000	0
L3	50→60	L Arkansas R: Sedgwick–Valley Center	0	1,000,000	0
L4	60→70	L Arkansas R: Valley Center–Mouth	0	1,000,000	0
L5	70→80	L. Arkansas R: Mouth–Arkansas R	0	1,000,000	0
L6	10→20	Arkansas R: Hutchinson–Maize	0	1,000,000	0
L7	20→25	Arkansas R: Maize–below Maize	0	1,000,000	0
L8	25→80	Arkansas R, below Maize–Wichita	0	1,000,000	0
L9	80→85	Arkansas R: Wichita–below Wichita	0	1,000,000	0
L10	85→110	Arkansas R: below Wichita–Arkansas City	0	1,000,000	0
L11	90→100	North Fork/Ninnescah R: Cheney Reservoir–Peck	0	1,000,000	0
L12	100→110	Ninnescah/Arkansas R: Peck–Arkansas City	0	1,000,000	0
L13	120→200	Pipeline: Equus Beds WF–WTP	0	349	10
L14	120→140	Pipeline: Equus Beds WF–RWF Junction	0	33	-75
L15	120→140	Pipeline: Equus Beds WF–RWF Junction	0	33	-50
L16	120→140	Pipeline: Equus Beds WF–RWF Junction	0	33	-25
L17	130→140	Pipeline: Reserve WF–RWF Junction	0	11	510
L18	130→140	Pipeline: Reserve WF–RWF Junction	0	11	535
L19	130→140	Pipeline: Reserve WF–RWF Junction	0	11	560
L20	140→200	Pipeline: RWF Junction–WTP	0	132	10
L21	90→200	Pipeline: Cheney Reservoir–WTP	0	144	10
L22	90→200	Pipeline: Cheney Reservoir–WTP	0	101	10
L23	150→200	Pipeline: Local WF–WTP	0	113	30
L24	160→200	Pipeline: Local WF Expansion–WTP	0	138	10
L25	170→200	Pipeline: Intake–WTP	0	0	20
L26	170→120	Pipeline: Intake/Diversion Wells–Equus Beds	0	306.9	30

The data for these model links is stored in an Access table named tblRnLink. The fields in this table are described in Table 11. For most model links, their intended purpose is self explanatory; however, there are a few exceptions that warrant additional explanation. These special cases are discussed below.

1.4.1 Bentley Reserve Well Field

The Bentley Reserve Well Field is located in the alluvium of the Arkansas River so pumping from this well field will induce infiltration of relatively saline water from the Arkansas River. To avoid excessive quality impacts to the City's water supply, the operations model is configured to provide mandatory blending of this Reserve Well Field water with better-quality water from the Equus Beds Well Field at a ratio of three to one (that is, three parts Equus Beds water for each one part Reserve Well Field water). The RESNET model does not have the direct capability to regulate the flow in one link based on the flow in a parallel link; therefore, this blending process is approximated by using three links each from the Equus Beds to RWF Junction (L14, L15 and L16) and three links from the Reserve Well Field to the RWF Junction (L17, L18 and L19).

Table 11: Data Fields in Link Table (tblRnLink)

Field Name	Description
ID	Unique record identifier assigned by system. This field contains the link IDs that are used to identify the links in each model run.
Number	Sequential link number. Used for more convenient reference only.
Name	Short link name
Origin Node ID	Identifier corresponding to origin node in tblRnNode
Terminal Node Id	Identifier corresponding to terminal node in tblRnNode
Minimum Flow	Minimum allowable flow in this link (acre-feet/day)
Maximum Flow	Maximum allowable flow in this link (acre-feet/day)
Cost	Unit cost of flow in this link (per acre-foot)
Loss Node ID	For leaky stream segment, ID for node where losses accrue. Not utilized in ILWS model.
Link Loss Percent	For leaky stream segments, percent of flow loss in link (percent). Not used in ILWS model.
Link Loss Max	Maximum loss in link (acre-feet/day). Not used in ILWS model.
Limit Link ID	Link ID used to limiting flow for this link. Not used in ILWS model.
Limit Demand ID	Demand ID used to limit flow in this link. Not used in ILWS model.
Source Link ID	Used for cloning only

When water is available from the Reserve Well Field and there is sufficient water supply demand to utilize this water, the operations model will first use up to 33 acre-feet/day of water from the Equus Beds Well Field via link L14 before then using up to 11 acre-feet/day of water from the Reserve Well Field through link L17. If there is additional water available from the Reserve Well Field, this process will continue with the model using in order links L15, L18, L16 and finally L19.

1.4.2 Cheney Reservoir Supply Pipeline

Deliveries from Cheney Reservoir to the City's water treatment plant are modeled using two parallel links even though there is only one physical supply pipeline. The first link (L21) has a maximum flow based on the City's original water right for Cheney Reservoir (47 million gallons per day [MGD] or 144 acre-feet/day). Water can be supplied to the City through this link whenever there is water available in the reservoir's conservation pool. The second link from Cheney Reservoir (L22) represents the balance of the capacity in this supply pipeline (80 MGD less 47 MGD = 33 MGD or 101 acre-feet/day). This additional supply capability is available only when the reservoir's conservation pool is full or near full.

1.5 Model Demands

In the ILWS operations model, system demands are used to accomplish a variety of purposes. The most obvious purpose is to satisfy actual water demands, such as the required raw water supply to the City's water treatment plant. The water extracted from the Equus Beds aquifer by farmers for irrigation is a similar consumptive water demand. All other model demands are termed flow-through demands because all of the water withdrawn at the given node is returned to the system at another node. These flow-through demands are used to represent minimum streamflow requirements and also the available supplies to pump stations.

In the RESNET model, each demand has a source node, annual demand volume and demand priority. Optionally, these demands can also have a return node and return percentage, and a specified annual demand distribution. If no demand distribution is provided, the annual demand volume is distributed evenly across each day of the year.

Demands with the highest priority yield the highest benefit per unit when satisfied. For example, a demand for 10 acre-feet/day with a priority of 500 will yield 5,000 benefit units when satisfied. Benefits are treated as negative costs (with the same units) in the RESNET model. Therefore, in order to minimize costs the model will try to satisfy the demands with the highest priorities first.

The model demands included in the ILWS operations model are described in Table 12.

Table 12: ILWS Model Demands

Demand No.	Origin Node No.	Annual Demand (ac-ft/yr)	Dmd Dist?	Priority	Return		Description
					Node No.	Per-cent	
D1	200	87,563.1	Yes	806	---	---	Wichita: 0-70%
D2	200	6,254.5	Yes	805	---	---	Wichita: 70-75%
D3	200	6,254.5	Yes	804	---	---	Wichita: 75-80%
D4	200	6,254.5	Yes	803	---	---	Wichita: 80-85%
D5	200	6,254.5	Yes	802	---	---	Wichita: 85-90%
D6	200	6,254.5	Yes	801	---	---	Wichita: 90-95%
D7	200	6,254.5	Yes	800	---	---	Wichita: 95-1000%
D8	80	5,604	No	850	150	100	E Wells: 0-5MGD
D9	80	5,604	No	800	150	100	E Wells: 5-10MGD
D10	80	22,418	No	750	150	100	S Wells: 20MGD
D11	150	33,627	No	10	85	100	Local WF Excess Return
D12	90	1,448,000	No	10	100	100	Cheney spillway drawdown
D13	20	5,000	No	875	130	100	Reserve WF supply
D14	130	11,209	No	10	25	100	RWF excess return

D15	120	26,500	Yes	900	---	---	Equus Beds irrigation
D16	50	56,044	No	825	170	100	Sedgwick recharge supply
D17	170	112,088	No	10	60	100	Excess recharge return
D18	70	50,440	No	825	160	100	Local WF Expansion supply
D19	160	50,440	No	10	85	100	Local WF Expansion excess return
D20	50	28,960	No	850	60	100	L Arkansas R minimum flow at Sedgwick
D21	70	14,480	No	850	85	100	L Arkansas R minimum flow at mouth
D22	80	362,000	No	825	85	100	Arkansas R minimum flow: 500 cfs
D23	80	724,000	No	775	85	100	Arkansas R minimum flow: 500-1500 cfs
D24	40	28,960	No	850	50	100	L Arkansas R minimum flow at Halstead
D25	40	56,044	No	825	170	100	Halstead recharge supply

The data for these model demands is stored in two Access tables: tblRnDemand and tblRnDemandData. The data fields in these tables are described in Tables 13 and 14.

Table 13: Data Fields in Demand Table (tblRnDemand)

Field Name	Description
ID	Unique record identifier assigned by system. This field contains the demand IDs that are used to identify the demands in each model run.
Node ID	Identifier for node where this demand originates
Number	Sequential demand number. Used for more convenient reference only.
Name	Short demand name
Description	Description of demand
Demand	Desired annual quantity for the current demand (acre-feet/year)
Priority	Priority for current demand
Return Node ID	Node ID for return node. Null if not applicable
Return Percent	Percentage of volume in this demand that is returned to system at specified node
Primary Demand	True/false flag that indicates if current demand is considered to be a primary demand.
Shortage Days	Output field that accumulates number of days during simulation period with shortages at current demand
Source Demand Id	Used for cloning only.

Table 14: Data Fields in Demand Distribution Table (tblRnDemandData)

Field Name	Description
ID	Unique record identifier assigned by system.
Demand ID	Identifier for corresponding demand in tblRnDemand
Month	Month number (1=Jan, 2=Feb, etc.)
Day	Day of month
Demand Percent	Portion of the annual demand volume that is desired on this day of year (percent of annual)

The model demands listed in Table 12 are discussed further below.

1.5.1 Wichita Raw Water Demands

The total raw water demand for the City of Wichita was segregated into seven parts for modeling purposes. These seven individual demands (D1-D7) were included to show the potential impact of additional water conservation measures on system reliability. The demand quantities listed in Table 3 for these demands total to 125,090 acre-feet/year, which is equivalent to an average of 111.8 MGD. This is the City's estimated average-day demand in 2050. For current conditions, a total City water demand of 78,768 acre-feet, or 70.4 MGD, was used. These demand estimates include the impact of typical conservation measures, such as existing City ordinances that require use of low-flow showerheads and toilets in new construction, but not additional conservation measures during dry periods, such as restrictions on lawn watering and vehicle washing. None of these additional conservation measures were implemented in the model runs used in the EIS, but they can be simulated by progressively reducing the demand priorities of demands D7, D6, etc. The distribution of the City's water demand was derived from actual usage data for calendar year 1991 (Burns & McDonnell, 2003).

1.5.2 Local Well Field

Demands D8–D11 and D22–D23 are used to model the City's existing Local Well Field, which is a combination of the Emergency and Sims well fields and, therefore, often referred to as the E&S well fields. The "E" wells have a total capacity of 10 MGD and the "S" wells a total capacity of 20 MGD. Demand D8 represents the first 5 MGD of supply from the "E" wells, with D9 the second half. Demand D10 represents the 20 MGD available from the "S" wells. Demand D11 is a low-priority demand that returns "excess" diversions to the Local Well Field back to the Arkansas River when not needed to satisfy the City's water demands. Demands D22 and D23 are flow-through demands (that is, in-stream flow requirements) that restrict when the Local Well Field can operate because of the lower-quality water available from the Arkansas River.

Among these five demands, D8 has the highest priority (850) so up to 5 MGD is assumed to be available from the "E" wells whenever there is flow in the Arkansas River at Node No. 80. The demand with the next lower priority is D22 (825) so the model will attempt to satisfy this demand next. This demand represents an in-stream flow requirement of 500 cfs. The water quality of the Arkansas River tends to improve at higher flow rates so demand D22 prevents the balance of the "E" wells (demand D9 with priority 800) from operating unless the flow in the Arkansas River is greater than 500 cfs. In a similar manner, demand D23, which has an average rate of 1,000 cfs, prevents the "S" wells from operating unless the flow in the Arkansas River totals over 1,500 cfs.

1.5.3 Local Well Field Expansion

In the model runs completed for the EIS, the Local Well Field was assumed to be expanded by 45 MGD with a series of alluvial wells along the Little Arkansas River. The supply and excess return from this new source is represented by demands D18 and D19. Demand D21 is a flow-through demand that also originates at Node No. 70. This demand, with a priority of 850, prevents the local well field expansion (demand D18 with priority 825) from operating unless the flow in the Little Arkansas River exceeds 20 cfs at its mouth.

1.5.4 Cheney Drawdown

The RESNET model attempts to put all available water to beneficial use. That is, it attempts to minimize spills (Section 1.5). In Cheney Reservoir, the elevation-storage data includes the flood control and surcharge pools. Without some means to evacuate these upper pools, the model would try to keep this water in storage if its release would contribute to a spill. Demand D12 mimics the reservoir's spillway to provide a means to draw the reservoir back down to the top of its conservation pool.

1.5.5 Reserve Well Field

The Bentley Reserve Well Field has a planned capacity of 10.8 MGD. This water source is represented in the operations model by a supply demand (D13) and an excess return demand (D14). Pumping at this well field is assumed to induce infiltration from the Arkansas River so this source is assumed available whenever there is sufficient flow in the Arkansas River. As discuss above (Section 1.3.1), the water withdrawn from this source must be blended with three times as much better-quality water from the Equus Beds Well Field.

1.5.6 Equus Beds Irrigation Demand

Within the Equus Beds Well Field area, agriculture is the dominate land use. Many of the farmers in this area irrigate with groundwater withdrawn from the Equus Beds aquifer. The demand for irrigation withdrawals from the aquifer is represented in the operations model by demand D15. This demand has an annual quantity of 26,500 acre-feet, which was derived from review of reported water usage records for the entire aquifer. These records are collected by the Kansas Division of Water Resources. Generally, only annual water usage data are available so these irrigation withdrawals are assumed to occur at a constant rate over the entire growing season (mid-May through mid-September).

1.5.7 Equus Beds Recharge

Recharge to the Equus Beds aquifer is represented in the operations model by demands D16, D17, D25, D20 and D24. Demands D20 and D24 are flow-through demands that restrict withdrawals from the Little Arkansas River to periods when the flow exceeds 40 cfs. The potential recharge supply is represented by demands D16 and D25, which total to either 100 or 150 MGD, depending on alternative. Fifty percent of these withdrawals are assumed to occur above Halstead (D25) and the balance between Halstead and Sedgwick. The operations model makes no distinction between withdrawals via a surface water intake or through alluvial wells. The supply demands (D16 and D25) will withdraw water from the Little Arkansas River whenever conditions permit. If the Equus Beds aquifer is fully recharged, demand D17 provides a means to return this water back to the river.

1.6 Model Imports

In RESNET an import is a fixed quantity of water that accrues at a specified node each year. Only one import is used in the ILWS operations model. This import represents the average annual natural recharge to the Equus Beds aquifer. Imports and their corresponding annual distribution data are stored in two Access tables: tblRnImport and tblRnImportData. The data fields for these two tables are listed in Tables 15 and 16.

Table 15: Data Fields in Import Table (tblRnImport)

Field Name	Description
ID	Unique record identifier assigned by system. This field contains the import IDs that are used to identify the imports in each model run.
Node ID	Identifier for node where this import accures
Import	Annual quantity for the current import (acre-feet/year)
Source Import ID	Used for cloning only.

Table 16: Data Fields in Import Distribution Table (tblRnImportData)

Field Name	Description
ID	Unique record identifier assigned by system.
Import ID	Identifier for corresponding import in tblRnImport
Month	Month number (1=Jan, 2=Feb, etc.)
Day	Day of month
Import Percent	Portion of the annual import volume that is received on this day of year (percent of annual)

1.7 Model Spills

A spill is a final sink for any water in the system that is left over after all possible demands are met and reservoirs filled. In the ILWS model, there is only one designated spill (S1), which is located at the most downstream node in the system, the Arkansas River at Arkansas City (Node No. 110). This spill is assigned a very high unit cost (15,000 per acre-foot) so the model will minimize spill quantities to the extent practicable in finding the least-cost network solution for each time step.

In RESNET, spill data is stored in an Access table named tblRnSpill. The data fields in this table are described in Table 17.

Table 17: Data Fields in Spill Table (tblRnSpill)

Field Name	Description
ID	Unique record identifier assigned by system. This field contains the spill IDs that are used to identify the spills in each model run.
Node ID	Identifier for node where this spill originates
Cost	Unit cost of water lost to system through this spill (per acre-foot). Spill costs are usually relatively high such a 10,000 or more.
Source Import ID	Used for cloning only.

2 Operations Model Output Data

Execution of the operations model generates data that depicts the daily water balance calculated for each day during the 85-year simulation period. These data are stored as four separate data streams, with one stream each for nodes, reservoirs, links and demands. These four data streams are described below.

2.1 Node Operations Data

The ILWS operations model will output a water balance for each node in the model for each day. These data are stored in an Access table named tblRnNodeOperations. The individual fields in this table are described in Table 18.

Table 18: Data Fields in Node Operations Table (tblRnNodeOperations

Field Name	Description
ID	Unique record identifier assigned by system
Node ID	Identifier for corresponding node from tblRnNode table. These node IDs are unique to each alternative model run.
Date	Date for these data (mm/dd/yyyy)
Inflow	The unregulated inflow (if any) to this node on specified date (acre-feet).
Upstream Release	The total flow on specified date in all links that terminate at this node (acre-feet). For example, at Node No. 110, this field would include the total flow in links L10 and L12.
Import	The import to this node on specified date (acre-feet). This field will be zero for all nodes except Node No. 120.
Demand Return	If the current node is a return node for any flow-through demand, this field will contain the total return flow at this node (acre-feet). If this node is the return node for multiple demands (for example, Node No. 85 is the return node for demands D11, D19, D21, D22 and D23), this field will contain the total for all return flows.
Downstream Release	The total flow on specified date in all links that originate at the current node (acre-feet).
Demand	The total for all demands that originate at the current node satisfied on specified date (acre-feet).
Spill	Total spills on specified date from this node (acre-feet). This field will be zero except at Node No. 110.
Losses	Total reservoir losses on specified date from this node (acre-feet). This field will be zero for all nodes except Node No. 120.

2.2 Reservoir Operations Data

The data included in the node operations table shows a complete water balance at each node except for storage nodes. At these storage nodes or reservoirs, the additional data needed to complete the water balance are listed in the reservoir operations data table. These data are stored in an Access table named tblRnReservoirOperations. The individual fields in this table are described in Table 19.

Table 19: Data Fields in Reservoir Operations Table (tblRnReservoirOpeations)

Field Name	Description
ID	Unique record identifier assigned by system
Reservoir ID	Identifier for corresponding reservoir from tblRnReservoir table. These reservoir IDs are unique to each alternative model run.
Date	Date for these data (mm/dd/yyyy)
Evap Rate	The net evaporation loss rate from this reservoir on specified date (inches). On date with net gain from precipitation, this rate will be negative.
Evap Volume	The net evaporation volume from the current reservoir on specified date (acre-feet). Evaporation volumes are calculated as the product of the evaporation rate and average reservoir surface area [BOPArea+EOPArea)/2].
BOP Area	Estimated pool area for current reservoir at start of specified day (acres).
BOP Storage	Storage contents of current reservoir at start of specified day (acre-feet).
EOP Area	Estimated pool area for current reservoir at end of specified day (acres).
EOP Storage	Storage contents of current reservoir at end of specified day (acre-feet).
EOP Pool Elev	Pool elevation of current reservoir at end of specified day (feet).
Loss 1	Net losses from current reservoir to first loss node on specified date (acre-feet).
Loss 2	Net losses from current reservoir to second loss node on specified date (acre-feet).
Loss 3	Net losses from current reservoir to third loss node on specified date (acre-feet).
BOP Recharge	Balance in recharge credit account for current reservoir at start of specified day (acre-feet). Applies only to Node No. 120.
EOP Recharge	Balance in recharge credit account for current reservoir at end of specified day (acre-feet). Applies only to Node No. 120.
BOP Water Right	Balance in annual water right account for current reservoir at start of specified day (acre-feet). Applies only to Node No. 120.
EOP Water Right	Balance in annual water right account for current reservoir at end of specified day (acre-feet). Applies only to Node No. 120.

2.3 Link Operations Data

The flow in each model link on each day is summarized in the link operations table, which is named tblLinkOperations in the Access database. The individual fields in this table are described in Table 20.

Table 20: Data Fields in Link Operations Table (tblRnLinkOperations)

Field Name	Description
ID	Unique record identifier assigned by system
Link ID	Identifier for corresponding link from tblRnLink table. These link IDs are unique to each alternative model run.
Date	Date for these data (mm/dd/yyyy)
Flow	The flow in the current link on specified date (acre-feet).
Loss	Flow loss from current link on specified date (acre-feet). This model option is not used for the ILWS model so this field will always be zero.

2.4 Demand Operations Data

The final operation table used in the RESNET model is the demand operations data table (tblRnDemandOperations). The individual fields in this table are described in Table 21.

Table 21: Data Fields in Demand Operations Table (tblRnDemandOpearations)

Field Name	Description
ID	Unique record identifier assigned by system
Demand ID	Identifier for corresponding demand from tblRnDemand table. These demand IDs are unique to each alternative model run.
Date	Date for these data (mm/dd/yyyy)
Demand	Actual volume for current demand satisfied on specified date (acre-feet).
Demand Shortage	Difference between desired and actual volume for current demand on specified date (acre-feet).
Return Flow	Portion of current demand that is returned to system on specified date (acre-feet).

2.5 Post-processing Data

Execution of the RESNET model generates the four output tables described above. To aid in subsequent analysis, several Access routines have been developed that generate auxiliary data tables from the data contained in the four primary output tables. These routines are available in the main RESNET model database file and will generate the following summary tables:

2.5.1 Discharge Summary Data

In the RESNET model, minimum required streamflow and deliveries to pump stations are modeled as flow-through demands. For this reason, the flow in a stream below a given model node is often a combination of terms at some locations. The process for calculating these flows is outlined below.

- Arkansas River near Hutchinson (Node No. 10): Flow in Link L6 only
- Arkansas River near Maize (Node No. 25): Flow in Link L8 only
- Arkansas River below Wichita (Node No. 85): Flow in Link L10 only
- Little Arkansas River at Alta Mills (Node No. 30): Flow in Link L1 only
- Little Arkansas River at Halstead (Node No. 40): Flow in Link L2 plus Demand D24 plus lesser of Demands D17 and D24
- Little Arkansas River at Sedgwick (Node No. 50): Flow in Link L3 plus Demands D20 and D17
- Little Arkansas River at Valley Center (Node No. 60): Flow in Link L4 only
- Little Arkansas River at Mouth (Node No. 70): Flow in Link L5 plus Demands D19 and D21
- North Fork Ninnescah River (Node No. 90): Flow in Link L11 plus Demand D12
- Ninnescah River near Peck (Node No. 100): Flow in Link L12 only
- Arkansas River at Arkansas City (Node No. 110): Spill at Node 110 (sum of flows in Links L10 and L12)

A post-processing routine has been developed that generates a discharge summary table (tblRnDischargeSummary) that combines the various link and demand flows listed above for each day during the model simulation period. The individual fields in this table are listed in Table 22.

Table 22: Data Fields in Discharge Summary Table (tblRnDischargeSummary)

Field Name	Description
ID	Unique record identifier assigned by system
Model ID	Identifier for corresponding model run in tblRnModel table.
Date	Date for these data (mm/dd/yyyy)
Halstead	Mean daily flow in Little Arkansas River near Halstead (cfs).
Sedgwick	Mean daily flow in Little Arkansas River near Sedgwick (cfs).
Valley Center	Mean daily flow in Little Arkansas River at Valley Center (cfs).
L Ark Mouth	Mean daily flow in Little Arkansas River at it mouth in Wichita (cfs)
Wichita	Mean daily flow in Arkansas River at Wichita (cfs)
Below Cheney	Mean daily flow in North Fork Ninnescah River below Cheney Reservoir (cfs)
Peck	Mean daily flow in Ninnescah River near Peck (cfs)
Ark City	Mean daily flow in Arkansas River at Arkansas City (cfs)

2.5.2 Storage Summary Data

The daily end-of-day storage in Cheney Reservoir and storage deficits in the Equus Beds aquifer are available in the storage summary table (tblRnStorageSummary). The fields in this table are described in Table 23.

Table 23: Data Fields in Storage Summary Table (tblRnStorageSummary)

Field Name	Description
ID	Unique record identifier assigned by system
Model ID	Identifier for corresponding model run in tblRnModel table.
Date	Date for these data (mm/dd/yyyy)
Cheney	End-of-day storage in Cheney Reservoir on this date (acre-feet).
Equus Beds	End-of-day storage deficit in Equus Beds aquifer (acre-feet).

2.5.3 Water Supply Summary Data

The City's total raw water demand each day is determined by the related demand and demand distribution data described above (Section 1.5.1). The supply summary table (tblRnSupplySummary) shows where the water to meet this demand comes from each day. This table also summaries the water delivered to the Equus Beds for recharge and aquifer gains and losses from the Arkansas and Little Arkansas rivers. The fields in the supply summary table are listed in Table 24

Table 24: Data Fields in Supply Summary Table (tblRnSupplySummary)

Field Name	Description
ID	Unique record identifier assigned by system
Model ID	Identifier for corresponding model run in tblRnModel table.
Date	Date for these data (mm/dd/yyyy)
Cheney	Water supplied from Cheney Reservoir on this date (acre-feet).
Equus Beds	Water supplied from Equus Beds well field on this date (acre-feet).
Bentley Reserve	Water supplied from the Bentley Reserve well field (acre-feet).
Local WF	Water supplied from the existing local (E&S) well fields (acre-feet)
Local Expansion	Water supplied from the planned expansion of the local well field (acre-feet).
L Ark Diversion	Water supplied by direct diversion from the Little Arkansas River (acre-feet)
Equus Beds Recharge	Water diverted from the Little Arkansas River for recharge of the Equus Beds aquifer (acre-feet)
Ark Losses	Net losses from Equus Beds aquifer to Arkansas River (acre-feet)
L Ark Gains	Net losses from Equus Beds aquifer to Little Arkansas River (acre-feet)

2.5.4 Water Surface Elevation Summary Data

The water surface elevations at four locations in the model area are estimated from the modeled daily discharges at these locations. These locations are as follows:

- Little Arkansas River at Valley Center
- Arkansas River at Wichita
- Ninnescah River near Peck
- Arkansas River at Arkansas City

These four locations are all located at active USGS stream gages. The water surface elevations at these locations are calculated using rating tables obtained from the USGS. The rating table data for these gages are stored in a database table named tblRnGageRating. The fields in the gage rating table are described in Table 25.

Table 25: Data Fields in Gage Rating Table (tblRnGageRating)

Field Name	Description
ID	Unique record identifier assigned by system
Number	Station number for USGS stream gage
Gage Height	Gage height reading (feet)
WS Elev	Water surface elevation corresponding to this gage height (feet NGVD). Equivalent to gage height plus gage datum elevation.
Discharge	Estimate stream discharge at this gage height (cfs)

The estimated water surface elevations at the four stream nodes are written to a summary table named tblRnWSElevSummary. This table also contains the end-of-day pool elevation and pool area for Cheney Reservoir. The fields in the water surface elevation summary table are listed in Table 26.

Table 26: Data Fields in Water Surface ElevationSupply Summary Table (tblRnSupplySummary)

Field Name	Description
ID	Unique record identifier assigned by system
Model ID	Identifier for corresponding model run in tblRnModel table.
Date	Date for these data (mm/dd/yyyy)
Valley Center	Estimated water surface elevation in Little Arkansas River at Valley Center (feet NGVD).
Wichita	Estimated water surface elevation in Arkansas River at Wichita (feet NGVD).
Cheney	End-of-day pool elevation in Cheney Reservoir (feet NGVD).
Peck	Estimated water surface elevation in Ninnescah River near Peck (feet NGVD)
Ark City	Estimated water surface elevation in Arkansas River at Arkansas City (feet NGVD).
Cheney Area	End-of-day pool area for Cheney Reservoir (acres)

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Complete citations for the references cited in this document are listed below:

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* * * * *

Attachment B

Supplemental Information on Development of Equus Beds Groundwater Elevation and Storage Deficit/Stream Gain and Loss Relationships

Equus Beds Groundwater Elevation and Storage Deficit/Stream Gain and Loss Relationship

prepared for

City of Wichita
Wichita, Kansas

November 2008

Project No. 49305

prepared by

Burns & McDonnell Engineering Company, Inc.
Kansas City, Missouri

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1.0 INTRODUCTION

The *Equus* bed aquifer, located northwest of Wichita, supplies municipal and industrial water for the City and for agricultural irrigation. Development for municipal use began in the 1930's. The City owns water rights for up to 40,000 acre-feet per year (AFY) in the *Equus* beds aquifer, one of its major sources of municipal and industrial water.

Equus beds groundwater use for irrigation developed in the 1970's and 1980's with additional water rights granted for an additional amount of about 50,000 AFY. Combined municipal and irrigation pumping is greater than the estimated safe yield of the aquifer, accelerated water level declines resulted, with the greatest decline or deepest groundwater level being recorded in October 1992.

The City has maintained water level measurements from over 100 monitoring wells since before pumping began in 1940. The U.S. Geological Survey (USGS) has been analyzing the data and publishing reports of water-level altitude maps periodically since 1949. More recently, the USGS has been publishing reports of groundwater levels and storage volume in the *Equus* beds aquifer under contract with the City of Wichita.

* * * * *

2.0 GROUNDWATER-SURFACE WATER INTERACTION

2.1 GENERAL

Many studies have addressed the interaction of the *Equus* beds aquifer with the Arkansas and Little Arkansas rivers, including investigations by the U.S. Bureau of Reclamation (USBR) and USGS as reported by Pruitt in 1993 and Myers in 1995.

Prior to groundwater development in the *Equus* beds, there was little exchange of water between the aquifer and the Arkansas River because the groundwater gradient was approximately parallel to the river. The Little Arkansas River, extending from the northern portions of the aquifer to the east and south and paralleling the eastern aquifer boundary, serves as a drain to the aquifer. A relatively large amount of annual precipitation, estimated to be about 20 percent, recharges the aquifer and moves downgradient; that which is not intercepted by pumping ultimately discharges to the Little Arkansas River and lower reaches of the Arkansas River.

With groundwater development, the potentiometric head of the aquifer was lowered; this created a gradient from the Arkansas River toward the aquifer and induced infiltration of saline river water into the aquifer. Additionally, the reduced head in the aquifer reduced the gradient of flow from the aquifer to the Little Arkansas River causing a decline in the river's baseflow.

Concerns that high-chloride water was moving into the aquifer and degrading its excellent water quality led to studies by both the USGS and the USBR. These studies used groundwater modeling to estimate future impacts to the aquifer under various pumping, recharge and management scenarios. The groundwater models used by the agencies were also used to evaluate the feasibility for the Wichita Equus beds aquifer recharge project.

For this analysis, groundwater modeling was used to establish a relationship between water elevation at a representative target well and aquifer-stream interaction. To develop the relationship, the model was run at various pumping stresses to determine aquifer inflow from streams and losses to streams at different elevations at the target well.

2.2 GROUNDWATER MODEL

MODFLOW, a three-dimensional, finite-difference groundwater flow model, was used to simulate the *Equus* Beds aquifer in the vicinity of the City of Wichita well field. MODFLOW is a well-documented groundwater model that is widely used and accepted by many regulatory agencies. The groundwater model currently in use was originally developed by the USGS office in Lawrence, Kansas (Myers et al 1996). The model was refined by the USBR for analysis of chloride migration in the Burrton, Kansas area. The model was later further refined by Burns & McDonnell Engineering Company, Inc. (Burns & McDonnell) and used to evaluate the City's Aquifer Storage and Recovery (ASR) Project and later to track recharge credits for the accounting reports required by the Kansas Department of Agriculture Division of Water Resources (DWR).

2.2.1 Initial USGS Model

The USGS groundwater flow model was developed to study the stream-aquifer interaction between the Arkansas River and the *Equus* Beds aquifer and to help evaluate chloride migration into the aquifer. The USGS model area includes the current study area along the Little Arkansas River. The original USGS model grid consists of 34 rows, 42 columns, and 3 layers, and covers an area of approximately 950 square miles. Row spacing varied from 1000 feet to 10,000 feet; column spacing was 5000 feet. A conceptual depiction of the model construction is shown in Figure 2.1. The location and extent of the model area is shown in Figure 2.2.

The model uses constant-head nodes along the margins of the model boundary to represent areas where the aquifer extends beyond the model boundary. No-flow boundaries represent areas where shale provides a natural barrier to groundwater flow. The model includes areal recharge, evapotranspiration, stream flow and well pumpage.

More extensive details of the USGS model including information regarding model set-up, calibration, sensitivity analysis, and model results are contained in Myers et al (1996).

2.2.2 USBR Model

The USBR modified the USGS model for a contaminant transport study for the *Equus* Beds Groundwater Management District No. 2 (GMD2). To improve the accuracy of the transport modeling, the USBR reduced model grid spacing and adjusted the grid cells to a more uniform dimension. This resulted in a

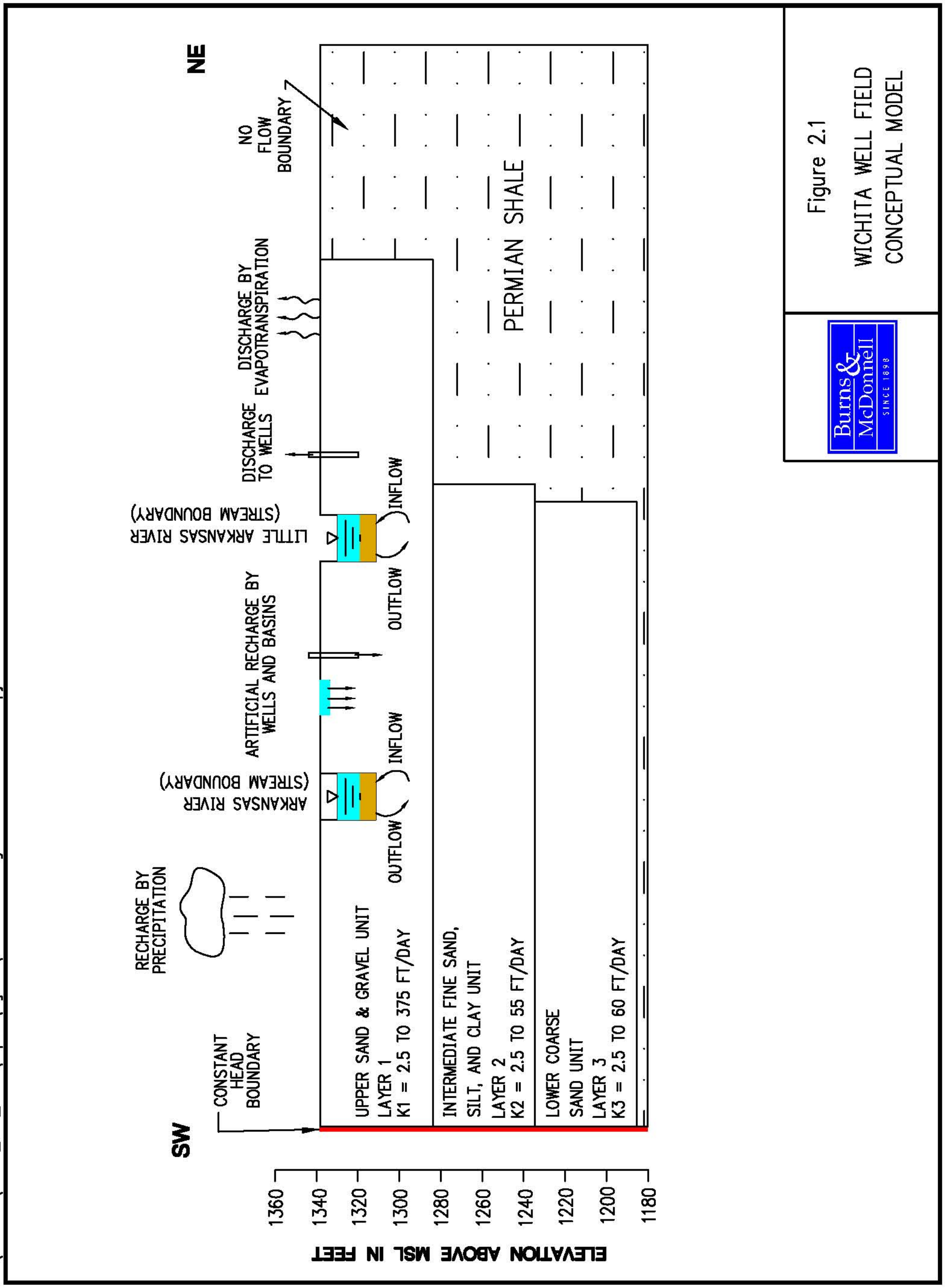
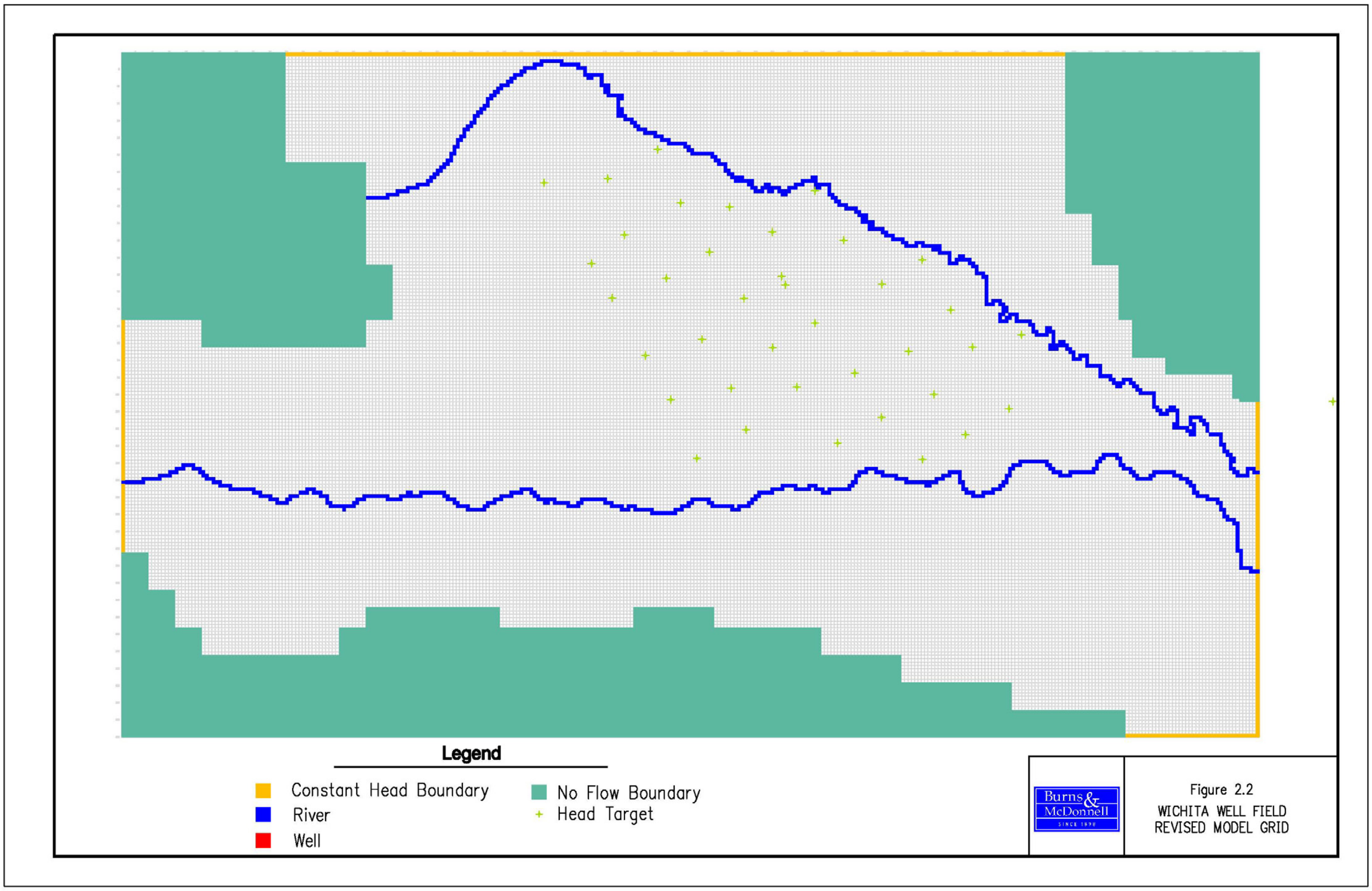


Figure 2.1
WICHITA WELL FIELD CONCEPTUAL MODEL


Legend
Constant Head Boundary
River
Well
No Flow Boundary
Head Target
Burns & McDonnell
Figure 2.2
WICHITA WELL FIELD
REVISED MODEL GRID

model grid consisting of 54 rows and 84 columns. Details of the USBR modeling are given in Pruitt (1993).

The primary area of interest during the initial investigation for the ASR Project was the Wichita well field. As a result, the USBR model grid spacing in the well field area was too great for proper analysis, and the model was re-gridded to provide better resolution in this area. The finest grid spacing was 1000 feet by 1000 feet and resulted in a model domain with 84 rows and 120 columns.

2.2.3 Current Model

2.2.3.1 Setup and Implementation

The groundwater model used currently for the Wichita ASR accounting has been upgraded and refined with data acquired during various phases of investigation for the ASR project. Basic model refinements include reducing model cell size to a uniform 632.5 feet by 617.6 feet, resulting in a grid with 200 rows and 340 columns. The reduced cell size required repair of stream parameters. Additionally, some adjustments were made to aquifer parameters in areas where additional data was available.

The original model received from USBR was translated into a pre- and post-processing software program (Groundwater Vistas, V 3.0) and the simulations were performed using MODFLOW 98. The current version of the Wichita *Equus* Beds model was recently upgraded to a newer version of Groundwater Vistas (V 4.0) and is run using MODFLOW 2000.

2.2.3.2 Model Aquifer Parameters

2.2.3.2.1 Hydraulic Conductivity

The current versions of the model used for recharge credit accounting uses a large number of monitoring wells for calibration; however, the calibration at the target well 886 was not particularly good. Well 886 was established by USGS as representative of aquifer heads in the area of greatest historical drawdown in numerous USGS reports describing water level changes and estimate storage volumes (Hansen, 2007). Well 886 was used in the original EIS operation model to identify storage volumes available. Model hydraulic conductivity was reduced by one-half compared to the value used in the USGS model (Myers et al, 1996) to improve calibration at target well 886 for this application. Some pumping test results in the general area suggest that a reduction in hydraulic conductivity is appropriate.

Although these modifications resulted in slight changes to modeled heads, stream gain and loss, and aquifer storage compared to the previous EIS results, the current results are relatively close to the original EIS results. Table A-2 in Appendix A compares stream gain and loss for the two models, and Figure A-4 compares storage deficits calculated from each model and the USGS storage depletion estimates.

2.2.3.2.2 Storativity

Specific yield has been reduced from 0.15 to 0.1, and specific storage for the middle and lower layers was reduced by one-half from 0.0001 ft^{-1} to 0.00005 ft^{-1} compared to the original EIS Model and the USGS transient model (Myers et al, 1996). It should be noted that when computing storage volume changes for the dewatered portions of the aquifer, the USGS has typically used a specific yield value of 0.2 (Hansen, 2007).

2.2.3.2.3 Streambed Conductance and Streambed Roughness

Streambed conductance has been reduced from 50 feet/day to 40 ft/d for the Arkansas River, and from 5.0 ft/d to 4.0 ft/day for the Little Arkansas River compared to the original EIS Model and the USGS transient model (Myers et al). Several model runs varying the streambed conductance showed that the model is not very sensitive to this parameter.

Streambed roughness was not modified in the current version of the model.

2.2.3.3 Area Stresses for Model Input

2.2.3.3.1 Precipitation and Recharge

A percentage of annual precipitation contributes to natural recharge. The USGS used average precipitation from three area weather stations and then distributed the recharge across the model area based on soil type, ground cover, and model calibration. The current model employs data from the same locations used by USGS, plus an additional station added at Newton, Kansas.

2.2.3.3.2 Stream Flow

Stream flow can contribute to aquifer recharge depending on river stage, river bed conductivity, and elevation of the underlying groundwater table. Variations in river stage and flow are considered in the groundwater model using the MODFLOW stream package. In this package, a starting flow is assigned to the upstream river node with MODFLOW assigning river flow and stage in all downstream nodes. The

USGS determined that the appropriate starting river flow was that flow with a 70 percent return interval within the modeled stress period.

The 2007 river flows were used for this model evaluation. At the Alta Mills gage on the Little Arkansas River, a value of 8.5 cubic feet per second (cfs) was determined for the 70 percent return interval. The flow for the Arkansas River was determined to be 263 cfs at Hutchinson.

2.2.3.3.3 Groundwater Pumping

Groundwater pumping data for GMD2 has been from Kansas Department of Agriculture Division of Water Resources (DWR) from the early 1990s. Water use reported in acre-feet by DWR was converted to average daily pumping rates, and well locations reported in geographic coordinates (latitude and longitude) were converted to model coordinates. The converted data was then imported into the model. For this evaluation, pumping data from 2003 was used as the base case. Pumping rates for the stress periods were then set at 0, 10, 30, 50, 70, 90, 115, 130 and 145 percent of the base case to stress the aquifer. The stress period using a pumping rate of 145 percent of the 2003 rates simulated water levels lower than or approximately equal to those recorded in 1992.

2.2.3.3.4 Natural Recharge

The amount of natural recharge entering an aquifer system is based on many factors including the amount of precipitation, the surface conditions of soil texture and slope, and the type and amount of groundcover. The GMD2 has determined that approximately 20 percent of rainfall is recharged to the aquifer. The USGS groundwater model used average rainfall from Wichita, Hutchison, and Mount Hope for model input and distributed recharge based on soil type, slope, and land use. Actual values used in the model are increased or decreased with a ratio of the base case to the precipitation for the current year. Since that time, an additional weather station in Newton has become available. Recharge is distributed across the model based on soil type and other factors. Recharge for 2003 is based on the annual rainfall totals shown in Table 2.1.

2.2.3.3.5 Evaporation and Transpiration

Evapotranspiration is estimated in the model. Earlier USGS studies estimated maximum evapotranspiration to be approximately 3.5 inches per year. The USGS model incorporated a maximum

Table 2.1
2003 Annual Rainfall Totals

Station	2003 Precip. (in.)
Hutchinson E.	35.42
Mount Hope	27.64
Wichita	32.60
Newton	36.05
Average	32.93

value of 3.5 inches per year when the water table is at the surface. The rate is reduced with deeper groundwater levels and is equal to 0 when the water table is 10 feet or more below the surface.

2.2.3.4 Model Calibration

Modeled pumping rates were based on the period (2003) in which the highest observed pumping rates in recent history occurred (where more complete records are available).

Calibration was performed by comparing modeled heads at the end of the 100% stress period (2003) to the observed heads at well 886 at the end of 2003 (actually measured in early 2004).

Reductions in the values for hydraulic conductivity and storage were required to simulate aquifer heads at the target well 886, established by USGS as representative of aquifer heads in the area of greatest historical drawdown (Hansen, 2007). This essentially results in calibrating to a single point as opposed to multiple points in previous versions of the model.

Final calibration resulted in difference of 5.4 feet between the model and observed values (modeled elevation 1384.7 vs. observed 13794 feet).

The current model has a water budget mass balance discrepancy of -0.08 percent, a residual mean of -9.44 feet, and an absolute residual mean (compared to observed January 2004 water level measurements in 38 index monitoring wells) of 9.50 feet. The absolute residual mean is the average absolute difference between measured water levels and computed water levels at the same location. Differences are due to seasonal variations in local weather (recharge), timing of local pumping, and other operations factors.

* * * * *

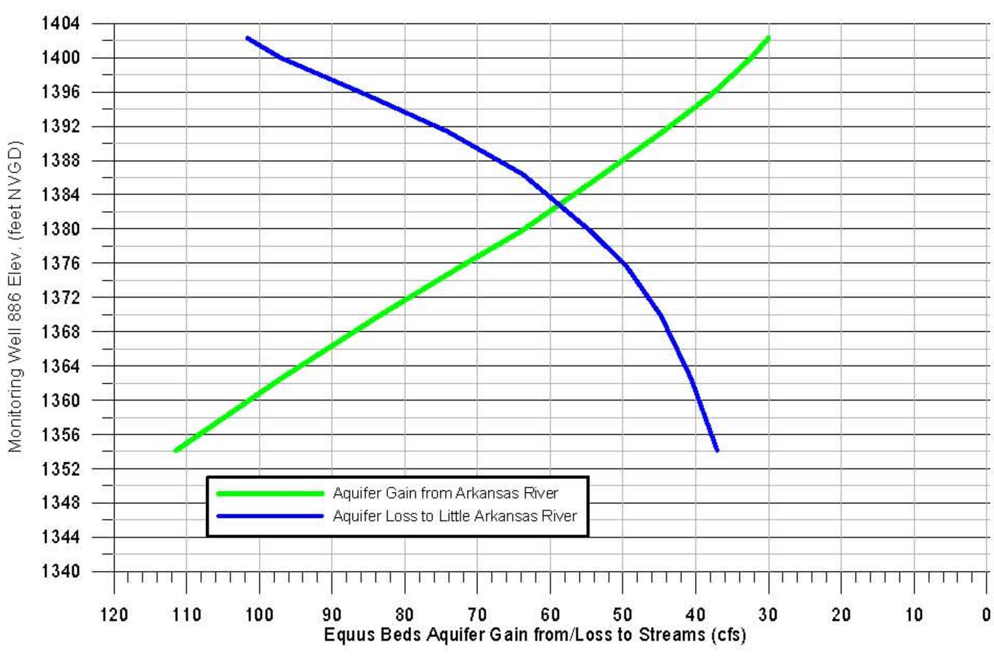
3.0 GROUNDWATER ELEVATION - STREAM GAIN AND LOSS

3.1 INFILTRATION FROM STREAMS

When aquifer levels are lower than water levels in a stream, there is a potential for water inflow or infiltration from the stream to the aquifer. The amount of flow depends on the difference in water levels and the permeability of the streambed. The rate of infiltration from streams is reported in the model water budget for each time and stress period. For this evaluation it is assumed that the infiltration is from the Arkansas River. Minor amounts may actually infiltrate from the Little Arkansas River; however, the amount reported in the model is the net impact on the aquifer. The data from the ten stress periods are graphed with the calculated water level at Monitoring Well 886 to illustrate the change in river inflow dynamics with changes in groundwater elevation (Figure 3.1).

Figure 3.1

Modeled Groundwater Elevation at Monitoring Well 886 vs. Aquifer Loss/Gain to Streams



3.2 GROUNDWATER DISCHARGE TO STREAMS

When aquifer levels are higher than water levels in a stream, there is a potential for water inflow or infiltration from the aquifer to the stream. The amount of flow depends on the difference in water levels and the permeability of the streambed. The rate of aquifer loss to streams is reported in the model water budget for each time and stress period. For this evaluation, it is assumed that aquifer losses are to the Little Arkansas River. Minor amounts may actually be lost to the Arkansas River; however, the amount reported in the model is the net impact on the aquifer. Data from the ten stress periods are graphed with the calculated water level at Monitoring Well 886 to illustrate the change in river inflow dynamics with changes in groundwater elevation (Figure 3.1).

* * * * *

4.0 GROUNDWATER ELEVATION - STORAGE DEFICIT

The City of Wichita, GMD2, and the USGS collect water level data in over 100 monitoring wells on a quarterly basis to monitor groundwater level changes. The USGS identified four noteworthy periods of water-level changes. They include the initial period of pumping, the severe drought conditions of the mid-1950's, a period of relatively stable levels from 1958 to 1977, and a period of declines due to increased irrigation pumping from 1978 to 1992. Subsequent to these identified periods, the City has adopted its Integrated Local Water Supply Plan Project (Project) which calls for greater use of water from Cheney Reservoir when available and reduced pumping from the Equus beds aquifer. The reduced withdrawal from the aquifer has resulted in recent rebound of water levels.

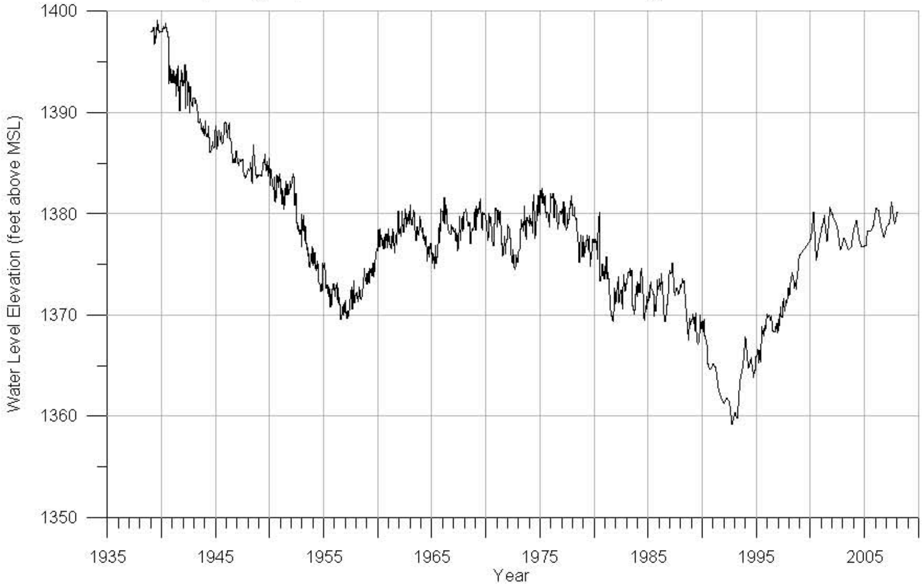
4.1 USGS STORAGE VOLUME ESTIMATES

In the current USGS report (Hansen, 2007), three water-level altitude maps of the water level data are presented. These include 1940 (pre-development), 1992 (lowest levels recorded), and current (2006) levels. Additionally, a number of water level change maps showing the difference in water levels for several periods are presented.

