Missouri Water Plan

BACKGROUND DATA AND METHODOLOGY

MISSOURI DEPARTMENT OF NATURAL RESOURCES

January 2016

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