The USGS selected monitoring well 886 as a representative descriptor of historical water-level changes in the area of maximum water-level declines which occur in the central part of the study area near the historic center of pumping by the City. Figure 4.1 is a hydrograph of water levels recorded in monitoring well 886.

The USGS has calculated the storage-volume changes for several time periods covering the recorded well field data (Hansen, 2007). USGS defines the changes in storage volume as the change in saturated aquifer volume multiplied by the specific yield of the aquifer; a specific yield of 0.2 has been used by the USGS as representative of the *Equus* beds aquifer. Volume calculations were computed using computer-generated Thiessen polygons based on the measured water-level changes at wells and manually drawn lines of equal water-level change (Hansen, 2007). Table 4.1, developed by the USGS, lists the calculated storage-volume changes in acre-feet and percent for various time periods for the complete study area and the central part of the study area which is the immediate areal extent of the Wichita municipal wells.

Figure 4.1
Hydrograph of Water Levels in Monitoring Well 886



4.2 DETAILED STORAGE VOLUME ESTIMATES

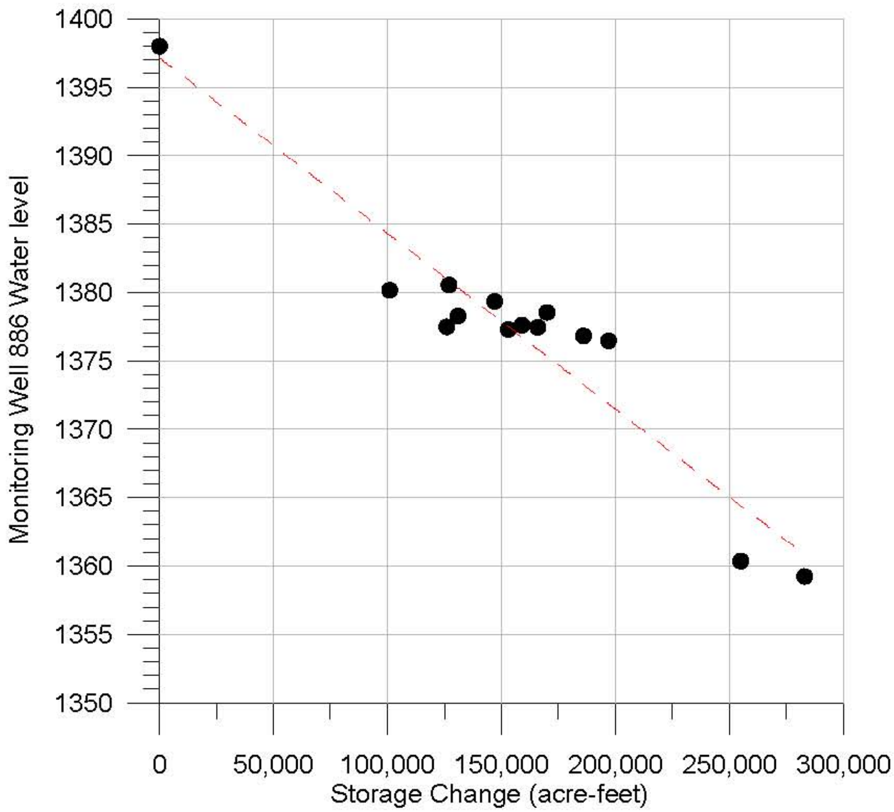
Storage volumes were determined by Burns & McDonnell for each section in the immediate study area, based on drilling and geophysical logs obtained for this project. The total thickness of coarse- and fine-grained material within the allowable vertical ASR zone was determined and storage factors were applied to calculate the total available volume within each section. The calculated total available volume for the immediate study area is about 200,000 acre-feet. This is comparable to the USGS evaluation for a slightly larger study area. Details of the evaluation, drill logs, cross-sections and methods are described in the Concept Design Report (Burns & McDonnell, 2000).

4.2.1 Storage Volume – Groundwater Level Relationship

A relationship between water levels in target well 886 and storage volumes calculated by the USGS is shown in Figure 4.2. The Figure shows the USGS calculated changes in storage from 1940 levels with well 886 elevations for the time of the calculations.

Table A-1 shows the modeled aquifer-stream losses and gains with groundwater elevations at target well 886 and the storage-volume deficit based on the USGS calculations as shown in Figure 4.2. The

Figure 4.2
Well 886 Elevation - Storage Change
USGS SIR 2006-5321



relationship between the storage-volume deficit and the aquifer-stream losses and gains is used directly in the operation model. Table A-2 compares the current model values with the original EIS estimates.

Table 4.1
Storage-volume changes in *Equus* Beds Aquifer near Wichita, South-central Kansas, August 1940-January 2006.

	Change in storage volume in the study area				Change in storage volume in the central part of the study area			
End date of time period	Since August 1940 (acre-feet)	Since October 1992 (acre-feet)	Since October 1992 (percent)	Since January 2003 (acre-feet)	Since August 1940 (acre-feet)	Since October 1992 (acre-feet)	Since October 1992 (percent)	Since January 2003 (acre-feet)
October 1992	[1]-283,000	--	--	--	[1]-159,000	--	--	--
January 1993	[2]-255,000	+28,000	+10	--	[2]-154,000	+5,000	+3	--
January 2000	[1]-126,000	[3]+157,000	+55	--	[1]-70,600	[3]+88,400	[3]+56	--
April 2000	[3]-101,000	[3]+182,000	[3]+64	--	[3]-74,500	[3]+84,500	+53	--
January 2003	[3]-159,000	[3]+124,000	+44	--	[3]-83,400	[3]+75,600	+48	--
April 2003	-153,000	+130,000	+46	+6,000	-84,400	+74,600	+47	-1,000
July 2003	-197,000	+86,000	+30	-38,000	-89,300	+69,700	+44	-5,900
October 2003	-186,000	+97,000	+34	-27,000	-92,300	+66,700	+42	-8,900
January 2004	-170,000	+113,000	+40	-11,000	-89,900	+69,100	+43	-6,500
April 2004	-147,000	+136,000	+48	+12,000	-83,600	+75,400	+47	-200
July 2004	-166,000	+117,000	+41	-7,000	-86,900	+72,100	+45	-3,500
October 2004	-158,000	+125,000	+44	+1,000	-86,200	+72,800	+46	-2,800
January 2005	-143,000	+140,000	+49	+16,000	-82,700	+76,300	+48	+700
April 2005	-131,000	+152,000	+54	+28,000	-80,500	+78,500	+49	+2,900
July 2005	-137,000	+146,000	+52	+22,000	-74,300	+84,700	+53	+9,100
October 2005	-131,000	+152,000	+54	+28,000	-74,300	+84,700	+53	+9,100
January 2006	-127,000	+156,000	+55	+32,000	-68,900	+90,100	+57	+14,500

[1] Storage-volume change previously reported by Hansen and Aucott (2001).
[2] Storage-volume change previously reported by Aucott and Myers (1998).
[3] Storage-volume change previously reported by Hansen and Aucott (2004).

(Table from USGS Scientific Investigations Report 2006-5321)

* * * * *

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* * * * *

APPENDIX A - GROUNDWATER MODEL INFORMATION

Table A-1

Equus Beds Elevation-Storage-Gain-Loss Data

Elevation (feet)*	Storage Deficit (acre-feet)**	Gain from Arkansas River (cfs)	Loss to Little Arkansas River (cfs)
1342	NA	NA	NA
1360	290,000	100	38
1366	245,000	89	43
1370	212,000	82	44
1375	173,000	73	48
1380	135,000	62	53
1385	95,000	54	60
1390	55,000	48	70
1395	20,000	38	82
1396	10,000	36	85
1402	0	29	99

* Aquifer head at monitoring well 886
** Storage deficit read directly from graph and rounded to nearest 1000 ac-ft

Table A-2

Equus Beds Elevation-Storage-Gain-Loss Data

	Original EIS Model		EIS Model Update	
Elevation (feet)*	Gain from Streams (cfs)	Loss to Streams (cfs)	Gain from Streams (cfs)	Loss to Streams (cfs)
1342	138.2	-2.0	NA	NA
1360	90.5	8.2	100	38
1366	74.5	11.6	89	43
1370	63.9	13.9	82	44
1375	57.3	19.8	73	48
1380	50.2	29.2	62	53
1385	40.3	41.9	54	60
1390	29.1	56.3	48	70
1395	17.7	72.0	38	82
1396	15.1	75.2	36	85
1402	NA	NA	29	99

* Aquifer head at monitoring well 886

Figure A-1. Hydraulic Conductivity Zones in Layer 1

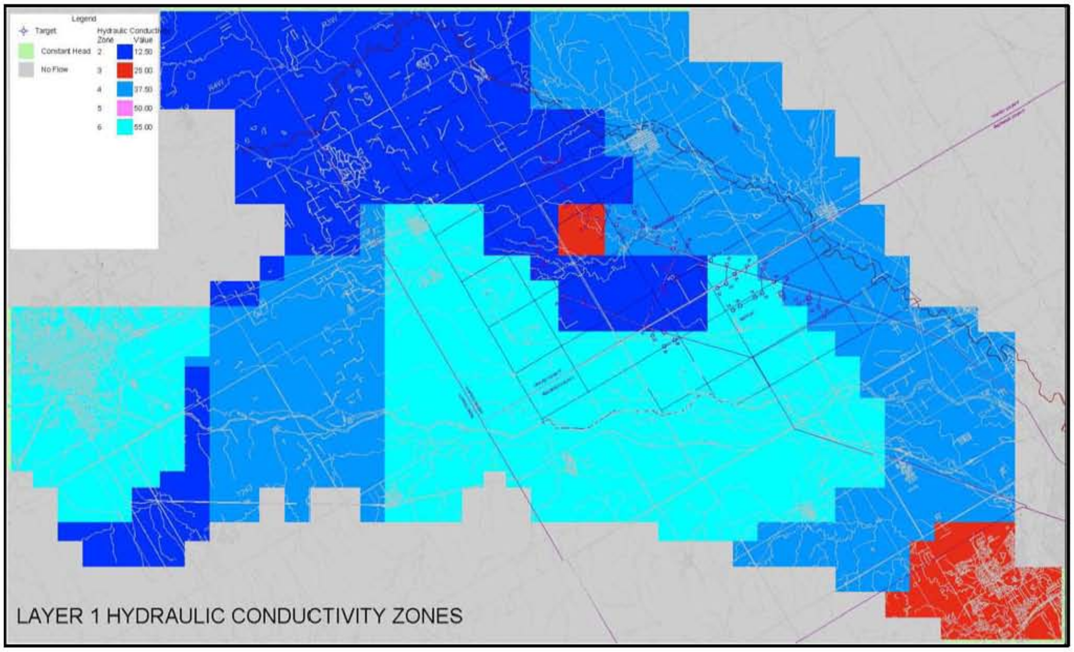


Figure A-2. Hydraulic Conductivity Zones in Layer 2

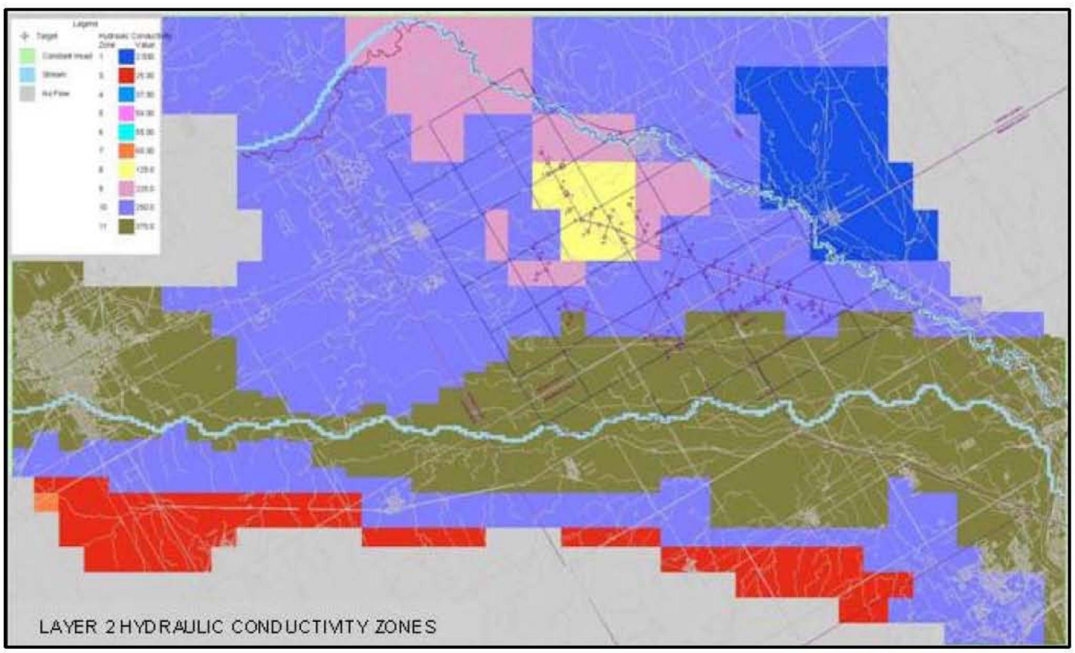


Figure A-3. Hydraulic Conductivity Zones in Layer 3

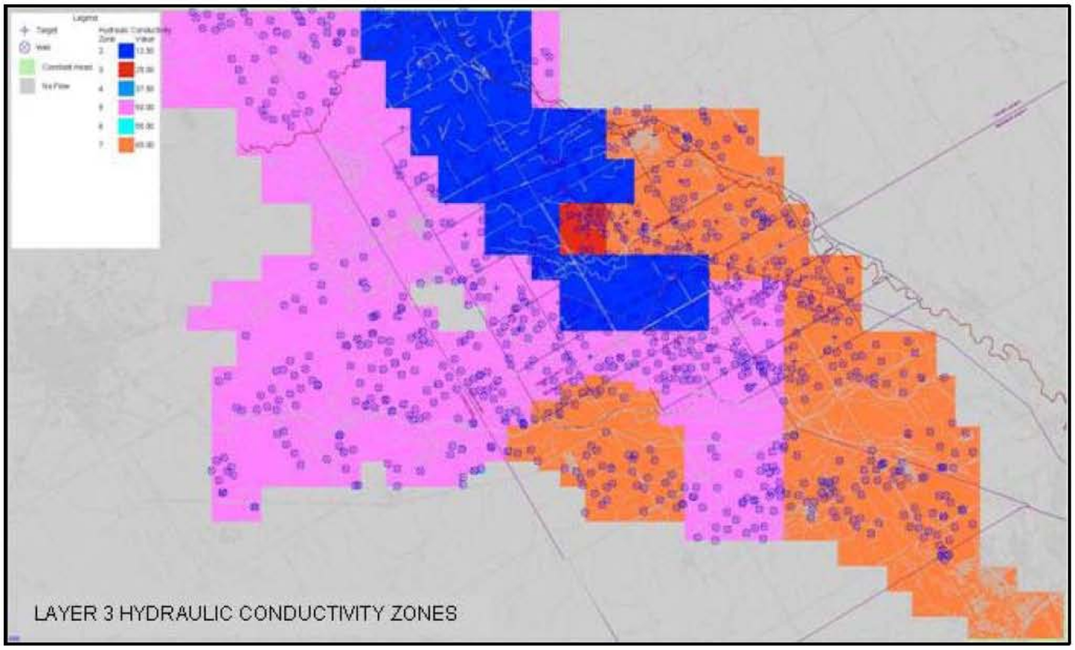
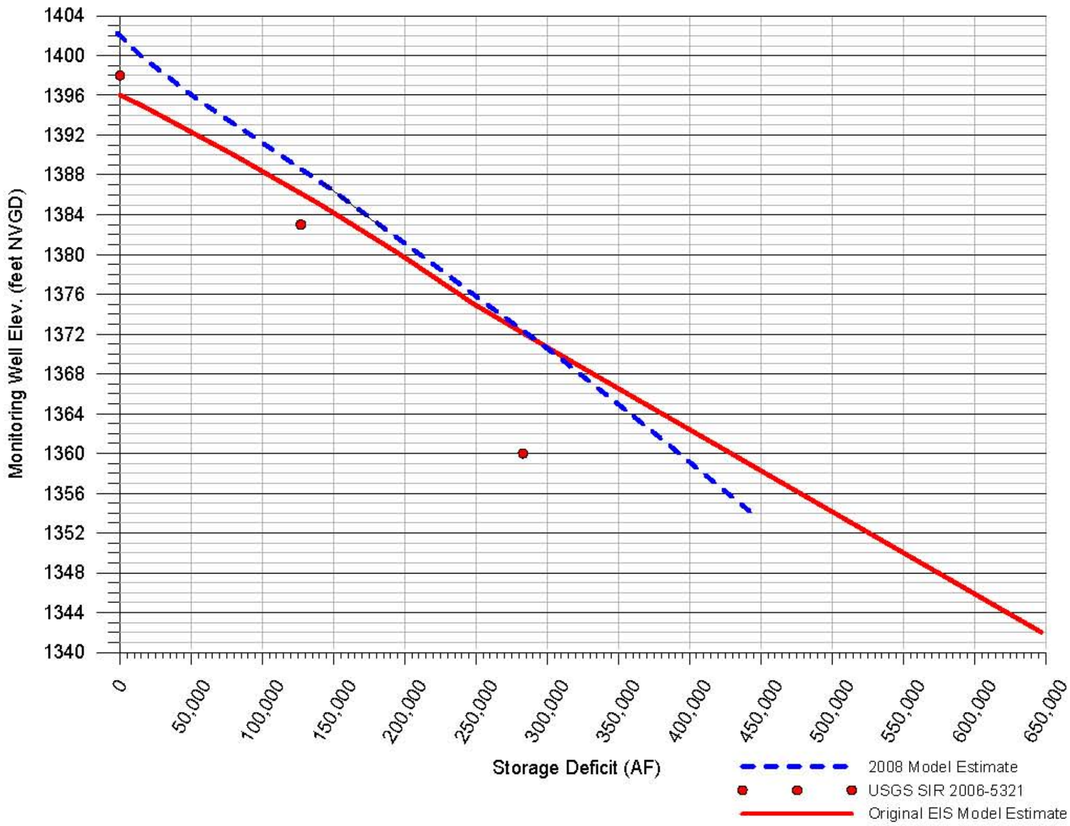


Figure A-4. Comparison of Storage Deficit vs Aquifer Head



Attachment C

Supplemental Information on Cheney Reservoir Evaporation Rates

RESERVOIR EVAPORATION RATES

This appendix documents the reservoir evaporation rate estimates that have been developed for use in planning studies for the City of Wichita's Integrated Local Water Supply (ILWS) Plan. Discussed below are the base climatic and hydrologic data, the methodology used to develop the evaporation estimates and the resulting estimates.

Background

A computer model was developed to simulate operation of the ILWS system under various scenarios. This operations model was used initially to help with the conceptual design of the ILWS system and later to quantify potential hydrologic impacts for the project's environmental impact statement (EIS). The operations model calculates a water balance for the ILWS system each day during the 85-year model simulation period (water years [WY] 1923–2007) using the following hydrologic data:

- Historical mean daily stream discharge at selected points within the project area
- Historical monthly reservoir evaporation rates
- Available storage and other physical data for Cheney Reservoir
- Available storage, natural recharge and other parameters for the Equus Beds aquifer
- City's current and projected water demands
- Irrigation demands for agriculture in the Equus Beds Well Field area
- Minimum desirable streamflow requirements
- Supply capability and other operating parameters for all current and potential water supply sources
- Preferred allocation order for each water supply source

The City's existing Cheney Reservoir is one of the principal supply sources in the ILWS system. This reservoir is located on the North Fork Ninnescah River (North Fork) about 26 miles west of downtown Wichita. Simulating the operation of this reservoir requires estimates of all significant inflow to and outflow from the reservoir, including the net evaporation from the reservoir surface. The evaporation rate estimates discussed below were used to estimate the net evaporation losses from this reservoir.

Climatic Data

The evaporation rate estimates are based directly or indirectly on recorded climatic data. The climatic data utilized in this analysis are described below:

Pan Evaporation Data

The City of Wichita has collected pan evaporation data at Cheney Reservoir since shortly after the reservoir was placed in service. These data were provided to Burns & McDonnell in the form of monthly pan evaporation rates. The period of record for these data is September 1965 through August 2008; however, there are frequent missing values during the winter months prior to 1975.

Pan evaporation data for two other stations in the vicinity of Cheney Reservoir were also collected for comparison purposes. These data are described below:

- Wichita Weather Service Office: The National Weather Service has developed estimates of average monthly pan evaporation at the Weather Service Office (WSO) in Wichita for the period 1956–1970 (NOAA, 1982b). This office is located near the Wichita airport, which is about 21 miles east-southeast of Cheney Reservoir.

- Fall River Dam: Pan evaporation data were collected at Fall River Dam from 1948–1978. This dam is located approximately 95 miles east of Cheney Reservoir.

The pan evaporation data available from these sources were converted into estimates of lake, or free water surface, evaporation by multiplying by a pan coefficient of 70 percent (NOAA, 1982a). Table 1 and Figure 1 present the average monthly lake evaporation rates calculated from these data. Review of this table and graph show that the recorded monthly evaporation at Cheney Reservoir is typically higher than at the other two locations. This condition is not unexpected because evaporation in Kansas tends to increase in a westerly direction as the climate becomes more arid.

Other Climatic Data

Other types of monthly climatic data were also collected for use in these evaporation rate estimates. These additional data were all collected at the National Weather Service office in Wichita. The available types of climatic data, along with their respective units and periods of record, are listed below:

Table 1: Average Monthly Lake Evaporation Rates (inches)

Month	Cheney Reservoir[a,b]	Wichita WSO[a,c]	Fall River Dam[a,d]
Jan	1.32	1.14	0.71
Feb	1.48	1.47	1.65
Mar	2.58	2.90	3.12
Apr	4.52	4.12	4.92
May	5.46	5.25	5.40
Jun	7.11	6.13	6.08
Jul	8.41	6.76	7.22
Aug	7.61	6.42	6.98
Sep	5.14	4.20	4.50
Oct	3.84	3.28	3.41
Nov	2.03	1.84	1.88
Dec	1.53	1.39	0.75
Annual	51.03	44.90	46.62
May-Oct	37.57	32.04	33.59

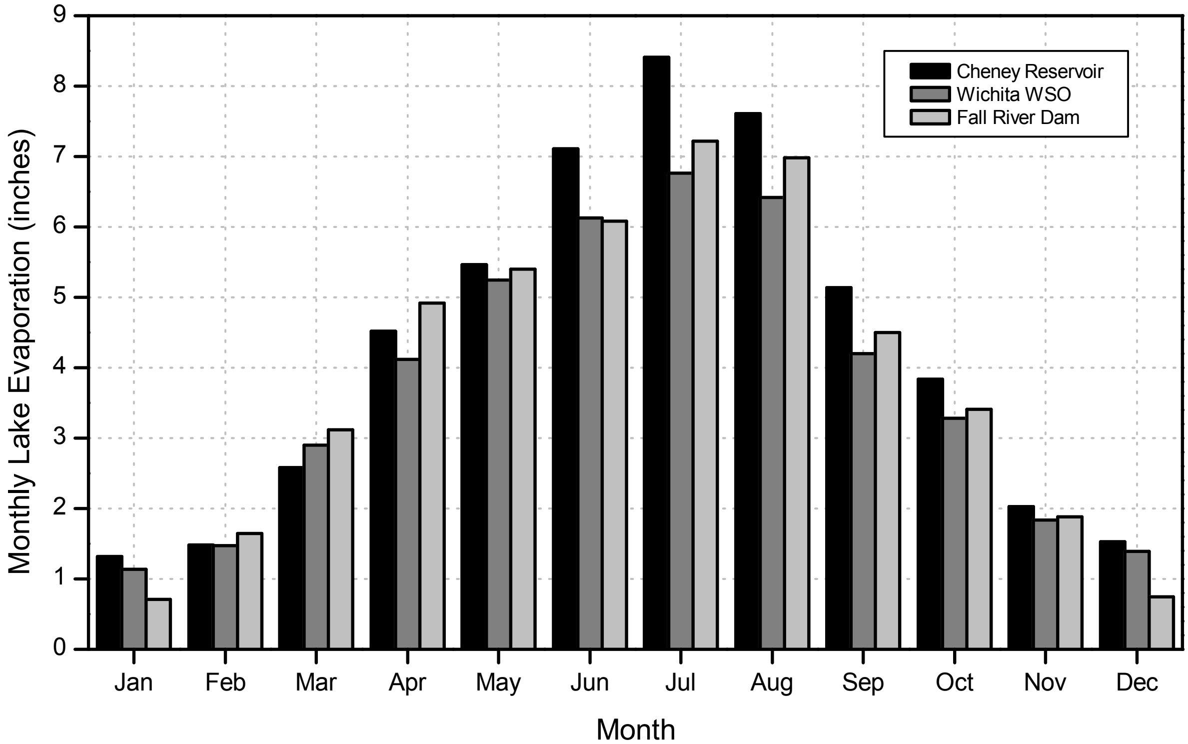
a. Calculated from recorded or estimated pan evaporation data using pan coefficient of 70 percent.

b. Pan evaporation data collected by City for period Sep 1965-Aug 2007.

c. National Weather Service estimates of pan evaporation for period 1956–1970.

d. Pan evaporation data collected for period 1948–1978.

Figure 1: Average Monthly Lake Evaporation Rates



- Average monthly temperature (degrees F.) — Jan 1922–Dec 2007
- Total monthly precipitation (inches) — Jan 1930–Dec 2007
- Average monthly relative humidity (percent) — Jan 1954–Dec 1997
- Average monthly wind speed (miles/hour) — Jan 1954–Dec 1997
- Average monthly barometric pressure (millibars) — Jan 1954–Dec 1997
- Average monthly sunshine (percent of possible sunshine) — long-term averages by month only
- Average solar radiation (megajoules/square meter) — long-term averages by month only

Average monthly values for these data are listed in Table 2. Appendix A contains a complete listing of the data types that have long periods of record: temperature, precipitation, relative humidity, wind speed and barometric pressure. As noted above, many of these data types are only available starting in 1954. For earlier periods when these data types are missing, long-term average monthly values were used as a substitute for actual monthly data.

Table 2: Average Monthly Climatic Data[a]

Month	Temper-ature	Precip-itation	Percent Sunshine	Relative Humidity	Solar Radiation	Wind Speed	Baro. Pressure

	(deg. F.)	(inches)		(percent)	(MJ/m^2)	(mph)	(millibars)
Jan	31.3	0.88	61	74.4	9.29	10.0	971.5
Feb	36.5	1.03	61	72.8	11.97	10.9	970.2
Mar	45.0	2.07	61	69.4	15.99	11.6	966.7
Apr	56.2	2.67	64	69.4	19.76	11.8	965.7
May	65.6	4.04	65	74.4	22.78	10.3	965.4
Jun	75.7	4.47	70	72.8	25.20	10.2	965.7
Jul	81.1	3.42	76	67.8	22.12	9.3	967.4
Aug	81.0	3.25	75	68.8	19.32	9.1	967.8
Sep	71.1	3.21	68	72.6	18.71	9.7	968.6
Oct	59.3	2.48	65	71.5	14.40	9.9	969.4
Nov	44.9	1.50	59	73.4	10.26	10.2	969.4
Dec	34.7	1.16	58	75.2	8.29	9.8	970.8

a. All of these data were collected at the Wichita Weather Service Office. The period of record for these data varies. Percent sunshine and solar radiation available only as long-term averages by month.

Evaporation Model

The pan evaporation data collected by the City at Cheney Reservoir are considered to provide the best possible estimates of reservoir evaporation when available (Table B-1 in Appendix B). However, these data start in the mid-1960s when the reservoir was placed in operation and do not cover the entire simulation period used in the operations model (WY1923–2007). For the period prior to 1965, reservoir evaporation rate estimates were calculated for Cheney Reservoir using Burns & McDonnell's ETCALC computer model. This model uses a form of the Penman Equation to estimate evaporation depths. In general, the ETCALC model uses the following procedure to estimate evaporation rates.

- Advective Losses: The ETCALC model contains a number of relationships to estimate advective, or aerodynamic, losses from the reservoir surface. Advective losses occur as water evaporates from the reservoir into the air immediately over the water surface. This process will occur whenever this air is unsaturated with water vapor (that is, has a relative humidity less than 100 percent). Wind that flows across the reservoir surface will then carry this "wetter" air away and replaces it with air that is relatively drier, allowing the process to continue. Advective losses are primarily a function of air temperature, relative humidity and wind speed.

- Energy Budget: A substantial amount of heat energy is required to transform water in liquid form into water vapor. The ETCALC model also contains relationships to estimate the amount of evaporation that would occur using an energy budget, or heat balance, methodology. The principal source of heat energy that controls evaporation is the Sun. Incident solar radiation at the reservoir varies seasonally, based on the inclination of the Earth's axis and its distance from the Sun, and with the amount of cloud cover (percent possible sunshine).

- Weighting Function: The Penman Equation uses a weighting function to estimate potential evapotranspiration from the separate advective loss and energy balance estimates. This weighting function is based on the slope of the saturation-vapor-pressure versus temperature curve at the given air temperature. (Linsley, et. al., 1982).

The relationships build into the ETCALC model — the relationships that estimate the advective loss, energy budget and weighting function terms described above — use the types of climatic data listed in the previous section as inputs. For the most accurate evaporation estimates, these inputs should be daily data. However, records of daily climatic data have become widely available only in recent years. Therefore the ETCALC model was designed to use monthly inputs and generate monthly evaporation rate estimates.

Model Calibration

The ETCALC model must be calibrated to yield accurate evaporation estimates. There are two calibration coefficients available in the model that can be used to adjust the resulting evaporation rate estimates. The model was calibrated using the available pan evaporation data collected by the City at Cheney Reservoir, which start in September 1965. When available, the ETCALC model will use recorded evaporation data to calculate a goodness-of-fit statistic based on the differences between monthly recorded and estimated evaporation rates (sum of the squares of the residuals). For calibration, the ETCALC model was executed for a period September 1965–December 1996. The calibration coefficients were adjusted by trial and error until a minimum value for this goodness-of-fit statistic was obtained.

Evaporation RATE Estimates

Once the ETCALC model was successfully calibrated, it was re-executed to estimate monthly evaporation rates for the entire simulation period, WY1923–2007. The evaporation rates estimated in the ETCALC model are gross rates for Cheney Reservoir. These estimated evaporation rates were combined with the data recorded by the City to yield a composite record. That is, whenever recorded evaporation data were available, they were used in preference to values estimated by the ETCALC model. The resulting gross evaporation rate estimates are listed in Table B-2.

Precipitation that falls directly on the surface of Cheney Reservoir will tend to offset some of the gross evaporation from the reservoir. The resulting evaporation — gross evaporation less direct precipitation — is referred to as net reservoir evaporation. Not all of the precipitation that strikes the surface of a reservoir is considered to reduce evaporation. In the absence of the reservoir, some of this precipitation would have run off from the portion of the watershed that is covered by the reservoir itself and contribute to the discharge in the North Fork. This direct runoff was accounted for in the reservoir's inflow estimates. Therefore, to avoid double counting this water, monthly net evaporation estimates (N) were calculated using the following formula:

$$N = G - P + R$$

In this equation, G is the estimated monthly gross evaporation and P is the estimated total monthly precipitation at Cheney Reservoir. The direct runoff component (R) is also a function of precipitation and was estimated to be 30 percent of direct precipitation. Substituting this relationship for direct runoff ($R = 0.3P$) into the above equation yields the following equation for net evaporation:

$$N = G - 0.7\ P$$

Substituting the values of gross evaporation (G) (Table B-2) and precipitation (P) (Table A-2), yields the monthly net evaporation rates estimates. These net evaporation rates are listed in Table B-3. These net evaporation rates can be negative in months when precipitation exceeds evaporation.

Summary

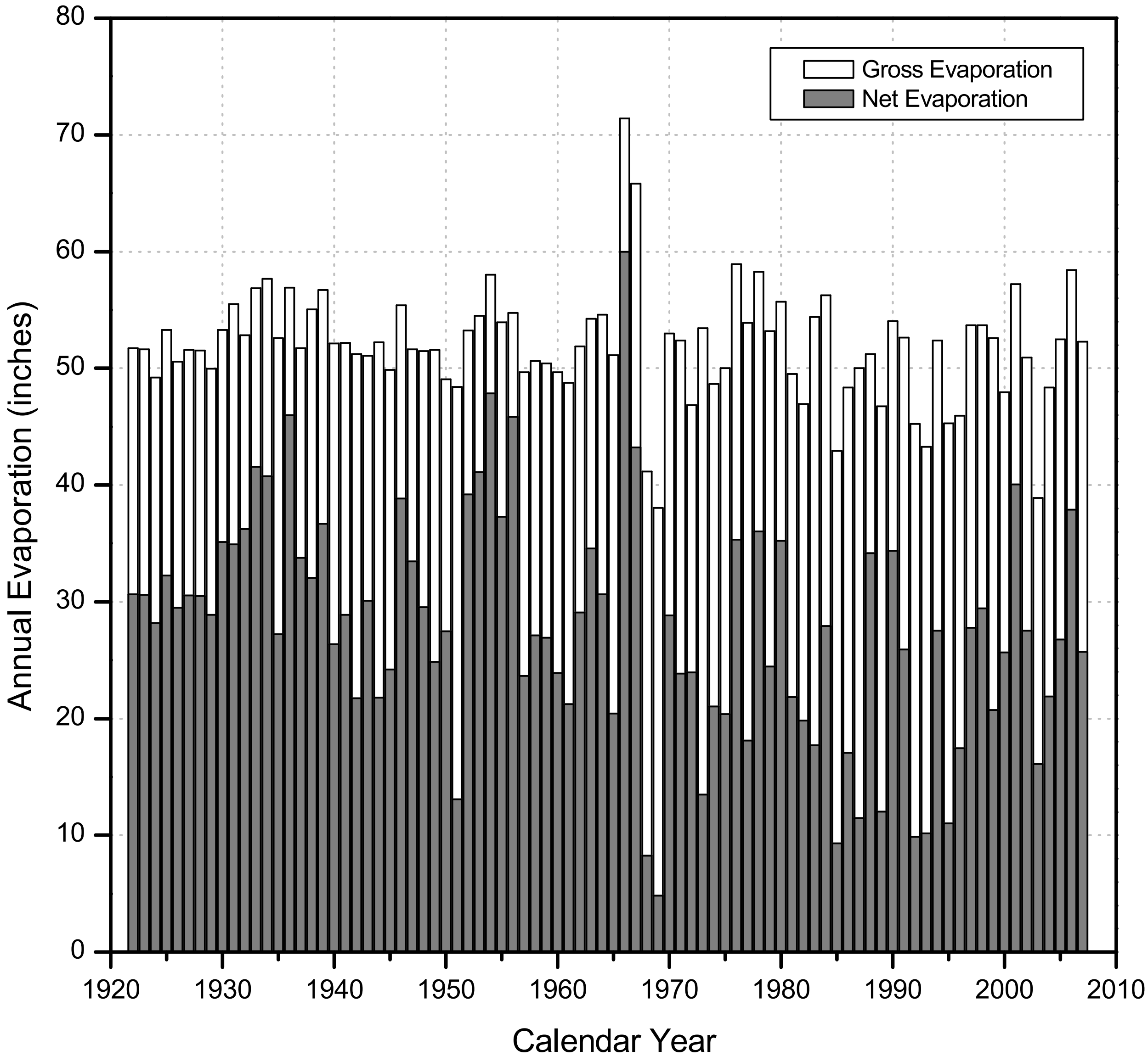
Table 3 is a summary that lists average monthly rates for gross and net evaporation. Figure 2 is a graph of estimated annual gross and net evaporation rates that shows how these rates vary from year to year.

Table 3: Average Monthly Evaporation Rates at Cheney Reservoir

Month	Gross Evaporation (inches)	Net Evaporation (inches)
Jan	1.53	0.85
Feb	1.71	0.92
Mar	2.66	0.94
Apr	4.18	2.04
May	5.25	2.01
Jun	6.88	3.26
Jul	8.31	5.57
Aug	7.86	5.26
Sep	5.47	2.90
Oct	4.08	2.10
Nov	2.27	1.06
Dec	1.68	1.06
Annual	51.88	27.67

Review of Figure 2 shows that annual gross evaporation ranged from a low of 38.02 inches in 1969 to a high of 71.42 inches in 1966; annual gross evaporation averages 51.88 inches. Annual net evaporation is more variable than gross evaporation because it is influenced by precipitation, which can vary significantly from year to year. The range in annual net evaporation was from about 5 to 60 inches, with an average of nearly 28 inches.

Figure 2: Annual Gross and Net Reservoir Evaporation (inches)



The operations model uses a daily time step so it requires estimates of daily evaporation. The daily evaporation rates used in the operations model were estimated from these monthly data by simply dividing the monthly totals by the number of days in each month to yield average daily values by month.

References

Complete citations for the references cited in this document are listed below:

Linsley, R., Kohler, M. & Paulhus, J. (1982). *Hydrology for engineers.* NewYork: McGraw-Hill Book Company

National Oceanic and Atmospheric Administration (NOAA). (1982a, July). *Evaporation Atlas for the Contiguous United States* [Technical Report NWS 33]. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Weather Service: Washington, DC.

NOAA. (1982b, December). *Mean Monthly, Seasonal, and Annual Pan Evaporation for the United States* [Technical Report NWS 34]. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Weather Service: Washington, DC.

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Attachment D

Supplemental Information on Streamflow Discharge Development for RESNET Model

STREAMFLOW ESTIMATES

This appendix documents the streamflow estimates that have been developed for use in planning studies for the City of Wichita's Integrated Local Water Supply (ILWS) Plan. Discussed below are the base historical streamflow data, the methodology used to synthesize flow estimates, and the resulting estimates.

Background

A computer model was developed to simulate operation of the ILWS system under various scenarios. This operations model was used initially to help with the conceptual design of the ILWS system; it was later used to quantify potential hydrologic impacts for the project's environmental impact statement (EIS). The operations model calculates a water balance for the ILWS system each day during the 85-year model simulation period (water years [WY] 1923–2007) using the following hydrologic data:

- Historical mean daily stream discharge at selected points within the project area
- Historical monthly reservoir evaporation rates
- Available storage and other physical data for Cheney Reservoir
- Available storage, natural recharge and other parameters for the Equus Beds aquifer
- City's current and projected water demands
- Irrigation demands for agriculture in the Equus Beds Well Field area
- Minimum desirable streamflow requirements
- Supply capability and other operating parameters for all current and potential water supply sources
- Preferred allocation order for each water supply source

The ILWS system is represented in the operations model as a network of nodes with connecting links. The majority of the model nodes represent locations on project area streams; the remaining nodes represent off-stream features, such as well fields, treatment plants and pipeline junctions. A schematic of the overall operations model network is shown in Figure 1. The nodes shown in Figure 1 with dark shading are stream nodes that receive unregulated surface runoff. These stream nodes are listed in Table 1 along with their corresponding node numbers.

Figure 1: Operations Model Schematic

(see Page A4 of Attachment A)

Table 1: Model Stream Nodes with Unregulated Inflow

Model Stream Node (Node Number)	Model Stream Node (Node Number)
Arkansas River near Hutchinson (10)	Little Arkansas River at Mouth (70)
Arkansas River near Maize (20)	Arkansas River at Wichita (80)
Little Arkansas River at Alta Mills (30)	NF Ninnescah River at Cheney Reservoir (90)
Little Arkansas River at Halstead (40)	Ninnescah River near Peck (100)
Little Arkansas River near Sedgwick (50)	Arkansas River at Arkansas City (110)
Little Arkansas River at Valley Center (60)	

To maintain a daily water balance for the ILWS system, the operations model requires estimates of mean daily streamflow at each of these stream nodes. As there is no practicable method available that can predict future hydrologic conditions with any certainty, these streamflow estimates are based on historical data. These historical data are used as a surrogate for possible future streamflow. The historical streamflow estimates developed for the operations model are described below.

Recorded Stream Discharge Data

In the United States, stream discharge data are collected primarily by the U.S. Geological Survey (USGS). Although the USGS maintains a network of stream gaging stations located throughout the country, it does not operate gaging stations at each of the stream nodes identified above. Therefore, it was necessary to synthesize some of the stream discharge data used in the operations model from those data that were available. The available stream gages of interest in the project vicinity are listed in Table 2 along with other relevant data. A map showing the locations of these gages is included as Figure 2 (USGS, no date). The recorded mean daily discharge for these gages was downloaded from the USGS' National Water Information System (NWIS), an online database system.

Review of Table 2 shows these streamflow records start as early as 1921 for the Arkansas River; however, only two of these gages, the Little Arkansas River at Valley Center (Station 07144200) and Arkansas River at Arkansas City (Station 07146500), have long continuous records. Under the ILWS plan, the Little Arkansas River is the primary new water source, both for direct use and aquifer recharge; therefore, this gage's period of record was used to define the simulation period for the project operations model: WY 1923-2007 (October 1922–September 2007).

Table 2: USGS Stream Gaging Stations[a]

Station Number	Name	Location (Latitude/ Longitude)	Drainage Area[b] (sq. mi.)	Period of Record
07143330	Arkansas River near Huchinson, KS	37°56'47" 97°45'29"	31,724	10/01/59- 09/30/07
07143375	Arkansas River near Maize, KS	37°46'53" 97°23'33"	31,924	03/01/87- 09/30/07
07143400	Arkansas River near Wichita, KS	37°42'30" 97°21'50"	31,978	10/01/21- 03/31/35
07143665	Little Arkansas River at Alta Mills, KS	38°06'44" 97°35'30"	681	06/06/73- 09/30/07
07143672	L. Arkansas River at Hwy 50 near Halstead, KS	38°01'43" 97°32'25"	685	05/01/95 09/30/07
07144100	Little Arkansas River near Sedgwick, KS	37°52'59" 97°25'27"	1,165	10/01/93- 09/30/07
07144200	Little Arkansas River at Valley Center, KS	37°49'56" 97°23'16"	1,253	06/10/22- 09/30/07
07144200	Little Arkansas River Floodway[c]	---	---	---
07144300	Arkansas River at Wichita, KS	37°38'41" 97°20'06"	33,227	10/01/34- 09/30/07
07144300	Big Slough-Cowskin Floodway[d]	---	---	---
07144550	Arkansas River at Derby, KS	37°32'34" 97°16'31"	33,567	10/01/68- 09/30/07
07144780	N. Fork Ninnescah River above Cheney Res., KS	37°50'41" 97°56'09"	550	07/01/65- 09/30/07
07144795	North Fork Ninnescah River at Cheney Dam, KS	37°43'17" 97°47'39"	664	10/01/64- 09/30/07
07144800	North Fork Ninnescah River near Cheney, KS	37°40'00"	685	10/01/50-

		97°46'00"		09/30/64
07145500	Ninnescah River near Peck, KS	37°27'26" 97°25'20"	1,785	04/01/38- 09/30/07
07146500	Arkansas River at Arkansas City, KS	37°03'23" 97°03'32"	36,106	10/01/21- 09/30/07

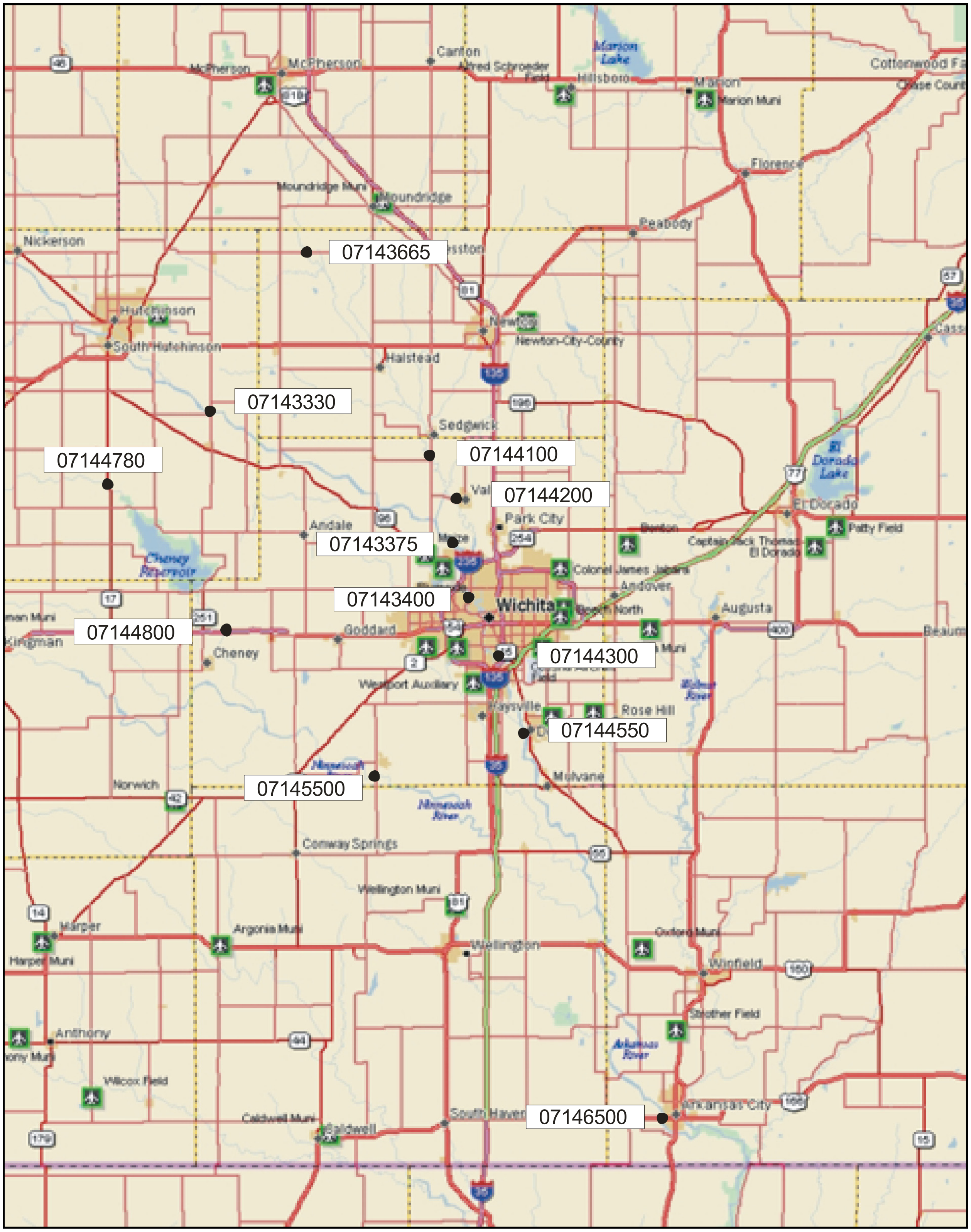
a. The available data at these gaging stations were downloaded from USGS NWIS database system.

b. Contributing drainage area.

c. During periods of high flow, some of the flow in the Little Arkansas River is diverted through the Little Arkansas Floodway into the Arkansas River. Flow data for Station 07144200 is a composite of flow in main stem of Little Arkansas River and Little Arkansas River Floodway.

d. During periods of high flow, some of the flow in the Arkansas River is diverted around Wichita through the Big Slough-Cowskin Floodway. These diverted flows re-enter the Arkansas River downstream of Wichita near Derby, KS. Flow data for Station 07144300 is a composite of flow in main stem of Arkansas River and Big Slough-Cowskin Floodway.

Figure 2: Location Map for USGS Stream Gages



Stream discharge can vary significantly from day to day and year to year based on weather patterns and other factors. On an annual basis, this variability is illustrated in a graph of the annual discharge in the Little Arkansas River at Valley Center (Valley Center gage) (Figure 3). These annual discharges have ranged from a low of approximately 18,000 acre-feet in WY 1934 to 1.23 million acre-feet in WY 1993, a factor of more than 100.

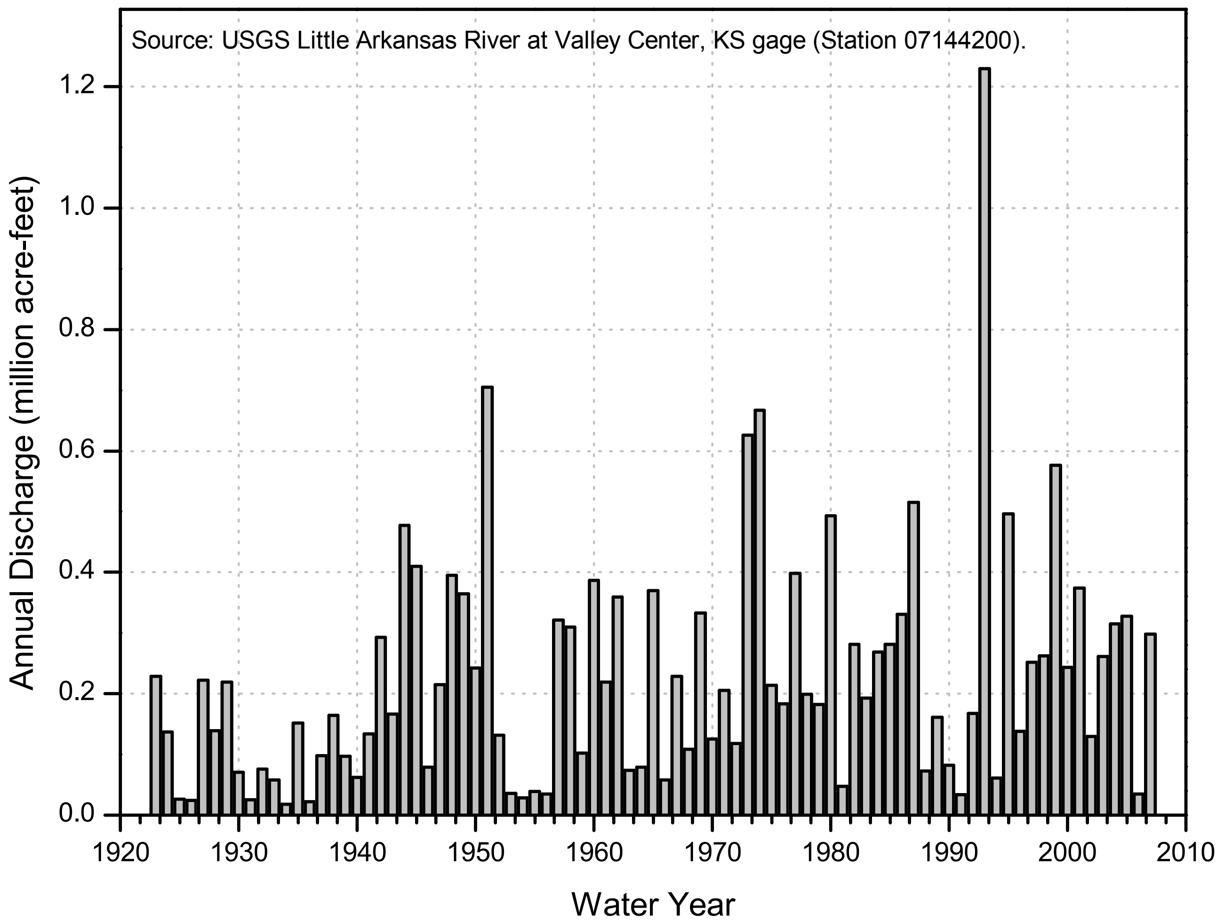


Figure 3: Annual Discharge in Little Arkansas River at Valley Center

For water supply purposes, the most critical periods during the available record are times of drought. In Kansas and much of the central plains region, the drought of record occurred in the mid-1950s. Following widespread flooding in WY 1951 and normal flows in WY 1952, the next four consecutive water years (1953–1956) proved to be exceptionally dry. Individually, there were several water years during the "dust bowl" of the 1920s and 1930s that were drier than these four years (1934, 1936, 1926, 1931, and 1925), but never more than two in a row. This drought generally ended in February 1957 with heavy rains across the region.

On a daily basis, the mean flow at the Valley Center gage has ranged from 1.1 to 28,600 cubic feet per second (cfs), and averages 315 cfs. Figure 4 is a flow duration curve for this stream gage that shows this daily variability. From this figure, the median (50 percent) discharge in the Little Arkansas River is shown to be 59 cfs, approximately one fifth of the average flow. The 10- and 90-percent flows at this gage are 494 and 21 cfs, respectively.

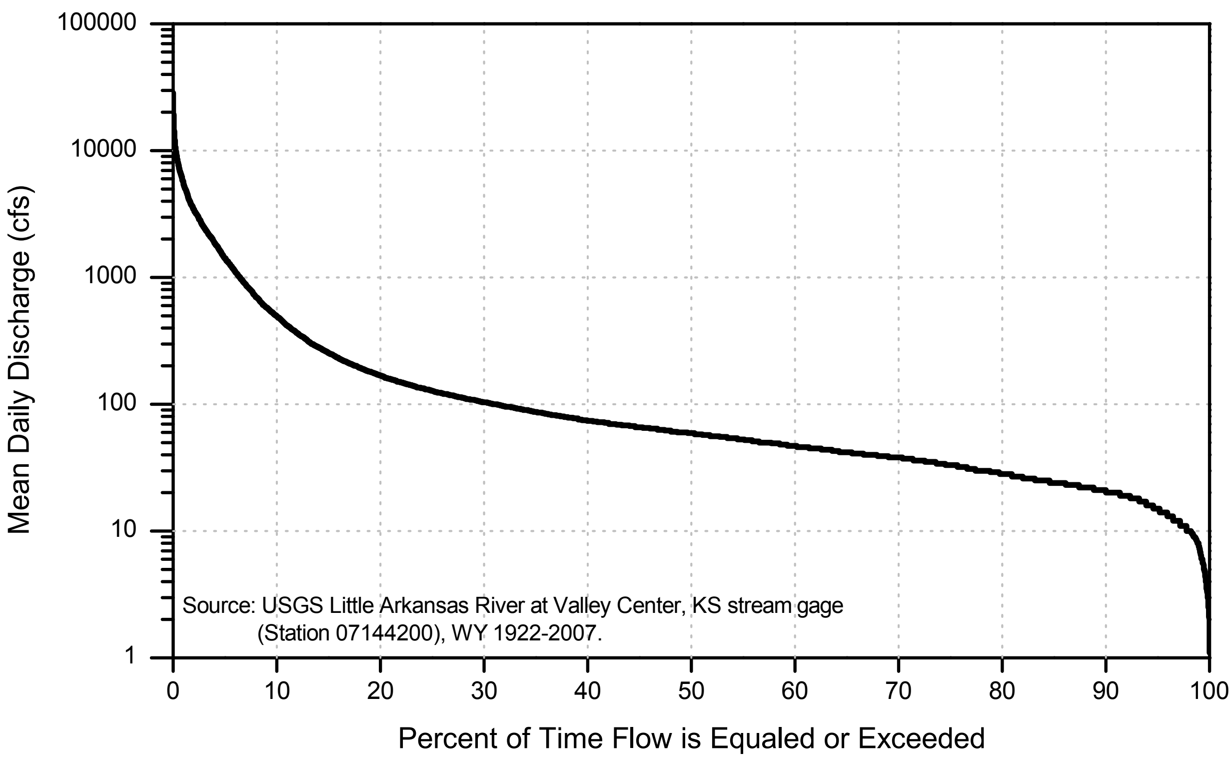


Figure 4: Flow Durations in Little Arkansas River at Valley Center

Natural Stream Discharge

Natural stream discharge is the discharge that would have occurred in a stream without any man-made influences. These influences can include construction of an upstream reservoir, direct withdrawals for water supply or irrigation, or indirect withdrawals caused by groundwater depletions. Over time, these influences tend to become more pronounced as the water resources within a stream's watershed area are developed.

As a typical first step in the development of a computer model for a water supply system, the available recorded streamflow data are naturalized. That is, they are adjusted to reflect estimated natural conditions by attempting to remove the affects of significant man-made influences. Estimating these influences, however, requires detailed records of applicable stream withdrawals and reservoir operations plus estimates of stream-aquifer interactions (discharges from aquifer to stream and depletions from stream to aquifer). Unfortunately, many of the necessary historical data often do not exist. Even where these data do exist, collection of these data can become a daunting task for a watershed the size of the Arkansas River.

Within the ILWSP project area, there are three primary streams of interest: the North Fork Ninnescah, Little Arkansas and Arkansas rivers. Each of these streams is discussed separately below.

North Fork Ninnescah River

The North Fork Ninnescah River is home to Cheney Reservoir. Other than Cheney Reservoir itself, there is little development within this watershed that would significantly impact streamflow volumes. Land use within the watershed upstream of the reservoir is largely agricultural. Some of this cropland is irrigated but this water is supplied from groundwater and not by diversions from the river. The flow in this river and its tributaries is sporadic enough that surface water diversions have limited utility without accompanying storage. The City has relatively senior surface water rights for Cheney Reservoir and a comprehensive watershed protection program is in place for the reservoir's catchment area.

There are two stream gages on this stream that were used to estimate Cheney Reservoir inflow. The gage near Cheney (Station 07144800) is located below Cheney Dam; this gage was discontinued when the reservoir was placed in service. The other gage of interest (Station 07144780) is located above the reservoir. As a result, neither of these flow records requires adjustment because of the reservoir. Therefore, given there has been little other surface water development in this watershed, the recorded flow at these two gages is considered reasonably equivalent to natural flow.

About 15 miles downstream of Cheney Reservoir, the North and South Forks meet to form the main stem of the Ninnescah River. There is another stream gage downstream on the Ninnescah River that was included as a stream node in the operations model: Ninnescah River near Peck (Station 07145500). About 37 percent of this gage's drainage area is located above Cheney Dam and the recorded flow at this gage has been impacted by operation of the reservoir since it went online in 1964. Therefore, the recorded flows at this gage are generally less than natural in recent years. However, this node was included in the operations model only to show the impacts (discharge differences) of the various alternatives. For this reason, natural flow at this gage was not estimated.

Little Arkansas River

The Little Arkansas River is the major new water source that will be developed under the ILWS plan. The water in this river will be used directly to meet current City water demands and for aquifer recharge. Land use within this river's watershed is mostly agricultural, except at its extreme northern extent where the City of McPherson is located. Water supplies within this area are derived almost exclusively from groundwater. There are a few small surface water rights on the Little Arkansas River but none result in significant depletions.

There are four USGS stream gages on the Little Arkansas River that were used as stream nodes in the operations model: Alta Mills (Station 07143665), Halstead (Station 07143672), Sedgwick (Station 07144100), and Valley Center (Station 07144200). Given the general lack of significant surface water diversions within the Little Arkansas River watershed and the Alta Mills gage's location relatively high in the watershed, no adjustments were made to this gage's record.

Similarly, the flow record at the Sedgwick, Halstead and Valley Center gages has not been significantly influenced by surface water diversions. However, groundwater discharge from the Equus Beds aquifer does contribute to the base flow in the river at these gages. The operations model includes routines to estimate this groundwater discharge so the incremental runoff between these gages was adjusted later to remove the estimated historical groundwater discharge. This process avoids double counting of this groundwater discharge in the operations model and yields more accurate results.

Arkansas River

The Arkansas River runs through Wichita but because of its poor quality characteristics (high saline content), it is not currently a major water source for the City; use of this water source will increase under the ILWS plan but not significantly. Above Wichita, the Arkansas River drains a contributing watershed that covers more than 33,000 square miles, including about one-half of the State of Kansas. The water resources of the Arkansas River have been extensively developed, with the first ditch diversions for irrigation occurring in the late 1800s.

Although these surface water diversions have impacted the flow in this river, the more significant impacts have occurred because of groundwater development. The High Plains and other aquifers of the central plains states have been developed extensively for irrigation, municipal, and industrial use. This groundwater usage exploded beginning in the late 1960s with the development of reliable center pivot irrigation systems, which encouraged farmers to begin irrigating thousands of square miles of cropland in eastern Colorado and western Kansas. The resulting declines in groundwater levels have turned the Arkansas River into a losing stream; historically, the discharge from alluvial aquifers helped maintain the base flow in this river. Figure 5 provides an illustration of just how significant these flow impacts have been. This graph shows the annual flow in the Arkansas River at Dodge City, which is located about 150 miles west of Wichita. Prior to the 1970s, the discharge at Dodge City was typically 40,000 acre-feet or more even in drier years. By the mid-1970s, typical dry-year flows had dropped to zero or nearly zero.

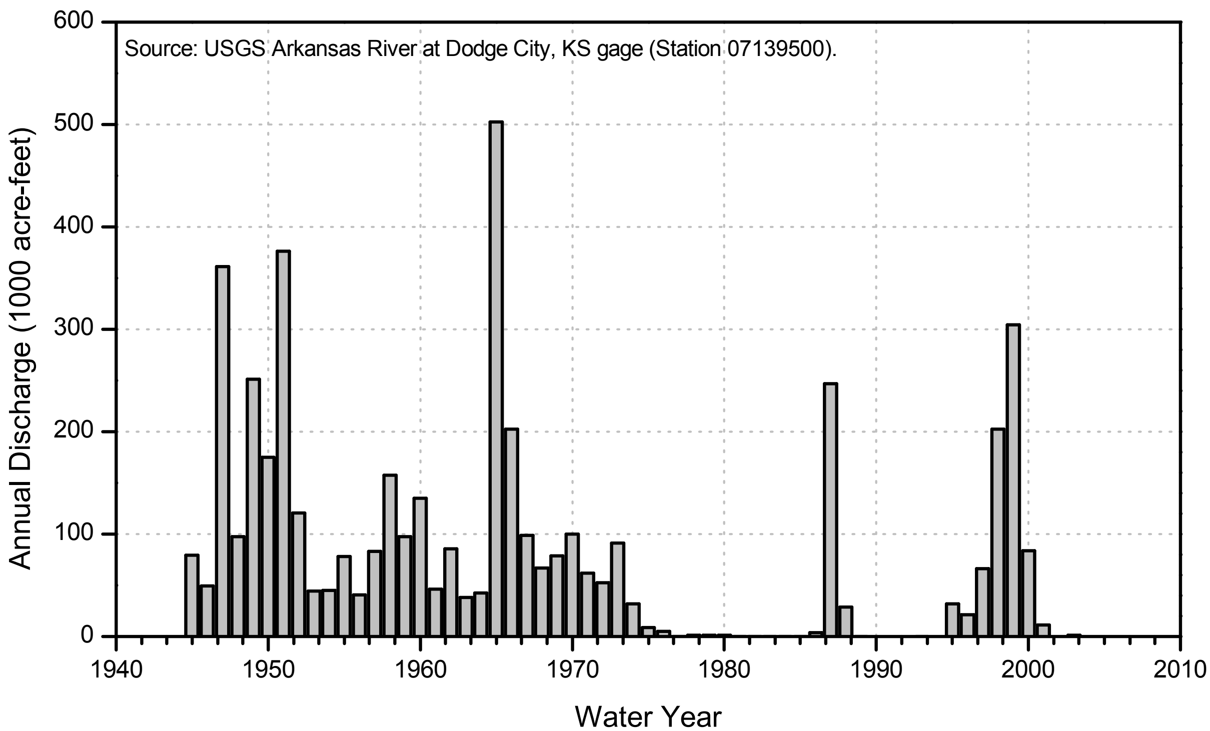


Figure 5: Annual Arkansas River Discharge at Dodge City

Downstream in Wichita, the impacts of stream depletions can be seen when comparing flow durations for periods before and after this groundwater development period. Figure 6 shows two flow duration curves for the Arkansas River at Wichita: one for water years (WY) 1935–1975 and the second for WY 1976–2007. Examination of these graphs show that flows have typically decreased in the midrange, from about 20 to 80 percent. However, the lowest flows — those with durations greater than 85 percent — have actually increased. This latter observation is counterintuitive but may be a result of increased wastewater or other man-made discharges.

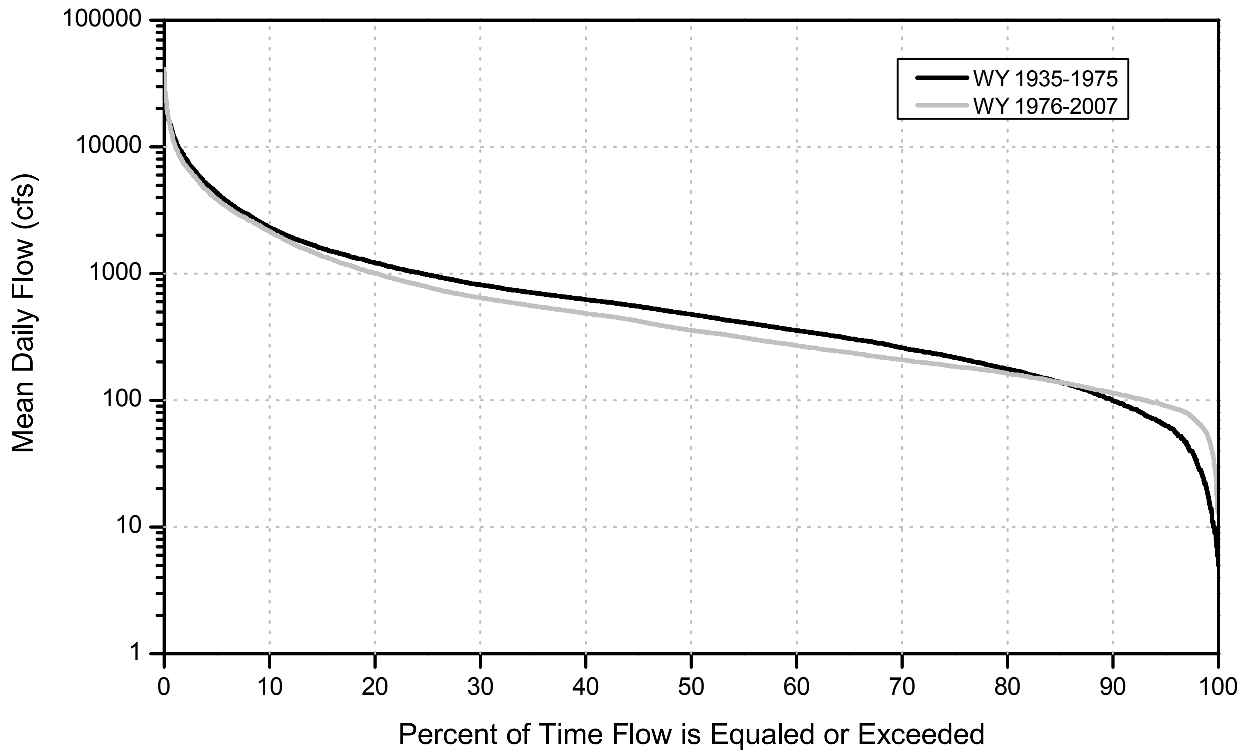


Figure 6: Flow Durations for Arkansas River at Wichita

Naturalizing the flow records for the Arkansas River would require collecting historical data on direct stream diversions from the river and its tributaries, and on groundwater withdrawals plus development of a groundwater model capable of estimating stream-aquifer interactions. Such a major effort was not considered practicable or justifiable given the comparisons presented above and the fact that the Arkansas River is a relatively minor water source for the City of Wichita.

Synthesis of Streamflow Estimates

As mentioned in Section 2, there are only two stream gages in the project vicinity with long continuous records that span the entire model simulation period: the Valley Center and Arkansas River at Arkansas City (Arkansas City) gages. At all other model stream nodes (Table 1), all or portions of the flow data used in the operations model were synthesized. The methods used to synthesize these data are described below:

Methodology

For stream nodes located at stream gages, whether active or discontinued, there are discharge data that cover a portion of the model simulation period. At these locations, it was necessary to fill in the missing data with estimates based on recorded data at other nearby gages. At stream nodes that are not located at an active or discontinued stream gage, a complete 85-year record was generated. In either case, the missing flow data at the target stream node were estimated based on the recorded data at a nearby source gage or gages that have data for the missing period. In selecting source gages, preference was given to gages available on the same stream, located either upstream or downstream of the target stream node, that have comparable drainage areas. For target gages without any nearby upstream or downstream gages, data for a gage on another, nearby stream were used.

For target nodes located at an active or discontinued stream gage, the missing data were estimated by first calculating the average annual unit discharge at the target and source stream gages. Unit discharge was calculated by dividing a gage's flow by its contributing drainage area, yielding values in cfs/square mile. When the target and source gages have an overlapping period of record, regression analyses were used to determine a best-fit line through these data:

$$q_t = a + bq_s$$

Where:

q_t = Recorded average annual unit discharge for target stream node (cfs/square mile)
q_s = Recorded average annual unit discharge for source stream gage (cfs/square mile)
a = Intercept of best-fit line through data
b = Slope of best-fit line through data

When the regression analyses returned a best-fit line with a negative intercept or relatively large positive intercept, an alternate analysis was performed with an intercept forced to go through zero. This adjustment avoided problems later on days when the flow in the source gage was zero or near zero. With a negative intercept, the equation above returns an invalid negative flow estimate. Where the regression analysis returns a large positive intercept, the calculated flows yielded unrealistically high minimum flows. When there is no overlapping period of record for the target and source gages, the intercept and slope were assumed to be zero and one, respectively.

The regression analyses described above were based on average annual flows but later used to develop daily flow estimates. The mean daily discharges at the target stream node were estimated using these regression results in the following equation:

$$Q_t = \left(a + b \times \frac{Q_s}{A_s} \right) * A_t$$

Where:

Q_t = Estimated mean daily discharge at target stream node (cfs)
Q_s = Recorded mean daily discharge at source gage(s) (cfs)
A_s = Contributing drainage area at source gage (square miles)
A_t = Contributing drainage area at target stream node (square miles)

For those source and target gages that have no overlapping period of record, this equation simplifies to a straight drainage area ratio when substituting $a = 0$ and $b = 1$.

Arkansas River near Hutchinson

The uppermost stream node on the Arkansas River is located about 24 miles upstream of Wichita at the USGS' Arkansas River near Hutchinson stream gage (Station 07143330). The period of record at this gage starts in October 1959 and runs through the end of the model simulation period. Prior to October 1959, the flow data for this stream node were estimated from two downstream gages on the Arkansas River: Arkansas River near Wichita and Arkansas River at Wichita. The specifics of these estimates are described below:

- Arkansas River near Wichita gage (Station 07143400): The period of record for this source gage runs from October 1921–March 1934, so it does not overlap the record at the near-Hutchinson gage. Therefore, the flow at this target stream node was estimated from the data at this source gage using a multiplier based on the ratio of the respective drainage areas. The flow estimates derived from this source gage extend from October 1922–September 1934.

- Arkansas River at Wichita gage (07144300): This stream gage began operation in October 1934, replacing the near-Wichita gage discussed in the previous bullet item. This gage has been in continuous operation since that time, so there is an overlapping period of record for the target, near-

Hutchinson stream node and this source gage (October 1959–September 2007). A major tributary, the Little Arkansas River, enters the Arkansas River between the Hutchinson and Wichita gages. The flow in this tributary (as measured at the Valley Center gage) was netted out of the flow at the Wichita gage before making flow comparisons. These comparisons are shown in Figure 7. The best-fit regression line through these points has an intercept of 1.9277E-4 and a slope of 0.80236, with a coefficient of determination (R^2) of about 0.947. For the period October 1934–September 1959, mean daily discharge at the near-Hutchinson stream node was estimated from this source gage using these regression results.

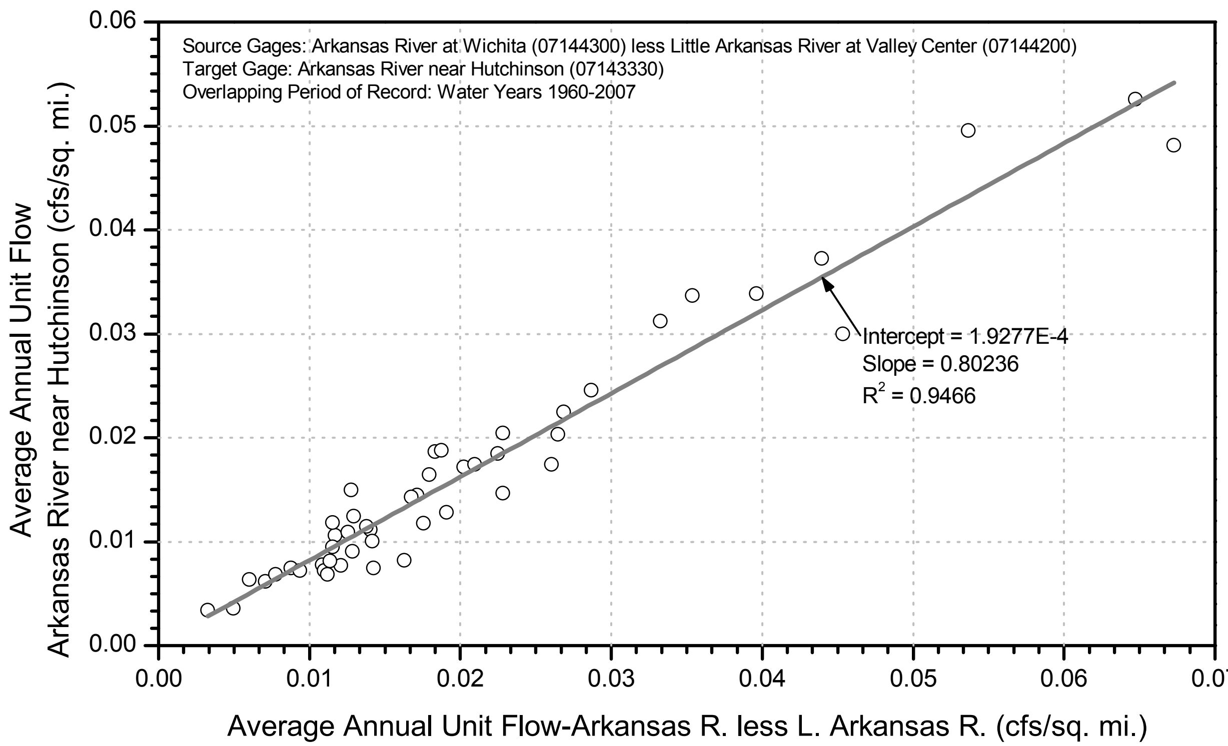


Figure 7: Discharge Comparison–Arkansas River near Hutchinson vs. at Wichita

If the unit runoff at these two Arkansas River gages was equivalent (that is, proportional to their respective drainage areas), the regression line shown in Figure 7 would have an intercept of zero and a slope of one. This seemingly large discrepancy results because the Arkansas River frequently runs dry in central Kansas because of upstream regulation and stream depletions. Therefore, the true effective contributing drainage area for these gages usually starts in central Kansas and not at the continental divide in Colorado.

Starting in October 1959, the actual recorded data at the near-Hutchinson stream gage was used for this stream node.

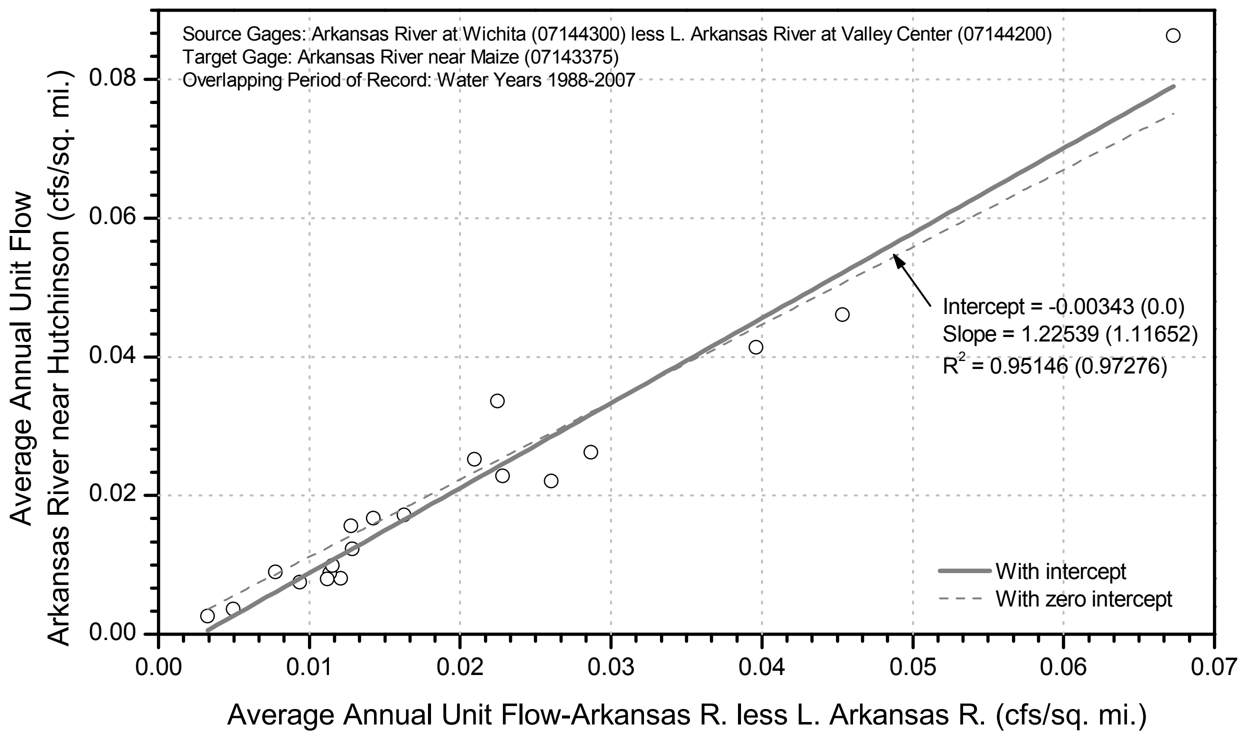
Arkansas River near Maize

The USGS' Arkansas River near Maize, Kansas stream gage (Station 07143375) is located a short distance upstream of the Wichita metropolitan area. The period of record for this gage is March 1987 to present. Prior to March 1987, the flow data for this stream node were estimated using the Arkansas River near Wichita and Arkansas River at Wichita gages. The methods used to estimate the missing flow data at this node are described below:

- Arkansas River near Wichita gage (Station 07143400): The period of record for this source gage runs from October 1921–March 1934; therefore, its record does not overlap that at the near-Maize gage. For this reason, the target node flow estimates derived from this source gage's data were developed using a drainage area ratio. The ratio of the contributing drainage areas at the near-Maize and near-Wichita gages is 0.998 (31,924 square miles/31.978 square miles). The flow estimates developed from this source gage extend from October 1922–September 1934.

- Arkansas River at Wichita gage (Station 07144300): This source gage is the active stream gage on the Arkansas River in Wichita. The period of record for this gage is October 1934 to present. The multiplier used to estimate the flow data at the near-Maize node from this gage's data was derived from regression analyses using average annual unit flow data. Figure 8 is a scatter plot that shows the relationship between the average annual unit flows at the near-Maize gage and the net average annual unit flow at the at-Wichita and Valley Center gages. The best-fit regression line through these points has an intercept of -0.00343 and a slope of 1.22539, with an R^2 of 0.95146. An alternate regression line with a forced intercept of zero yields a slope of 1.11652 and R^2 of 0.97276. These latter regression results were used to generate the flow estimates using this source gage. These estimates start in October 1934 and end in March 1987, when the near-Maize gage became active.

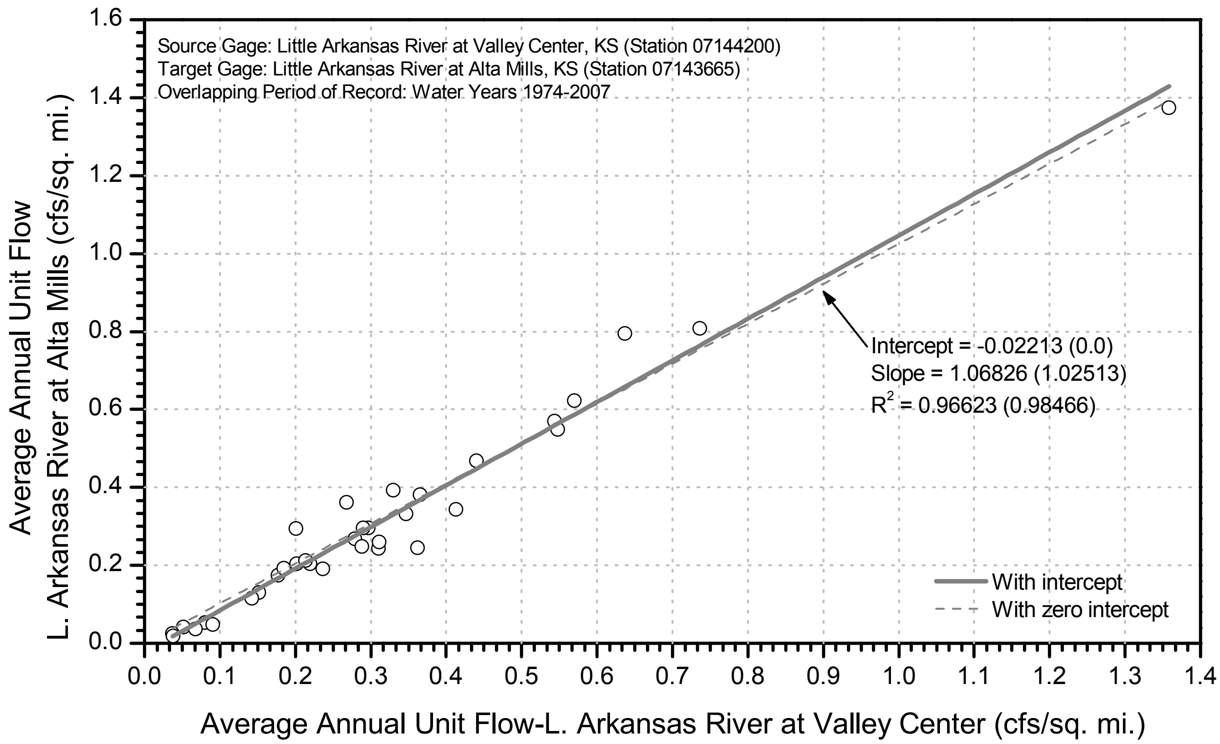
Figure 8: Discharge Comparison-Arkansas River near Maize vs. at Wichita



Little Arkansas River at Alta Mills

The USGS has operated a stream gaging station on the Little Arkansas River at Alta Mills (Station 07143665) since 1973. The location of this gage was selected as the farthest upstream node on the Little Arkansas River. For the balance of the model simulation period, the flow at this gage was estimated from the flow records at the downstream Valley Center gage. A scatter plot that compares the average annual flow at these two gages for the available 34-year overlapping period of record is shown in Figure 9. The best-fit line through these points has an approximate intercept of -0.02213, a slope of 1.06826, and an R^2 of 0.96623. An alternate regression line with a forced intercept of zero was also added to this graph. This line has a slope of 1.02513 and R^2 of 0.98466. The results of this alternate regression analysis were used to estimate the discharge at Alta Mills for the missing period, October 1922–June 1973.

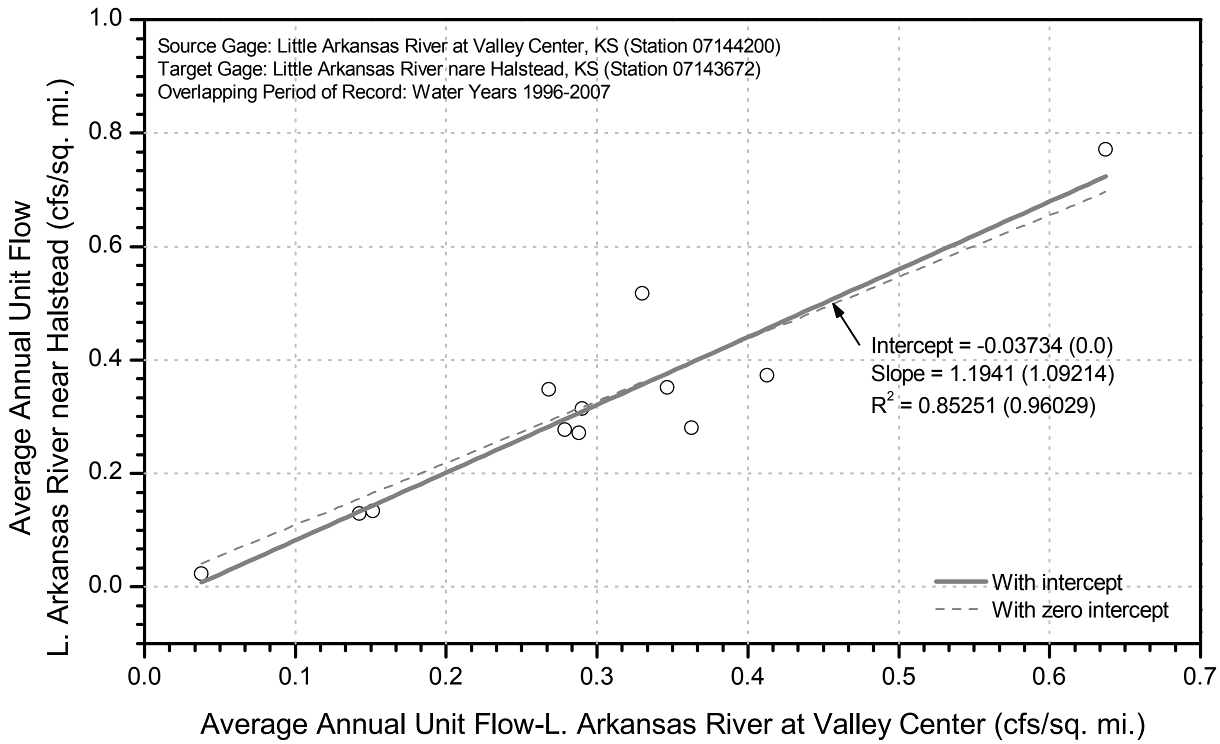
Figure 9: Little Arkansas River Discharge Comparison–Alta Mills vs. Valley Center



Little Arkansas River at Halstead

As originally conceived, the ILWSP included a proposed surface water intake and/or diversion wells on the Little Arkansas River near Halstead. There is a stream gage near this location (Little Arkansas River at Highway 50 near Halstead, Kansas [Station 07143672]); the record at this station begins in May 1995. For the balance of the model simulation period, the flow at this gage was estimated from the flow records at the downstream Valley Center gage. A scatter plot that compares the average annual flow at these two gages for the available 12-year overlapping period of record is shown in Figure 10. The best-fit line through these points has an approximate intercept of -0.03734, a slope of 1.1941, and an R^2 of 0.85251. An alternate regression line with a forced intercept of zero was also added to this graph. This line has a slope of 1.09214 and R^2 of 0.96029. The results of this alternate regression analysis were used to estimate the discharge at Halstead for the missing period, September 1922–April 1995.

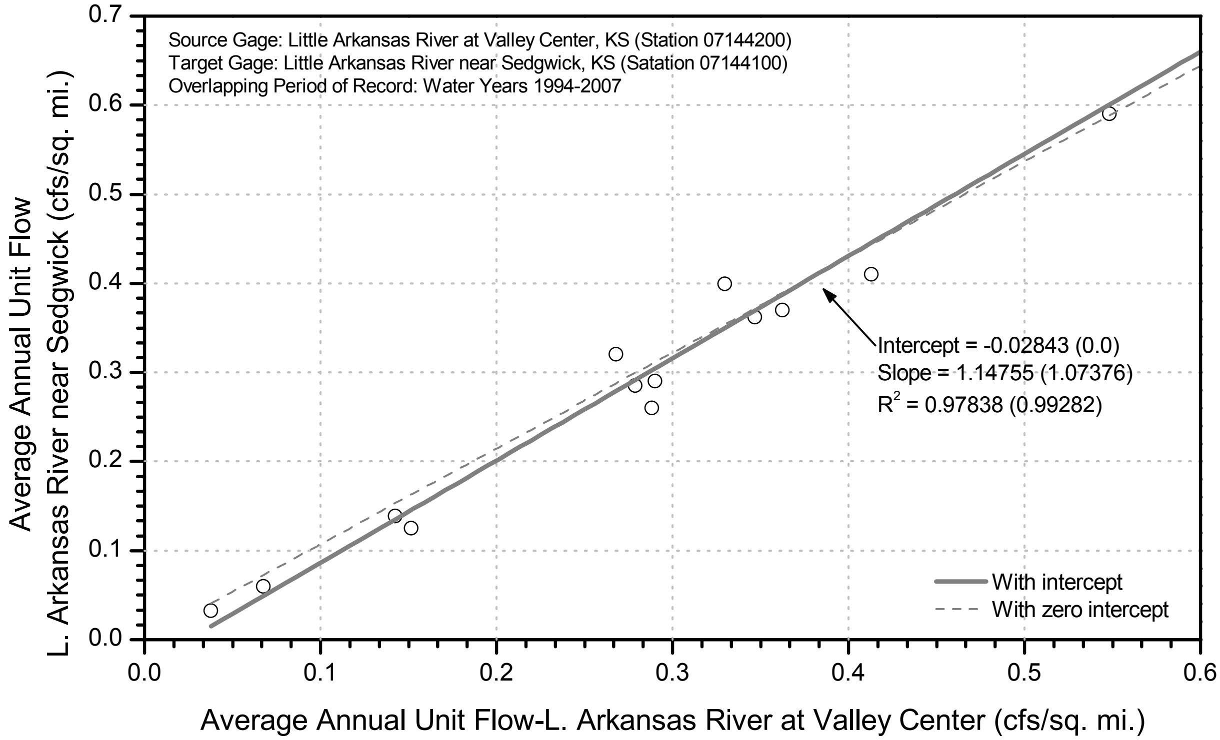
Figure 10: Little Arkansas River Discharge Comparison–Halstead vs. Valley Center



Little Arkansas River near Sedgwick

The USGS' Little Arkansas River near Sedgwick gage had been in operation since October 1993. Figure 11 shows that the average annual unit flow at the Sedgwick and Valley Center gages has a very nearly linear relationship. The best-fit line through these points has an intercept of -0.02843 and a slope of 1.14755 with an R^2 of 0.97838. An alternate best-fit line with a zero intercept has a slope of 1.07376 and an R^2 of 0.99282. The discharge at this stream node for the period prior to October 1993 was estimated from the data at the Valley Center gage using the results of this latter regression analysis.

Figure 11: Discharge Comparison–Little Arkansas River near Sedgwick vs. at Valley Center



Little Arkansas River at Valley Center

The Valley Center stream node on the Little Arkansas River is located at the USGS' stream gage of the same name (Station 07144200). The available data at this stream gage cover the entire model simulation period, so no streamflow estimates were necessary.

Little Arkansas River at Mouth

There are no stream gages on the Little Arkansas River below Valley Center; some of the proposed elements of the ILWS plan will impact the flow in the lowest reaches of this river. Therefore, it was necessary to develop flow estimates for the Little Arkansas River near its mouth in downtown Wichita. These flow estimates were developed from the data available at the Valley Center gage using a flow multiplier based on the ratio of the respective drainage areas. The drainage area of the Little Arkansas River at it mouth was estimated as 1,314 square miles, yielding a drainage area ratio of 1.049.

Arkansas River at Wichita

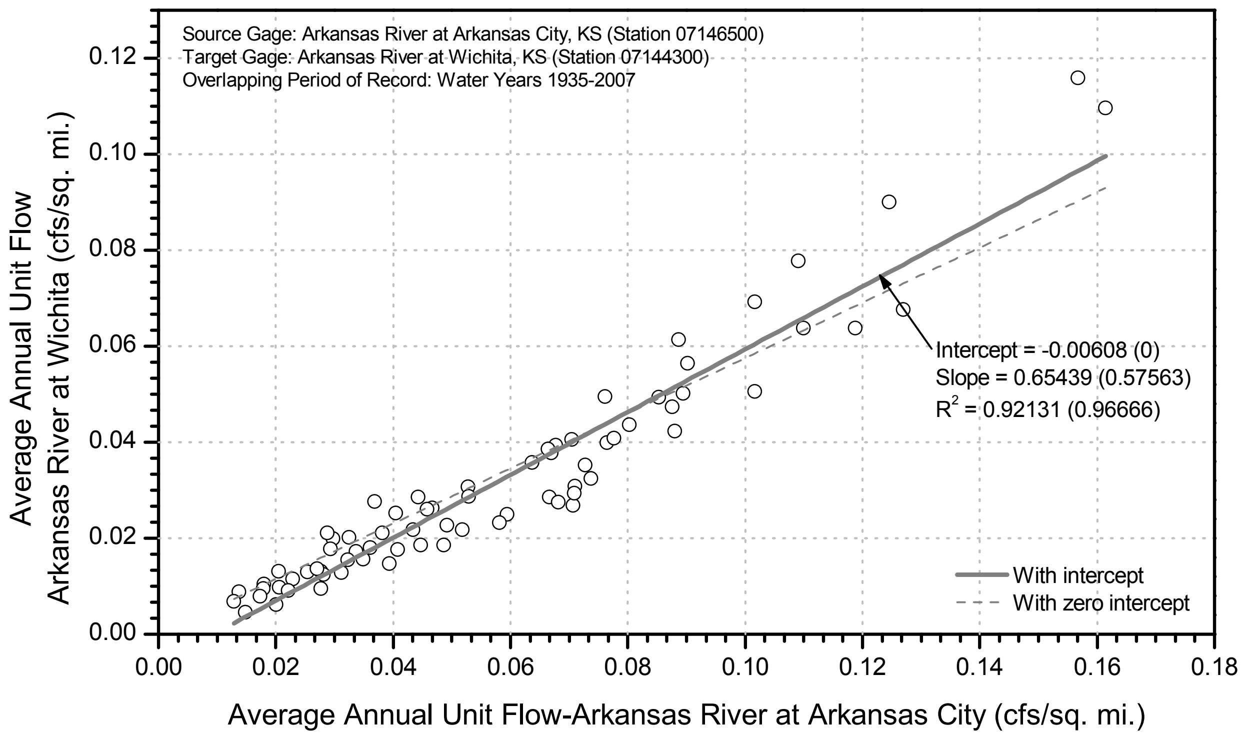
In Wichita, the discharge in the Arkansas River is recorded at a USGS stream gage located at the South Broadway Bridge (Station 07144300). This stream gage (Arkansas River at Wichita) has been in continuous operation since October 1934. Prior to this date, two possible methods were investigated to extend this record back to the start of the model simulation period. These methods are discussed below:

- Arkansas River near Wichita (Station 07143400): There is another stream gage located about six miles upstream of the target stream node that has flow records extending back beyond the start of the model simulation period. This gage (Arkansas River near Wichita) was discontinued shortly after the at-Wichita gage was placed in operation (March 1935). As there are only six months of overlapping data at the near-Wichita and at-Wichita gages, the results of any regression analysis would not be considered to have much validity. Although this gage is located only a short distance upstream, it is also above the confluence of the Little Arkansas River and has a significantly different (smaller) drainage area. Therefore, one method for estimating the flow at this target node would be to total the flow in the Arkansas River at the near-Wichita gage and the estimated flow in the Little Arkansas River at its mouth (Section 4.8).

- Arkansas River at Arkansas City (Station 07146500): The USGS stream gage on the Arkansas River at Arkansas City is one of the few gages with data for the earliest portion of the model simulation period. Figure 12 is a scatter plot that shows the relationship between the average annual unit flows at this gage and the target stream node. Two best-fit regression lines were plotted through these points. The first line has an intercept of -0.00608, an approximate slope of 0.65439, and an R^2 of 0.92131. The second line has a zero intercept, slope of 0.57563 and R^2 of 0.96666.

The flow record at the Wichita stream node was extended using the first method described above — sum of the discharge data for the near-Wichita gage and estimated flow in Little Arkansas River at its mouth.

Figure 12: Discharge Comparison–Arkansas River at Wichita vs. at Arkansas City



North Fork Ninnescah River at Cheney Reservoir

Cheney Reservoir is one of the City's principal water sources. This reservoir is located on the North Fork Ninnescah River above Cheney, Kansas. There is a stream gage located at Cheney Dam that was placed in operation at about the same time as the reservoir (October 1964); however, this gage (Station 07144795) records reservoir discharge only. For the operations model, estimates of reservoir inflow are required. These inflow data were estimated from the following sources:

- North Fork Ninnescah River near Cheney, Kansas (07144800): This source stream gage was located downstream of Cheney Dam. Its period of record starts in October 1950 and ends in September 1964. The inflow to Cheney Reservoir for this same period was estimated from this gage's data using a drainage area ratio (664 square miles/685 square miles = 0.969).

- North Fork Ninnescah River above Cheney Reservoir (Station 07144780): This source stream gage is located just a few miles upstream of the reservoir. This gage was placed in service after the reservoir became operational (July 1965) and is still active at present. The reservoir inflow estimates developed from this source gage were developed by multiplying recorded flows by the ratio of contributing drainage areas of the dam and gage (664 square miles/550 square miles = 1.207).

- Little Arkansas River at Valley Center (Station 07144200): Prior to installation of the near-Cheney gage, there are no stream flow records for the North Fork Ninnescah River. For this period, Cheney Reservoir inflow was estimated using data for the Valley Center gage on the Little Arkansas River. Figure 13 is a scatter plot that compares the average annual unit discharge at this gage with those for the near-Cheney and above-Cheney-Reservoir gages. The regression analyses for these data were developed after excluding one outlying data point. This single outlier was shown to have a significant influence on the regression results. The best-fit line through the remaining data points has an intercept of 0.08256 and a slope of 0.62079. Using these regression results to estimate the missing flow data for this target gage results in an unrealistically high minimum reservoir inflow estimate; therefore an alternate regression line with a zero intercept was used to estimate Cheney Reservoir inflow for the period October 1922–September 1950 and October 1964–June 1965. This zero-intercept regression line has a slope of 0.82864 and an R^2 of 0.90329.

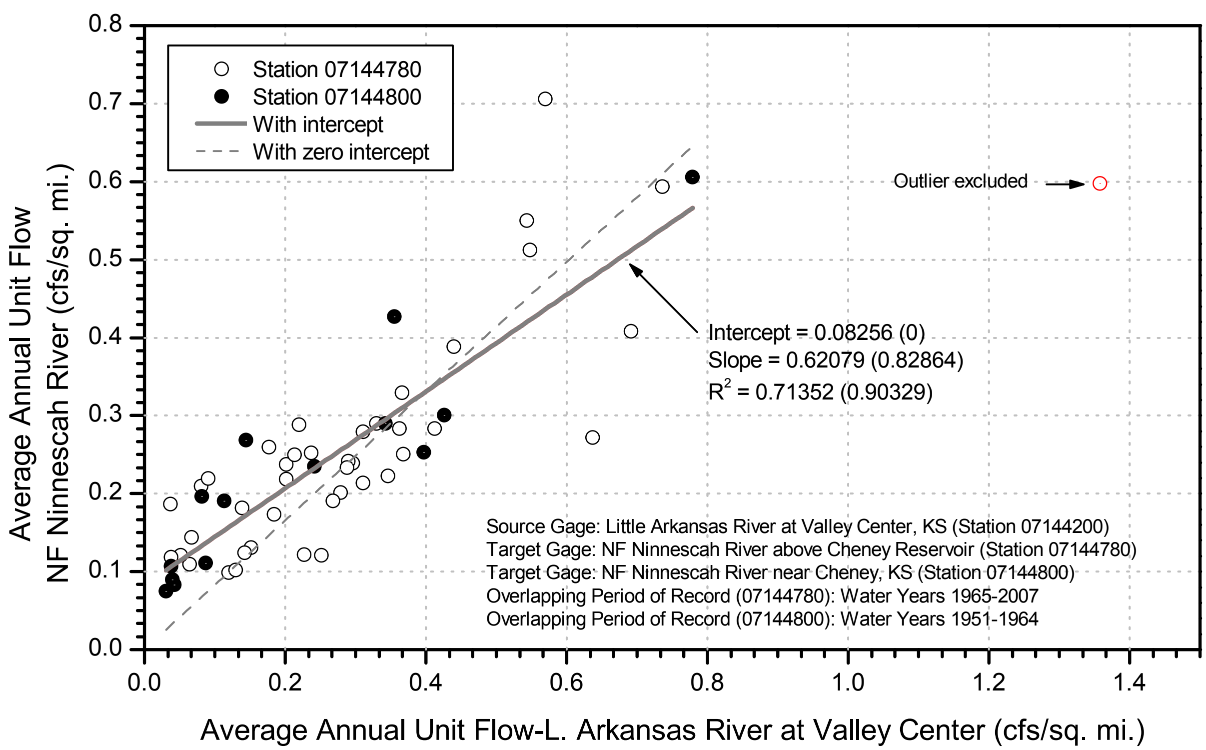


Figure 13: Discharge Comparison–Little Arkansas River vs. NF Ninnescah River

Ninnescah River near Peck

Below Cheney Reservoir on the main stem of the Ninnescah River is a USGS stream gage near Peck (Station 07145500). This gage has a period of record from April 1938 to the present. For the early portion of the model simulation period before this gage became active, these flows were estimated using data for the Arkansas City gage on the Arkansas River (Station 07146500). A scatter plot that compares the average annual unit flow at these source and target gages is included as Figure 14. From regression analyses, the best-fit line through these data points has an intercept of 0.05233, a slope of 4.10385, and an R^2 of 0.84037. The missing data at this stream node were estimated using the results of this regression analysis.

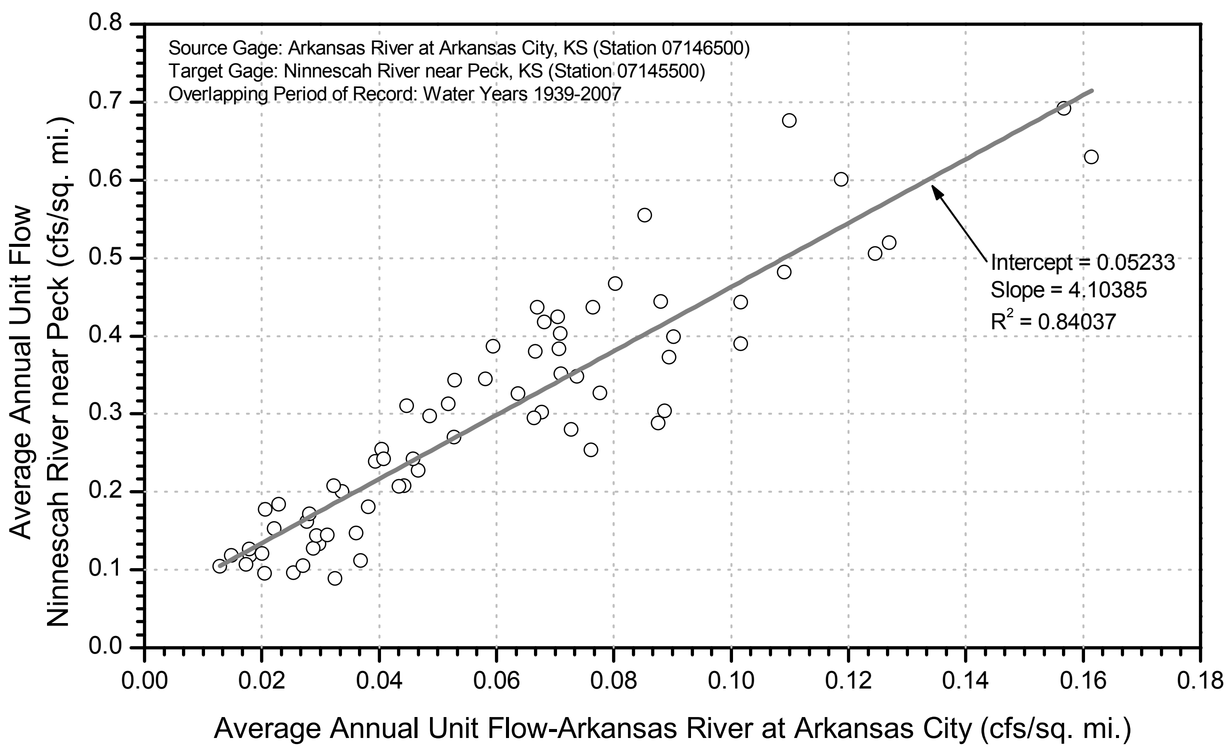


Figure 14: Discharge Comparison–Arkansas River vs. Ninnescah River

Arkansas River at Arkansas City

The last stream node used in the operations model is located on the Arkansas River near the Kansas-Oklahoma state line. This stream node is located at the USGS' Arkansas River at Arkansas City stream gage (Station 07146500). The available data at this stream gage cover the entire model simulation period so no streamflow estimates were necessary.

Unregulated stream node inflow

The streamflow data presented above includes estimates of the mean daily flow at each stream node for the entire model simulation period. The flow input data required for the operations model, however, are the unregulated inflow at each stream node. The unregulated inflow to a stream node is defined as the net runoff that accrues to the stream between that node and any upstream nodes. For example, the Arkansas River at Wichita stream node is located downstream of two other stream nodes: Arkansas River near Maize and Little Arkansas River at Mouth. Therefore, the unregulated inflow at the Wichita stream node is calculated as the estimated discharge at this node less the estimated discharge at the two upstream nodes. These unregulated inflow data can be negative at times when there are net depletions within a stream reach. These data can also be negative because of differences in the timing of storm hydrographs, which can cause the discharge at an upstream gage to be higher on a given day than the discharge at a downstream gage.

The streamflow estimates at each stream node were converted to unregulated inflow estimates by subtracting the flow from any upstream flow nodes. The upstream nodes at each stream node (if any) can be discovered by examination of Figure 1, but are also listed in Table 4 for convenience.

Table 4: Upstream Nodes at each Stream Node

Node No.	Node Name	Upstream Node(s)	
		Node No.	Node Name
10	Arkansas R. near Hutchinson	---	---
20	Arkansas R. near Maize	10	Arkansas R. near Hutchinson
30	L. Arkansas R. at Alta Mills	---	---
40	L. Arkansas R. at Halstead	30	L. Arkansas R. at Alta Mills
50	L. Arkansas R. near Sedgwick	40	L. Arkansas R. at Halstead
60	L. Arkansas R. at Valley Center	50	L. Arkansas R. near Sedgwick
70	L. Arkansas R. at Mouth	60	L. Arkansas R. at Valley Center
80	Arkansas R. at Wichita	50	L. Arkansas R. near Sedgwick
		70	L. Arkansas R. at Mouth
90	NF Ninnescah R. at Cheney Dam	---	---
100	Ninnescah R. near Peck	90	NF Ninnescah R. at Cheney Dam

110	Arkansas R. at Arkansas City	80	Arkansas R. at Wichita
		100	Ninnescah R. near Peck

Inflow Adjustments for Groundwater Interaction

Groundwater modeling has shown there is a strong hydraulic connection between the Arkansas and Little Arkansas rivers and the Equus Beds aquifer. The rates at which the aquifer gains or loses water to these streams is a function of aquifer water levels and storage. Table 5 lists the estimated rates of aquifer gain from and loss to local rivers as a function of aquifer water levels (Burns & McDonnell, 2008a).

Table 5: Equus Beds Aquifer Gain and Loss Rates

Aquifer Water Level (feet NGVD)[a]	Total Aquifer Gain Rate[b] (cfs)	Total Aquifer Loss Rate[b] (cfs)	Net Aquifer Loss Rate[c] (cfs)
1342	133[d]	23[d]	-110
1360	100	38	-62
1366	89	43	-46
1370	82	44	-38
1375	73	48	-25
1380	62	53	-9
1385	54	60	6
1389	48	68	20
1390	46	70	24
1395	38	82	44
1396	36	85	49
1402	29	99	70

a. Aquifer water level is the water elevation measured in Monitoring Well 886.

b. Estimates of gains and losses to area streams from MODFLOW groundwater model (Burns & McDonnell, 2008a).

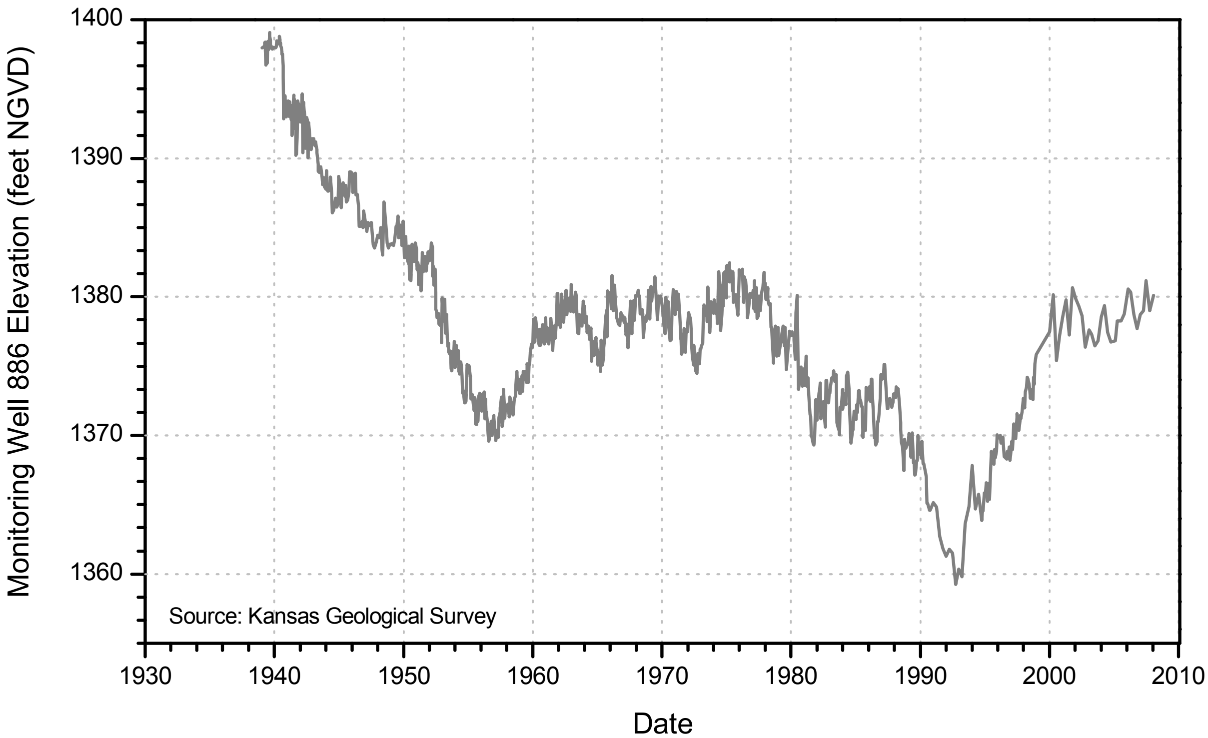
c. Negative values indicate a net aquifer gain.

d. Values extrapolated from remaining data.

In past analyses, it has been generally assumed that all Equus Beds aquifer gains come from Arkansas River depletions and all aquifer losses from discharge to the Little Arkansas River. The Little Arkansas River is down gradient of the aquifer so the assumption that all aquifer gains must come from the Arkansas River seems valid. However, review of measured flows in the Little Arkansas River seems at odds with the assumption that all aquifer discharge accrues to this river. The reasons for this conclusion are discussed further below.

The aquifer gain and loss rates listed in Table 5 are relative to aquifer water levels (piezometric water surface elevations) measured in Monitoring Well 886. A hydrograph of historical water levels in this monitoring well is plotted in Figure 14. These measured water levels have ranged from a peak elevation of 1399.09 feet NGVD in August 1939 to a low of 1359.24 feet NGVD in October 1992. From the data in Table 5, the corresponding aquifer discharge would have ranged from a minimum rate of about 37 cfs in 1992 to a maximum of 92 cfs in 1939. With an average water level of nearly 1382 feet, the historical aquifer discharge would have averaged about 56 cfs. If all of this aquifer discharge accrues to the Little Arkansas River then one would expect the baseflow in this stream to be comparable to these groundwater discharge values (that is, to average 56 cfs and never be less than 37 cfs). If fact the measured flow in this river has been less than 56 cfs at Valley Center about 48 percent of the time and less than 37 cfs about 30 percent of the time (Figure 4).

Figure 14: Water Levels in Equus Beds Aquifer



Various methods were tested to find a means to reconcile these estimated Equus Beds aquifer discharge rates with measured flows in the Arkansas and Little Arkansas River, but none of these methods were completely successful. The method that was adopted was to apportion the aquifer discharge between the Little Arkansas and Arkansas rivers in a manner that best balances flows in the Little Arkansas River. Preference was given to balancing flows in the Little Arkansas River because it is the primary new water supply source — both for direct use and aquifer recharge — to be developed under the ILWS plan. This analysis included the following steps:

- The historical water levels measured for Well 886 (Figure 14) were paired with the gain and loss rates listed in Table 5 to yield estimates of historical aquifer gain and loss rates for the entire model simulation period. The first available aquifer level reading (1397.98 feet NGVD) was collected on January 14, 1939. Prior to this date, the aquifer water level was assumed to be a constant 1398 feet NGVD. The recording interval for these data varied from approximately weekly to quarterly. Between sample dates, water levels were assumed to vary linearly with time. After water levels were estimated for each day, the corresponding aquifer gain and loss rates were estimated using these water levels and the data in Table 5.

- The apparent groundwater accretions to the Little Arkansas River were estimated for each day during the 85-year modeling period as the difference in the measured or estimated flows at Alta Mills and Valley Center.
- The apparent net groundwater accretions to the Arkansas River were estimated for each day as the flow at Wichita less the flows at Hutchinson and Valley Center.
- The datasets described above were filtered to eliminate those days when the flow at Valley Center was greater than or equal to its median value of 59 cfs. On the remaining days in these flow records, it was assumed that most of the flow in these streams came from baseflow and not surface runoff.

From the data subsets described above, the following statistics were developed:

- Average total loss from Equus Beds aquifer to rivers: 61.8 cfs
- Average total gain from rivers to Equus Beds aquifer: 60.0 cfs
- Average net loss from Equus Beds aquifer to rivers: 1.8 cfs
- Average flow in Little Arkansas River at Alta Mills: 15.5 cfs
- Average flow in Little Arkansas River at Valley Center: 33.1 cfs
- Average net flow accretion in Little Arkansas River between Alta Mills and Valley Center: 17.6 cfs
- Average flow in Arkansas River near Hutchinson: 197.1 cfs
- Average flow in Arkansas River at Wichita: 254.4 cfs
- Average net flow accretion to Arkansas River between Hutchinson and Wichita: 24.2 cfs

From these statistics, it was concluded that only 28.5 percent of total Equus Beds losses should be assumed to enter the Little Arkansas River (17.6 cfs / 61.8 cfs = 0.285). This percentage of total aquifer losses should approximately preserve the flow balance in the Little Arkansas River. Unfortunately, the same cannot be said for the Arkansas River. These statistics show that, on average, the Arkansas River gains 24.2 cfs through this reach. However, using the remaining gains and losses from the aquifer one would expect a net loss from the Arkansas River (0.715 * 61.8 cfs – 60.0 cfs = -15.8 cfs). From these data, there is no apparent way to balance the accretion rates to both the Arkansas and Little Arkansas rivers.

If Equus Beds discharge (loss) is distributed as indicated above, 28.5 percent will accrue to the Little Arkansas River and the remaining 71.5 percent to the Arkansas River. With 100 percent of the aquifer gains assumed to be from the Arkansas River, the resulting net aquifer loss rates are listed in Table 6.

Table 6: Allocation of Equus Beds Aquifer Loss Rates

Aquifer Water Level (feet NGVD)[a]	Net Aquifer Loss to (Gain from) Arkansas River[b] (cfs)	Net Aquifer Loss to Little Arkansas River[b] (cfs)
1342	-116.6	6.6
1360	-72.8	10.8
1366	-58.3	12.3
1370	-50.5	12.5
1375	-38.7	13.7
1380	-24.1	15.1
1385	-11.1	17.1
1389	0.6	19.4
1390	4.1	20.0
1395	20.6	23.4
1396	24.8	24.2
1402	41.8	28.2

a. Aquifer water level is the water elevation measured in Monitoring Well 886.

b. All aquifer gains and approximately 71.5 percent of aquifer losses accrue from/to Arkansas River. The remaining 28.5 percent of aquifer losses accrue to the Little Arkansas River.

For the project study period, the estimated historical discharge between the Equus Beds aquifer and the Arkansas and Little Arkansas rivers each day was estimated using the rates in Table 6 and the recorded water levels in Well 886 (Figure 14). These estimates were then used to adjust the unregulated inflow data at three stream nodes. The net losses from the Equus Beds aquifer to the Arkansas River were assumed to occur between the near-Hutchinson and near-Maize stream nodes. Therefore, the unregulated inflow at Maize was adjusted by adding estimated Arkansas River losses (aquifer gains) and subtracting corresponding river gains (aquifer discharge). In the Little Arkansas River, the estimated historical gains from the Equus Beds aquifer were split between two stream nodes. Forty percent of these gains were subtracted from the unregulated inflow at the Halstead stream node and the remaining 60 percent from the inflow at Sedgwick. If an estimated negative flow adjustment on a particular day was greater than the original recorded or estimated streamflow at the same point, the adjusted inflow on that date was limited to a minimum of zero.

Flow Estimate Spreadsheet

The Microsoft Excel workbook file that accompanies this appendix contains all of the source and estimated flow data described herein. This worksheets included in this workbook are described below:

- Stream Gages — List of USGS stream gages utilized in this streamflow appendix
- Recorded Flows — Copy of USGS flow records for referenced gages
- Flow Estimates — Complete record of flow estimates at model stream nodes. Where applicable, there data are a composite of recorded and estimated flow data.
- Unregulated Inflow — Unregulated inflow estimates used in RESNET operations model
- Equus Beds GainLoss — Estimates of historical Equus Beds aquifer gain and loss rates
- Inflow Adjustments — Groundwater interaction adjustments made to Maize, Halstead and Sedgwick flow data.

References

Complete citations for the references cited in this document are listed below:

Burns & McDonnell. (2003). *Final Environmental Impact Statement for Integrated Local Water Supply Plan, Wichita, Kansas.* Prepared for City of Wichita, Department of Water and Sewer. Kansas City, MO: Published by author.

Burns & McDonnell. (2008a, October). *Equus Beds Groundwater Elevation and Storage Deficit/Stream Gain and Loss Relationship.* Prepared from City of Wichita, Department of Water and Sewer. Kansas City: Published by author.

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Appendix B

Socioeconomic Impact Evaluation

Equus Beds Aquifer Recharge and Recovery Project: Regional Economic Impacts, Payment Capability, and Environmental Justice

Background

Over the last few decades the withdrawal of water from the Equus Beds aquifer for agricultural, municipal, industrial, and domestic uses has exceeded recharge. The water table has dropped significantly in many areas and water quality has also been adversely affected. Water demands in the Equus Beds area are projected to increase, so the current water system will need to be expanded and new water sources developed. As a result, the Equus Beds Aquifer Recharge and Recovery Project has been proposed to provide a reliable water supply to the Wichita water service area.

Two possible funding alternatives are possible for the recharge and recovery project. The first is for the water users to self-finance an expanded water supply and the second includes some level of Federal cost sharing for the project. This analysis is somewhat unique in that the only difference between the alternatives evaluated from an economic perspective is the source of funding. Essentially the same action will be taken regardless of Federal participation. This analysis evaluates the regional economic impacts that would be expected under each of the two scenarios, the affordability of each scenario for water users, and potential environmental justice issues that may result from a water supply project.

In general, water supply projects will generate positive regional economic impacts. One source of these positive impacts is from project funding obtained from outside the economic region defined for the project. Outside funding represents money injected into the region and represents a net increase in regional spending. Another potential positive impact could result from a reduction in the probability and duration of a municipal water shortage (improved reliability). The availability of water supplies for commercial users can influence the level of output, production costs, the location of activities, and the types of businesses locating in a region in the future.

The fact that essentially the only difference between the alternatives evaluated is the funding source, complicates the regional impact analysis. For example, it is clear that Federal funding sources represent an exogenous (outside region) change in spending, where funds flow into the region from an outside source and lead to increased economic activity. However, self-financing water supply improvements from water user payments represents a shift in spending by households from typical household spending patterns to spending for municipal water supply projects. Since water supply project construction spending increases at the expense of residential household spending for other items under the self financing scenario, the overall regional impact of the project is the net difference between the impacts of the two different types of spending.

The regional economic impacts from construction and operation of facilities associated with each alternative stem from capital, labor, energy, and other expenditures within the region. These expenditures will generally lead to positive regional output and employment impacts. However, for the self financing scenario the net difference in regional impacts may actually be negative if the regional activity associated with water supply project expenditures is less than the activity associated with typical household expenditures. This analysis describes the potential regional economic impacts associated with a municipal water supply project and the methods used to estimate these impacts.

Affordability or financial feasibility refers to the ability of households, businesses, and other water users to pay the costs associated with the provision of a water supply. If water users have the financial resources to pay the allocated costs of a project, including construction and operation and maintenance costs, then the project would be considered financially feasible. These costs may be paid through monthly user fees, retirement of debt incurred to build the project, tax assessments, or through other funding methods. The source of funding is to some extent irrelevant. What is relevant is the amount that must be paid by water users and how that compares with their payment capability. If project costs are determined to be greater than the ability of water users to pay for a project, then imposing the cost of project repayment on water users will result in financial hardship unless some government cost sharing is made available to make the water supply project affordable.

Different financing alternatives will have varying effects on the affordability of a water supply project. Clearly, a greater Federal or state cost share will reduce the amount that must be paid by water users and will improve affordability from the perspective of the water users. In order to evaluate water supply affordability for the Equus Beds project, the impact of each scenario on water bills to water users is estimated and compared to water affordability thresholds. If the analysis indicates that a water supply project is affordable regardless of available cost sharing, then Federal participation would not be a financial constraint to expanding the water supply. This analysis describes different methods for determining affordability thresholds and evaluates the affordability of various water supply funding alternatives for the study area.

Environmental justice addresses potential concerns about disproportionately large negative project impacts that are imposed on low income or minority populations in a project area. For example, if project construction occurs primarily in low income areas and disrupts activities in these areas, then this could be a significant environmental justice issue. An analysis comparing the distribution of project impacts with the location of low income and minority populations is needed to address Environmental Justice issues. This analysis focuses on the impact of funding a water supply project on water rates and the impact of these costs on low income households and analyzes the extent to which project impacts are disproportionate.

Methodologies

Regional Impact Analysis

A regional economic impact analysis measures changes in economic activity that occurs as a result of a project or some other action within a defined area. Economic activity can be measured in terms of income, value of output produced, or employment. Regional impacts represent flows of money (or employment) into and out of a region. Spending associated with an action may lead to substantial increases in income or employment within a specific region. However, these regional impacts do not necessarily translate into benefits to society at the national level. Economic benefits represent an improvement in efficiency or resource use that improves social welfare. Regional impacts are simply a measure of economic activity in a specified region of interest. It is also possible that an action may result in reduced regional output and income in a particular area, while generating positive benefits to the nation as a result of environmental enhancement or other improvements that are not translated into actual money flows. Therefore, estimates of project benefits and regional impacts are not directly comparable. A regional impact analysis can also be useful for environmental justice analysis because a regional analysis provides information on where the greatest economic impacts occur and the extent of those impacts.

When completing a regional economic impact analysis, there are three basic steps that need to be followed. First, the impact region of concern must be determined. Second, the types of activities that will be affected by the action under consideration must be identified and expenditures associated with each activity must be estimated. Third, the changes in expenditures that represent a change in final demand must be determined and the resulting spin-off effects estimated.

The study area considered in a regional economic impact analysis includes those areas that experience a direct monetary impact from construction or changes in operations. From an economic perspective these direct impacts may extend well outside the impact areas typically considered for other resources in order to account for flows of goods, services, and payments to major trade centers outside of direct impact areas. For this analysis the construction impact area is larger than the water user area and includes all of the water user counties. For purposes of consistency, the construction impact region was used to evaluate all categories of regional impacts. The counties included in the economic impact region are listed in table 1.

Table 1 – Counties included in the economic impact region

Impact Analysis Counties
Butler
Harvey
Kingman
Marion
McPherson
Reno
Rice
Sedgwick

The impacts associated which each of the alternatives are measured in terms of changes in industry output, value added, employee compensation, and employment. Industry output is a measure of the value of industry's total production. Industry output is directly comparable to Gross Regional Product. Value added represents payments made by industry to workers, interest payments, profits, and indirect business taxes. Employee compensation represents wages and benefits paid to employees. Employment is measured as full and part-time jobs combined.

The types of activities associated with construction of a water supply project include construction of intake facilities, wells, water lines, buildings, and instrumentation. Activities associated with operation and maintenance of these facilities include water treatment, facility repair, pumping, and storage. The costs for each of these activities are estimated by cost category. These categories include materials, equipment, fuel, and labor.

The regional impacts from construction and operation and maintenance expenditures were analyzed using the IMPLAN (IMpact analysis for PLANing) model. The IMPLAN model uses the Department of Commerce national input-output model to estimate flows of commodities used by industries and commodities produced by industries. Social accounts are included in the IMPLAN model data base for each region under consideration. Social accounts represent the flow of commodities to industry from producers and consumers, as well as consumption of the factors of production from outside the region. Social accounts are converted into input/output accounts and the multipliers for each industry within the region, which accounts for the multiple effects of changes in spending associated with land retirement. The IMPLAN model also accounts for the percentage of expenditures in each category that would remain within the region and expenditures that would flow outside the region.

In order to estimate the regional economic impacts associated with an alternative, estimates of changes in expenditures for goods and services must be input into the IMPLAN model. Estimating the impacts of construction and operation, maintenance, and repair activities requires estimates of these expenditures by expenditure category.

Affordability Analysis

Several federal laws related to the protection of water resources and provision of clean water supplies require an evaluation of water supply affordability. Some of these laws include the Safe Drinking Water Act, the Clean Water Act, the Toxic Substances Control Act, the Asbestos Hazard Emergency Response Act, the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), and the Resources Conservation and Liability Act (RCRA). The Environmental Protection agency (EPA) has included affordability criteria as part of their guidelines for evaluating compliance with federal laws, assessing financial responsibility, establishing penalties and fines, setting standards, and when allocating grants and credit assistance.

There is no universally accepted method of measuring payment capability or affordability for domestic water supplies. Government agencies, water resource consultants, and academic institutions have used a wide range of methods to evaluate how much water users can pay for domestic water supply improvements. The most common method of evaluating affordability is the cost of water as a percentage of median household income. Using this measure of affordability, total annual user charges are divided by median household income and compared to a predetermined threshold value of water utility affordability. There are variations to this basic formula, such as the use of average (mean) household income in the denominator or using cost of living indices to account for differences in household expenditures. Affordability criteria are often used in conjunction with other measures that consider general socio-economic conditions such as poverty rates or unemployment rates.

In 1980 the EPA Office of Drinking Water completed a Water Utility Financing Study that was initiated as a result of a 1977 Congressional requirement that EPA study the costs of complying with new drinking water regulations (EPA, 1980). The study evaluated the cost of water service to households and concluded that an annual user cost divided by household income of 1.5% to 2.5% was of questionable affordability and an annual user cost/income greater than 2.5% was not affordable (EPA, 1980). These rates correspond with rate increases of 100% to 200% being of questionable affordability and an increase of 200% or greater as being unaffordable. A subsequent EPA study of the affordability of the 1986 Safe Drinking Water Act estimated a threshold of 2.0% of median household income (EPA, 1993).

A 1990 EPA municipal ability-to-pay study indicated an average user charge per household greater than 1.0% of median household income for a water system should require additional financial resources to reduce the percentage to less than 1.0% (EPA, 1990). In addition, the study estimated that the short-run threshold for rate increases was 25% of the current rate, beyond which financial hardship would be created for water users.

The Environmental Protection Agency established affordability criteria for drinking water systems as a result of 1996 Amendments to the Safe Drinking Water Act. These Amendments allowed small public water supply systems to use less extensive water treatment technology if the most effective technology was not considered affordable. Therefore, EPA was required to define affordability in the context of household bills for sewer and drinking water service. As a result, EPA established a 4% of household income benchmark for affordability (2% for wastewater treatment and 2% for drinking water supplies). This was later amended to 4 ½% to allow 2 ½% for drinking water expenses.

It is important to understand that this benchmark is applied to whole systems, not to individual households. This measure of affordability was not intended to be applied to individual households. In other words, as a whole system 4% to 4 ½% of the system-wide household income could be used to pay for wastewater and drinking water service, but some households could pay more and some households may only be able to pay much less. The overall threshold does not recognize variations in income distribution. An analysis by The Congressional Budget Office indicated that about 7% of all households spent more than 4% of their household income and almost 2% of households spent 10% or more of their income on sewer and water services (CBO, 2002). This indicates that the 4% to 4 ½% of income thresholds for water and sewer bills do not preclude some households from the ability to spend more than 4% of their household on water and sewer bills.

It should be noted that the EPA affordability threshold is not a true measure of affordability, but is instead based on acceptability of fee increases by lending institutions and the cost of other utilities. It should also be recognized that simply using ratios of costs to income to determine affordability ignores other important factors related to paying for water system improvements.

The Department of Housing and Urban Development has set an affordability threshold of 1.3% of household income for water payments and 1.4% for sewer payments (EPA, 2006). A study by the National Consumer Law Center independently set affordability thresholds for water bills and sewer bills at 2.0% of average household income for each service (National Consumer Law Center, 1991). United States Department of Agriculture (USDA) Rural Development grant eligibility criterion uses a threshold debt service portion of annual user charge of greater than 0.5% of income when income is below 80% of the state median household income (EPA, 2006). The USDA Rural Development threshold for the debt service portion of annual user charge is greater than 1.0% of income when income is between 80% and 100% of the state median household income (EPA, 2006).

Payment capability/affordability based on a household budgeting approach

The affordability thresholds discussed above are based on a variety of factors including financing considerations, current rates, household income, and costs of alternate water supplies. The thresholds do not necessarily represent a maximum payment that can be made for water supplies. The actual ability of water users to pay for water supplies can be defined as the maximum amount households could pay for water given their income after accounting for housing expenses, transportation costs, food costs, insurance payments, other necessary expenses, and some level of discretionary spending. However, it would be very difficult to account for all possible household expenses to derive residual income that would potentially be available for making water payments.

A 1999 study assessing the financial and economic feasibility of rural water system improvements provided a framework for using a simple household budgeting methodology to estimate the ability to pay of water users for water supply improvements (Piper and Martin, 1999). This methodology accounts for necessary household expenses, differences in household income, and assumes that the highest observed water payments as a percentage of income made by households in a specific region represent an upper limit of ability to pay. The study identified a five step process that could be followed to estimate household payment capability.

Step 1 Gather water cost information for water users outside the area being evaluated.

Step 2 Collect household income, housing cost, tax payment, utility cost, insurance payment, and other necessary expense data for households outside the study area but in the same general region.

Step 3 Calculate residual household income (income less payments for housing, taxes, utilities other than water, etc.).

Step 4 Calculate the cost paid for water per $1,000 of residual income by water users outside the study area but in the same region (ability to pay factor).

Step 5 Apply the ability to pay factors to the residual income of households in the study area. The factors applied could be the highest factor observed from the data, the factor that separates the top 10% of factors from the other 90% of factors, median factor, or some other factor that represents maximum ability to pay.

The ability to pay factors represent the proportion of discretionary income that households served by various utilities must spend for domestic water supplies. Therefore, they are a measure of dollars spent on water service per dollar of discretionary household income. The ability to pay factors represent actual payments made by households for water. Therefore, the higher factors are likely to be the best estimate of maximum ability to pay.

The calculations used to estimate the ability to pay factors and total ability to pay for each household in the study area are shown below:

Residual Income	=	household income	–	home payment	-	non-water utilities	- payments for necessities
Ability to Pay factor	=	average water bill paid			÷	residual income in 1,000's of dollars	
Ability To pay	=	ability to pay factor			x	residual income in study area in 1,000's of dollars	

This methodology provides an estimate of payment capability that accounts for variation in household income, household expenses, and costs of living that are not considered when using set percentages of household income. Accounting for the variation in the percentage of total income spent by different levels of income may better represent household ability to pay for water supplies. This approach is used in this analysis to estimate water supply affordability in the Equus Beds area. The EPA affordability criterion of 2 ½% of median household income is also applied as a basis for comparison.

Environmental Justice Analysis

Environmental justice refers to the pursuit of equal protection under environmental laws for a clean environment for all people regardless of socioeconomic status, race, or ethnicity. Any action that harms the environment and provides little no improvement in income or employment in a low income area but provides economic improvements to a wealthy region may violate the intent of environmental justice.

An evaluation of environmental justice impacts is mandated by Executive Order 12898 on Environmental Justice (February 11, 1994) for Federal actions that affect the environment. Environmental justice addresses the fair treatment of people of all races and incomes, where fair treatment implies that no group of people should bear a disproportionate share of negative impacts from an action. The impacts of an action can be considered disproportionately distributed if the percentage of total impacts imposed on a specific group is greater than the percentage of the total population represented by that group. A group can be defined by race, ethnicity, income, community, or some other grouping.

Evaluating potential environmental justice concerns requires an understanding of where the project impacts are likely to occur and where potentially affected groups are located. The analysis relies on demographic data from sources such as the U.S. Bureau of the Census, individual counties and municipalities, and local school districts to determine the location of different groups of people. Identifying the location of specific groups can be difficult when nonpermanent residents, such as migrant workers, are in the affected area. Demographic data are poor for many groups of people. Census data do not account for all nonpermanent residents because some cannot be contacted or some may not want to be counted. In addition, the Census has a tendency to undercount the number of people in rural areas, due to difficulties encountered with contacting residents in sparsely population regions. However, Census data are typically the most complete and comparable demographic and economic data available for individuals and households.

The environmental justice evaluation in this analysis is based on the impact of funding a water supply project on water rates and the impact of these costs on low income households. The analysis is completed using U.S. Census data at the Zip Code level.

Regional Economic Impacts from Construction, Operation, and Maintenance Costs

In order to estimate the regional economic impacts that could occur as a result of construction and annual operation of an expanded Wichita water supply, the costs of building and operating the proposed system must be known. These expenditures will lead to a change in final demand for goods and services within the project area. The estimated change in final demand used in a regional impact analysis is equal to the change in local spending that is directly attributable to the project. Construction costs represent a one-time infusion of spending that would occur during the construction period. Updated construction cost estimates were obtained from R.W. Beck, Inc. (2008) and were broken down into materials, labor, and equipment related costs. The accuracy of the regional impact estimates is improved if costs are placed into specific categories.

Project expenditures that occur within the study region represent a change in final demand for those categories of goods and services. There are two basic questions that must be considered to determine the expenditures that actually represent a change in final demand and influence regional output. First, is the money used to purchase product related goods and services coming from inside or outside the study region? Money coming from outside the region that is spent on goods and services within the region will generate regional economic impacts while spending that originates from within the study region generally represents a redistribution of income and output rather than an increase in regional economic activity. For this analysis regional purchase coefficients (RPC's) are used to address the question of where the construction and operation related goods and services come from. RPC's are ratios provided within the IMPLAN model and represent the portion of regional demands purchased from local producers and trade flows in the model.

The second question is if the money used to purchase goods and services is determined to originate from inside the region, would those expenditures have otherwise flowed outside the region if the project under consideration was not built? If so, then the project may generate net positive regional impacts even if the source of funds is from within the region. This is a much more difficult question to answer because it requires very specific data on consumer spending patterns that generally does not exist. For the purposes of this analysis it is assumed that any water supply related costs that are avoided by households would be spent in the local region.

Labor costs were treated as household expenditures in this analysis, where the average percentage of household expenditures by category for a household in the study area was applied to labor costs. The assumption is that all labor costs are translated into household income. While some labor costs actually fit into benefit categories that cannot be translated directly into income, the majority of costs are income. Equipment costs were split up into fuel costs and non-fuel costs. Fuel costs are input into the regional model as direct fuel expenditures while non-fuel costs are placed into an appropriate equipment category for that specific construction activity. The estimated construction costs used to evaluate the one-time impacts from building water supply facilities are presented in table 2.

The source of information used to estimate the regional impacts associated with annual operation and maintenance costs was a 2000 Concept Design Study completed by Burns and McDonnell Consulting Engineers and the Final Environmental Impact Statement for Integrated Local Water Supply Plan – Wichita, Kansas completed by Burns and McDonnell (2003). Operation and maintenance costs were separated into material, labor, equipment, fuel, and power costs using previously estimated percentages of costs for a regional water supply in South Dakota, Iowa, and Minnesota (U.S. Bureau of Reclamation, 1993). The category percentages applied to operation and maintenance costs are shown below in table 3. Cost estimates for operation and maintenance by cost category are presented in table 4.

Table 2 – Construction costs by category used to estimate regional impacts

Construction Feature	Total Cost	Materials Cost	Labor Cost	Equipment Non-Fuel	Equipment Fuel
Recharge/Recovery Wells at Existing Sites					
Recharge/Recovery Well	$3,109,000	$1,119,882	$552,239	$949,796	$487,083
Control Building	$1,536,000	$926,417	$551,906	$32,827	$24,850
Piping and Valving	$995,000	$696,500	$248,750	$35,048	$14,702
Monitor Wells (1 shallow & 1 deep)	$124,000	$41,100	$19,991	$39,426	$23,482
SCADA	$311,000	$248,037	$62,963	$0	$0
Electrical and Instrumentation	$1,710,000	$1,561,864	$108,686	$19,409	$20,040
Site Work, Access and Fence	$622,000	$450,511	$83,839	$53,703	$33,947
Subtotal	**$8,407,000**	**$5,044,312**	**$1,628,374**	**$1,130,209**	**$604,105**
Recharge/Recovery Wells at New Sites					
Recharge Well	$1,473,000	$530,584	$261,643	$450,000	$230,773
Control Building	$727,000	$438,480	$261,221	$15,537	$11,762
Piping and Valving	$515,000	$360,500	$128,750	$18,140	$7,610
Monitor Wells (1 shallow & 1 deep)	$59,000	$19,556	$9,512	$18,759	$11,173
SCADA	$147,000	$117,239	$29,761	$0	$0
Electrical and Instrumentation	$810,000	$739,831	$51,483	$6,346	$12,340
Land	$91,000	$65,911	$12,266	$7,857	$4,966
Site Work, Access and Fence	$368,000	-	-	-	-
Subtotal	**$4,190,000**	**$2,272,100**	**$754,635**	**$516,640**	**$278,624**

Waterlines					
12-inch DIP	$489,000	$234,958	$157,282	$62,962	$33,797
16-inch DIP	$966,000	$506,481	$289,200	$109,570	$60,749
20-inch DIP	$491,000	$258,677	$147,981	$53,846	$30,495
24-inch DIP	$1,562,000	$908,549	$417,391	$150,220	$85,840
30-inch DIP	$1,023,000	$698,413	$194,800	$91,502	$38,286
36-inch DIP	$7,822,000	$5,252,988	$1,505,749	$750,579	$312,684
42-inch DIP	$2,139,000	$1,432,504	$416,315	$205,040	$85,141
48-inch DIP	$3,007,000	$1,987,709	$599,134	$297,117	$123,039
66-inch PCCP	$33,857,000	$25,393,341	$4,950,675	$2,480,456	$1,032,528
Subtotal	**$51,356,000**	**$36,673,620**	**$8,678,528**	**$4,201,293**	**$1,802,559**
Computer and Radio Systems					
Power Lines	$4,909,000	$3,681,750	$981,800	$75,764	$169,686
Transmission Lines	$6,620,000	$4,288,543	$1,544,428	$492,438	$294,590
Service Drop	$119,000	$106,856	$9,143	$1,502	$1,499
Subtotal	**$6,739,000**	**$4,395,399**	**$1,553,572**	**$493,940**	**$296,089**
Surface Water Treatment (Membrane - 30 MGD)	$59,600,000	$41,720,000	$11,920,000	$3,874,000	$2,086,000
Sedgewick Surface Water Intake (60 MGD)	$4,935,000	$3,454,500	$987,000	$320,775	$172,725
Substation	$4,908,000	$3,435,600	$981,600	$319,020	$171,780
Standpipe	$505,000	$353,500	$101,000	$32,825	$17,675
Raw project cost	**$145,549,000**	**$101,287,000**	**$27,656,000**	**$10,992,000**	**$5,614,000**
Contingency @ 30%	**$43,664,700**	**$30,386,100**	**$8,296,900**	**$3,297,700**	**$1,684,000**
Administrative, legal, planning costs	**$47,303,400**	**$21,002,700**	**$26,300,700**	**-**	**-**
TOTAL PROJECT COSTS	**$236,517,100**	**$152,675,800**	**$62,253,600**	**$14,289,700**	**$7,298,000**

Table 3 – Percentages applied to O&M cost categories

Activity	Material Costs	Labor	Power	Equipment	Fuel
Treatment	17.5%	32.5%	38.0%	9.0%	3.0%
Wells	26.0%	36.0%	-	35.0%	3.0%
Water lines	63.0%	26.0%	-	11.0%	-

Table 4 – Operation and maintenance costs by category used to estimate regional impacts

Construction Feature	Total Cost	Materials cost	Labor cost	Equipment		Power
				Non-fuel	Fuel	
Capture flow from Little Arkansas River						
Surface water intake	$147,200	$38,400	$53,150	$51,250	$4,400	-
Recharge water treatment	$2,300,000	$404,800	$747,500	$209,300	$69,000	$869,400
Equus beds aquifer recharge						
Recharge (vertical wells)	$290,950	$75,900	$105,000	$101,300	$8,750	-
Recharge (recovery wells)	$539,350	$140,750	$194,650	$187,750	$16,200	-
Surface water recharge	$263,350	$68,700	$95,050	$91,700	$7,900	-
Waterlines	$17,250	$10,850	$4,500	$1,900	-	-
Powerlines	$11,500	$7,250	$3,000	$1,250	-	-
SCADA	$79,350	$49,950	$20,700	$8,700	-	-
Expansion of local well field						
Horizontal collector wells	$46,000	$12,000	$16,600	$16,000	$1,400	-
Vertical wells	$14,950	$3,900	$5,400	$5,200	$450	-
Waterlines and powerlines	$2,300	$1,450	$600	$250	-	-

Development of Bentley field Vertical wells	$26,000	$6,800	$9,400	$9,050	$750	-
Raw water delivery and treatment improvements Pipeline improvements	$6,900	$1,800	$2,500	$2,400	$200	-
Treatment plant (phase I)	$747,500	$130,800	$244,800	$67,300	$22,400	$282,200
Treatment plant (phase II)	$1,322,500	$231,450	$433,100	$119,000	$39,700	$499,250
Total O&M Costs	**$5,815,100**	**$1,184,800**	**$1,935,950**	**$872,350**	**$171,150**	**$1,650,850**

In order to accurately estimate the regional impacts associated with building and operating water supply facilities, it is important to know if the funds are from local sources. If the project is funded entirely by water users, then water supply related expenditures are made in place of expenditures for other items. A change in the distribution of final demands will result in a change in regional output and income if the demand sectors have different rates of leakage. Leakages occur as a result spending on goods and service that are not produced within the regional economy and do not generate additional local spending. If demand shifts from a good or service sector which has a high level of leakage to a sector with few leakages, there will be a positive effect on overall regional output and income.

The impacts from construction spending and annual operating expenditures are estimated assuming a range of local spending. Impacts at the low end of the range are based on the assumption that the project is paid entirely by local sources. The high range of impacts is based on the assumption that the project is paid entirely by outside sources, such as the Federal Government. Regional impacts are also estimated for intermediate scenarios, where 30%, 50%, and 70% cost sharing is assumed.

Construction of a municipal water supply project would generally be expected to generate positive regional economic impacts because of relatively high costs. However, as noted previously, the net effect of a municipal water supply construction project depends on the proportion of local spending with and without the water supply project and the amount of cost sharing. The estimated regional economic impacts associated with different construction cost categories are shown in table 5. These one-time construction impacts would be realized only if the project was funded entirely from outside sources. It is also important to note that these impacts will occur in total over the period of time that project construction takes place. For example, if the construction period is five years the total impacts over five years would equal the total shown in table 5 assuming 100% funding from outside of region sources.

Table 5– Regional economic impacts associated with construction spending assuming all project costs are paid by sources outside the region

Construction Expenditure Category	***Cost of* feature** (millions)	**Impact Category**			
		Value Added (millions)	Employee Compensation (millions)	Employment (total)	Output (millions)
Recharge/recovery wells	$4.582	$1.796	$0.861	27.5	$5.963

Control Building	$2.263	$1.744	$1.045	32.1	$3.585
Piping and Valving	$1.510	$0.621	$0.316	8.8	$2.126
Monitor Wells	$0.183	$0.050	$0.023	0.8	$0.218
SCADA	$0.458	$0.107	$0.064	1.6	$0.556
Electrical and Instruments	$2.520	$0.409	$0.266	6.7	$2.895
Site work, Access, Fence	$0.990	$0.256	$0.123	3.9	$1.169
Land	$0.091	$0.047	$0.011	0.6	$0.115
Waterlines	$51.356	$7.664	$3.753	112.2	$21.004
Computer, Radio Systems	$4.909	$0.897	$0.456	13.2	$5.671
Powerlines	$6.739	$1.472	$0.750	22.0	$7.975
Surface Water Treatment	$59.600	$26.987	$15.171	462.8	$80.550
Water Intake	$4.935	$1.484	$0.734	21.4	$6.172
Substation	$4.908	$3.713	$2.287	71.9	$7.624
Standpipe	$0.505	$0.123	$0.063	1.8	$0.604
Administrative, planning, legal, management costs	$47.303	$22.004	$12.512	338.7	$62.961
Contingency	$43.665	$20.812	$11.531	337.8	$62.756
Total	**$236.52**	**$90.186**	**$49.966**	**1,463.8**	**$271.944**

The regional impacts shown in table 5 represent the high end of the range of possible impacts. The low end of the impact range would assume that all project funding comes from local water users, through increased water bills or some other user based funding mechanism, and that the funds would otherwise be spent on typical household items for households making $35,000 to $50,000 annually. The proportion of income spent on various types of goods and services and the RPC's were obtained from the IMPLAN model database. Table 6 shows the impacts from water supply project expenditures (the same total impacts shown in table 5) and regional impacts if the same level of expenditures were spent in the same proportion as representative households in the region.

Table 6– Regional economic impacts associated with water supply project expenditures and equivalent household spending

	Impact Category			
Construction Expenditure Scenario	Value Added (millions)	Employee Compensation (millions)	Employment (total)	Output (millions)
Regional impacts from household expenditures equal to project cost	$165.8	$83.2	2,365	$382.4
Project expenditure impacts	$90.2	$50.0	1,464	$271.9

The results in table 6 clearly show that there are considerably greater leakages associated with water supply project spending than for representative household spending. This should not be surprising considering household items would be more likely to be produced, or a greater proportion of their total value produced, in the local region. The data provided in table 6 is used to interpolate a range of impacts for various cost sharing scenarios. The regional impacts from project expenditures were constant for all scenarios, but the regional impacts lost as a result of reduced local spending was reduced by the percentage of project cost sharing. The results are shown in table 7.

Table 7- Regional economic Impacts of No Action and the Water Supply Alternative, assuming various levels of Federal cost sharing

	Impact Category			
Construction Expenditure Scenario	Value Added (millions)	Employee Compensation (millions)	Employment (total)	Output (millions)
No Action (equivalent to no cost share)	-$75.6	-$33.2	-901	-$110.5
Project 30% cost shared	-$25.9	-$8.2	-192	+$4.2
Project 50% cost shared	+$7.3	+$8.4	+281	+$80.7
Project 70% cost shared	+$40.5	+$25.0	+754	+$157.2
Project 100% cost shared	+$90.2	+$50.0	+1,464	+$271.9

The construction impact analysis indicates that a minimum 50% cost share from outside of region sources would be required in order for a water supply project in the Wichita area to generate net positive regional impacts. A water supply project funded entirely by water users would result in a loss in the value of regional out of slightly over $110 million and 900 jobs lost.

The same type of analysis was completed for O&M related expenditures. The estimated annual O&M related impacts are presented in table 8 along with the impacts associated with equivalent household income impacts.

Table 8 – Annual regional impacts from O&M expenditures and impacts from equivalent household spending

	Annual regional impacts from O&M expenditures			
Component	Value Added	Employee compensation	Employment	Output
Intake and recharge O&M	$134,600	$67,200	1.9	$524,400
Water treatment O&M	$1,832,400	$673,100	16.1	$5,173,200
Well O&M	$227,900	$109,600	3.4	$1,083,400
Powerlines, waterlines, SCADA	$38,400	$19,200	0.5	$149,800
O&M	**$2,233,300**	**$869,100**	**21.9**	**$6,930,800**
Total impact				
	$4,462,700	$2,012,300	75.3	$11,025,400
Equivalent household income impacts				

The impacts associated with O&M expenditures are also presented for different cost sharing scenarios. However, it is very unlikely that annual O&M would be cost shared on a permanent basis. Therefore, the scenario with O&M paid by water users is most likely to actually occur with or without Federal participation over the long run. The regional impacts associated with each financing scenario are shown in table 9.

Table 9 – Annual regional impacts from O&M expenditures resulting from various cost sharing scenarios

	Impact Category			
Construction Expenditure Scenario	Value Added (1,000's)	Employee Compensation (1,000's)	Employment (total)	Output (1,000's)
Impacts if O&M 100% cost shared	$2,233.3	$869.1	21.9	$6,930.8
Impacts if O&M 50% cost shared	-$1,114.7	-$571.6	-26.7	-$2,047.3
Impacts if O&M paid by water users	-$2,229.4	-$1,143.1	-53.4	-$4,084.6

Affordability Analysis - What can water users afford to pay towards municipal water supplies?

As discussed in the Methodologies section, EPA and various rural development agencies have used water payments and household income estimates as a basis for evaluating the potential of water users to pay for water system improvements. Financial investment firms evaluate the revenues and expenses of public and private water utilities seeking funds for improvements as a measure of investment risk. The primary consideration in evaluating the financial viability of water supply improvements is the cost of the improvement relative to available income. Many of these analyses do not account for the effect of varying household expenses on ability to pay for increased water rates.

The proportion of income that households can pay towards water bills will vary considerably from region to region. In regions with low housing costs, the percentage may be much greater than in areas with high housing costs. Households in areas that have very poor water supplies may be willing to give up some goods and services and use those payments toward higher water costs. The household budgeting approach discussed in the Methodologies section is used to evaluate water supply affordability.

Ability to pay can be defined as the maximum amount households can pay for water given their income and other household expenses. This does not consider consumer preferences in determining the allocation of income to goods and services. Housing costs, local tax payments, utility costs other than water, average health insurance payments, and other payments for necessities are subtracted from household income to derive discretionary income.

Payment Capability of Water Users in the Equus Beds Study Region

Estimates of water costs and use in the Equus Beds study area and outside the study area were developed using data obtained from the report Kansas Municipal Water Use 2006 (Kansas Water Office 2008). The report provided detailed water use and water rate data for municipalities and rural water suppliers throughout Kansas. Housing cost data were obtained from the U.S. Bureau of the Census 2000 data. This was the most recent data available at the municipal level.

Housing costs were estimated for each municipality using data for percentage of households owning a home with a mortgage, home owners without a mortgage, percentage of renters, and average costs for each category of home occupancy. A weighted average housing cost for all types of housing was then derived. Average health care costs for Kansas were estimated to be $4,089 annually (U.S. Department of Health and Human Services 2008). Representative costs for food ($5,366), transportation ($8,166), and insurance ($3,630) were obtained for the Midwest region from the 2000 Consumer Expenditure Survey (U.S. Bureau of Labor Statistics 2008). Median household income data were obtained from the 2000 Census (2008) for each of the municipalities included in the Kansas Water Office water use report.

Representative household expenditures were subtracted from median household income to estimate residual income for each municipality. Water cost was then divided by residual income to estimate payment capability factors. These factors were estimated for all Kansas municipalities and rural water suppliers included in the water use report, for water suppliers in Kansas but outside the study area region, and suppliers within the study region. Payment capability factors for all three groups are presented in table 10 for comparison. However, only the factors estimated for the Kansas suppliers excluding the study area are used to evaluate payment capability.

Table 10 – Payment capability factors

Measure	Complete Kansas data	Kansas, excluding study area	Study area only
Mean	.05118	.05983	.04032
Median	.04015	.04212	.03079
Top 10%	.13088	.13596	.05604
Top 25%	.05530	.07062	.04367

The mean payment capability factor for all of Kansas is about 5.1% of residual income. The top 10% factor of 13.1% of residual income is equivalent to 2.95% of median family income. Looking at the Kansas data excluding the Equus Beds project area municipalities, the top 10% factor is about 13.6% of residual income which translates to 2.59% of median household income. The top 10% payment factor excluding the Equus Beds area is slightly higher than but very similar to the EPA threshold of 2.5% of median household income.

The capability to pay for the Equus Beds study area is estimated by applying the top 10% factor estimated using the data excluding the study area of .13596 to the residual household income for Wichita. The residual annual household income for Wichita is estimated to be $7,275. Applying the top 10% factor to residual income results in a payment capability of $990 per connection per year. The median household income for Wichita was $39,939 in 2000. The estimated payment capability for Wichita is 2.48% of median household income. Coincidentally, this is essentially the same payment capability that would be calculated using the EPA threshold of 2.5% ($1,000 per household annually).

The Final Environmental Impact Statement for Integrated Local Water Supply Plan – Wichita, Kansas completed by Burns and McDonnell (2003) provided estimates of the number of water supply customers in 2000 and projections of the number of customers in 2050. These are used to estimate total payment capability over a 50 year project period to evaluate project affordability. There were an estimated 110,000 residential customers and 12,000 commercial customers for 2000. Projected service in the future was estimated to be 164,200 residential customers and 15,000 commercial customers by 2050. For the purposes of estimating the average cost per customer of the water supply project, residential and commercial customers were combined and the payment capability factors was applied to the total number of customers for these two sectors.

The construction cost for the proposed project is estimated to be about $236.52 million. The annual equivalent construction cost using the current water project planning rate of 4.875% over a 50 year period is about $12.71 million. The annual O&M costs for the project were estimated to be $5.82 million annually. Therefore, assuming all project costs (construction and O&M) were paid by project users, the annual project costs over the 50 year planning period would be $18.53 million. Using the base number of users the cost per customer would be $151.90 annually. Using the projected 2050 number of customers the cost per customer would be $103.50 annually. The average cost per customer over the entire 50 year period is $124.50 per customer, which is used to evaluate project affordability.

It is assumed that the current average amount paid for water would still need to be paid to cover current operating and replacement expenses. The average cost per customer for Wichita is estimated using the Kansas Municipal Water Use 2006 (Kansas Water Office, 2008) data. The current average water payment for Wichita is estimated to be about $342 per year. Therefore, total water supply costs with a water supply project are estimated to be about $467 annually. The estimated cost per household is much less than the estimated maximum payment capability of $990 for Wichita. This indicates that construction, operation, and maintenance costs can be paid by water users and meets affordability criterion.

Environmental Justice Analysis

The primary potential environmental justice issue associated with the water supply project is the effect of water payments on low income or minority households. In order to complete this analysis, income, race, and ethnic origin data were collected from the U.S. Bureau of the Census by Zip Code within the City of Wichita. The data are shown in table 11.

Table 11 – Selected zip code data for household income, race, and ethnicity in Wichita

Zip Code	Median HH Income	Black	American Indian	Hispanic
67037	$60,066	0.75%	0.53%	2.33%
67038	*$36,719	0.44%	*6.65%	1.92%
67050	$51,328	0.17%	0.28%	2.00%
67060	$48,463	0.45%	0.90%	2.49%
67101	$52,000	0.82%	0.66%	2.33%
67108	$46,464	0.70%	0.30%	0.30%
67202	*$17,384	*19.62%	0.85%	6.50%
67203	*$34,345	5.60%	*1.34%	*16.84%
67204	$41,181	3.13%	*1.26%	*21.93%
67205	$75,070	0.43%	*1.28%	3.01%
67206	$64,258	4.14%	0.55%	1.17%
67207	$43,251	*11.02%	0.89%	5.28%
67208	*$34,291	*29.80%	1.01%	3.77%
67209	$56,033	1.83%	0.79%	4.54%
67210	*$36,657	*10.86%	*1.47%	*18.46%
67211	*$29,794	7.96%	*1.52%	*12.51%
67212	$52,022	2.38%	0.88%	5.04%
67213	*$28,541	6.20%	*2.29%	*12.15%
67214	*$21,119	*54.98%	*1.32%	*17.85%
67215	$59,028	1.02%	1.07%	2.92%
67216	*$36,691	7.93%	*1.53%	8.02%
67217	*$39,874	4.72%	*1.45%	6.71%
67218	*$32,153	*10.25%	0.99%	*11.28%
67219	*$34,594	*30.43%	*1.38%	*9.29%
67220	$50,972	*25.92%	0.76%	3.52%
67226	$67,206	6.35%	0.11%	3.51%
67230	$93,593	2.76%	*1.61%	1.82%
67235	$80,472	1.58%	0%	4.90%
Area Average	**$43,459**	**10.12%**	**1.16%**	**8.78%**
All of Kansas	**$40,624**	**5.60%**	**0.92%**	**6.93%**

* Median household income for zip code less than for entire area or percentage of minority population for area code greater than for entire area.

Zip codes that have a median household income less than the median for the entire study area plus at least one additional category of minority population greater than the study area average include the following Zip Codes: 67038, 67202, 67203, 67208, 67210, 67211, 67213, 67214, 67216, 67217, 67218, 67219, and 67220. These zip codes have the potential to have environmental justice issues. Of particular concern are the area codes 67210, 67214, and 67219.

In order to evaluate potential environmental justice concerns in the Zip Codes identified as having the potential for problems, the average water cost per customer with and without the project were compared to median household in these zip codes. The resulting percentages can then be compared to thresholds established by other agencies and the threshold estimated as part of the payment capability analysis. The results of the water cost divided by household income calculations are shown in table 12. The threshold used for affordability is 2.5% of household income.

Table 12 – Water cost per consumer as a percentage of household income

Zip Code	Percentage of Household Income @ $342 per customer (current cost)	Percentage of Household Income @ $467 per customer (cost with project)
67038	0.93%	1.27%
67202	1.97%	2.69%
67203	1.00%	1.36%
67204	0.83%	1.13%
67205	0.46%	0.62%
67207	0.79%	1.08%
67208	1.00%	1.36%
67210	0.93%	1.27%
67211	1.15%	1.57%
67213	1.20%	1.64%
67214	1.62%	2.21%
67216	0.93%	1.27%
67217	0.86%	1.17%
67218	1.06%	1.45%
67219	0.99%	1.35%
67220	0.67%	0.92%
67230	0.37%	0.50%

The resulting calculations presented in table 12 indicate that under current conditions all of the Zip Codes of concern are within all threshold levels. However, with the additional cost of the Equus Beds project, Zip Code 67202 would not meet the 2.5% threshold criteria and 67214 would be fairly close to the threshold as well. However, an outside cost share of 26% or more would result in all Zip Codes being within the U.S. EPA threshold. Therefore, a 26% outside cost share would mitigate the potential environmental justice problems associated with the impact of increased water rates on low income households.

Other Possible Regional Impact Issues Associated with Municipal and Industrial Water Supplies

Municipal and industrial (M&I) water supplies can create regional economic impacts in several ways. As discussed in detail in the regional impact section above, expenditures for construction and continued operation, maintenance, and repair of M&I facilities can generate regional impacts. Changes in M&I water rates can have a significant impact on the composition of goods and services purchased by households and businesses, resulting in regional impacts. In addition, improvement in the availability of reliable and good quality water service associated with expanded water supplies may have an important impact on the number and types of businesses locating in a region. Expanding water supplies may lead to increased commercial activity and positive regional impacts due to increased certainty of available water in the future. However, in most cases the increase in commercial activity attributable to expanded water supplies is very difficult to estimate. The regional impacts associated with increased commercial activity are not estimated in this analysis.

Summary

The regional impact analysis of the Equus Beds Project indicates the without outside cost sharing, which is essentially the No Action Alternative, the project would actually result in negative regional economic impacts due to the change in household expenditures from typical household spending to spending for water construction and annual operation related costs. If outside cost sharing is equal to at least 50% of total project construction costs, then construction related regional impacts would be positive. Assuming operation, maintenance and repair costs will always be paid entirely by water users, regional impacts related to annual operation costs will be negative.

The payment capability analysis indicates that the water users are capable of payment project costs. However, the environmental justice analysis, which is basically an extension of the payment capability analysis, indicates that there could be environmental justice issues in one Zip Code area if there is no outside cost sharing. If there is outside construction cost sharing, the environmental justice concerns would be mitigated.

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Appendix C

EPA Environmental Justice Evaluation

MEMORANDUM

Subject: EJ Screen/Assessment Support for Wichita Equus Beds Groundwater Recharge Project Environmental Impact Statement

From: Debbie Bishop
Region 7 EJ Program

Thru: Althea Moses
Region 7 EJ Program Coordinator

To: Joe Cothern
Region 7 NEPA Coordinator

The Region 7 National Environmental Policy Act (NEPA) Program requested assistance from the Environmental Justice (EJ) Program to provide supporting documentation to the U.S. Bureau of Reclamation in the preparation of an Environmental Impact Statement (EIS) for the Wichita Equus Beds Groundwater Recharge Project. The EJ Program initiated the EJ screening process which includes information gathering, GIS analysis, and site-visit documentation. The information provided in the memo provides supporting documentation that details the EJ screening process and conclusions and/or recommendations.

Our Authority

EPA's authority to address EJ allegations falls under Presidential Executive Order 12898, which states that "To the greatest extent practicable and permitted by law, and consistent with the principles set forth in the report to the National Performance Review, each Federal Agency shall make achieving Environmental Justice part of its mission by identifying and addressing as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low income populations…"

Introduction

It is the goal of the Environmental Protection Agency (EPA) Region 7 EJ Program that principles of fair treatment and meaningful involvement are not only understood but acted upon. The purpose of this report is to provide information with regards to the environmental, social and economic characteristics of a community in an effort to ensure fair treatment and meaningful involvement of all people. Potential EJ areas of concern are determined on a census block group level based on three criteria: 1) facility concentration and compliance history; 2) 25% or greater minority population; and/or 3) 25% or greater low-income population. Areas are then assessed as to whether populations may be disproportionately impacted by negative and/or adverse effects.

The identification of potential EJ areas and concerns from this information is only the beginning step in a process to respond to and address potential EJ concerns. The information from this assessment is meant to assist staff and appropriate stakeholders to take caution and necessary measures to ensure fair treatment and meaningful involvement of populations that may be disproportionately impacted by a site or project. Please contact the EJ Program to discuss other opportunities or activities that may be conducted with the community to further enhance communications and ensure environmental justice.

Known Facility Data Summary

Zip codes 67135, 67056, 67147, and 67204 were identified as areas included within the recharge site areas. In order to determine the potential for disproportionate impacts within an area the EJ Program considers: facility density, number of facilities that have never been inspected, number of facilities with informal or formal enforcement actions and number of facilities that have been listed with two or more quarters of noncompliance. The information was obtained using EPA's Online Tracking Information System (OTIS) which provides enforcement and compliance information on all permitted facilities.

Zip Code	Total # of permitted facilities	# of facilities that have never been inspected	# of facilities with informal enforcement actions*	# of facilities with formal enforcement actions*	# of facilities with 2 or more quarters in non-compliance**
67135 (Sedgwick, KS)	23	13 (57%)	0	1	2
67056 (Halstead, KS)	31	15 (48%)	0	0	0
67147 (Valley Center, KS)	51	27 (53%)	2	1	1
67204 (NW Wichita, KS)	65	42 (65%)	4	2	1

Source: EPA OTIS database

Observation: According to the OTIS database, at least 50% of the permitted facilities within the zip codes of concern (67135, 67056, 67147, 67204) have never been inspected. The maps however, indicate only one facility located within a one-mile radius of the Halstead recharge site and no facilities within a one-mile radius of the Sedgwick recharge site.

Demographic Summary

The EJ Program looks at the demographics of the areas in relation to the surrounding potentially impacted sites. For this assessment, the EJ Program looked at demographics within one-mile, three-mile, five-mile and ten-mile radii to ensure that potentially impacted populations would be known. The information was obtained by using the U.S. Census Bureau data from 1990 and 2000. The NEPA Program and the Bureau of Reclamation were interested in learning about any historical demographic trends that may have occurred since the 1990 census data collection.

Sedgwick Recharge Site	Total # people	Population Density (persons per square mile)	Percent Minority	Percent Low-Income
One-mile	109	35	6%	5%
Three-mile	940	33	6%	5%
Five-mile	3,468	44	6%	5%
Ten-mile	21,824	70	6%	4%

Source: US Census Bureau / EPA Region GIS Sitemapper application

Halstead Recharge Site	Total # people	Population Density (persons per square mile)	Percent Minority	Percent Low-Income
One-mile	94	30	5%	5%
Three-mile	1,271	45	4%	5%
Five-mile	2,808	36	5%	6%
Ten-mile	8,808	28	8%	5%

Source: US Census Bureau / EPA Region GIS Sitemapper application

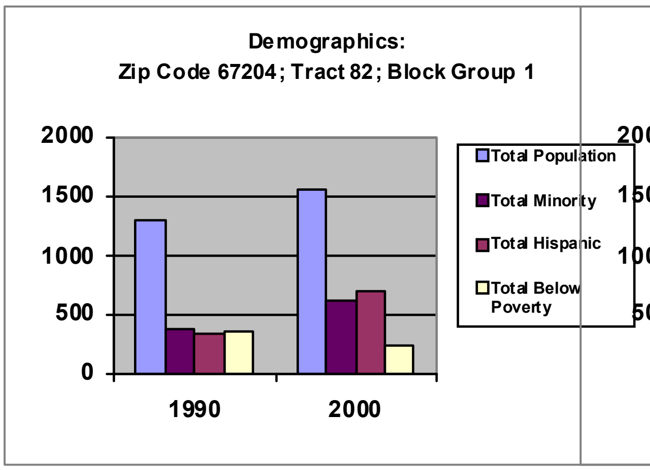
Observations:

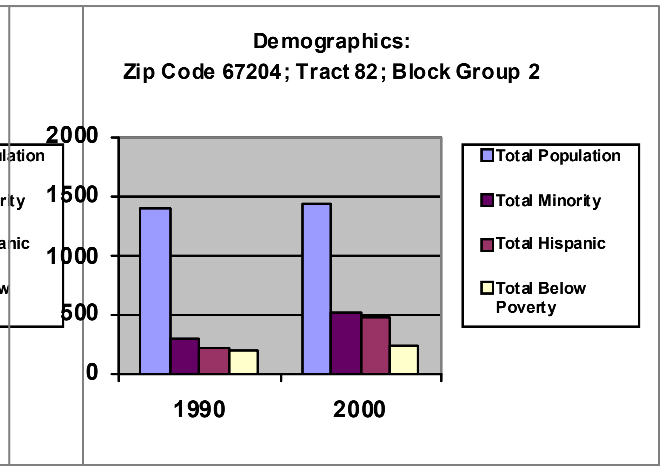
- According to the census data, there is low population density, low percent minority and low percent low-income populations within ten miles of the recharge sites. The project does not meet the region's indicator threshold for potential EJ concerns. There are however a few households and agricultural fields located within proximity of the treatment plant and recharge sites.

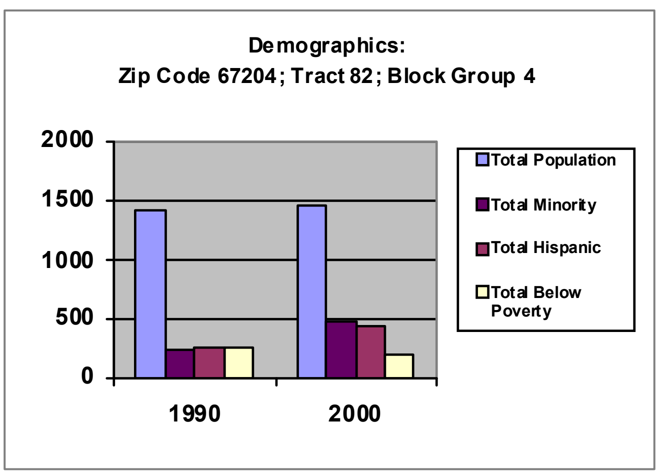
- During the site-visit with project leaders, the EJ Program asked questions with regards to any impacts such as noise, truck traffic, water depletion and whether or not the surrounding communities were informed. Project leaders noted that the surrounding immediate communities were informed about the project and had participated in public meetings. It was also noted that some surrounding farmers were worried about water resource use because most the agricultural fields were irrigated areas using surface and/or groundwater resources. Project leaders said they were committed to continue the dialogue with interested stakeholders and educate them on any impacts the project may have.

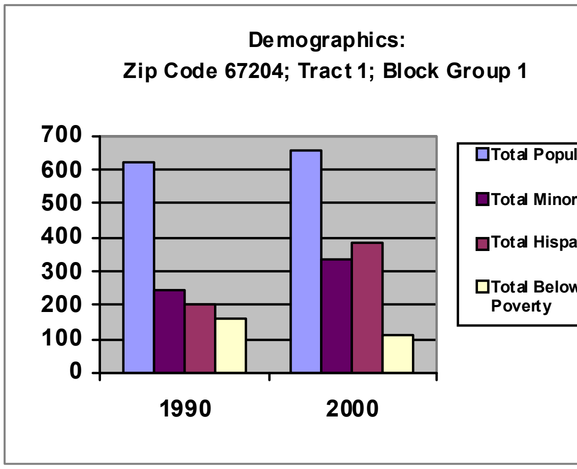
- Refer to maps for visual representation of data.

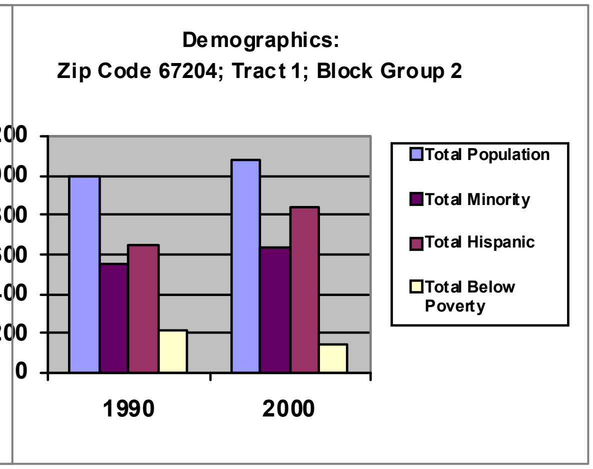
The EJ Program also looked at demographics in the NW section of Wichita, an area that was indicated to have been an area of significant growth in the past ten years. This area's growth was a concern with regards to the project and any impacts to surrounding populations that may be experienced.

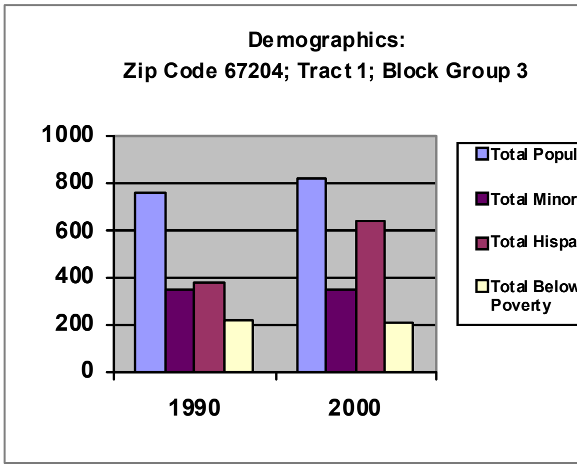


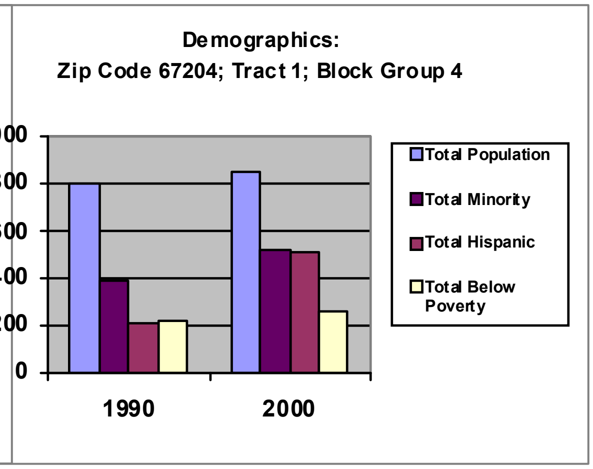












Source: US Census Bureau / EPA Region GIS Sitemapper application

Observations:

- There is a large Hispanic population along the Little Arkansas River in NW Wichita about 13.25 miles from the Sedgwick recharge site. (3,995 total Hispanics in the seven block groups closest to site, according to the 2000 Census) The EJ Program concentrated on zip code 67204 in NW Wichita, the closest residential population to the recharge site areas. The charts above depict demographic data for zip code 67204 for 1990 and 2000 at the census block group level, which provides the greatest detail for analysis.

- The average population growth from 1990 to 2000 for each of the seven block groups within zip code 67204 was less than 10%. The Hispanic population grew by an average of 91% in each block group and more than doubled in three of the seven block groups. Based on population growth trends from 1990 to 2000, there has most likely been very significant growth of the Hispanic community in NW Wichita from 2000 to 2008.

- If the project is going to draw significant amounts of water from the Little Arkansas River, it has the potential to affect all communities downstream of the site. After the site-visit conducted on August 18, 2008, project leaders from the city of Wichita stated that surface water from the Little Arkansas River would only be diverted when the river is above base stream flow. In which case, the Equus Beds Groundwater Recharge Project should have no detrimental impact on communities downstream that may access the river.

- Refer to map for visual representation of data.

Conclusions & Recommendations

Based on the EJ Screening analysis performed and the site-visit to the project area, it is the opinion of the EJ Program that the project will not have any disproportionate negative environmental burden on nearby communities.

As discussed in previous sections, the project leaders have made the necessary efforts to invite public participation and communicate with the public with regards to their planned activities. Residents nearest the recharge areas have the potential to be impacted by increased truck noise and/or traffic near the treatment plants. Any expected increases are probably minimal, based on the seasonality of the project.

The nearest densely populated area in NW Wichita has seen significant population growth with increased Hispanic residents. The main water resource for this project, the Little Arkansas River is not expected to be impacted, therefore not impacting any populations that may use it for recreational and/or subsistence fishing purposes.

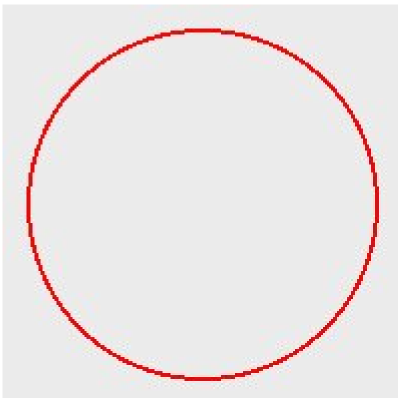
Project leaders should continue commitment to communicate the activities of the project with interested stakeholders and invite public participation and/or comment as a part of transparency and openness. A list of community resources is attached to assist the project leaders in enhancing outreach and/communication efforts.

Attachments:
1. Maps 1-9
2. Demographic Comparison Table for NW Wichita zip code 67204
3. Demographic Summary Reports surrounding recharge areas (Sedgwick & Halstead)
4. Site-Visit Summary Report
5. Community Resources

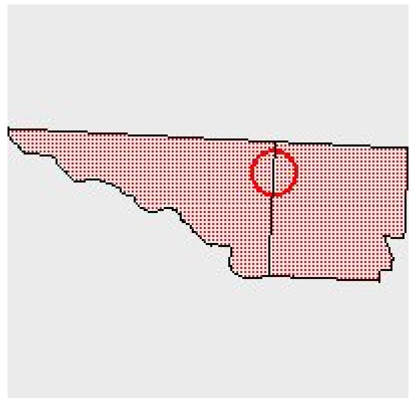
2000 Census Demographic Summary within 1 mile(s) of:
Geographic Point 37.8919562 -97.4817094
Sedgwick Recharge site; 1-mile radius

Report Created: Mon Oct 06 13:38:59 CDT 2008

The Radius for this Report



Intersects 2 Census Block Group(s)



DEMOGRAPHIC TOTALS

Demographic information recalculated to reflect the proportion of each block group that falls all or partway within the radius or polygon.

TOTAL RADIUS AREA = 3.14 sq. miles
TOTAL AREA OF DEMOGRAPHIC REPORTING UNITS = 3.13 sq. miles

TOTAL POPULATION = 109
POPULATION DENSITY = 35 persons per sq. mile (rounded)

TOTAL MINORITY = 6
PERCENT MINORITY = 6% (rounded)

One Race Persons = 107
White Persons = 104
Black Persons = 0
American Indian Persons = 1
Asian Persons = 0
Pacific Islander Persons = 0
Other Persons = 2
Multi-Race Persons = 2

Hispanic Persons = 3
White Hispanic Persons = 1

POVERTY STATUS INFORMATION

Total Households = 1
Total Persons of Poverty Status = 6
Percent Poverty Status = 5% (rounded)

TOTALS FOR SITES IN THE CURRENT RADIUS OF 1 MILE(S)

AFS - Major = 0

AFS - Minor = 0

RCRA TSD = 0

RCRA LQG = 0

Superfund NPL = 0

Superfund = 0

TRIS = 0

NPDES - Major = 0

NPDES - Minor = 0

PWS Wells = 0

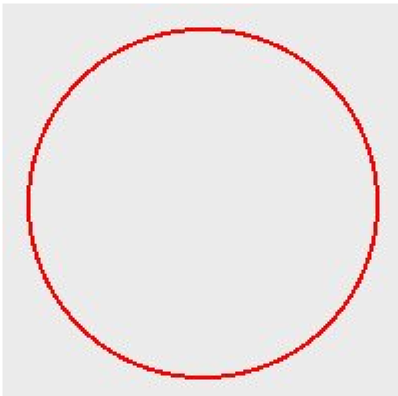
PWS Intakes = 0

TOTAL NUMBER OF SITES = 0

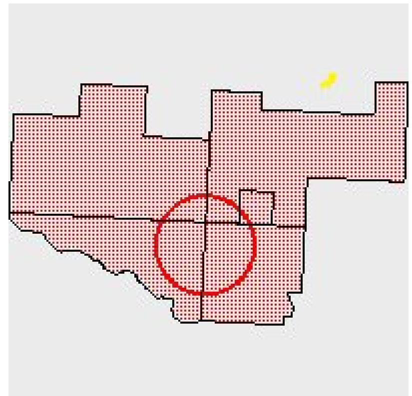
2000 Census Demographic Summary within 3 mile(s) of:
Geographic Point 37.8919562 -97.4817094
Sedgwick Recharge site; 3-mile radius

Report Created: Mon Oct 06 13:40:29 CDT 2008

The Radius for this Report



Intersects 5 Census Block Group(s)



DEMOGRAPHIC TOTALS

Demographic information recalculated to reflect the proportion of each block group that falls all or partway within the radius or polygon.

TOTAL RADIUS AREA = 28.27 sq. miles
TOTAL AREA OF DEMOGRAPHIC REPORTING UNITS = 28.16 sq. miles

TOTAL POPULATION = 940
POPULATION DENSITY = 33 persons per sq. mile (rounded)

TOTAL MINORITY = 54
PERCENT MINORITY = 6% (rounded)

One Race Persons = 924
White Persons = 895
Black Persons = 3
American Indian Persons = 11
Asian Persons = 1
Pacific Islander Persons = 0
Other Persons = 14
Multi-Race Persons = 15
Hispanic Persons = 27
White Hispanic Persons = 10

POVERTY STATUS INFORMATION

Total Households = 7
Total Persons of Poverty Status = 47
Percent Poverty Status = 5% (rounded)

TOTALS FOR SITES IN THE CURRENT RADIUS OF 3 MILE(S)

AFS - Major = 0

AFS - Minor = 0

RCRA TSD = 0

RCRA LQG = 0

Superfund NPL = 0

Superfund = 0

TRIS = 0

NPDES - Major = 0

NPDES - Minor = 0

PWS Wells = 0

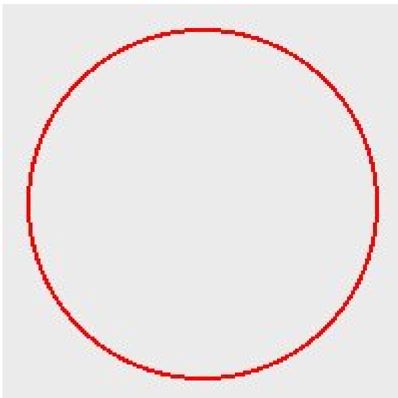
PWS Intakes = 0

TOTAL NUMBER OF SITES = 0

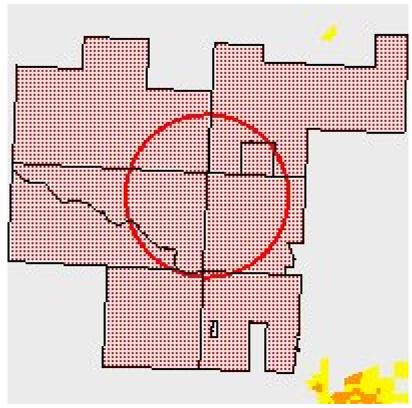
2000 Census Demographic Summary within 5 mile(s) of:
Geographic Point 37.8919562 -97.4817094
Sedgwick Recharge site; 5-mile radius

Report Created: Mon Oct 06 13:41:25 CDT 2008

The Radius for this Report



Intersects 8 Census Block Group(s)



DEMOGRAPHIC TOTALS

Demographic information recalculated to reflect the proportion of each block group that falls all or partway within the radius or polygon.

TOTAL RADIUS AREA = 78.54 sq. miles
TOTAL AREA OF DEMOGRAPHIC REPORTING UNITS = 78.25 sq. miles

TOTAL POPULATION = 3468
POPULATION DENSITY = 44 persons per sq. mile (rounded)

TOTAL MINORITY = 198
PERCENT MINORITY = 6% (rounded)

One Race Persons = 3415
White Persons = 3310
Black Persons = 8
American Indian Persons = 47
Asian Persons = 6
Pacific Islander Persons = 1
Other Persons = 43
Multi-Race Persons = 53
Hispanic Persons = 97
White Hispanic Persons = 40

POVERTY STATUS INFORMATION

Total Households = 49
Total Persons of Poverty Status = 159
Percent Poverty Status = 5% (rounded)

TOTALS FOR SITES IN THE CURRENT RADIUS OF 5 MILE(S)

AFS - Major = 1

AFS - Minor = 6

RCRA TSD = 0

RCRA LQG = 0

Superfund NPL = 0

Superfund = 0

TRIS = 1

NPDES - Major = 0

NPDES - Minor = 1

PWS Wells = 1

PWS Intakes = 0

TOTAL NUMBER OF SITES = 10

1 AFS - Major Site(s)

KS0057905
TEXACO TRADING & TRANSPORTATION INC
S1-T26S-R1W
WICHITA, KS 000000000

6 AFS - Minor Site(s)

KS0059611
MASSMAN CONSTRUCTION COMPANY
NO STREET ADDRESS
PORTABLE, KS 000000000

KS0989730
SKYLINE HOMES
920 W. SECOND
HALSTEAD, KS 67056

KS0057936
EQUILON PIPELINE COMPANY L.L.C.
1901 W. 77TH N.
VALLEY CENTER, KS 67147

KS0055782
DELANGE SEED HOUSE INCORPORATED J A
610 N. WASHINGTON
SEDGWICK, KS 67135

KS0055756
ANDALE FARMERS COOPERATIVE
EAST 4TH STREET AT NORTH JACKSON AVENUE
SEDGWICK, KS 67135

KS0059679
MASSMAN CONSTRUCTION COMPANY
NO STREET ADDRESS
PORTABLE, KS 000000000

1 TRIS Site(s)

67056SKYLN920WE
SKYLINE HOMES
920 W. SECOND
HALSTEAD, KS 67056

1 NPDES - Minor Site(s)

KS0081108
SEDGWICK CITY OF WWTP

SEDGWICK COUNTY,

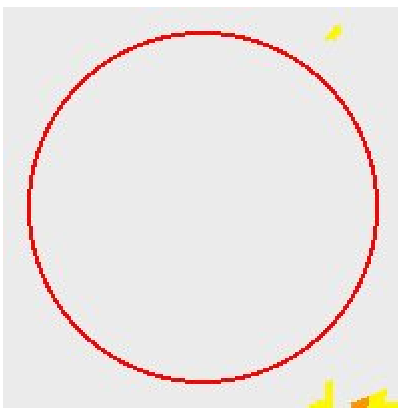
1 PWS Wells Site(s)

1537
KS2007904
67135 WL

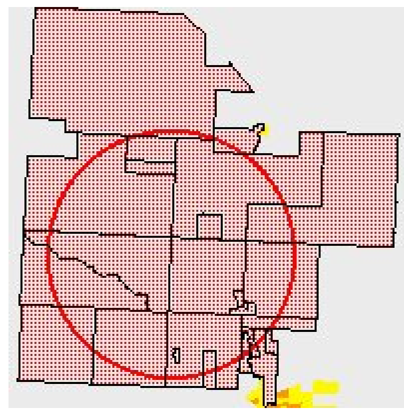
2000 Census Demographic Summary within 10 mile(s) of:
Geographic Point 37.8919562 -97.4817094
Sedgwick Recharge site; 10-mile radius

Report Created: Mon Oct 06 13:42:19 CDT 2008

The Radius for this Report



Intersects 25 Census Block Group(s)



DEMOGRAPHIC TOTALS
Demographic information recalculated to reflect the proportion of each block group that falls all or partway within the radius or polygon.

TOTAL RADIUS AREA = 314.16 sq. miles
TOTAL AREA OF DEMOGRAPHIC REPORTING UNITS = 313.71 sq. miles

TOTAL POPULATION = 21824
POPULATION DENSITY = 70 persons per sq. mile (rounded)

TOTAL MINORITY = 1232
PERCENT MINORITY = 6% (rounded)

One Race Persons = 21484
White Persons = 20864

Black Persons = 113
American Indian Persons = 183
Asian Persons = 89
Pacific Islander Persons = 4
Other Persons = 232
Multi-Race Persons = 339
Hispanic Persons = 558
White Hispanic Persons = 272

POVERTY STATUS INFORMATION

Total Households = 270
Total Persons of Poverty Status = 795
Percent Poverty Status = 4% (rounded)

TOTALS FOR SITES IN THE CURRENT RADIUS OF 10 MILE(S)

AFS - Major = 4

AFS - Minor = 27

RCRA TSD = 0

RCRA LQG = 3

Superfund NPL = 0

Superfund = 0

TRIS = 8

NPDES - Major = 0

NPDES - Minor = 0

PWS Wells = 12

PWS Intakes = 0

TOTAL NUMBER OF SITES = 54

4 AFS - Major Site(s)

KS0057995
COLEMAN COMPANY INCORPORATED BEACON FACILITY
5605 NORTH 119TH STREET WEST
MAIZE, KS 67101

KS0057905
TEXACO TRADING & TRANSPORTATION INC
S1-T26S-R1W
WICHITA, KS 000000000

KS0057699
WESTERN RESOURCES GORDON EVANS
6001 NORTH 151ST ST. WEST
COLWICH, KS 67201

KS0057958
JAYHAWK MERGED W 1730120
6358 NORTH MERIDIAN
VALLEY CENTER, KS 67204

27 AFS - Minor Site(s)

KS0055778
FARMERS COOPERATIVE GRAIN & MERC COMPANY
106 EAST NORTH STREET
HALSTEAD, KS 670560000

KS0059611
MASSMAN CONSTRUCTION COMPANY
NO STREET ADDRESS
PORTABLE, KS 000000000

KS0990549
ALL PETS CREMATORY
5500 NORTH WEST STREET
WICHITA, KS 67204

KS0057972
CENTER TERMINAL COMPANY WICHITA
7452 NORTH MERIDIAN STREET
VALLEY CENTER, KS 67147

KS0989730
SKYLINE HOMES
920 W. SECOND
HALSTEAD, KS 67056

KS0057809
HIGH PLAINS CORPORATION
523 EAST UNION AVENUE
COLWICH, KS 67030

KS0057936
EQUILON PIPELINE COMPANY L.L.C.
1901 W. 77TH N.
VALLEY CENTER, KS 67147

KS0990566
EPCO CARBON DIOXIDE PRODUCTS INCORPORATED
521 EAST UNION AVENUE
COLWICH, KS 00000

KS0055762
FARMERS COOP ELEVATOR CO
302 W 1ST
HALSTEAD, KS 67056

KS0057934
DOLESE BROS CO
5620 N 119TH W
MAIZE, KS 000000000

KS0057748
BERT & WETTA SALES INCORPORATED
5551 NORTH 119TH STREET WEST
MAIZE, KS 67101

KS0055782
DELANGE SEED HOUSE INCORPORATED J A
610 N. WASHINGTON
SEDGWICK, KS 67135

KS0780962
BARTON SOLVENTS INCORPORATED WICHITA BRANCH
201 S. CEDAR
VALLEY CENTER, KS 67147

KS0057980
LONE STAR INDUSTRIES INCORPORATED
330 E. KECHI RD
KECHI, KS 67067

KS0057983
ONEOK FIELD SERVICES COMPANY
15701 WEST 61ST STREET NORTH
COLWICH, KS 00000

KS0057788
ANDALE FARMERS COOPERATIVE
143 NORTH COLORADO STREET
COLWICH, KS 67030

KS1005947
A & C ENTERPRISES
225 W. 1ST
HALSTEAD, KS 67056

KS0057880
DELANGE SEED
206 E. ALBERT
MAIZE, KS 67101

KS0055756
ANDALE FARMERS COOPERATIVE
EAST 4TH STREET AT NORTH JACKSON AVENUE
SEDGWICK, KS 67135

KS0057935
JAYHAWK PIPELINE L.L.C.
6559 N. MERIDIAN
VALLLEY CENTER, KS 000000000

KS0965730
LEGG COMPANY INCORPORATED
325 E. 10TH STREET
HALSTEAD, KS 67056

KS0059679
MASSMAN CONSTRUCTION COMPANY
NO STREET ADDRESS
PORTABLE, KS 000000000

KS0055791
IDAHO TIMBER CORPORATION
515 INDUSTRIAL PARK
HALSTEAD, KS 67056

KS0055777
FARMERS COOPERATIVE GRAIN & MERCANTILE COMPANY
222 EAST FIRST
HALSTEAD, KS 670560000

KS1005946
WOOTEN ENTERPRISES
321 E. 1ST
HALSTEAD, KS 67056

KS1005171
HAYES COMPANY INC.
7700 HAYES DRIVE
VALLEY CENTER, KS 67147

KS0057868
ANDALE FARMERS COOPERATIVE COMPANY
101 SOUTH ASH
VALLEY CENTER, KS 67147

3 RCRA LQG Site(s)

KSD096537857
BARTON SOLVENTS INCORPORATED WICHITA BRANCH
201 S. CEDAR
VALLEY CENTER, KS 67147

KSD980971428
RITCHIE PAVING
2424 NORTH SHORE BOULEVARD
WICHITA, KS 67205

KSD984990903
NATIONAL PLASTICS COLOR INCORPORATED
2600 W. 77TH ST. N.
VALLEY CENTER, KS 671470127

8 TRIS Site(s)

67030GRDNV6001N
WESTERN RESOURCES GORDON EVANS
6001 NORTH 151ST ST. WEST
COLWICH, KS 67030

67205CRLSN4601N
CARLSON PRODUCTS
4601 NORTH TYLER ROAD
WICHITA, KS 67101

67147NTNLP2600W
NATIONAL PLASTICS COLOR INCORPORATED
2600 W. 77TH ST. N.
VALLEY CENTER, KS 67147

67101CLMNT5605N
COLEMAN COMPANY INCORPORATED BEACON FACILITY
5605 NORTH 119TH STREET WEST
MAIZE, KS 67101

67147HYSCN7700H
HAYES COMPANY INC.
7700 HAYES DRIVE
VALLEY CENTER, KS 671470430

67030HGHPL412NF
HIGH PLAINS CORPORATION
523 EAST UNION AVENUE
COLWICH, KS 67030

67147BRTNS201SC
BARTON SOLVENTS INCORPORATED WICHITA BRANCH
201 S. CEDAR
VALLEY CENTER, KS 67147

67056SKYLN920WE
SKYLINE HOMES
920 W. SECOND
HALSTEAD, KS 67056

12 PWS Wells Site(s)

60
KS2017333
67030 WL

18070
KS2007905
671140426 WL

74
KS2017330
67211 WL

350
KS2117308
67001 WL

1873
KS2007901
67056 WL

900
KS2117303
67101 WL

4883
KS2017318
67147 WL

870
KS2117304
67101 WL

1537
KS2007904
67135 WL

900
KS2117303
67101 WL

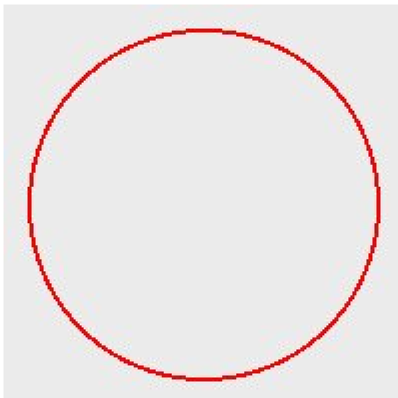
5814
KS2017303
672192499 WL

329249
KS2017308
672021679 WL

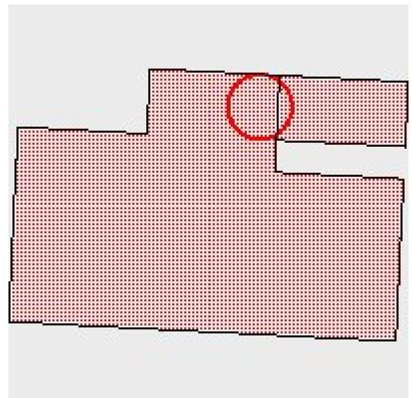
2000 Census Demographic Summary within 1 mile(s) of:
Geographic Point 38.014178 -97.5655979
Halstead Recharge site, 1-mile radius

Report Created: Mon Oct 06 13:33:05 CDT 2008

The Radius for this Report



Intersects 2 Census Block Group(s)



DEMOGRAPHIC TOTALS

Demographic information recalculated to reflect the proportion of each block group that falls all or partway within the radius or polygon.

TOTAL RADIUS AREA = 3.14 sq. miles
TOTAL AREA OF DEMOGRAPHIC REPORTING UNITS = 3.13 sq. miles

TOTAL POPULATION = 94
POPULATION DENSITY = 30 persons per sq. mile (rounded)

TOTAL MINORITY = 4
PERCENT MINORITY = 5% (rounded)

One Race Persons = 93
White Persons = 91
Black Persons = 0
American Indian Persons = 1
Asian Persons = 0
Pacific Islander Persons = 0
Other Persons = 1
Multi-Race Persons = 1
Hispanic Persons = 2
White Hispanic Persons = 1

POVERTY STATUS INFORMATION

Total Households = 2
Total Persons of Poverty Status = 5
Percent Poverty Status = 5% (rounded)

TOTALS FOR SITES IN THE CURRENT RADIUS OF 1 MILE(S)

AFS - Major = 1

AFS - Minor = 0

RCRA TSD = 0

RCRA LQG = 0

Superfund NPL = 0

Superfund = 0

TRIS = 0

NPDES - Major = 0

NPDES - Minor = 0

PWS Wells = 0

PWS Intakes = 0

TOTAL NUMBER OF SITES = 1

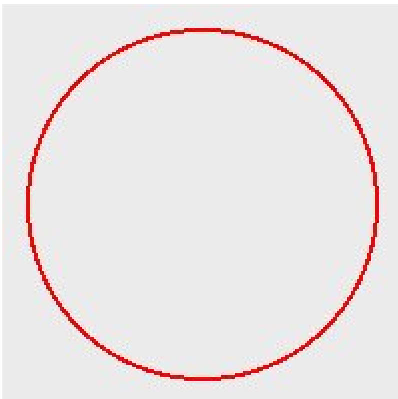
1 AFS - Major Site(s)

KS0055755
KINDER MORGAN OPERATING LP
HALSTEAD PUMP STA.
HALSTEAD, KS 67056

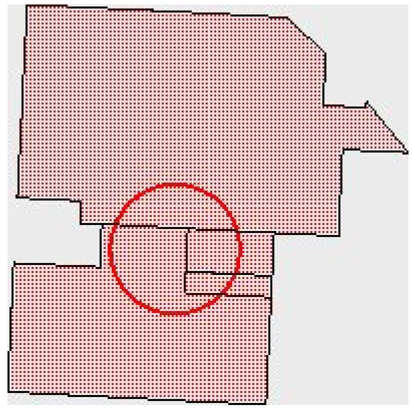
2000 Census Demographic Summary within 3 mile(s) of:
Geographic Point 38.014178 -97.5655979
Halstead Recharge site, 3-mile radius

Report Created: Mon Oct 06 13:34:21 CDT 2008

The Radius for this Report



Intersects 4 Census Block Group(s)



DEMOGRAPHIC TOTALS
Demographic information recalculated to reflect the proportion of each block group that falls all or partway within the radius or polygon.

TOTAL RADIUS AREA = 28.27 sq. miles
TOTAL AREA OF DEMOGRAPHIC REPORTING UNITS = 28.16 sq. miles

TOTAL POPULATION = 1271
POPULATION DENSITY = 45 persons per sq. mile (rounded)

TOTAL MINORITY = 55
PERCENT MINORITY = 4% (rounded)

One Race Persons = 1253
White Persons = 1231
Black Persons = 3
American Indian Persons = 6
Asian Persons = 5
Pacific Islander Persons = 0
Other Persons = 9
Multi-Race Persons = 18
Hispanic Persons = 27
White Hispanic Persons = 15

POVERTY STATUS INFORMATION

Total Households = 32
Total Persons of Poverty Status = 67
Percent Poverty Status = 5% (rounded)

TOTALS FOR SITES IN THE CURRENT RADIUS OF 3 MILE(S)

AFS - Major = 1

AFS - Minor = 1

RCRA TSD = 0

RCRA LQG = 0

Superfund NPL = 0

Superfund = 0

TRIS = 0

NPDES - Major = 0

NPDES - Minor = 0

PWS Wells = 0

PWS Intakes = 0

TOTAL NUMBER OF SITES = 2

1 AFS - Major Site(s)

KS0055755
KINDER MORGAN OPERATING LP
HALSTEAD PUMP STA.
HALSTEAD, KS 67056

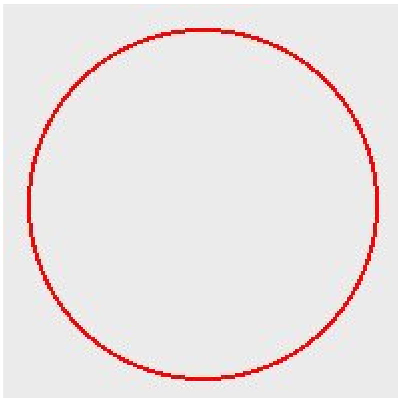
1 AFS - Minor Site(s)

KS0055791
IDAHO TIMBER CORPORATION
515 INDUSTRIAL PARK
HALSTEAD, KS 67056

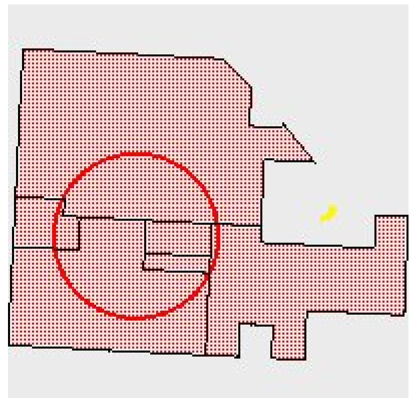
2000 Census Demographic Summary within 5 mile(s) of:
Geographic Point 38.014178 -97.5655979
Halstead Recharge site; 5-mile radius

Report Created: Mon Oct 06 13:35:18 CDT 2008

The Radius for this Report



Intersects 6 Census Block Group(s)



DEMGRAPHIC TOTALS

Demographic information recalculated to reflect the proportion of each block group that falls all or partway within the radius or polygon.

TOTAL RADIUS AREA = 78.54 sq. miles
TOTAL AREA OF DEMOGRAPHIC REPORTING UNITS = 78.23 sq. miles

TOTAL POPULATION = 2808
POPULATION DENSITY = 36 persons per sq. mile (rounded)

TOTAL MINORITY = 132
PERCENT MINORITY = 5% (rounded)

One Race Persons = 2766
White Persons = 2711
Black Persons = 9
American Indian Persons = 12
Asian Persons = 9
Pacific Islander Persons = 0
Other Persons = 25
Multi-Race Persons = 42
Hispanic Persons = 66
White Hispanic Persons = 34

POVERTY STATUS INFORMATION

Total Households = 63
Total Persons of Poverty Status = 157
Percent Poverty Status = 6% (rounded)

TOTALS FOR SITES IN THE CURRENT RADIUS OF 5 MILE(S)

AFS - Major = 1

AFS - Minor = 9

RCRA TSD = 0

RCRA LQG = 0

Superfund NPL = 0

Superfund = 0

TRIS = 0

NPDES - Major = 0

NPDES - Minor = 0

PWS Wells = 2

PWS Intakes = 0

TOTAL NUMBER OF SITES = 12

1 AFS - Major Site(s)

KS0055755
KINDER MORGAN OPERATING LP
HALSTEAD PUMP STA.
HALSTEAD, KS 67056

9 AFS - Minor Site(s)

KS0055778
FARMERS COOPERATIVE GRAIN & MERC COMPANY
106 EAST NORTH STREET
HALSTEAD, KS 670560000

KS0055762
FARMERS COOP ELEVATOR CO
302 W 1ST
HALSTEAD, KS 67056

KS0055784
TEXACO TRADING & TRANSPORTATION INCORPORATED
S34-T23S-R3W
BURRTON, KS 000000000

KS1005947
A & C ENTERPRISES
225 W. 1ST
HALSTEAD, KS 67056

KS0965730
LEGG COMPANY INCORPORATED
325 E. 10TH STREET
HALSTEAD, KS 67056

KS0055791
IDAHO TIMBER CORPORATION
515 INDUSTRIAL PARK
HALSTEAD, KS 67056

KS0055777
FARMERS COOPERATIVE GRAIN & MERCANTILE COMPANY
222 EAST FIRST
HALSTEAD, KS 670560000

KS1005946
WOOTEN ENTERPRISES
321 E. 1ST
HALSTEAD, KS 67056

KS0055769
PEOPLES NATURAL GAS
S21-T23S-R3W
BURRTON, KS 67020

2 PWS Wells Site(s)

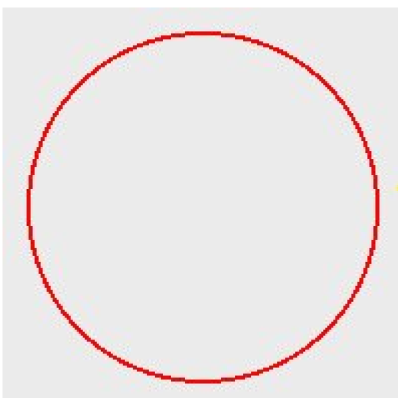
1873
KS2007901
67056 WL

329249
KS2017308
672021679 WL

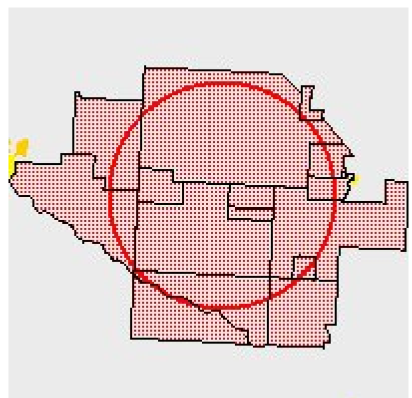
2000 Census Demographic Summary within 10 mile(s) of:
Geographic Point 38.014178 -97.5655979
Halstead Recharge site; 10-mile radius

Report Created: Mon Oct 06 13:36:16 CDT 2008

The Radius for this Report



Intersects 15 Census Block Group(s)



DEMGRAPHIC TOTALS

Demographic information recalculated to reflect the proportion of each block group that falls all or partway within the radius or polygon.

TOTAL RADIUS AREA = 314.16 sq. miles
TOTAL AREA OF DEMOGRAPHIC REPORTING UNITS = 312.85 sq. miles

TOTAL POPULATION = 8808
POPULATION DENSITY = 28 persons per sq. mile (rounded)

TOTAL MINORITY = 662
PERCENT MINORITY = 8% (rounded)

One Race Persons = 8653
White Persons = 8303
Black Persons = 58
American Indian Persons = 52
Asian Persons = 24
Pacific Islander Persons = 0
Other Persons = 217
Multi-Race Persons = 155
Hispanic Persons = 421
White Hispanic Persons = 157

POVERTY STATUS INFORMATION

Total Households = 135
Total Persons of Poverty Status = 453
Percent Poverty Status = 5% (rounded)

TOTALS FOR SITES IN THE CURRENT RADIUS OF 10 MILE(S)

AFS - Major = 2

AFS - Minor = 13

RCRA TSD = 0

RCRA LQG = 0

Superfund NPL = 0

Superfund = 0

TRIS = 1

NPDES - Major = 0

NPDES - Minor = 0

PWS Wells = 6

PWS Intakes = 0

TOTAL NUMBER OF SITES = 22

2 AFS - Major Site(s)

KS0055749
SOUTHERN STAR CENTRAL GAS PIPELINE INCORPORATED
7616 WEST DUTCH AVENUE
HESSTON, KS 67062

KS0055755
KINDER MORGAN OPERATING LP
HALSTEAD PUMP STA.
HALSTEAD, KS 67056

13 AFS - Minor Site(s)

KS0055778
FARMERS COOPERATIVE GRAIN & MERC COMPANY
106 EAST NORTH STREET
HALSTEAD, KS 670560000

KS0989730
SKYLINE HOMES
920 W. SECOND
HALSTEAD, KS 67056

KS0055762
FARMERS COOP ELEVATOR CO
302 W 1ST
HALSTEAD, KS 67056

KS0055758
YODER ELEVATOR INC (BURRTON BRANCH)
WEST EDGE OF TOWN
BURRTON, KS 000000000

KS0055784
TEXACO TRADING & TRANSPORTATION INCORPORATED
S34-T23S-R3W
BURRTON, KS 000000000

KS1005947
A & C ENTERPRISES
225 W. 1ST
HALSTEAD, KS 67056

KS0055768
PATTERSON-FARMERS CO-OP ELEVATOR CO.
RURAL
PATTERSON, KS 000000000

KS0965730
LEGG COMPANY INCORPORATED
325 E. 10TH STREET
HALSTEAD, KS 67056

KS0055791
IDAHO TIMBER CORPORATION
515 INDUSTRIAL PARK
HALSTEAD, KS 67056

KS0055777
FARMERS COOPERATIVE GRAIN & MERCANTILE COMPANY
222 EAST FIRST
HALSTEAD, KS 670560000

KS1005946
WOOTEN ENTERPRISES
321 E. 1ST
HALSTEAD, KS 67056

KS0975067
GOERING ENTERPRISES INCORPORATED
5304 W 1ST STREET
NEWTON, KS 671148621

KS0055769
PEOPLES NATURAL GAS
S21-T23S-R3W
BURRTON, KS 67020

1 TRIS Site(s)

67056SKYLN920WE
SKYLINE HOMES
920 W. SECOND
HALSTEAD, KS 67056

6 PWS Wells Site(s)

18070
KS2007905
671140426 WL

1873
KS2007901
67056 WL

932
KS2007903
670200200 WL

932
KS2007903
670200200 WL

3509
KS2007902
67062 WL

329249
KS2017308
672021679 WL

Equus Beds Aquifer Recharge Project Site Visit
SUMMARY REPORT

Location: Equus Beds Well Field, Southern Harvey County, near U.S. Hwy 50, West of Newton, KS

Date: Monday, August 18, 2008

Staff: Debbie Bishop, ECO/EJ, x7529; Joe Cothern, ENSV/NEPA, x7148; Ron Hammerschmidt, ENSV Director, x7566; Krista Kasper, ECO/EJ, x7212; Althea Moses, ECO/EJ, x7649; Amber Tucker, ENSV/NEPA, x7565

SUMMARY:

On Monday, August 18, 2008, staff and interns from EPA Region 7's EJ and NEPA teams met with Richard Robinson, city of Wichita, and Charles F. Webster, Bureau of Reclamation. Mr. Robinson provided us with a tour of the Equus Beds Aquifer Recharge Project Site, including the Phase 1 water treatment facility, a recharge basin, and a municipal well. The purpose of this visit was to get visual confirmation of the project site, as well as to learn more about the aquifer recharge process in order to determine if the project could have any negative effects on the EJ communities in Northwest Wichita. The information gathered will be included in the EJ screen report for the project, which was conducted on a request by the NEPA program in support of the Bureau of Reclamation's Environmental Impact Statement.

Richard Robinson explains the aquifer recharge process


Water quality testing equipment


Tank used to remove solids from the water

Leftover mud that was extracted from the river water- local farmers use it as topsoil

Injection Well

Recharge Basin

Appendix D

Kansas State Historical Society Consultation Letter

(51)

KANSAS

KSR&C No. 08-03-206

Kansas State Historical Society
Jennie Chinn, *Executive Director*

KATHLEEN SEBELIUS, GOVERNOR

March 20, 2008

Charles F. Webster
Environmental Protection Specialist
Oklahoma-Texas Area Office
Bureau of Reclamation
5924 NW 2nd St., Ste 200
Oklahoma City, OK 73127-6514

Dear Mr. Webster:

In accordance with 36 CFR 800, the Kansas State Historic Preservation Office has reviewed your agency's notice that the Environmental Impact Statement Scoping Document for the Equus Beds Aquifer Recharge and Recovery Project is available for inspection. According to our records, an earlier version of this project was reviewed and cleared in 2003. We assume that any additional ground disturbing activities beyond those already cleared will be submitted for review.

This information is provided at your request to assist you in identifying historic properties, as specified in 36 CFR 800 for Section 106 consultation procedures. If you have questions or need additional information regarding these comments, please contact Tim Weston at (785) 272-8681 (ext. 214).

Sincerely,

Jennie Chinn
State Historic Preservation Officer

Timothy Weston for

Patrick Zollner
Deputy State Historic Preservation Officer

6425 SW Sixth Avenue • Topeka, KS 66615-1099
Phone 785-272-8681 Ext. 205 • Fax 785-272-8682 • Email jchinn@kshs.org • TTY 785-272-8683
www.kshs.org

Appendix E

Biological Evaluation – Consultation with USFWS

RECLAMATION

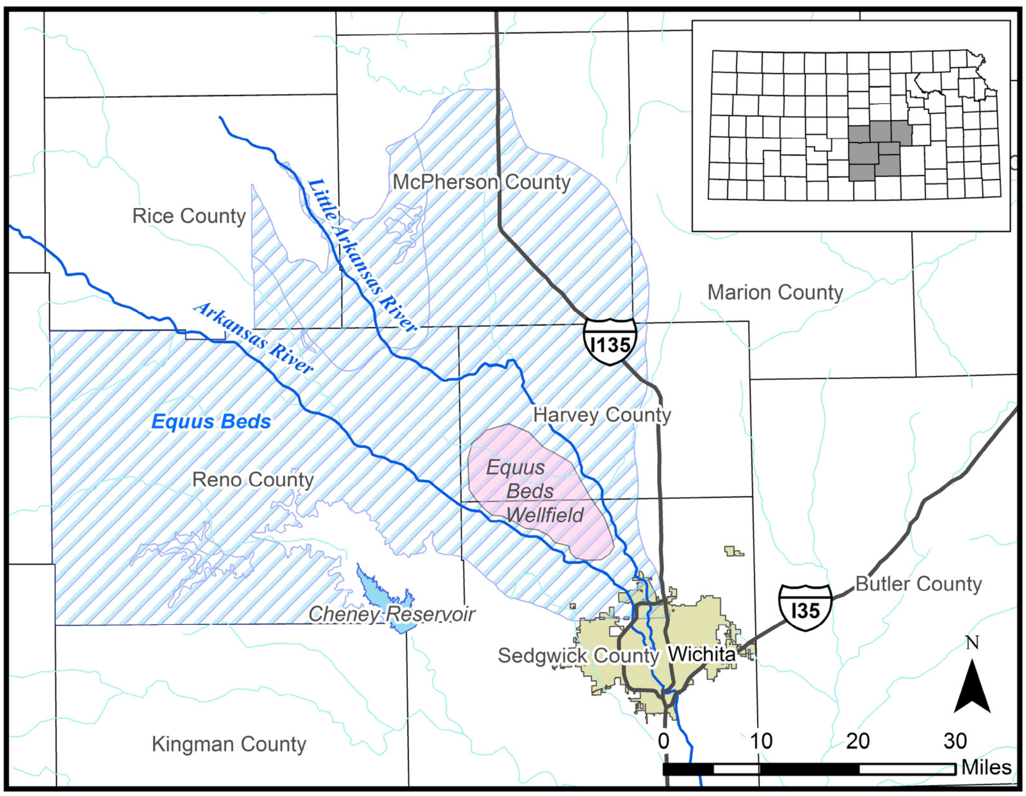
Managing Water in the West

BIOLOGICAL ASSESSMENT OF FEDERALLY LISTED SPECIES

Equus Beds Aquifer Recharge, Storage, and Recovery Project

Equus Beds Division, Wichita Project, Kansas

Great Plains Region



U.S. Department of the Interior
Bureau of Reclamation

April 2009

Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

Biological Assessment of Federally Listed Species

Equus Beds Aquifer Recharge, Storage, and Recovery Project

Equus Beds Division, Wichita Project, Kansas

Great Plains Region

Contents

BACKGROUND

The Bureau of Reclamation is authorized under Public Law 109-299 to assist the City of Wichita, Kansas (City) in funding and implementation of the Equus Beds Aquifer Recharge, Storage, and Recovery component (ASR Project) of the City's Integrated Local Water Supply Plan (ILWSP). Reclamation's funding of the ASR Project constitutes a federal action, and thus triggers consultation with the U.S. Fish and Wildlife Service (FWS) for potential impacts to threatened or endangered species. Reclamation is submitting this Biological Assessment (BA) to the FWS to satisfy an informal consultation requirement under the Endangered Species Act Regulations for a may affect, not likely to adversely affect determination on impacts to three federally listed species.

PROJECT DESCRIPTION

The City of Wichita (City) developed the ILWSP to identify several water management strategies aimed at alleviating a projected water deficit in 2050. When the ILWSP is fully implemented, it will include the following components:

- The ASR Project, which will transfer water from the Little Arkansas River into the Equus Beds aquifer (detailed in the next section)
- Expanded use of water from Cheney Reservoir
- Redevelopment of the abandoned Bentley Reserve Field along the Arkansas River (diluting the saline water with fresh water)
- Expansion of the Local Well Field along the Little Arkansas River
- Construction of a new water treatment plant
- Construction of more water pipelines and overhead power lines, and
- Implementation of additional water conservation measures.

The locations of the ASR Project, Bentley Reserve Field, and Local Well Field are detailed in Figure 1.

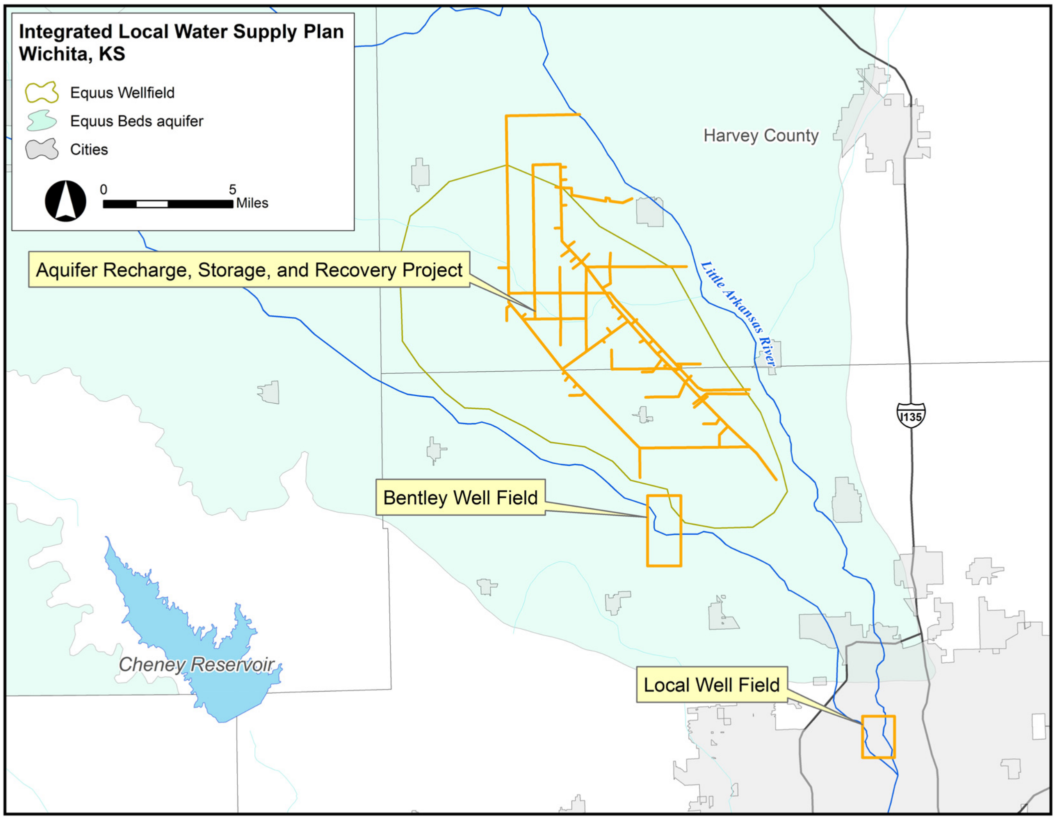


Figure 1. Project Area of the ILWSP

The ASR Project

Construction Activities

Construction activities of the ASR Project would occur in Sedgwick and Harvey counties in south-central Kansas (Figure 2). The ASR Project is being developed in four phases:

Phase 1

Phase 1 was completed prior to Reclamation participation in the project, is ineligible for federal reimbursement, and is considered part of the environmental baseline. This phase included a seven million gallons per day (MGD) surface water treatment plant, three induced infiltration wells, a seven MGD river diversion structure, four recharge wells, two recharge basins, and 14 miles of overhead power lines with a computerized Supervisory Control and Data Acquisition (SCADA) system. The City also installed 35 monitoring wells, seven of which were installed near induced infiltration wells along the banks of the Little Arkansas; 28 of which were installed near recharge sites.

Phase 2

Phase 2 of the ASR Project consists of two portions: Phase 2a includes the construction of 14 additional induced infiltration wells, connecting pipeline, a water treatment plant, associated overhead power lines, and a SCADA system. Phase 2a is not a part of the proposed Federal action, and will be completed by the City independently of Federal funding as a stand alone project.

Phase 2b of the ASR Project includes the installation of pipeline, overhead power lines, and a substation. Approximately 31 miles of pipeline would connect 15 recharge wells, and would include a SCADA system for data gathering.

Phase 3

Phase 3 of the ASR Project includes the construction of 21 additional induced infiltration wells and 14 recharge wells, along with additional transmission piping, and 12 miles of fiber optic cable to expand the SCADA system.

Phase 4

Phase 4 of the ASR Project includes the installation of 11 recharge basins, 10 miles of pipeline, 29 miles of fiber optic cable to expand the SCADA system, and an additional pre-treatment plant.

Additional recovery wells may be installed as needed through 2050 to meet the City's growing water demands, but withdrawals would be within the 100 MGD described in the operational activities section on page 5. Construction of additional wells would begin around 2020 and continue each decade through 2050.

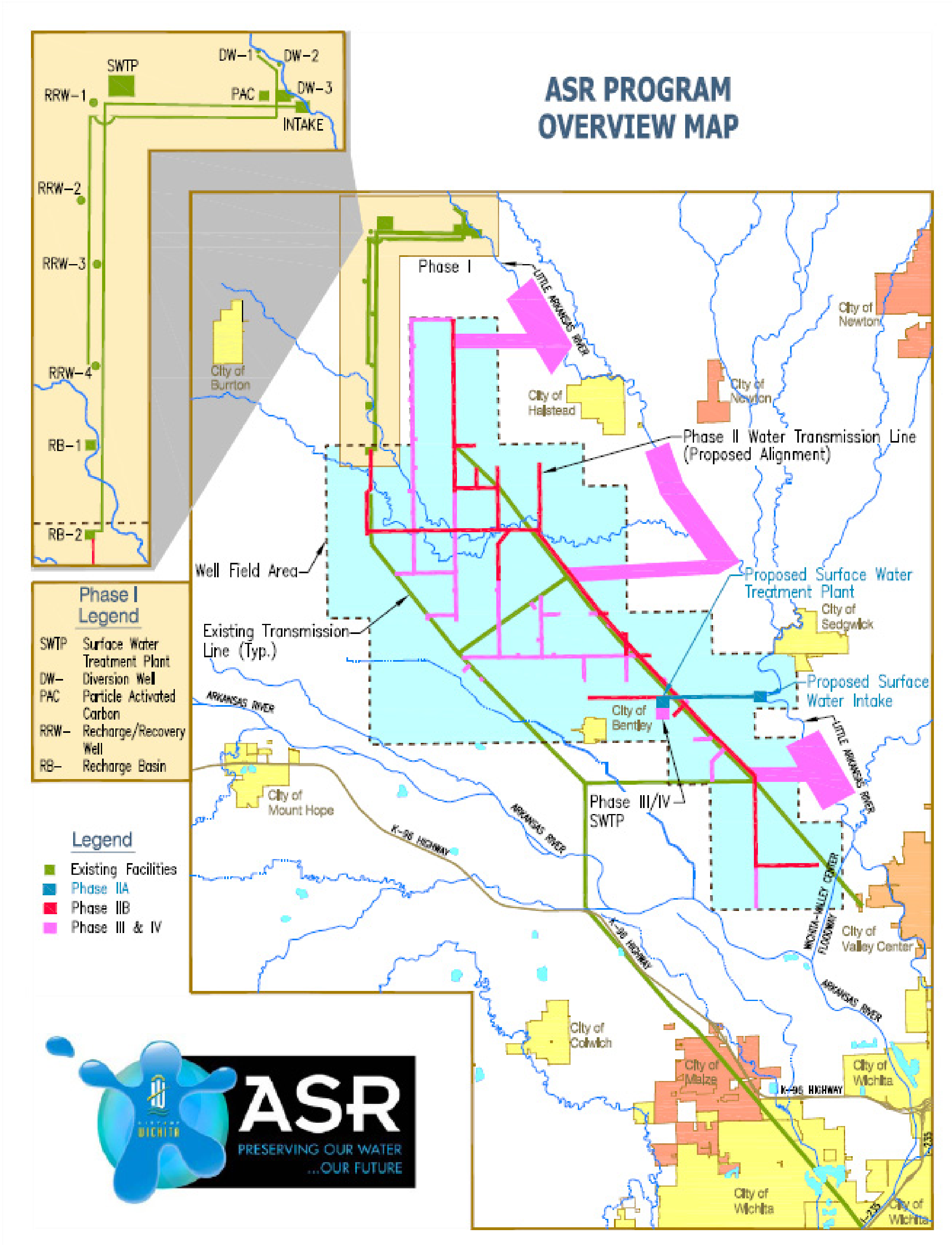


Figure 2. Overview of Phases 1 through 4 of the ASR

Operational Activities

Operational impacts of the ASR Project would occur in the Little Arkansas River in Harvey and Sedgwick counties (Figure 3). The presence of the LWF on the Little Arkansas River downstream of the ASR Project would make operational impacts below the LWF cumulative, and cumulative impacts are discussed later in this report.

Once complete, the ASR Project would remove 100 MGD of water from the Little Arkansas River and inject this water into the Equus Beds Aquifer. Of the 100 MGD, 40 MGD would be removed using bank storage wells, while 60 MGD would diverted directly from the river during "above base flow" conditions, when river flow exceeds 40 cubic feet per second (cfs).

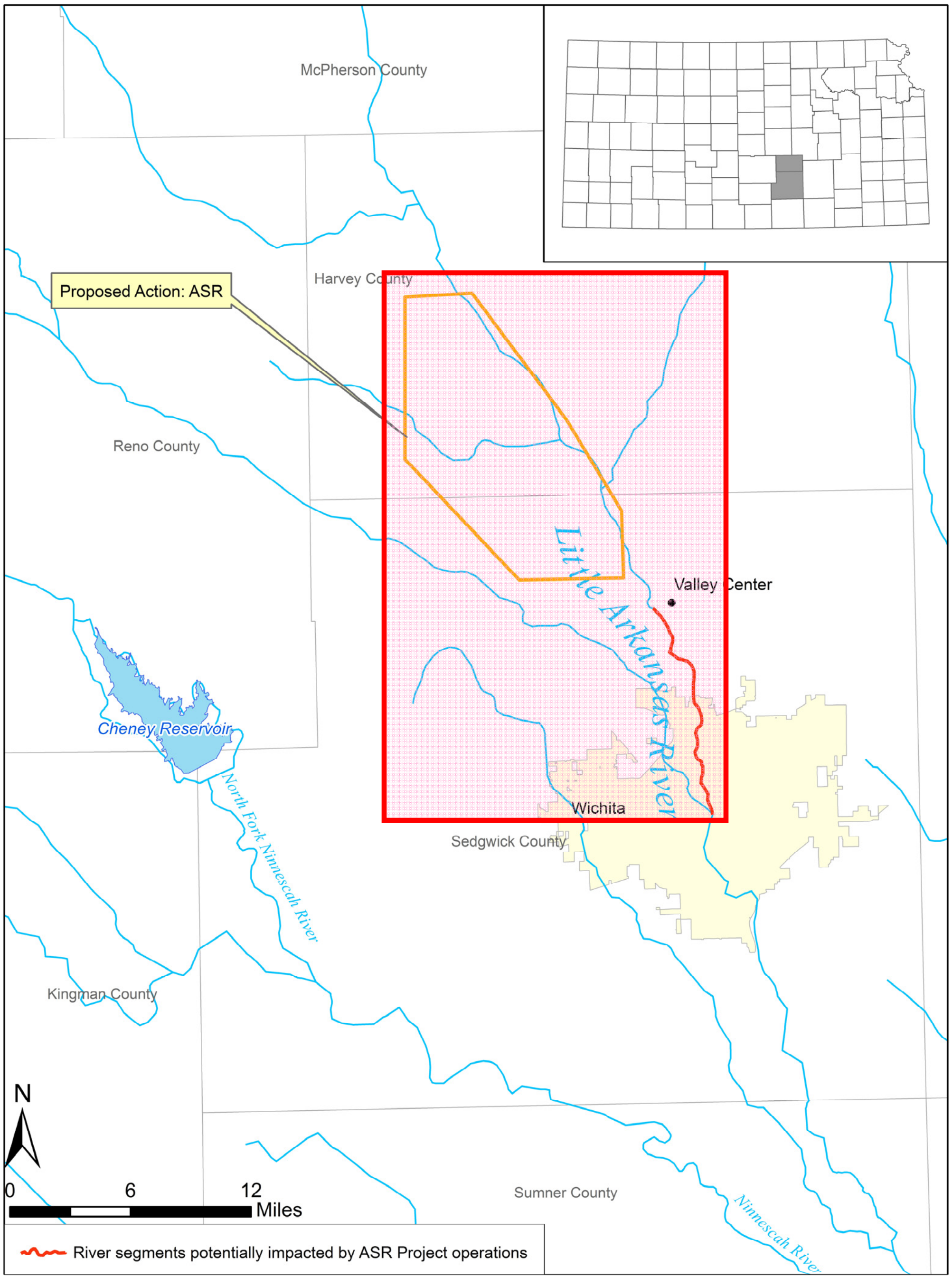


Figure 3. Equus Beds ASR Project Action Area. The focus is on the Little Arkansas River in the red box.

IMPACTS ON WATER RESOURCES

The Reservoir Network (RESNET) computer model was used to evaluate potential hydrologic impacts of the entire ILWSP, not just the ASR Project. This approach allowed for the impacts of the ASR Project alone to be extrapolated (where applicable), while also allowing for an evaluation of cumulative impacts of the ILWSP. The following datasets were used for the RESNET model:

- Historical stream gage data from the Little Arkansas, Arkansas, North Fork Ninnescah, and Ninnescah Rivers (Figure 4).
- Historical mean daily stream discharge at selected points within the project area
- Historical monthly reservoir evaporation rates
- Available storage and other physical data for Cheney Reservoir
- Available storage, natural recharge and other parameters for the Equus Beds aquifer
- The City's current and projected water demands
- Agricultural irrigation demands in the Equus Beds Well Field area minimum
- Minimum Kansas Desirable Stream flow requirements
- Supply capability and other operating parameters for all current and potential water supply sources
- The preferred allocation order for each water supply source

A simulation model for 1923-2007 (85 years) was developed based on these historical data. Where data for the entire time period were not available, they were extrapolated using historical climatological data along with other variables to create an estimated value.

Three alternatives were modeled in this analysis: Current, No Project, and ILWSP 100. The Current Alternative simulated impacts on hydrologic resources based on current (2000) water demand and without implementation of the ILWSP. The No Project Alternative simulated the future without the ILWSP and modeled impacts on hydrologic resources based on future water demand in 2050. The ILWSP 100 Alternative simulated impacts on hydrologic resources resulting from implementation of the ILSWP and is also based on future water demand in 2050.

Hydrologic impacts were evaluated using flow frequency duration curves, which were developed by the RESNET model for each gaging station within the ASR Project area.

Impacts on the Little Arkansas River

Three gaging stations were located within the proximity of the project impact area: Halstead, Sedgwick, and Valley Center (Figure 4).

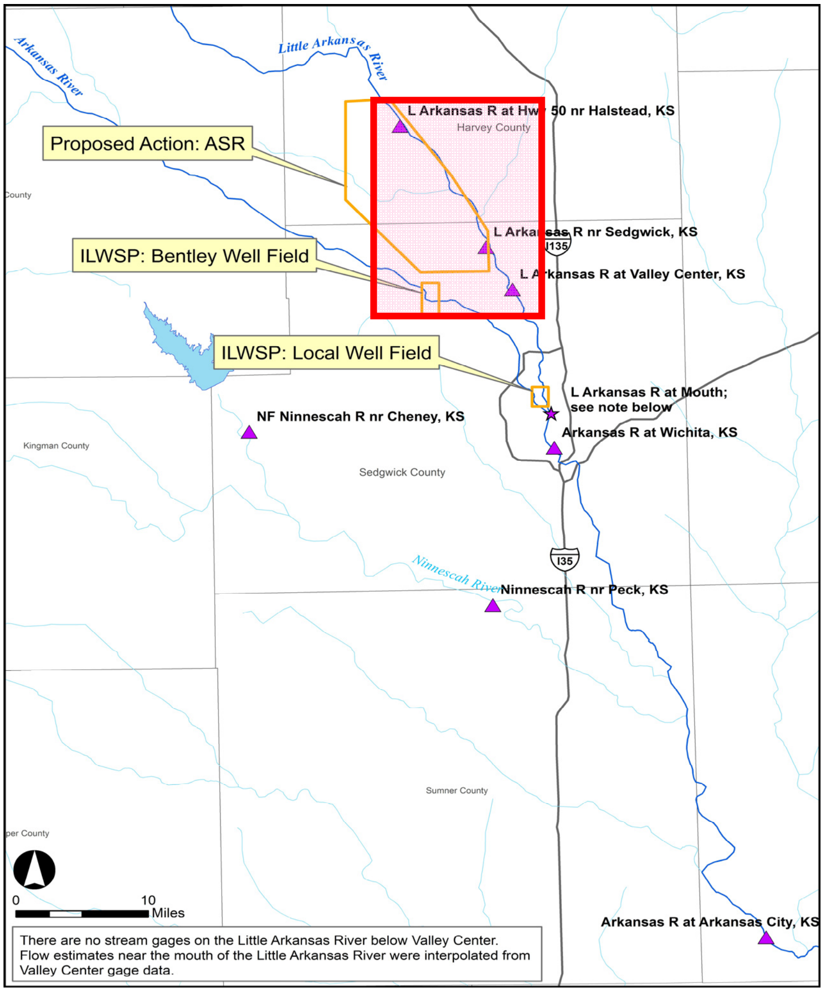


Figure 4. USGS gage stations used to evaluate hydrologic impacts. The focus here is on the red box.

The Halstead and Sedgwick gages are located within and upstream of the ASR Project area, and these gages do not detect the full impacts of the ASR Project. Therefore, these gages were not included in this analysis. The Valley Center gage was the only gage evaluated because it is located immediately downstream from all ASR Project withdrawal points, and thus captures the full impacts of the ASR Project on the Little Arkansas River.

As previously mentioned, the hydrologic modeling was conducted for the entire ILWSP 100; at this gaging station, the ILWSP 100 consists only of the ASR Project. Therefore, although labeled as ILWSP 100, this gage (in reality) displays impacts of the ASR Project.

Figure 5 illustrates the change in flow frequency following implementation of the ILWSP 100 (i.e., ASR Project) on an annual basis over the period of record. The frequency of flows between 80 and 300 cfs will decrease by 15 percent and five percent, respectively. Flows above 300 cfs will remain primarily unchanged; flows below 80 cfs would increase slightly following implementation of the ASR Project. This is due to discontinued ASR Project operations at low flows combined with additional groundwater discharge from the Equus Beds aquifer into the Little Arkansas River.

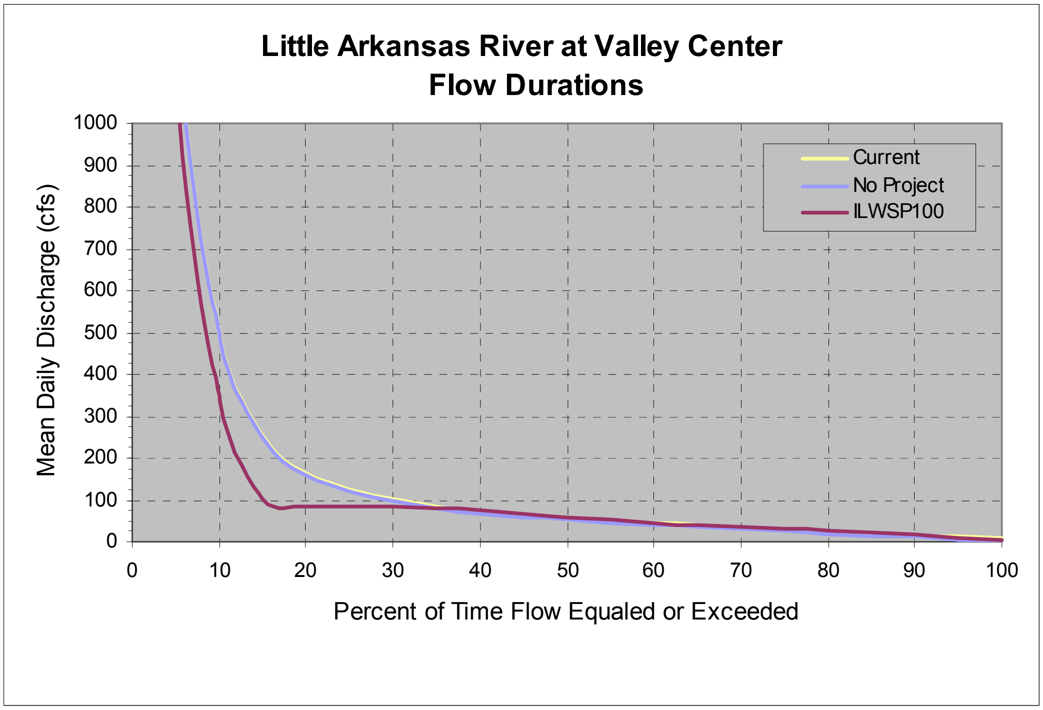


Figure 5. Frequency of flows on an annual basis at Valley Center, KS.

Figures 6 -17 (proceeding pages) illustrate the changes in flow frequency at Halstead for each month of the year over the period of record. During the fall and winter when the ASR Project is not operating at full capacity (i.e., when flows in the river are below 40 cfs), flow frequencies remain primarily unchanged, although the frequency of flows between 80 and 150 cfs decreases by about ten percent. During the spring and summer, the frequency of flows between 80 and 300 cfs decreases by about 20 percent and five percent, respectively. The frequency of flows over 300 cfs decreases by less than five percent, with no change in high flows near 1,000 cfs. Again, flows below 80 cfs would increase slightly following implementation of the ASR Project due to discontinued ASR Project operations at low flows combined with additional groundwater discharge from the Equus Beds aquifer into the Little Arkansas River.

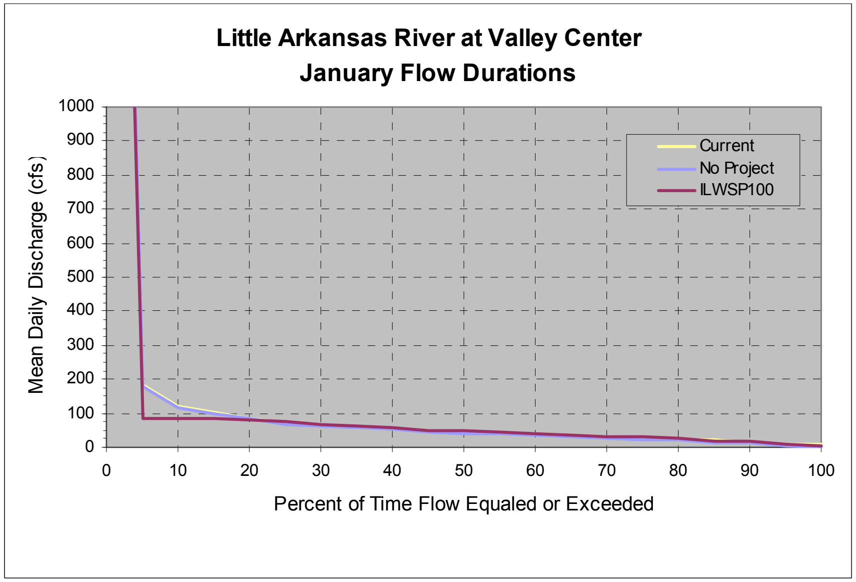


Figure 6. Frequency of flows in January at Valley Center, KS.

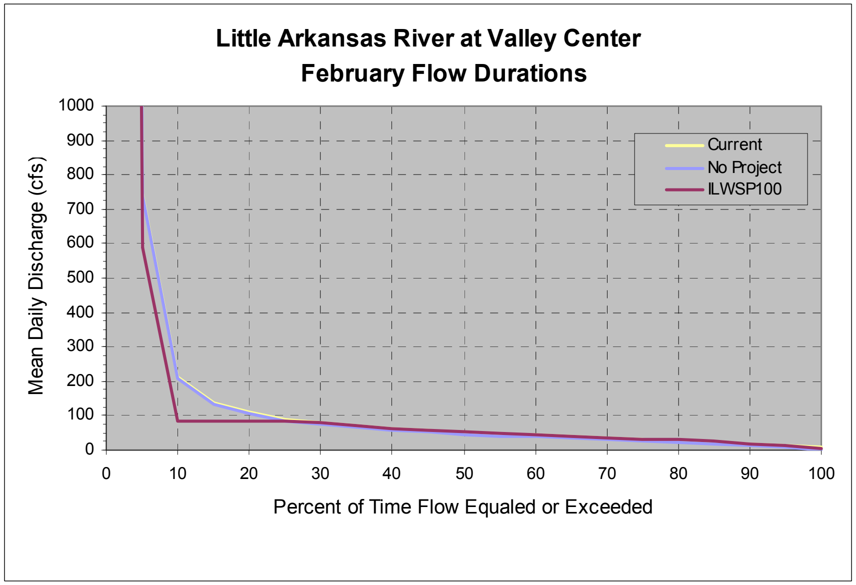


Figure 7. Frequency of flows in February at Valley Center, KS.

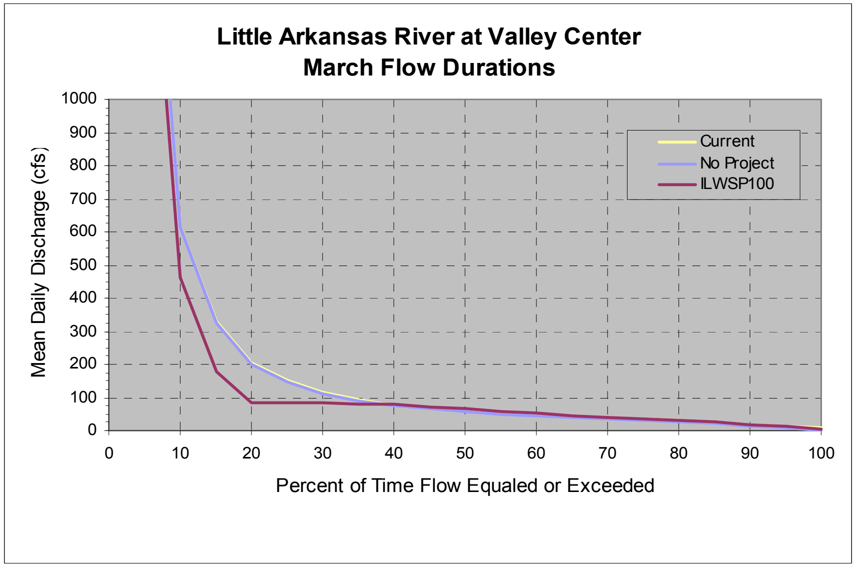


Figure 8. Frequency of flows in March at Valley Center, KS.

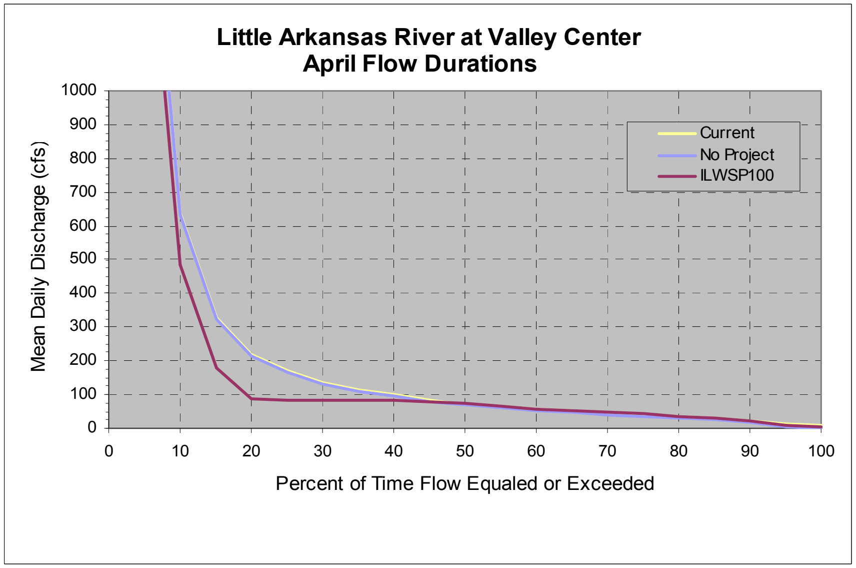


Figure 9. Frequency of flows in April at Valley Center, KS.

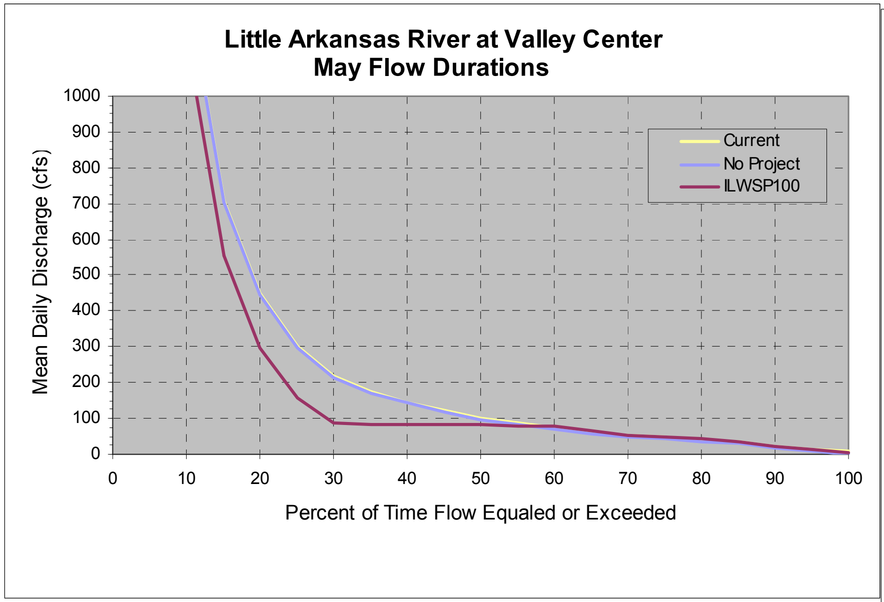


Figure 10. Frequency of flows in May at Valley Center, KS.

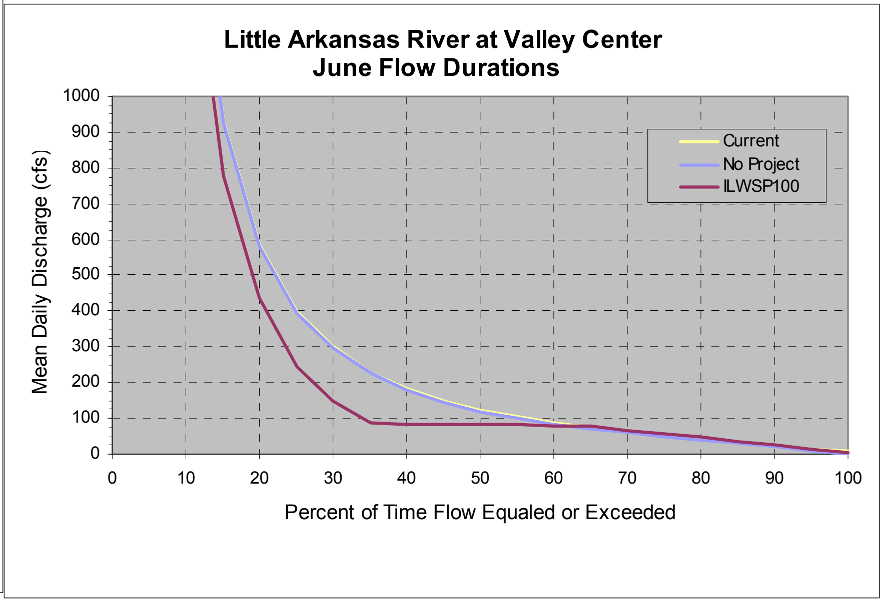


Figure 11. Frequency of flows in June at Valley Center, KS.

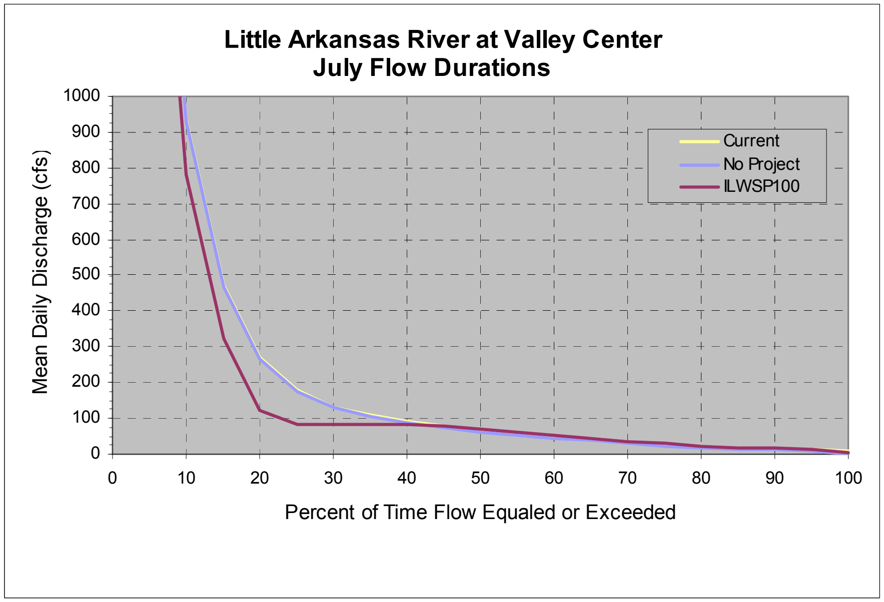


Figure 12. Frequency of flows in July at Valley Center, KS.

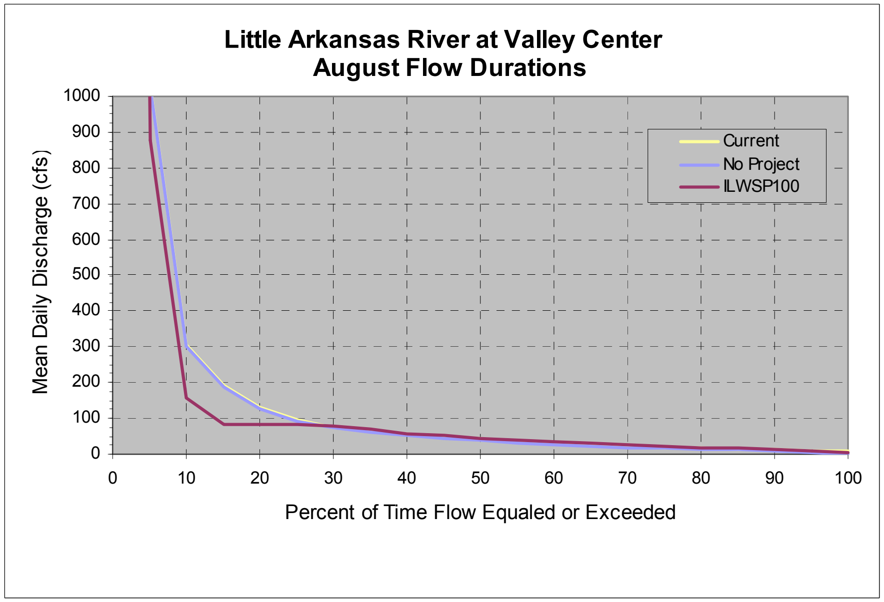


Figure 13. Frequency of flows in August at Valley Center, KS.

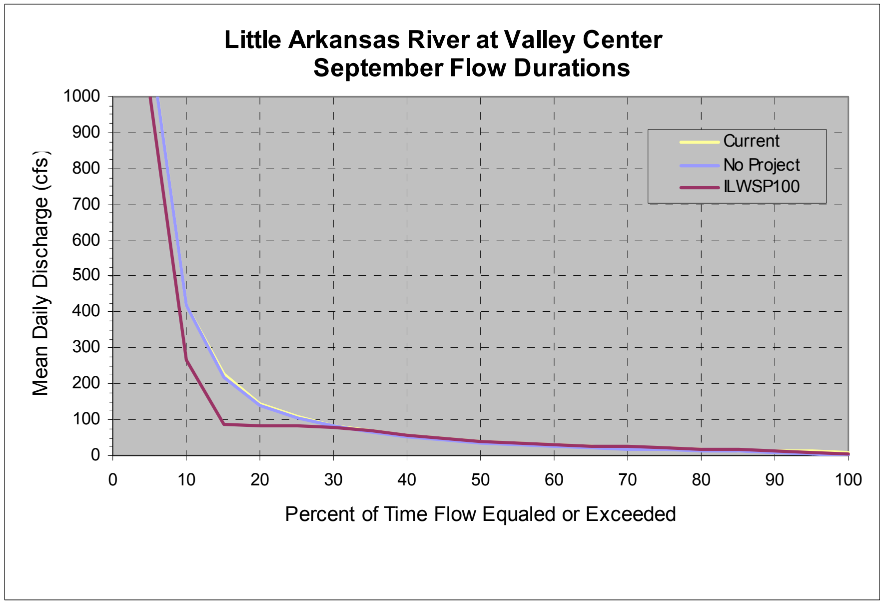


Figure 14. Frequency of flows in September at Valley Center, KS.

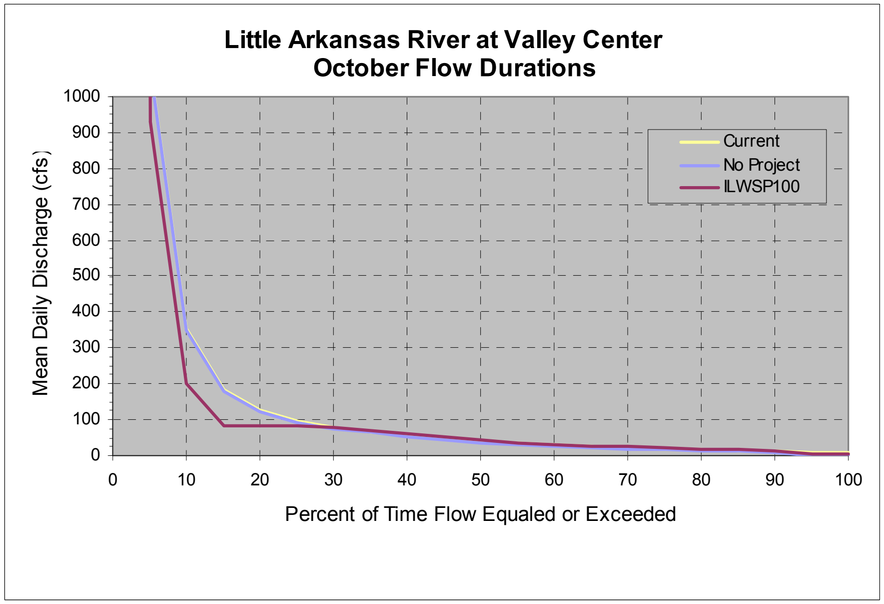


Figure 15. Frequency of flows in October at Valley Center, KS.

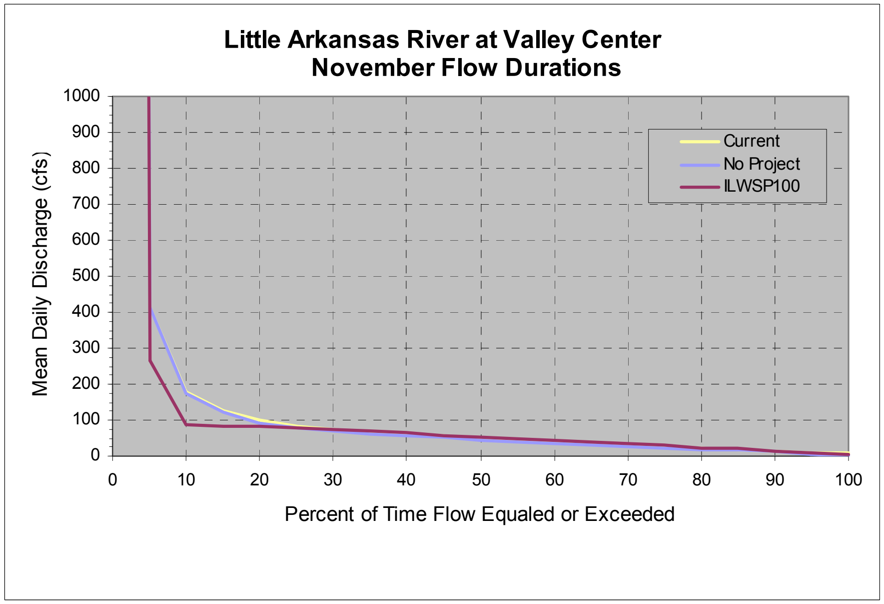


Figure 16. Frequency of flows in November at Valley Center, KS.

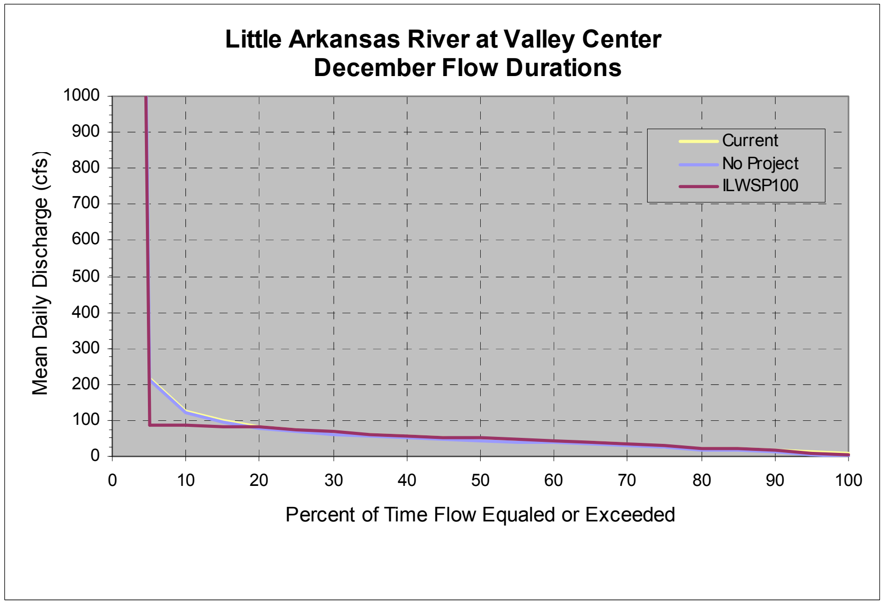


Figure 17. Frequency of flows in December at Valley Center, KS.

The Kansas Water Office established a year-round minimum desirable streamflow (MDS) of 20 cfs at Valley Center. All simulated median monthly flows would exceed the MDS with implementation of the ASR Project, and the ASR Project would slightly increase the probability of exceeding the MDS compared to conditions without the project (Figure 18). The Kansas Department of Wildlife and Parks (KDWP) has indicated a preferred 60 cfs MDS value at Valley Center in April, May, and June, when many aquatic species reproduce, and 34 cfs in all other months. Implementation of the ASR Project would also result in greater success rates for meeting KDWP flow recommendations (Figure 19).

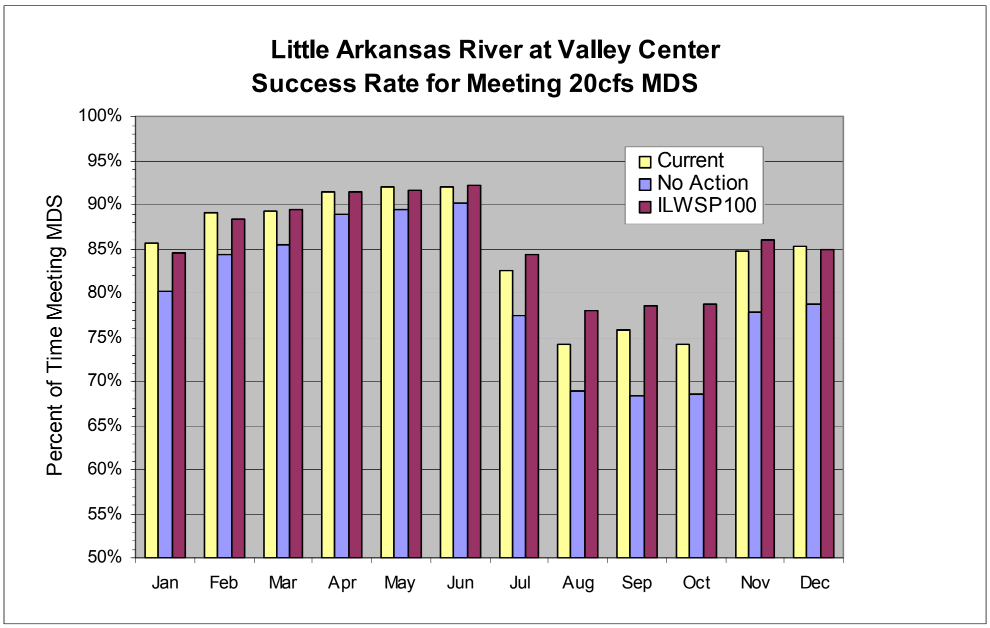


Figure 18. The frequency of meeting minimum desirable stream flows at Valley Center, KS.

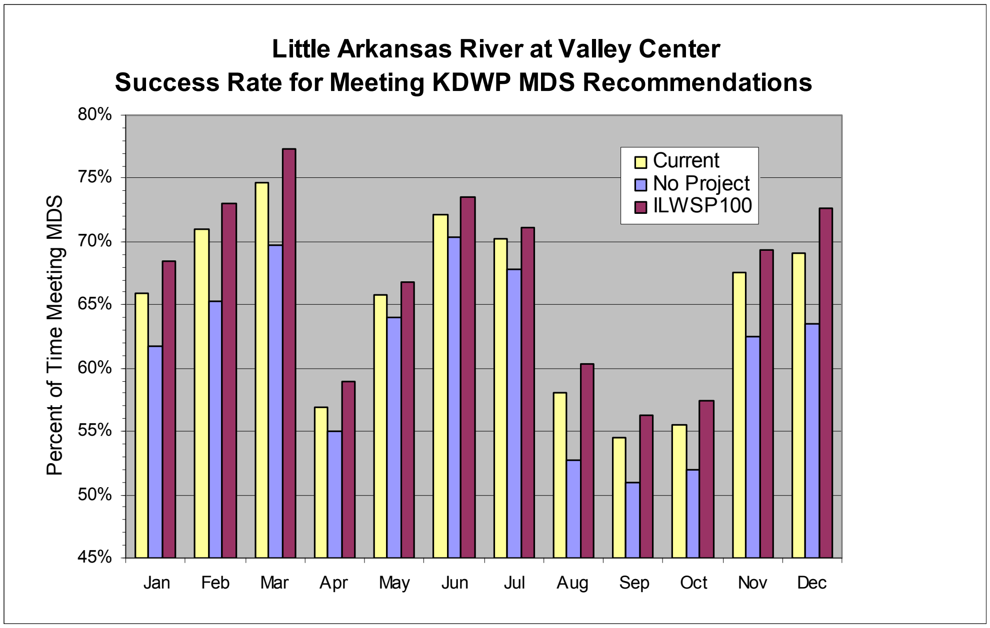


Figure 19. The frequency of meeting KDWP minimum desirable stream flows at Valley Center, KS.

Water Quality

The Kansas Department of Health and Environment (KDHE) include portions of the Little Arkansas River on its list of streams with water quality limitations. One segment is the headwaters of the Little Arkansas, which is well upstream of the ASR Project area. The other segment is below the ASR Project area near the confluence with the Arkansas River in Wichita. Water quality constituents of concern for the portion of the stream near the project area include chlordane, dissolved oxygen, oxygen demand, nutrients, and sediment (KDHE 2001). In addition the herbicide atrazine is found in this portion of the river during spring and summer months, when it is applied to agricultural fields in the Little Arkansas River basin.

An evaluation of Phase I activities of the ASR Project on water quality in the Equus Beds aquifer can provide some insight into potential impacts resulting from Phases II – IV. Upon evaluating water quality impacts from Phase I, Ziegler et al. (1999) found that the overall effects of artificial recharge on water quality in the Equus Beds aquifer were not substantial. In fact, median concentrations of chloride, arsenic, total coliform bacteria, and atrazine were similar both before and after recharge. Assuming this trend would be similar for activities carried out in Phases II - IV, there would be no anticipated negative impact on the Equus Beds aquifer. It is important to mention that an additional potential benefit of artificial recharge includes preventing degradation of the water quality of the aquifer by chloride plumes from the Arkansas River to the southwest and the Burrton oil field to the northwest.

In general, the Little Arkansas is a "gaining" stream within the project area, as indicated by higher water levels in the surrounding aquifer than in the stream (Myers et al. 1996; Aucott et al. 1998). "Gaining" streams are partially replenished from groundwater sources. The modeling results for this analysis, as illustrated by the aforementioned flow frequency duration curves, shows increases in base flows of the Little Arkansas River resulting from aquifer discharges. Assuming the results of water quality monitoring for Phase I activities would be similar to Phases II - IV, there would be no anticipated negative impacts on surface water of the Little Arkansas River from aquifer discharges.

CUMULATIVE IMPACTS ON WATER RESOURCES

Cumulative impacts include the impacts of future State, tribal, local, or private actions that are reasonably certain to occur in the action area considered in this biological evaluation. Cumulative impacts can result from individually minor, but collectively significant actions taking place over a period of time. Two criteria were used to determine whether an action should be considered under cumulative effects analysis:

1) *It must be reasonably certain to occur. It must have a legislative mandate, agreement, or formal proposal that specifies the scope of the action such that its content and intensity can be measurably calculated without speculation.*
2) *It must occur within the same action area such that a measurable, combined impact actually exists.*

Projects contained within the City's ILWSP are the only projects known to meet the cumulative effects criteria. In addition to the ASR Project, these projects include expansion of the Local Well Field (LWF) along the Little Arkansas River and the redevelopment of the Bentley Reserve Well Field along the Arkansas River.

The LWF is comprised of 17 wells constructed between 1949 and 1953 and three re-drilled wells that were constructed in 1997. The expansion would consist of combining the LWF with the City's E&S Well Field and adding four horizontal collector wells, five vertical wells with pumps and motors, and associated collections pipelines. The LWF is currently used during periods of peak demand to supplement water supplies. As part of the ILWSP, the City will expand the LWF to provide 45 MGD of additional water to the City of Wichita through the withdrawal of all flows in the Little Arkansas River over 20 cfs in most months, except during high flow events that exceed the capacity of the LWF. Full operation of the Local Well Field expansion should occur by 2014 before the ASR Project is complete. It is important to note that once the ASR Project is fully operational, it would not impact the operations of the LWF (i.e., the LWF would withdraw flows over 20 cfs regardless of ASR Project operations.

The Bentley Well Field (BWF) was developed by the City in the 1950s. The City drilled six wells; however, water produced by the well field was too salty for standard treatment, so the wells and water rights were abandoned. Under the ILWSP, the City would to redevelop these wells and reduce salinity by combining the well water with fresh water from other sources. Redevelopment of the BWF should provide an additional ten MGD of water for the City. Refurbishing of wells in the Bentley Well Field would begin in 2009 and be completed by 2010.

Cumulative operational impacts of the ASR Project, LWF, and BWF would occur in the Little Arkansas, Arkansas, North Fork Ninnescah, and Ninnescah rivers, along with Cheney Reservoir, in Harvey, Sedgwick, Reno, Kingman, Sumner, and Cowley counties, Kansas (Figure 20). The presence of Kaw Lake, a major surface water impoundment in Oklahoma on the Arkansas River, combined with the inflows of tributaries into the Arkansas River, would negate any potential cumulative operational impacts on the Arkansas River below Arkansas City; therefore, all water resources below Arkansas City, including those in Oklahoma, were not considered in the cumulative impacts analysis.

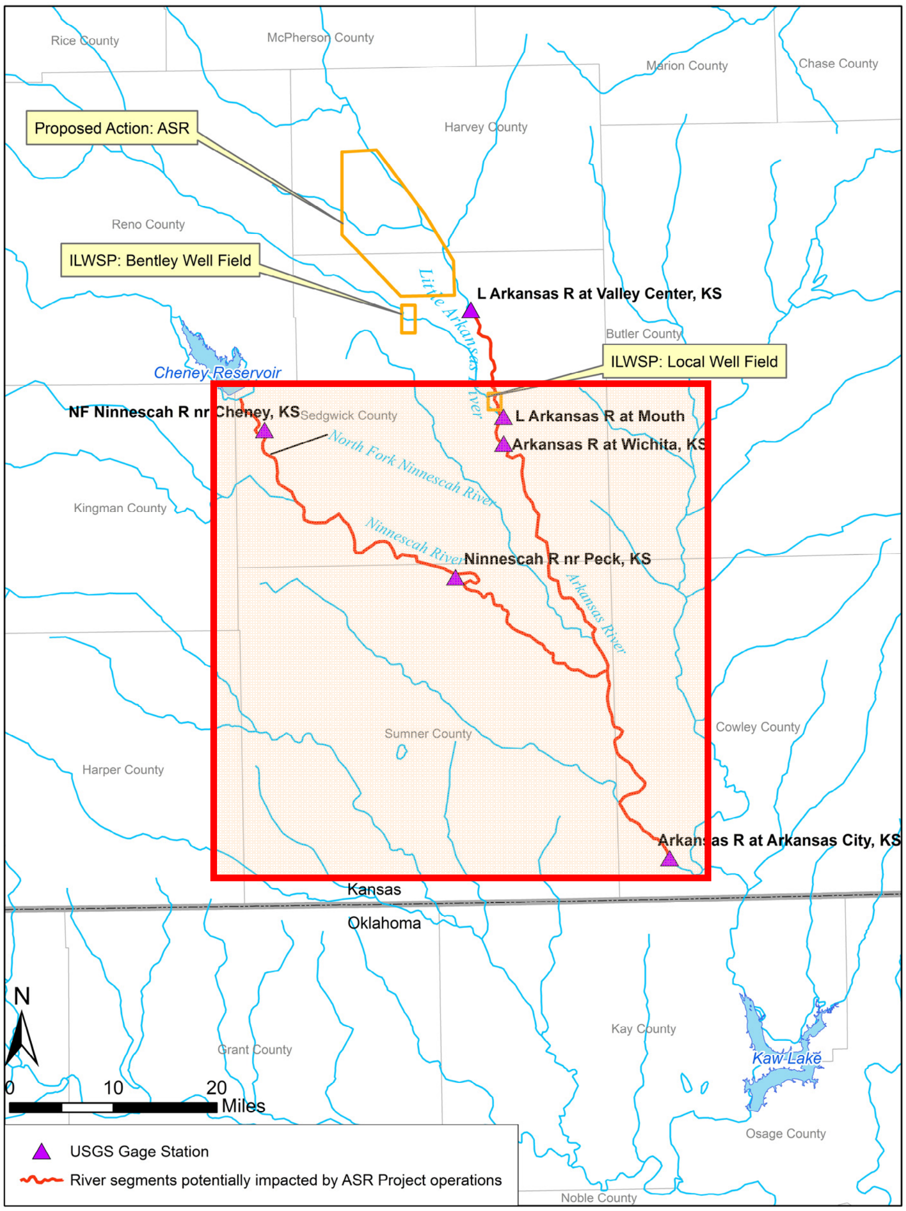


Figure 20. Project area where potential cumulative impacts of the ASR, LWF, and BWF projects could occur. The focus here is on the rivers within the red box.

A total of five USGS stations were located within the proximity of the ASR, LWF, and BWF project impact areas in Kansas (Figure 20).

Cumulative Impacts on the Little Arkansas River

The LWF combined with the ASR Project would have cumulative impacts on the Little Arkansas River during high flow events. Cumulative impacts on the Little Arkansas River were evaluated using flow frequency duration curves, which were developed by the RESNET model at the mouth of the Little Arkansas River just downstream of the ASR Project and LWF, and upstream of the confluence with the Arkansas River (Figure 20). Because no gage data exist at this location, historical flow data were extrapolated using data obtained from the Sedgwick gage immediately upstream.

Figure 21 illustrates the change in flow frequency following implementation of the ILWSP 100 (i.e., ASR Project + LWF) on an annual basis over the period of record. The LWF would withdraw flows over 20 cfs about 85 percent of the time regardless of ASR Project operations. The frequency of flows between 20 cfs and 80 cfs could be reduced by up to 60 percent from the Current conditions. The frequency of flows between 80 cfs and 300 cfs would decrease by 30 and five percent, respectively. The frequency of flows over 300 cfs would remain mostly unchanged.

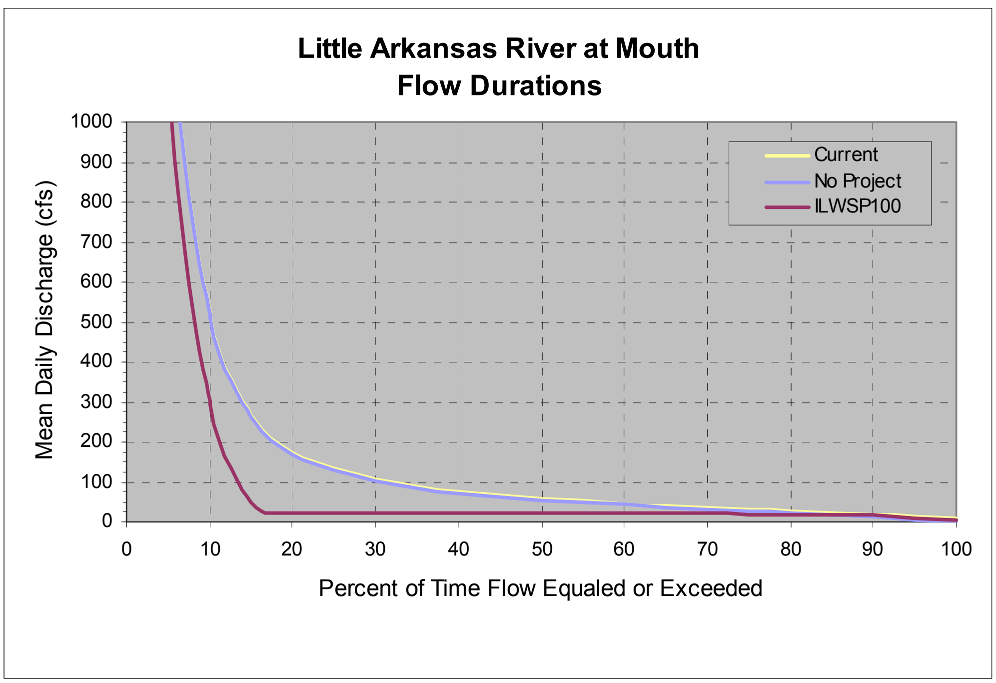


Figure 21. Frequency of flows on an annual basis at the mouth of the Little Arkansas River, KS.

Figures 22-33 (proceeding pages) illustrate the changes in flow frequency at the mouth of the Little Arkansas River for each month of the year over the period of record. Year round, the LWF withdraws flows over 20 cfs about 70 to 90 percent of the time. As previously mentioned, this occurs regardless of ASR Project operations. During the fall and winter, the frequency of flows between 20 cfs and 80 cfs could be reduced by 60 percent from the Current conditions. The frequency of flows over 300 cfs would remain primarily unchanged. In the spring and summer, the frequency of flows between 20 and 80 cfs would be reduced by 40 to 60 percent. The frequency of flows over 300 cfs would be reduced by no more than five percent, with flow frequencies over 1,000 cfs remaining primarily unchanged.

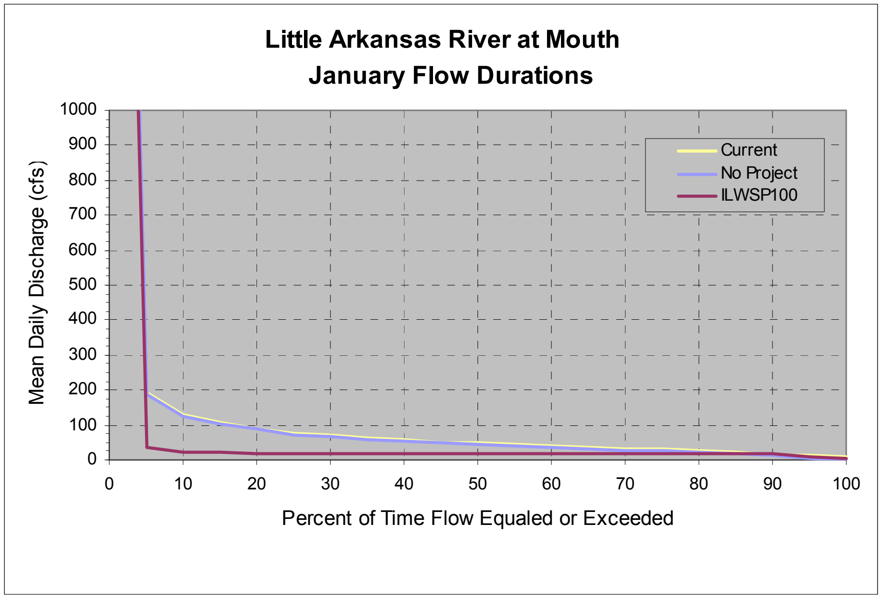


Figure 22. Frequency of flows in January at the mouth of the Little Arkansas River, KS.

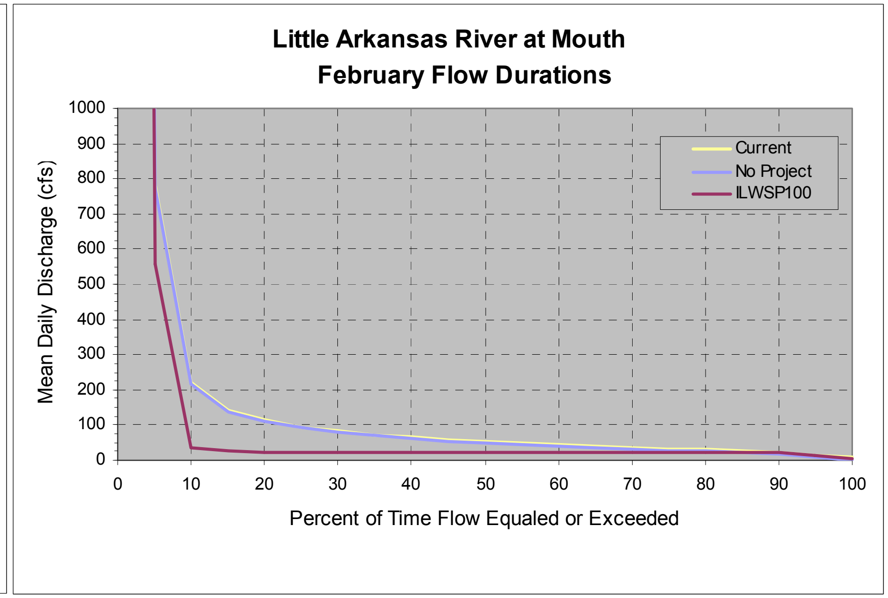


Figure 23. Frequency of flows in February at the mouth of the Little Arkansas River, KS.

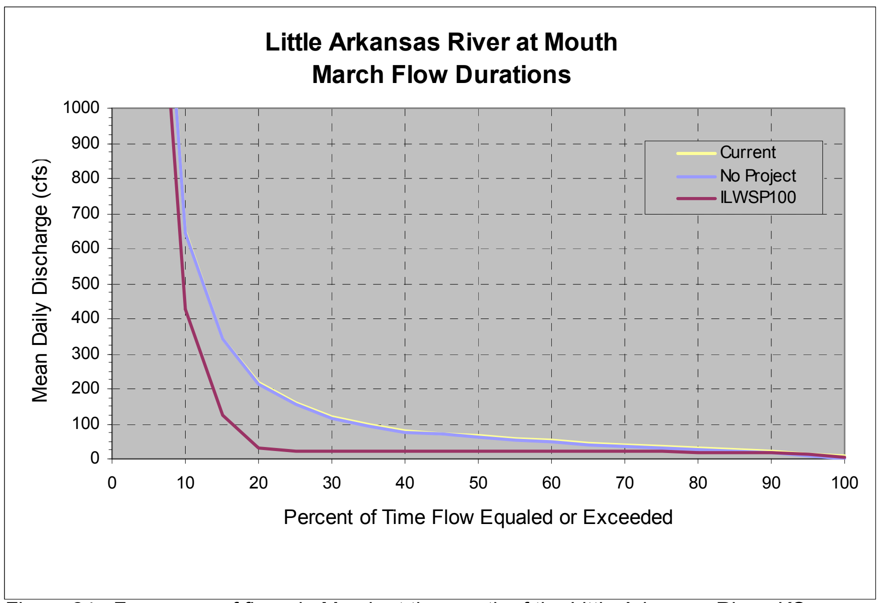


Figure 24. Frequency of flows in March at the mouth of the Little Arkansas River, KS.

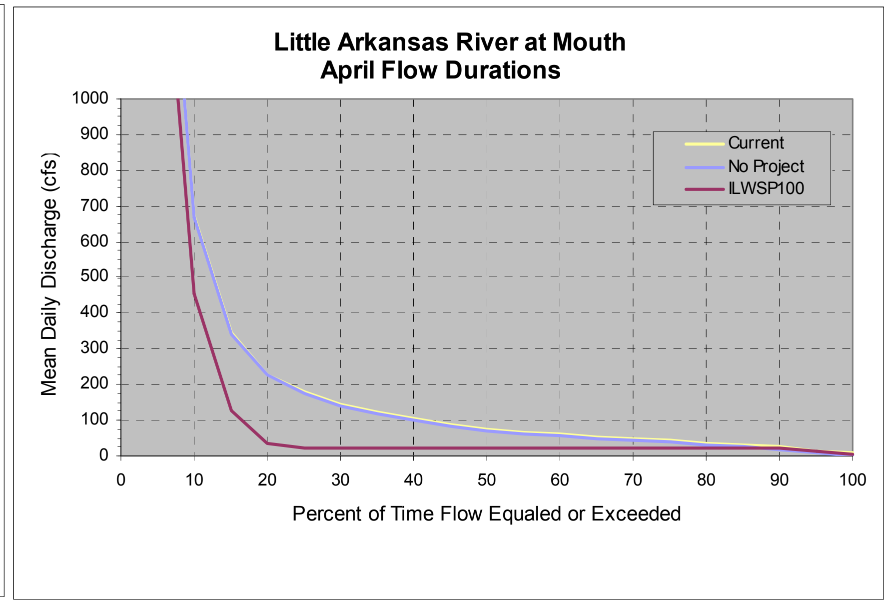


Figure 25. Frequency of flows in April at the mouth of the Little Arkansas River, KS.

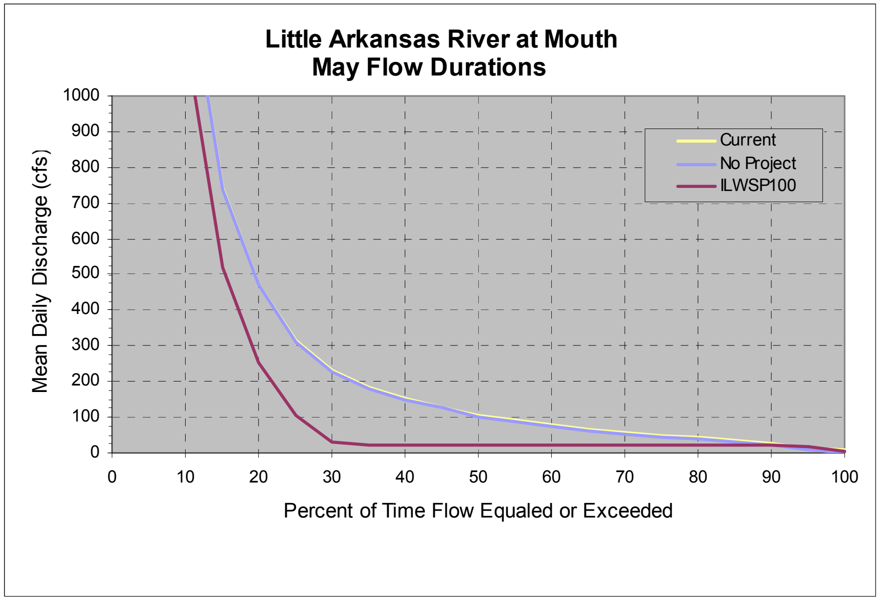


Figure 26. Frequency of flows in May at the Mouth of the Little Arkansas River, KS.

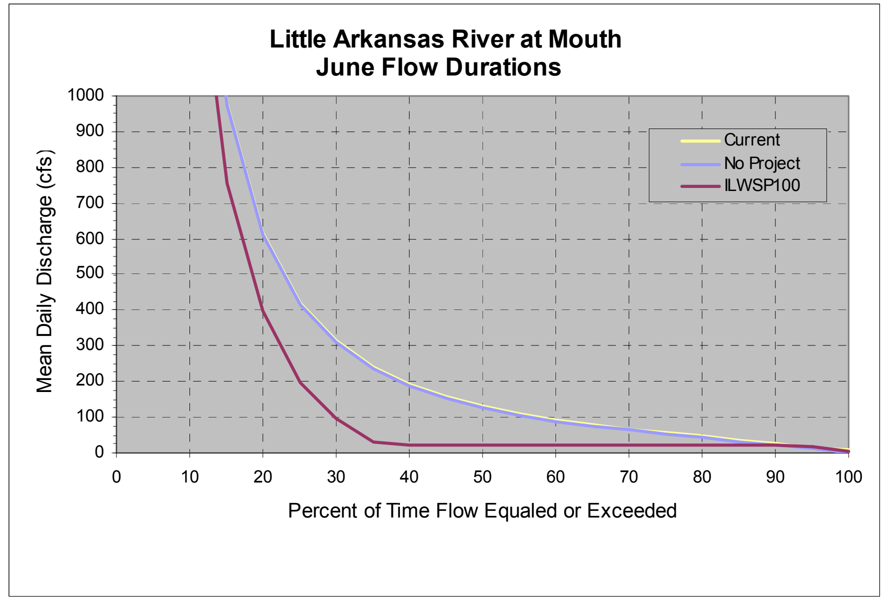


Figure 27. Frequency of flows in June at the Mouth of the Little Arkansas River, KS.

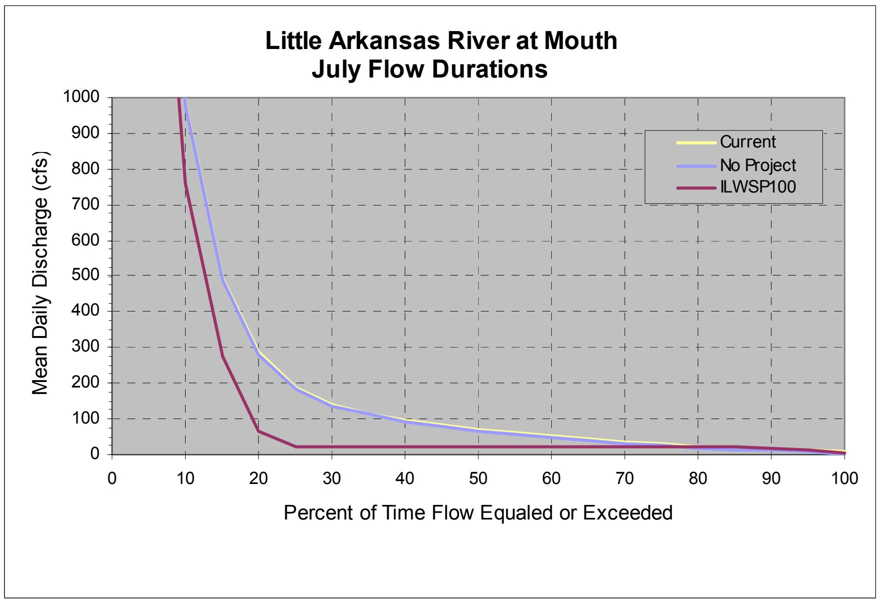


Figure 28. Frequency of flows in July at the Mouth of the Little Arkansas River, KS.

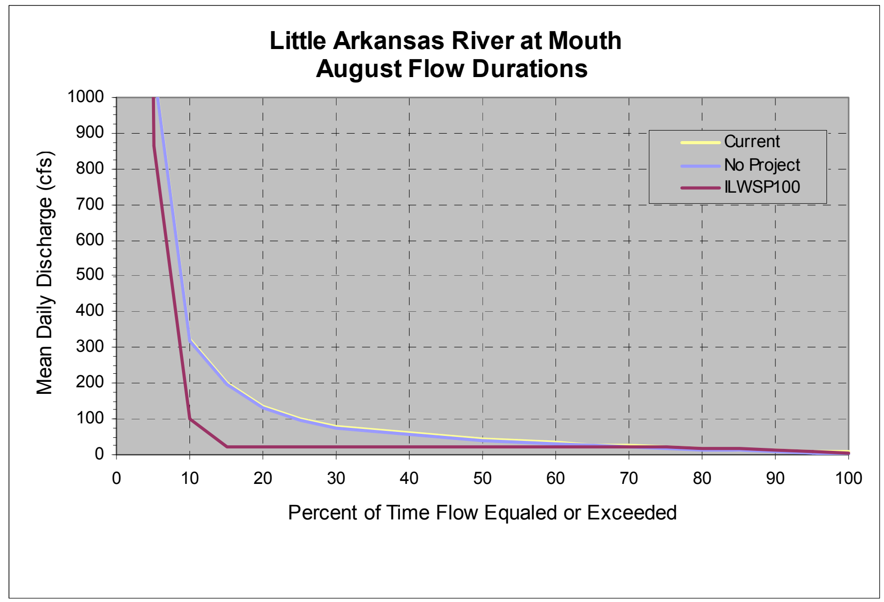


Figure 29. Frequency of flows in August at the Mouth of the Little Arkansas River, KS.

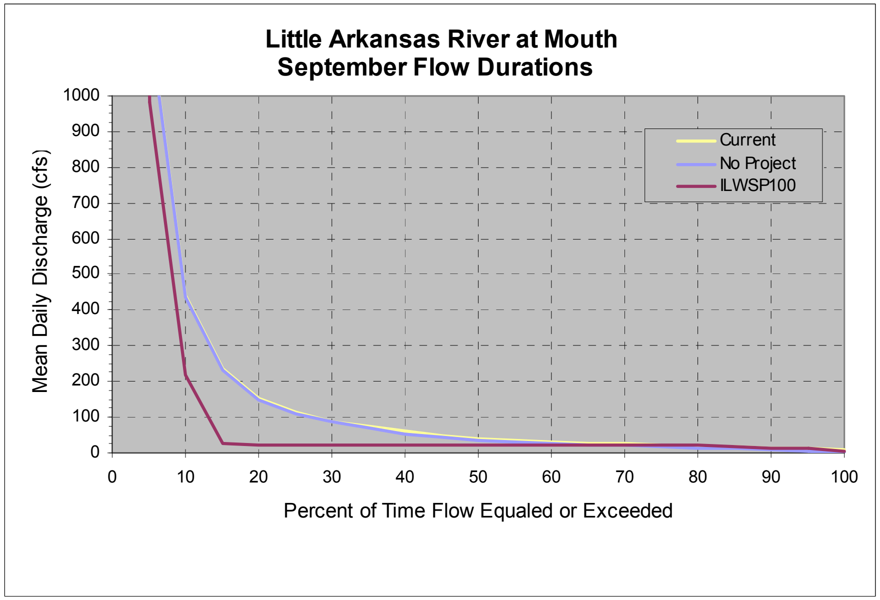


Figure 30. Frequency of flows in September at the Mouth of the Little Arkansas River, KS.

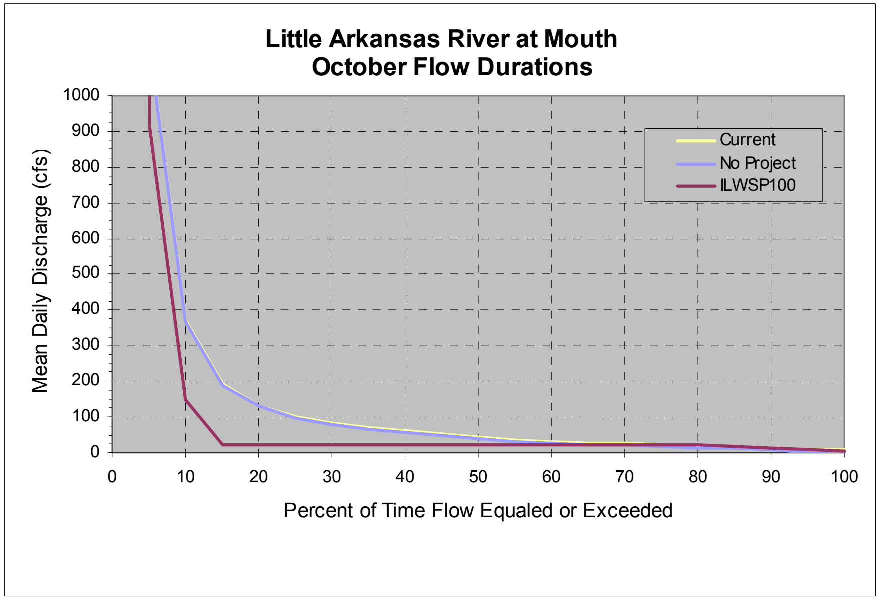


Figure 31. Frequency of flows in October at the Mouth of the Little Arkansas River, KS.

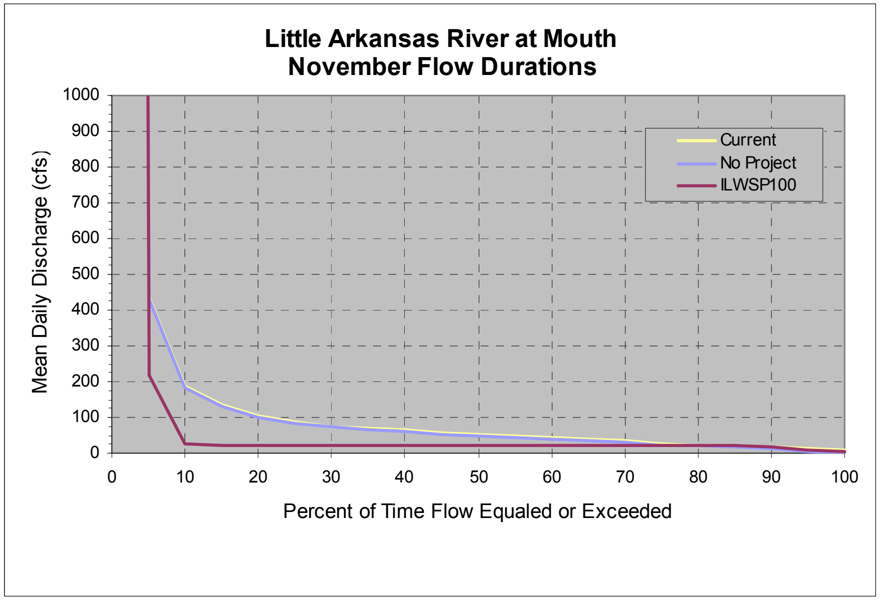


Figure 32. Frequency of flows in November at the Mouth of the Little Arkansas River, KS.

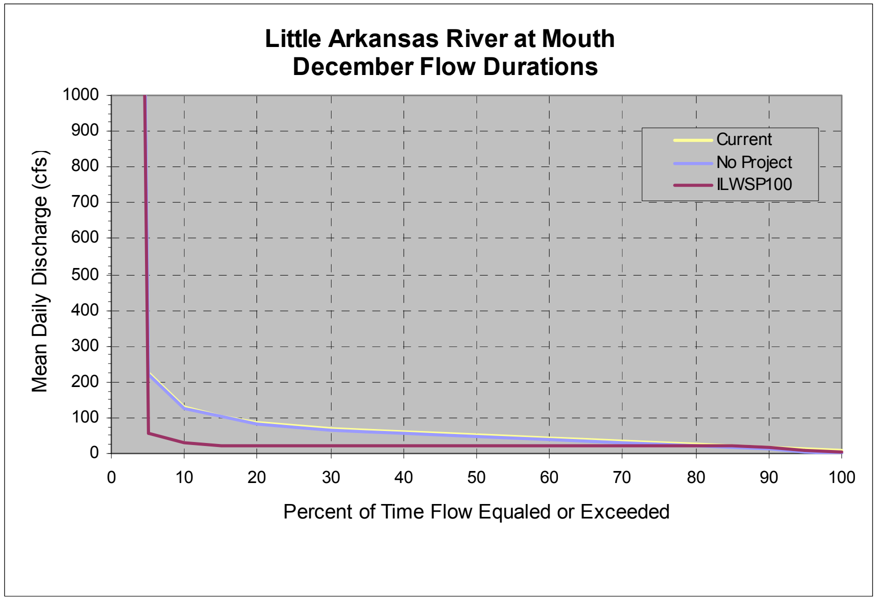


Figure 33. Frequency of flows in December at the Mouth of the Little Arkansas River, KS.

Water Quality
As described in the previous section, the Equus Beds aquifer would discharge flows into the Little Arkansas River, thereby potentially improving water quality in the river.

Cumulative Impacts on the Arkansas River

The BWF and LWF, combined with the ASR Project, would have cumulative impacts on the Arkansas River. Cumulative impacts on the Arkansas River were evaluated at two USGS gaging stations: Wichita and Arkansas City (Figure 20). Due to the presence of Kaw Lake, analyses were not performed at locations downstream of Arkansas City.

The first station is within the City of Wichita about four miles downstream of the confluence with the Little Arkansas River. At this location, the cumulative impacts of the BWF, LWF, and ASR Project can be evaluated. Figure 34 illustrates the change in flow frequency in the Arkansas River following implementation of the ILWSP 100 (i.e., ASR Project + BWF + LWF) on an annual basis over the period of record. Due to the relatively high flows in the Arkansas River, the frequency of low, medium and high flows remains primarily unchanged. The only impacts occur at flows between 300 and 2,000 cfs, which decrease by no more than three to five percent after the combined operations of the ASR Project, BWF, and LWF (Figure 34). Monthly flow duration curves illustrate a similar pattern. Monthly flow duration curves show a similar pattern with little or no variability across months. For the sake of brevity, these can be found in Appendix A.

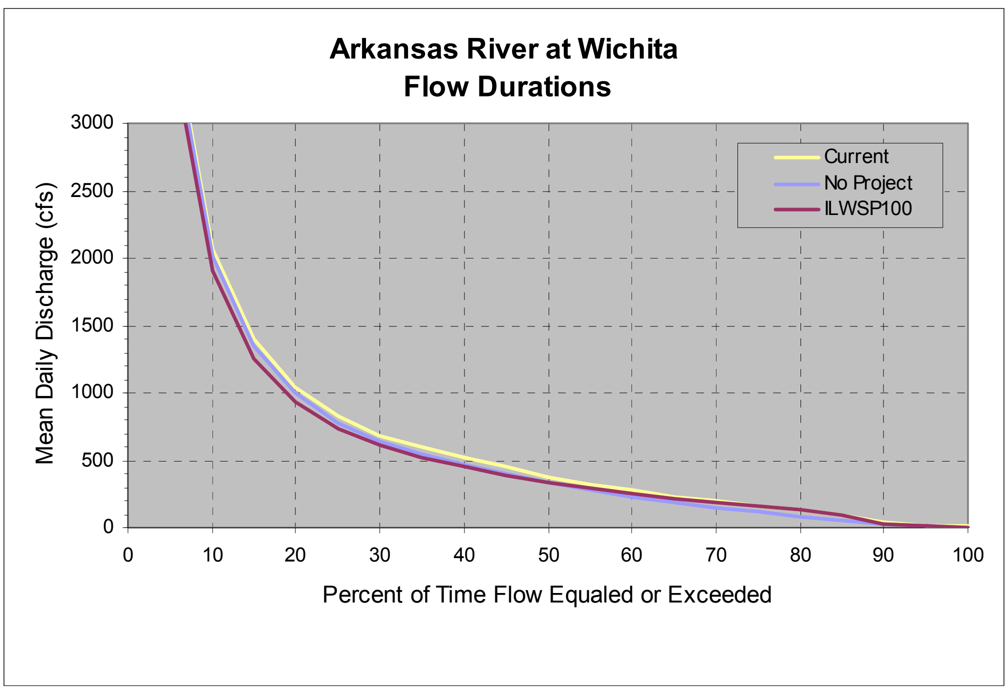


Figure 34. Frequency of flows in the Arkansas River at Wichita, KS.

The second USGS gaging station used in this evaluation is located in Arkansas City about 24 miles downstream from the confluence of the Ninnescah River near the Kansas-Oklahoma border. Figure 35 illustrates the change in flow frequency in the Arkansas River following implementation of the ILWSP 100 (i.e., ASR Project + BWF + LWF) on an annual basis over the period of record. Due to the relatively high flows in the Arkansas River, the frequency of low, medium and high flows remains primarily unchanged year-round after the combined operations of the ASR Project, BWF, and LWF. Monthly flow duration curves illustrate a similar pattern. Again, monthly flow duration curves show a similar pattern with little or no variability across months, and are found in Appendix A.

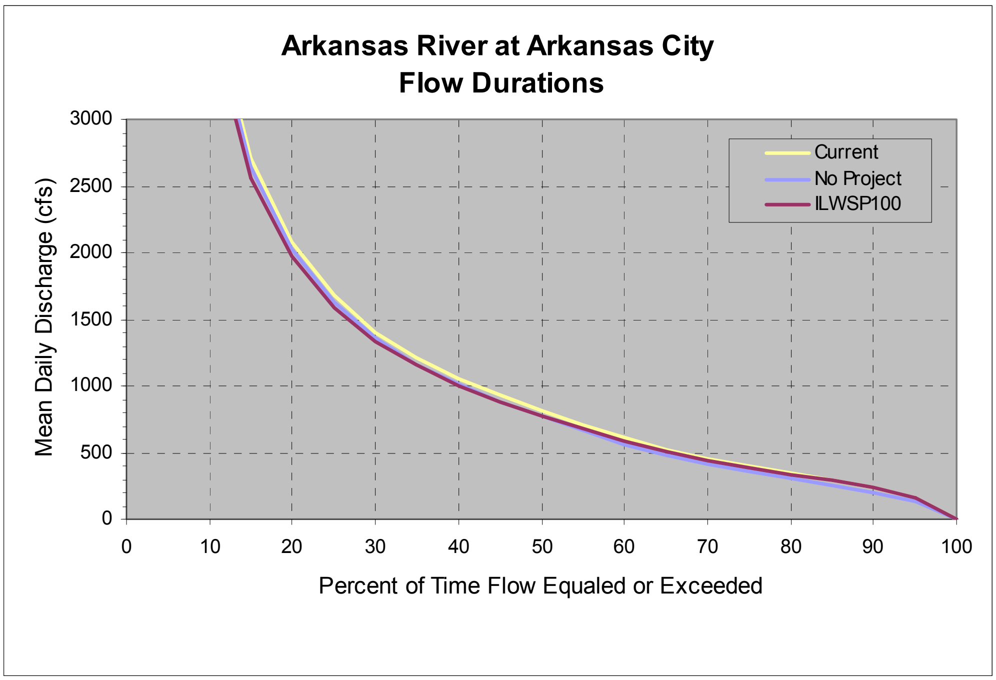


Figure 35. The frequency of flows in the Arkansas River at Arkansas City, KS.

Water Quality

Water quality impacts to the Arkansas River would primarily result from changes in the quantity and quality of water received from the Little Arkansas River. As previously stated, cumulative effects on water quality of the Little Arkansas River would be very minor. Therefore, subsequent impacts on the Arkansas River are expected to be minor, especially considering the dilution associated with mixing Little Arkansas River water with the high flows of the Arkansas River. As well, similar to the Little Arkansas River, flow simulations indicate that the Equus Beds aquifer would discharge high quality water and increase the base flow of the Arkansas River.

Cumulative Impacts on Cheney Reservoir

The ASR Project, combined with the BWF and LWF, would result in the City relying less on water supplies from Cheney Reservoir. This would increase the pool elevation of Cheney Reservoir by three feet, thereby increasing the frequency of flood releases out of Cheney Reservoir into the North Fork of the Ninnescah River (Figure 36).

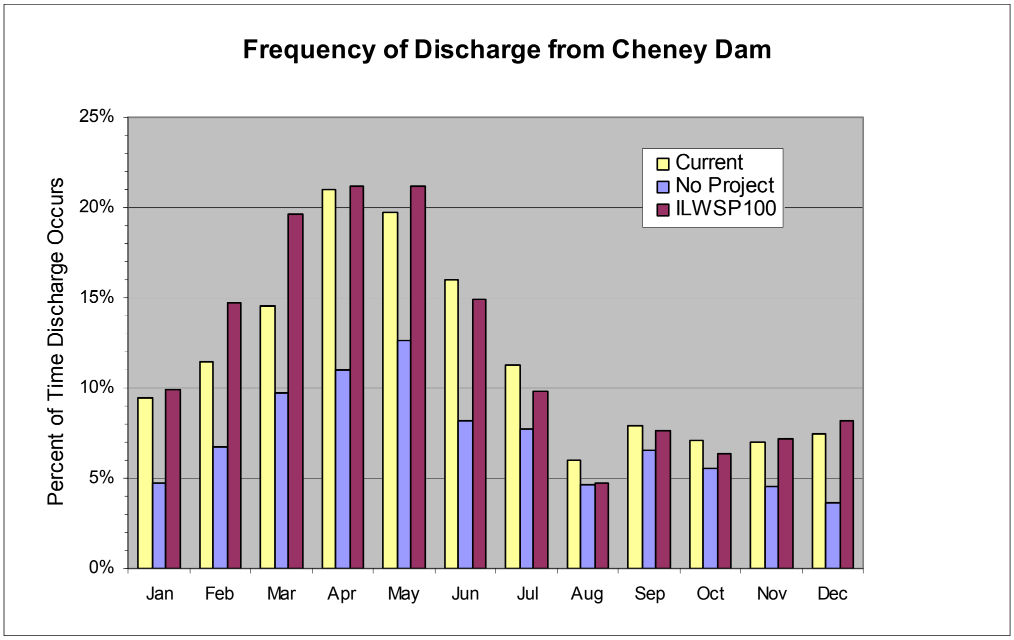


Figure 36. The frequency of flood discharges out of Cheney Reservoir, KS.

Water Quality

No impacts on Cheney Reservoir water quality are anticipated.

Cumulative Impacts on the North Fork of the Ninnescah River

The BWF and LWF, combined with the ASR Project, would have cumulative impacts on the North Fork Ninnescah River. As previously mentioned, because the City would rely less on Cheney Reservoir for its water supply, more water would be held in the reservoir, which would increase the frequency of flood releases out of the dam. These impacts were evaluated at one USGS gaging station just downstream of Cheney Reservoir (Figure 1).

Figure 37 illustrates the change in flow frequency in the North Fork Ninnescah following implementation of the ILWSP 100 (i.e., ASR Project + BWF + LWF) on an annual basis over the period of record. The frequency of flows below 100 cfs increases by up to five percent compared to the No Project conditions, and flows above 100 cfs remain primarily unchanged. For the sake of brevity, monthly flow duration curves were not developed at this location.

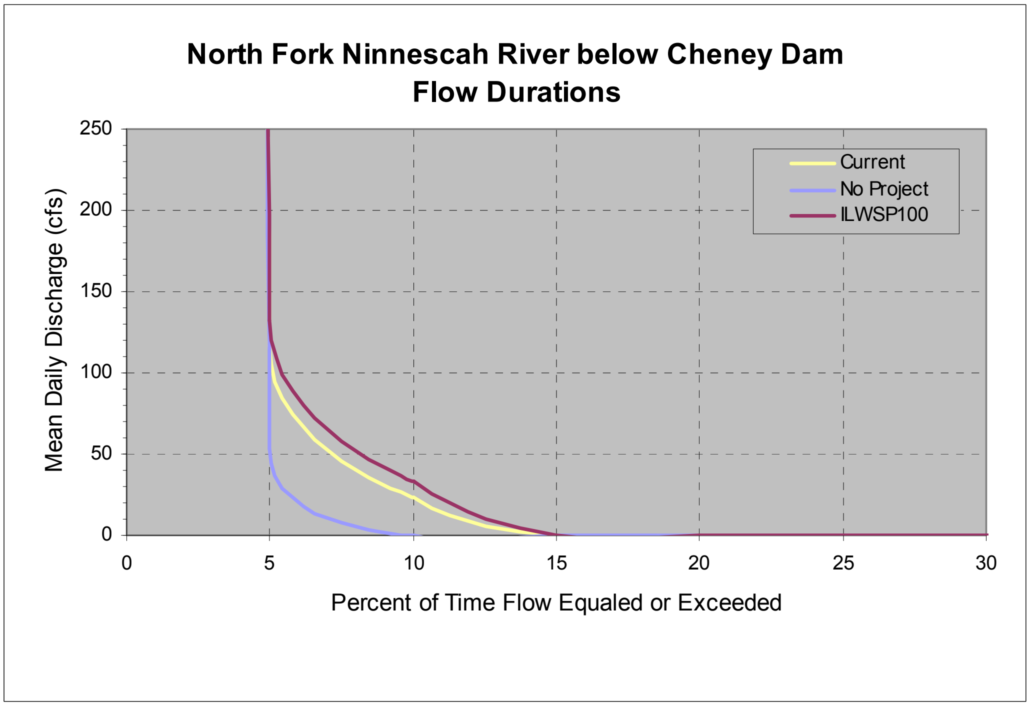


Figure 37. Frequency of flows in the North Fork Ninnescah River on an annual basis near Cheney Dam, KS.

Water Quality

Increased releases from Cheney Reservoir due to the ILWSP and ASR implementation should provide net positive water quality benefits in the North Fork of the Ninnescah River. The increased flows should increase dissolved oxygen levels for support of fish and wildlife species in the river and in adjacent riparian zones.

Cumulative Impacts on the Ninnescah River

The BWF and LWF, combined with the ASR Project, would also have cumulative impacts on the mainstem Ninnescah River. These impacts were evaluated at one USGS gaging station near Peck, Kansas (Figure 1).

Figure 38 illustrates the change in flow frequency in the North Fork Ninnescah following implementation of the ILWSP 100 (i.e., ASR Project + BWF + LWF) on an annual basis over the period of record. Flow frequency durations remain unchanged across all flows compared to the Current condition. For the sake of brevity, monthly flow duration curves were not developed at this location.

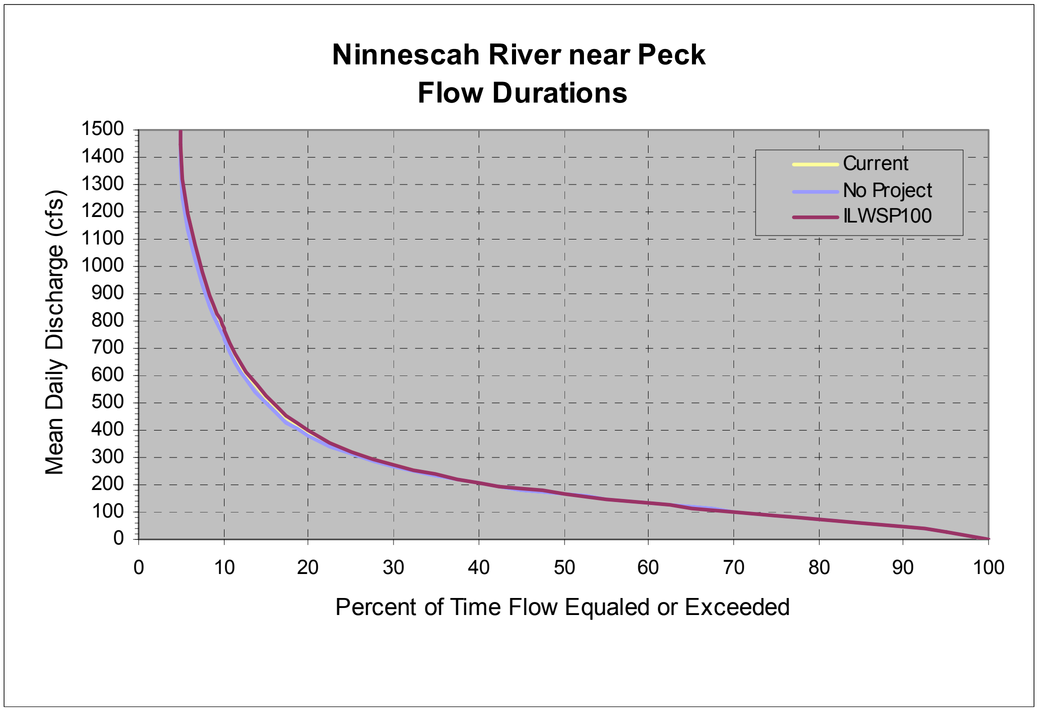


Figure 38. Frequency of flows on an annual basis in the Ninnescah River near Peck, KS.

The Kansas Water Office has also established a MDS for the Ninnescah River near Peck, Kansas. The MDS is 100 cfs from November to May, 70 cfs in June, 30 cfs from July through September, and 50 cfs in October. The success rate for meeting the MDS would vary little with implementation of the MDS, as shown in Figure 39.

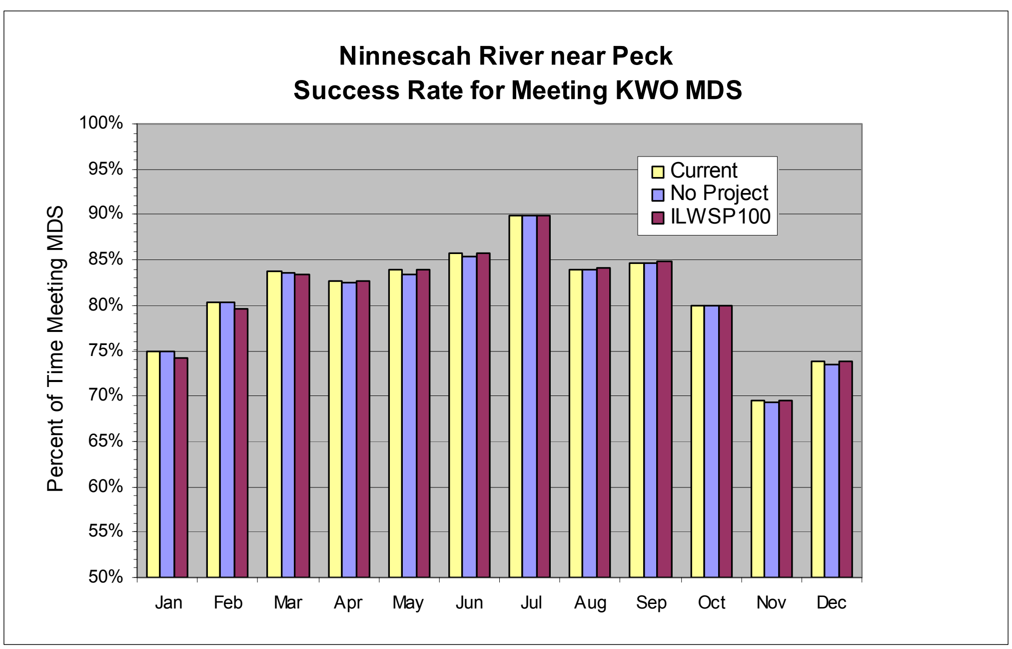


Figure 39. The success rate for meeting the MDS in the Ninnescah River near Peck, Kansas.

Water Quality

The BWF and LWF, combined with the ASR Project, would have no impacts on the water quality of the mainstem Ninnescah River.

SPECIES OF CONCERN

Three federally listed species were identified as occurring within Harvey, Sedgwick, Reno, Kingman, Sumner, and Cowley counties where construction and operational impacts, including cumulative impacts, of the ASR Project would occur (Table 1).

Table 1. Federally listed species that are potentially impacted by the ASR Project.

Common Name	Scientific Name	Status*	County	Rivers Where Potential Impacts Could Occur
Arkansas River Shiner	*Notropis girardi*	T	Sedgwick	Arkansas River
Interior Least Tern	*Sterna antillarum*	E	Sedgwick; Reno; Sumner; Cowley	Little Arkansas River; Arkansas River; N. Fork Ninnescah; Ninnescah
Whooping Crane	*Grus americana*	E	Harvey; Sedgwick; Kingman; Reno; Sumner	Little Arkansas River; Arkansas River; N. Fork Ninnescah; Ninnescah

* T = Threatened; E = Endangered

Status and Life History of Potentially Impacted Species

Arkansas River Shiner

The Arkansas River shiner (AR shiner) is a small fish listed by the U.S. Fish and Wildlife Service (FWS) as threatened. There are no known populations or designated critical habitat within the action area or its influence. However, it is included in this analysis as a potentially impacted species because consideration has been given to a future reintroduction of the AR shiner into segments of the Arkansas River in Kansas. These segments could be impacted by operations of ASR Project, along other components of the ILWSP (i.e., BWF and LWF).

The AR shiner has historically inhabited the main channels of wide, shallow, sandy bottomed rivers and larger streams of the Arkansas River basin in Kansas. It usually selects the protected leeward side of sand ridges that are formed by steady shallow water flow. The AR shiner spawns from June to August when streams approach flood stage. The eggs drift near the surface in the swift current of open channels and hatch within four days. Overall, the AR shiner requires 80 consecutive miles of river to complete its life cycle (USFWS 2001). The FWS has identified the following primary constituent elements (PCEs) for the Arkansas

River shiner (Federal Register 2005) in designated critical habitat along portions of the Cimarron and Canadian Rivers in Texas, Oklahoma, and southern Kansas. The presence of all of these PCEs is considered critical to the survival and reproduction of the AR shiner:

1. A natural, unregulated hydrologic regime complete with episodes of flood and drought or, if flows are modified or regulated, a hydrologic regime characterized by the duration, magnitude, and frequency of flow events capable of forming and maintaining channel and instream habitat necessary for particular Arkansas River shiner life-stages in appropriate seasons;
2. A complex, braided channel with pool, riffle (shallow area in a streambed causing ripples), run and backwater components that provide a suitable variety of depths and current velocities in appropriate seasons;
3. A suitable unimpounded stretch of flowing water of sufficient length to allow hatching and development of the larvae;
4. Substrates of predominantly sand, with some patches of silt, gravel and cobble;
5. Water quality characterized by low concentrations of contaminants and natural, daily and seasonally variable temperature, turbidity, conductivity, dissolved oxygen, and pH;
6. Suitable reaches of aquatic habitat, as defined by primary constituent elements 1 through 5 above, and adjacent riparian habitat sufficient to support an abundant terrestrial, semiaquatic, and aquatic invertebrate food base; and
7. Few or no predatory or competitive non-native fish species present.

Interior Least Tern

The interior least tern is listed by the FWS as endangered. The interior least tern is considered a transient in Kansas. However, recent development near the Arkansas River in downtown Wichita has created suitable habitat for the tern in and along the river, and this area in the Arkansas River now supports some populations of nesting interior least terns. There are no other known populations of interior least tern within the ASR Project area or its influence. There is no designated critical habitat for the interior least tern.

The interior least tern breeds along large rivers within the interior of the United States during summer months. It migrates south into Mexico, the Caribbean, and northern South America during the winter (Ridgely et al. 2003). It arrives at breeding sites in April to early June and spends four to five months breeding, nesting, and brooding. Egg-laying begins in late May in nests constructed on unvegetated sand or gravel bars within wide river channels, along salt flats, or on artificial habitats such as sand pits, which makes them susceptible to inundation. Nests are shallow, inconspicuous depressions scratched out by adults and located in the open, and may be collected in small colonies. Three brown spotted eggs are usually laid, and hatch in about 20 days. Chicks leave the nest only a few days after hatching, but adult terns continue to care for them until they fledge. The interior least tern feeds primarily on small fish, but also eats crustaceans, insects, mollusks, and worms. Terns harvest their food by diving out of mid-air into shallow water. They usually forage within a few hundred meters of nesting sites. No primary constituent elements have been identified by the FWS for the interior least tern. Based on existing literature, the following life-history requirements as necessary for the survival and reproduction of the interior least tern:

1. Exposed gravel bars or sandbars on which to nest and raise young. These sandbars may also have grass or other small vegetation to offer shelter for flightless nestlings;
2. Shallow water in pools or streams that attract small fish and other food sources for foraging terns;
3. Occasional high water periods that scour sandbars to prevent the encroachment of large or excess vegetation.

Whooping Crane

The whooping crane is listed by the FWS as endangered. It is considered a migrant in Kansas, and there are no known populations or designated critical habitat within the project area or its influence. In the spring, the whooping crane migrates north to Wood Buffalo National Park in Alberta, Canada, as well as other northern locations to breed. In the fall and early winter, it migrates south to the Gulf Coast of Texas. Along its migration route, the whooping crane roosts at Quivira National Wildlife Refuge and Cheyenne Bottoms Wildlife Area in western Reno County, Kansas. The whooping crane's diet consists of larval insects, frogs, rodents, small birds, berries, plant tubers, crayfish, and waste grains from harvested cropland. It roosts in riverine habitat on isolated sandbars and in large, palustrine wetlands dominated by trees, shrubs and emergent plants. The total population of whooping cranes reached a low of 240 individuals during the mid-1990s (NatureServe, 2007).

IMPACTS ON FEDERALLY LISTED SPECIES

Arkansas River Shiner

It is important to note again that the Arkansas River below Arkansas City was not considered for impacts on the AR Shiner because of the presence of Kaw Lake in Oklahoma. Similarly, the Little Arkansas River was not considered for impacts on the AR Shiner because the presence of a series of low-head dams at the mouth of the Little Arkansas River would make inhabitation of the Little Arkansas River impossible.

Consideration has been given towards the future reintroduction of the AR River shiner into segments of the Arkansas River in Kansas. These segments could be impacted by operations of ASR Project, along other components of the ILWSP (i.e., BWF and LWF). Construction activities of the ASR Project would have no direct impacts on the AR River Shiner. Operational impacts of the ASR Project, combined with those of the BWF and LWF, would be very minor. The frequency of flows in the Arkansas River at the Wichita and Arkansas City gage stations would remain primarily unchanged compared to the Current condition. Therefore, subsequent impacts on the PCEs of the AR River Shiner would remain unchanged. Overall, cumulative impacts on the AR River Shiner would be insignificant and discountable.

Interior Least Tern

Potential Little Arkansas River Populations

There are no known populations of interior least tern or designated critical habitat in the Little Arkansas River. Populations of interior least terns do inhabit the Arkansas River near Wichita downstream of the ASR Project area below the confluence with the Little Arkansas River. Based on discussions with the FWS, there is a possibility that the interior least tern could inhabit the Little Arkansas River in the future because of its proximity to the Arkansas River at Wichita.

Construction activities of the ASR Project would have no direct impacts on the interior least tern. Operational impacts of the ASR Project, combined with those of the LWF, would be minor, with potential positive benefits. As previously mentioned, project operations could decrease the frequency of flows that are between 20 and 80 cfs by up to 60 percent. This could provide more suitable habitat for the interior least tern by revealing sandbars that would otherwise be under water and by enlarging exposed sandbars. It could decrease the chances of inundating interior least tern nests as well. Furthermore, high and extreme high flow events would remain primarily unchanged, so conditions in the Little Arkansas River would still allow for sediment transport and the scouring of sandbars. Therefore, subsequent impacts on the life-history requirements of the interior least tern would remain primarily unchanged, and overall cumulative impacts on potential future populations of the interior least tern in the Little Arkansas River would be insignificant and discountable.

Existing and Potential Arkansas River Populations

The Arkansas River near Wichita is known to support nesting populations of interior least terns. Construction activities of the ASR Project would have no direct impacts on the interior least tern in the Arkansas River. Operational impacts of the ASR Project, combined with those of the BWF and LWF, would be very minor. The frequency of low, medium and high flows at both the Wichita and Arkansas City gaging stations would remain primarily unchanged after the combined implementation of the ASR Project, BWF, and LWF. Therefore, subsequent impacts on the life-history requirements of the interior least tern would be negligible, and overall cumulative impacts on existing or potential future populations of the interior least tern in the Arkansas River would be insignificant and discountable.

Potential North Fork Ninnescah River Populations

There are no known populations of interior least terns or designated critical habitat in the North Fork Ninnescah River. Based on discussions with the FWS, there is a possibility that the interior least tern could inhabit this river in the future. Construction activities of the ASR Project would have no direct impacts on the interior least tern in the North Fork Ninnescah River. Operational impacts of the ASR Project, combined with those of the BWF and LWF, would be very minor. An increase in flood releases out of the Cheney dam would increase the frequency flows in the North Fork Ninnescah that are over 100 cfs by 20 percent. This could have a minor negative impact on potential future populations of interior least terns because this could slightly increase the risk of nest inundation. However, flows over 100 cfs would remain unchanged, thus allowing allow for sediment transport and the scouring of sandbars. Therefore, subsequent impacts on the life-history requirements of the interior least tern would be minor, and overall cumulative impacts on potential future populations of the interior least tern in the North Fork Ninnescah River would be insignificant and discountable.

Potential Ninnescah River Populations

There are no known populations of interior least terns or designated critical habitat in the Ninnescah River. Based on discussions with the FWS, there is a possibility that the interior least tern could inhabit this river in the future as well. Once again, construction activities of the ASR Project would have no direct impacts on the interior least tern in the Ninnescah River, and operational impacts of the ASR Project, combined with those of the BWF and LWF, would be negligible. Low, medium, and high flows would remain primarily unchanged, and subsequent impacts on the life-history requirements of the interior least tern would be almost nonexistent. Overall, cumulative impacts on potential future populations of the interior least tern in the Ninnescah River would be insignificant and discountable.

Whooping Crane

There are no known populations of whooping cranes or designated critical habitat in any of the rivers where potential operational impacts, including cumulative impacts, of the ASR Project would occur. The whooping crane is considered a transient migrant and thus *could* temporarily utilize habitat along its migration route during the spring and fall. During this time, construction activities of the ASR Project would have no direct impacts on the whooping crane. The ASR Project, combined with the LWF, could result in a decrease the frequency of flows in the Little Arkansas River that are between 20 and 80 cfs by up to 60 percent. This could provide more suitable roosting or foraging habitat for the whooping crane by creating more shallow water, revealing sandbars that would otherwise be under water, and by enlarging exposed sandbars. Moreover, the ASR Project, combined with both the LWF and BWF, would result in negligible operational impacts in the Arkansas, North Fork Ninnescah, and Ninnescah rivers. Therefore, subsequent cumulative impacts to potential migrating whooping cranes would be considered insignificant and discountable.

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APPENDIX A: FLOW DURATION CURVES FOR THE ARKANSAS RIVER

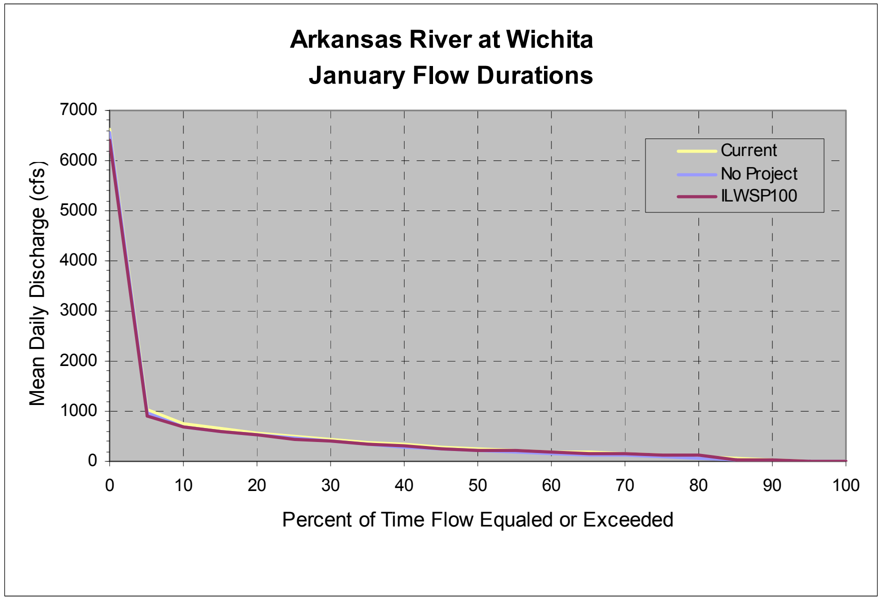

Figure 1. Frequency of flows for January in the Arkansas River at Wichita, KS.

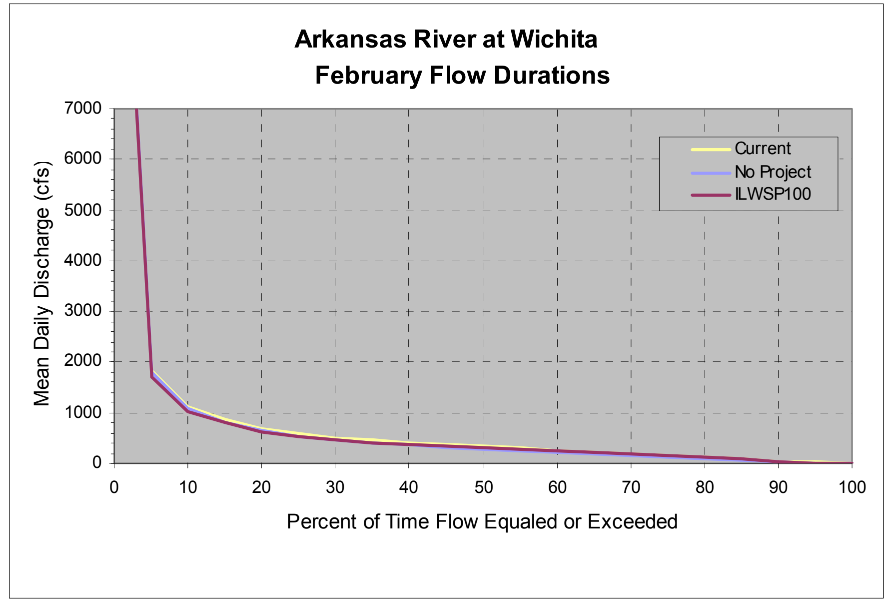

Figure 2. Frequency of flows for February in the Arkansas River at Wichita, KS.

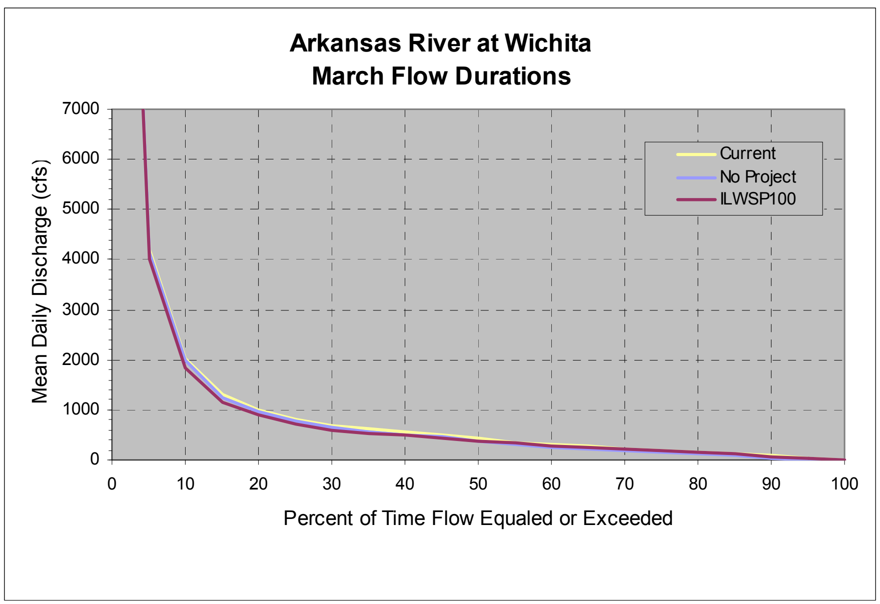

Figure 3. Frequency of flows for March in the Arkansas River at Wichita, KS.

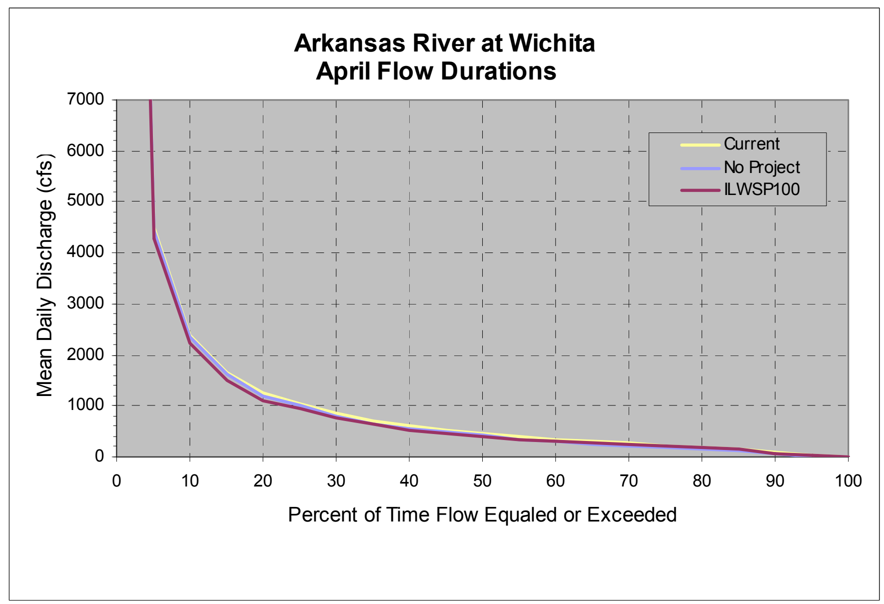

Figure 4. Frequency of flows for April in the Arkansas River at Wichita, KS.

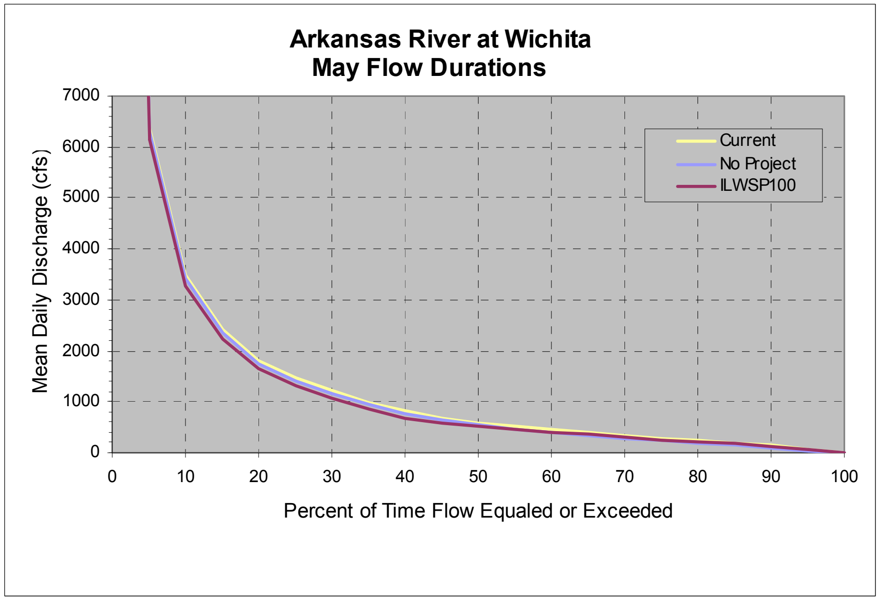

Figure 5. Frequency of flows for May in the Arkansas River at Wichita, KS.

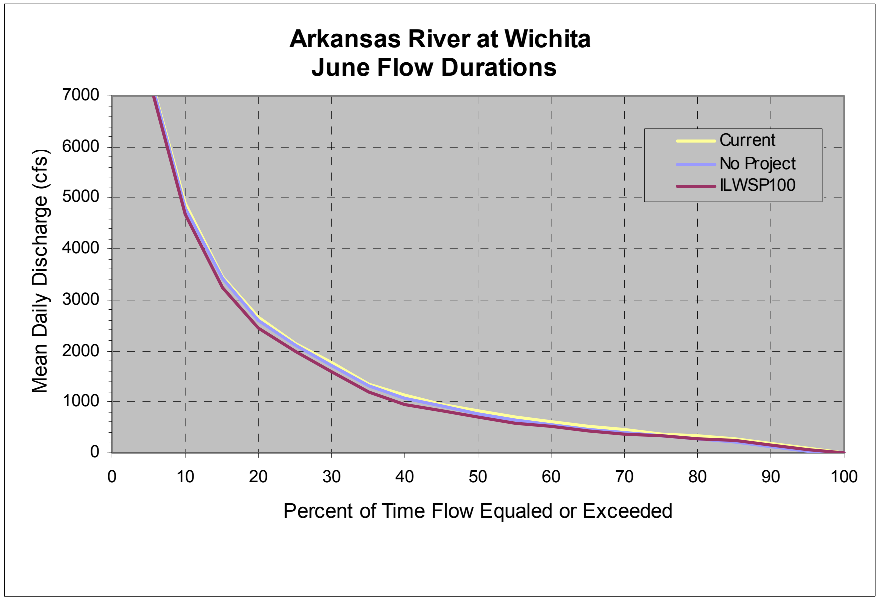

Figure 6. Frequency of flows for June in the Arkansas River at Wichita, KS.

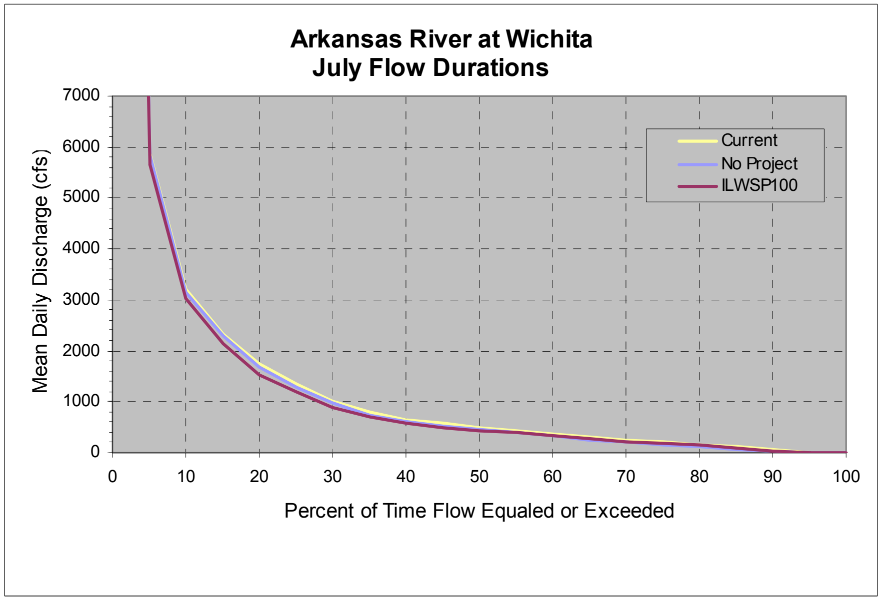

Figure 7. Frequency of flows for July in the Arkansas River at Wichita, KS.

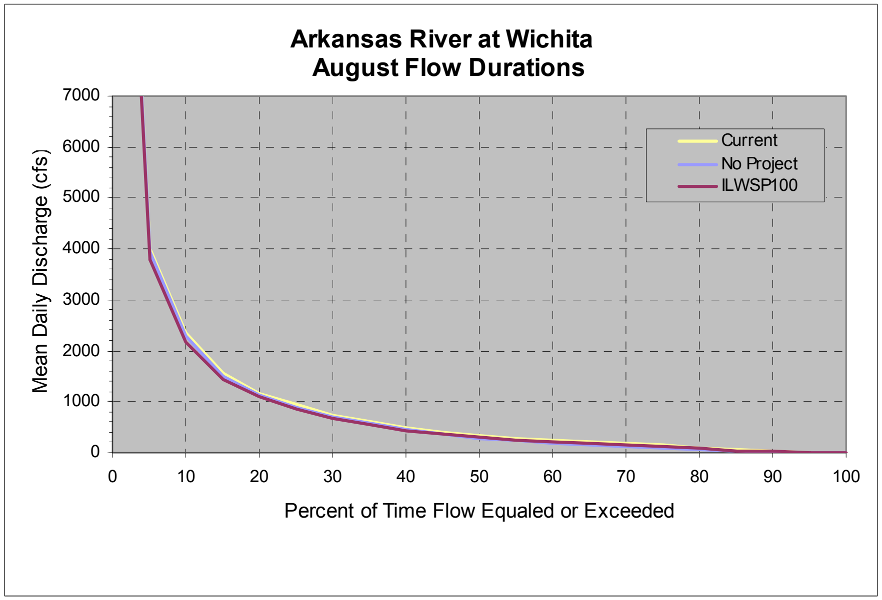

Figure 8. Frequency of flows for August in the Arkansas River at Wichita, KS.

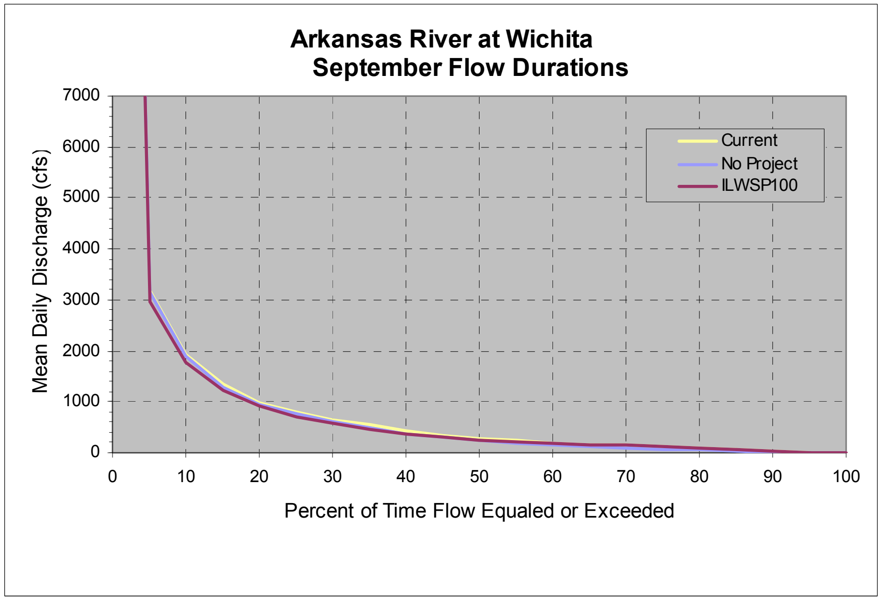

Figure 9. Frequency of flows for September in the Arkansas River at Wichita, KS.

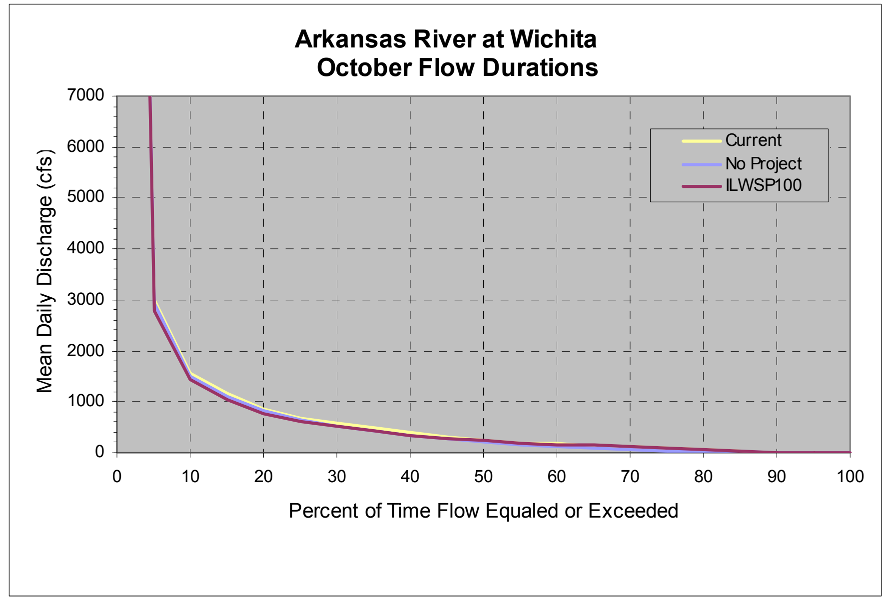

Figure 10. Frequency of flows for October in the Arkansas River at Wichita, KS.

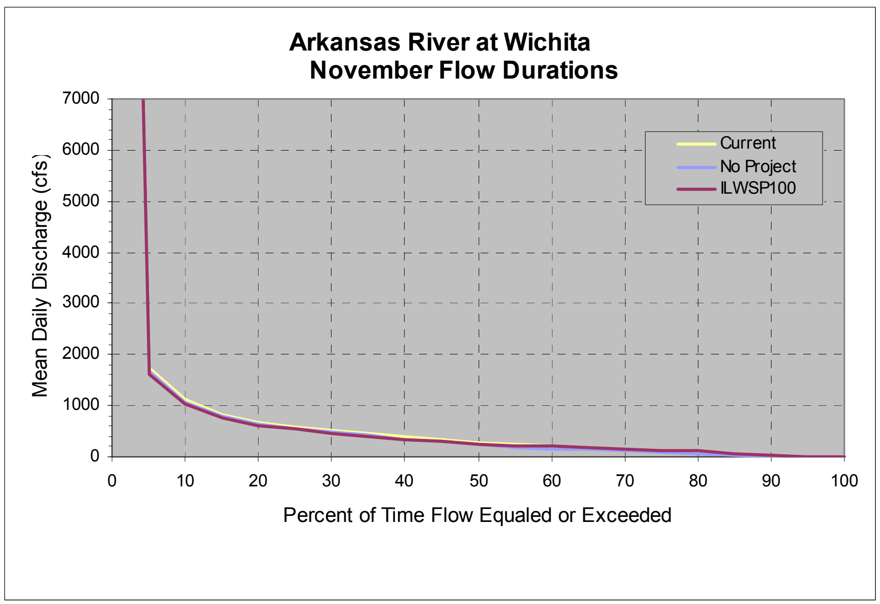

Figure 11. Frequency of flows for November in the Arkansas River at Wichita, KS.

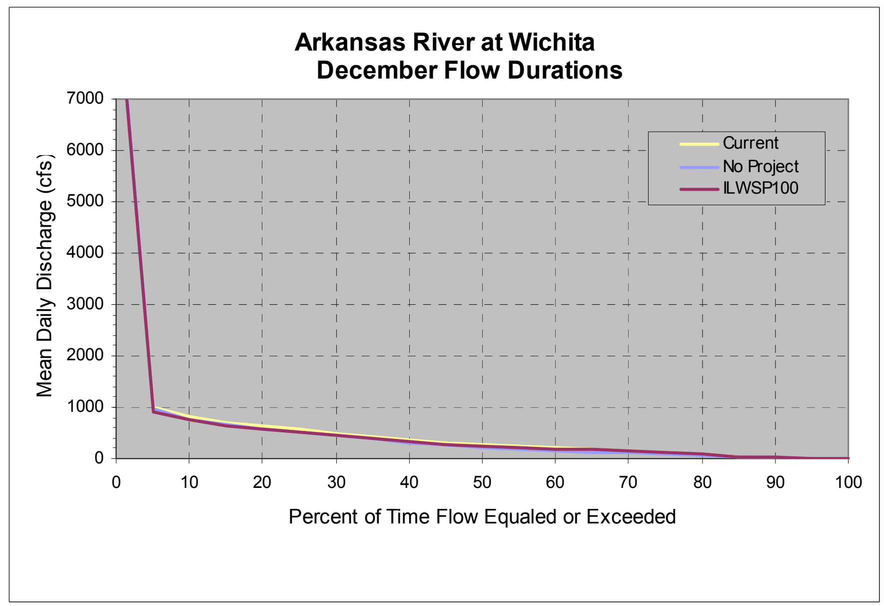

Figure 12. Frequency of flows for December in the Arkansas River at Wichita, KS.

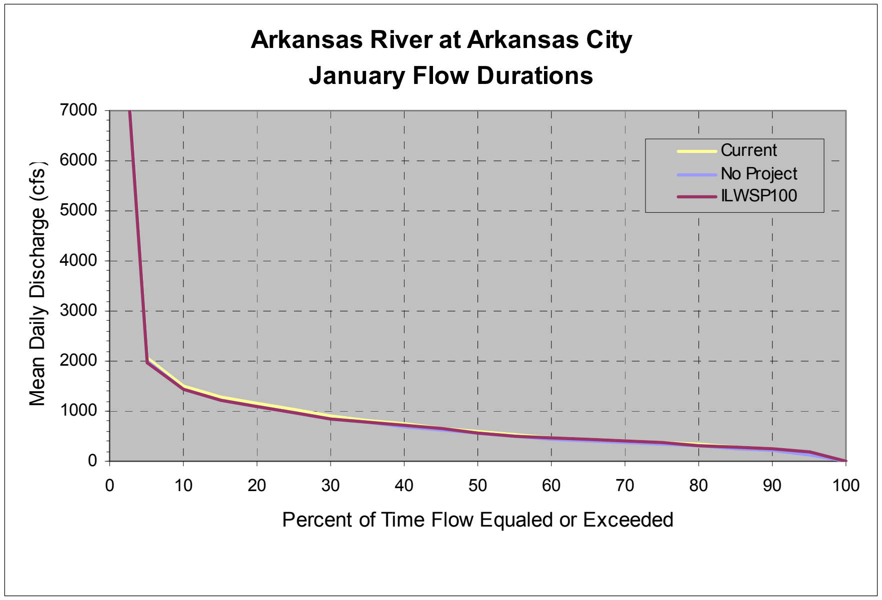

Figure 13. Frequency of flows for January in the Arkansas River at Arkansas City, KS.

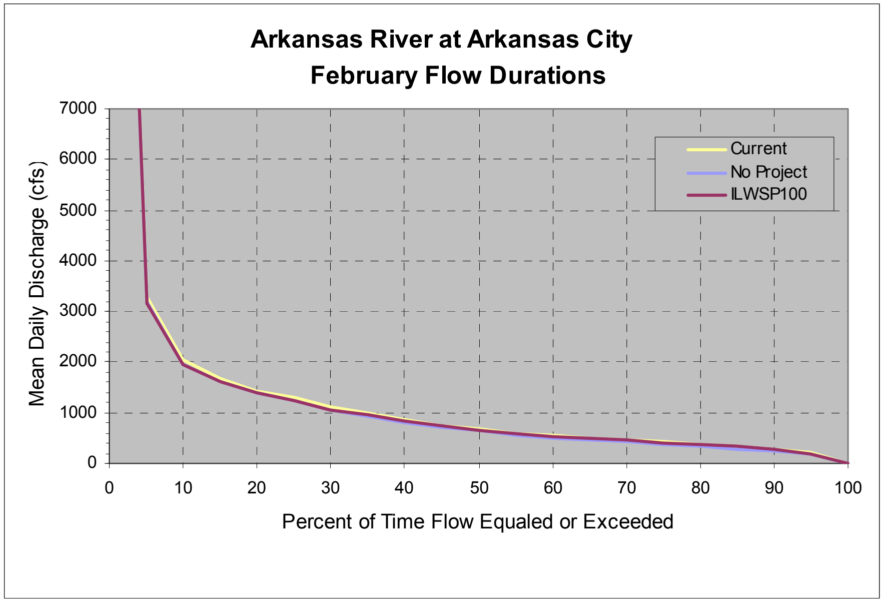

Figure 14. Frequency of flows for February in the Arkansas River at Arkansas City, KS.

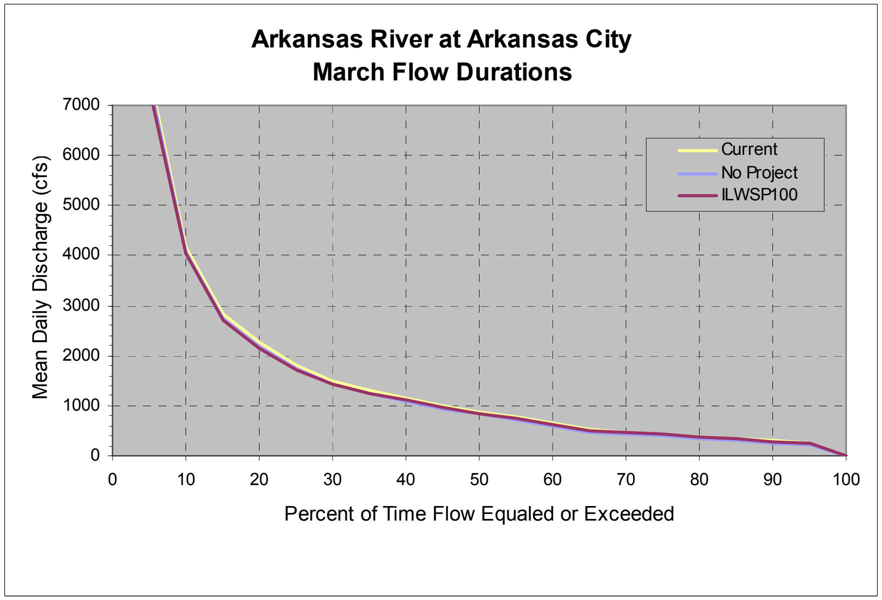

Figure 15. Frequency of flows for March in the Arkansas River at Arkansas City, KS.

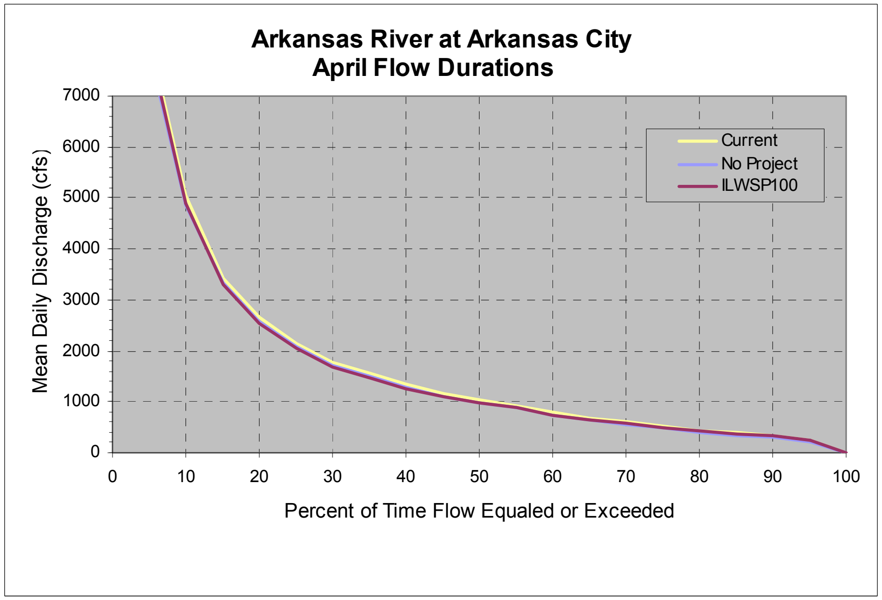

Figure 16. Frequency of flows for April in the Arkansas River at Arkansas City, KS.

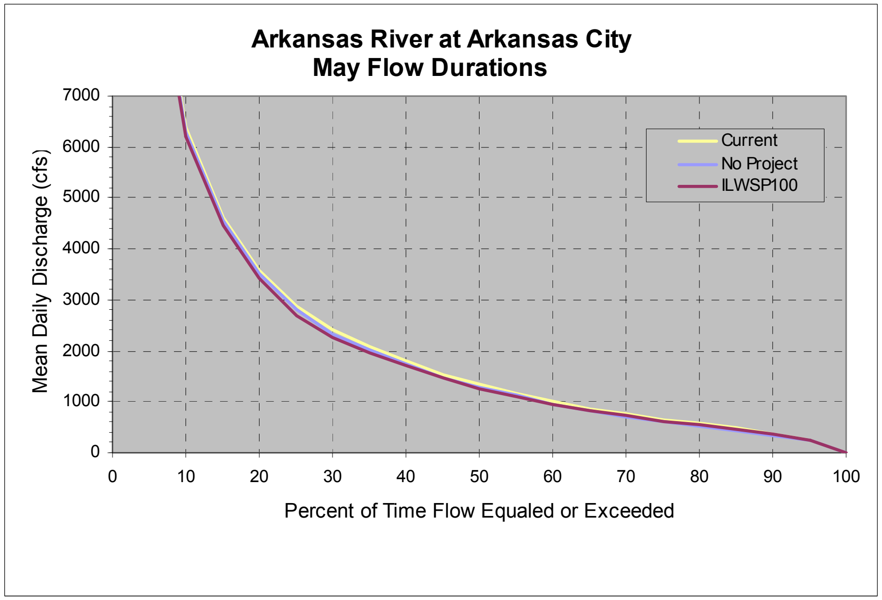

Figure 17. Frequency of flows for May in the Arkansas River at Arkansas City, KS.

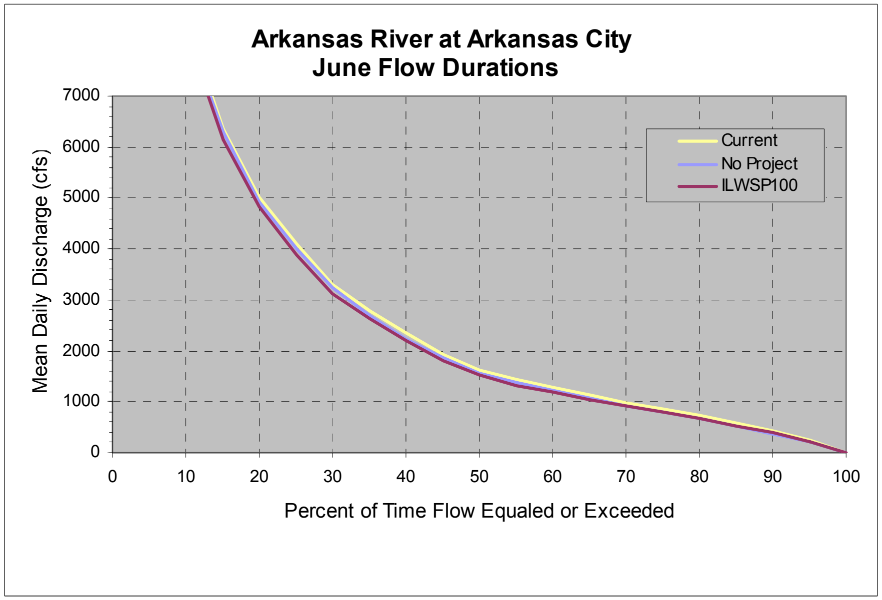

Figure 18. Frequency of flows for June in the Arkansas River at Arkansas City, KS.

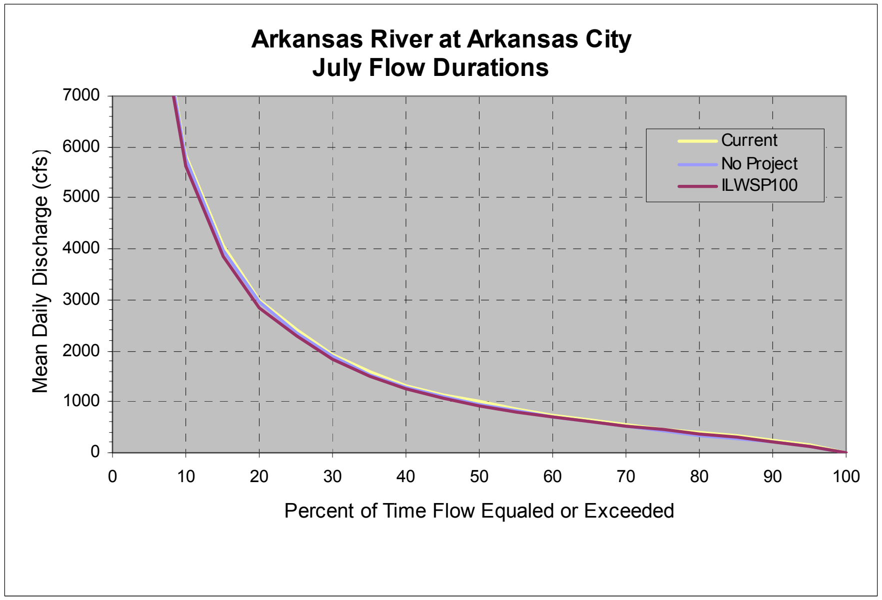

Figure 19. Frequency of flows for July in the Arkansas River at Arkansas City, KS.

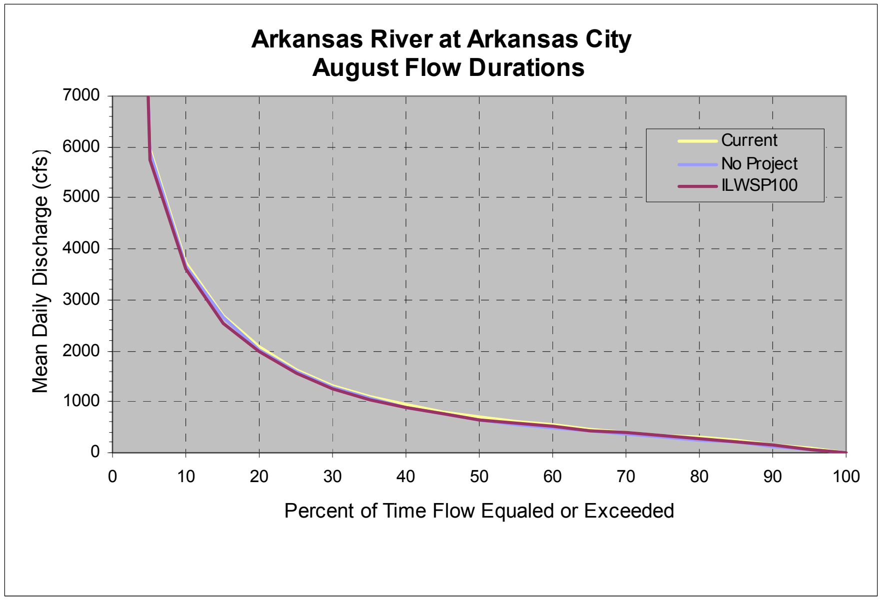

Figure 20. Frequency of flows for August in the Arkansas River at Arkansas City, KS.

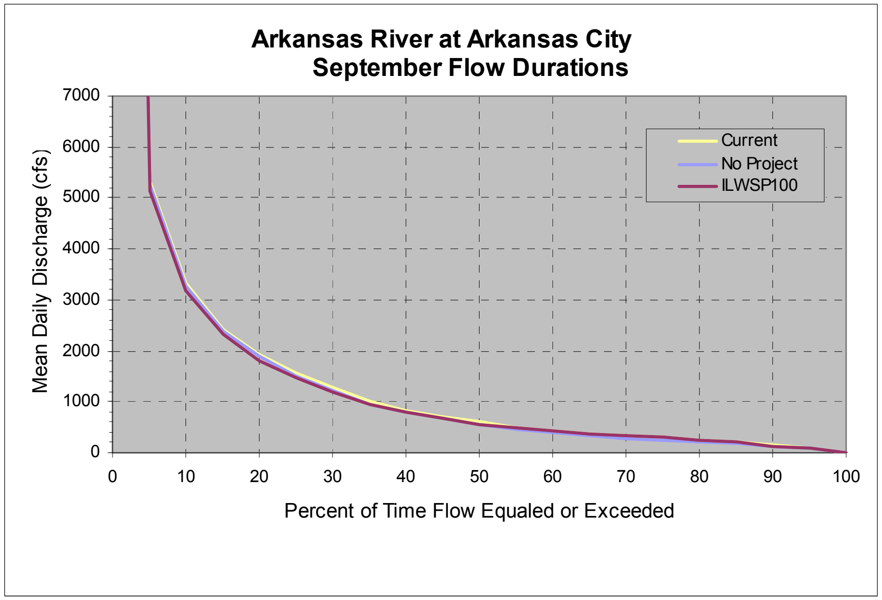

Figure 21. Frequency of flows for September in the Arkansas River at Arkansas City, KS.

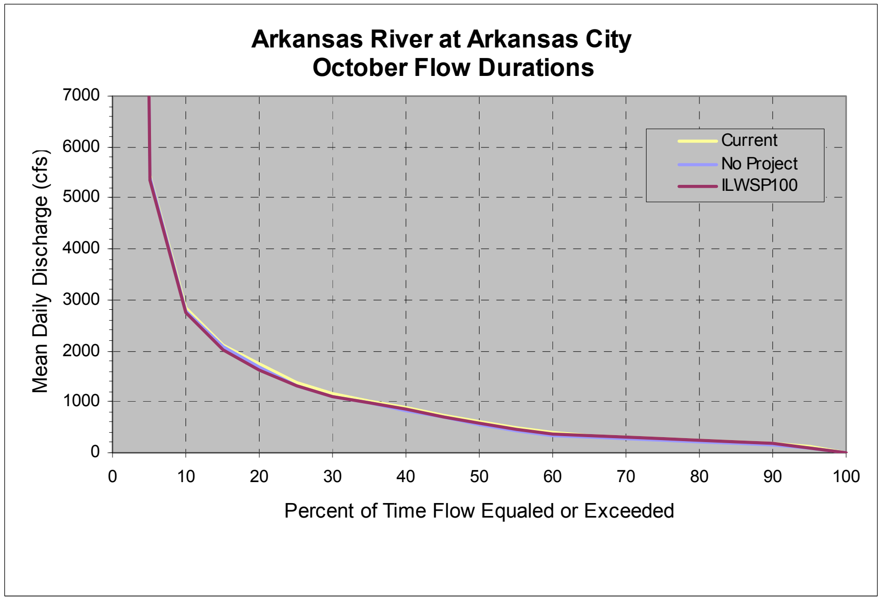

Figure 22. Frequency of flows for October in the Arkansas River at Arkansas City, KS.

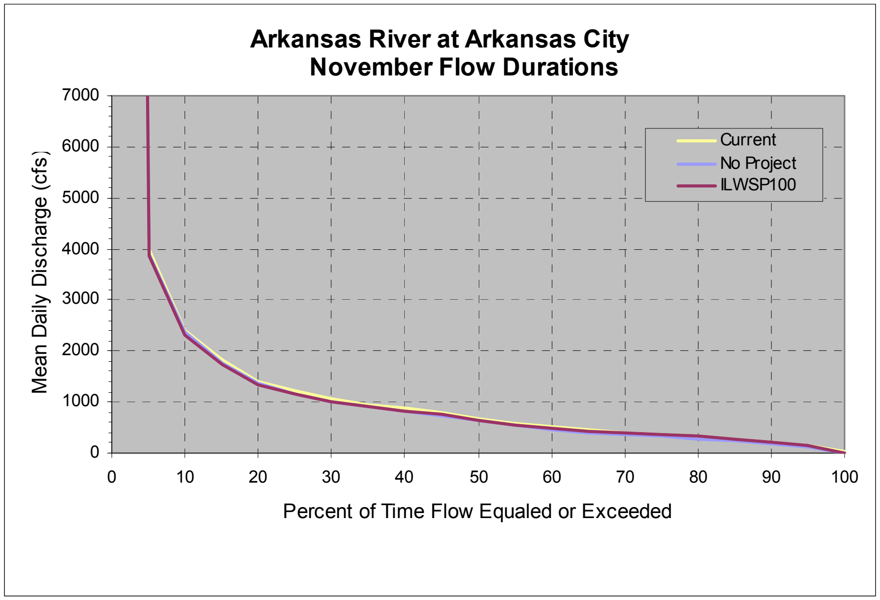

Figure 23. Frequency of flows for November in the Arkansas River at Arkansas City, KS.

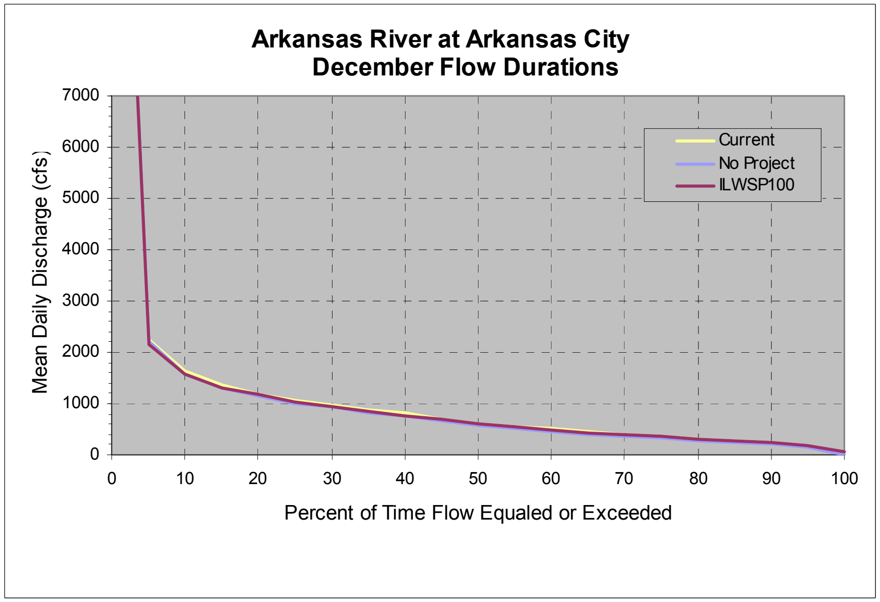

Figure 24. Frequency of flows for December in the Arkansas River at Arkansas City, KS.

TX-CB

APR 1 4 2009

Mr. Michael J. LeValley
Field Supervisor
U.S. Fish and Wildlife Service
Kansas Ecological Field Office
2609 Anderson Avenue
Manhattan, Kansas 66502

Subject: Informal Consultation Determination Letter for the Equus Beds Aquifer Storage and Recovery Project

Dear Mr. LeValley:

The City of Wichita (City) has requested funds from the U.S. Bureau of Reclamation (Reclamation) to implement an aquifer storage and recovery project (ASR Project) that stores flood flows withdrawn from the Little Arkansas River into the Equus Beds Aquifer. This would constitute a federal action and warrants consultation under Section 7 of the Endangered Species Act with the U.S. Fish and Wildlife Service.

Three Federally-listed species were determined to be potentially impacted by the project. These include the Arkansas River shiner (*Notropis girardi*), interior least tern (*Sterna antillarum*), and whooping crane (*Grus americana*).

Please find the attached *Biological Assessment of Federally Listed Species, Equus Beds Aquifer Storage and Recovery Project* for your review. It includes: 1) a description of the proposed project and affected area; 2) the status and life-history requirements of potentially impacted species; and 3) a description of direct, indirect, and cumulative impacts of the proposed project on those species.

Reclamation has determined that the construction and operation of the City's ASR Project would **not likely adversely affect any of the three species.** No direct impacts would occur because construction activities would be temporary and localized. Indirect and cumulative impacts that result from project operations would be **insignificant and discountable** because changes in the frequency of low, medium, and high flows in the Little Arkansas, Arkansas, North Fork Ninnescah, and Ninnescah rivers would have only minimal impacts on life-history characteristics of the three Federally-listed species.

Reclamation therefore requests your written concurrence with this determination. If you have any questions or need additional information, please call Ms. Ashley Ladd at (405) 470-4828. Thank you for your timely assistance in this matter.

Sincerely,

MARK A. TREVIÑO

Mark Treviño
Area Manager

Enclosure

cc: Mr. Eric R. Johnson, Ecologist
Kansas Department of Wildlife and Parks
Pratt Operations Office
512 SE 25th Ave.
Pratt, KS 67124
(w/enclosure)

bc: OK-Ladd, OK-Webster, OK-Claggett
(w/o enclosure to each)

GP-4200 (Davis), GP-4200 (LaFontaine)
(w/ enclosure to each)

WBR:CBalcombe:jms:04 13 09
Filename: Equus Beds ASR Project Consultation Letter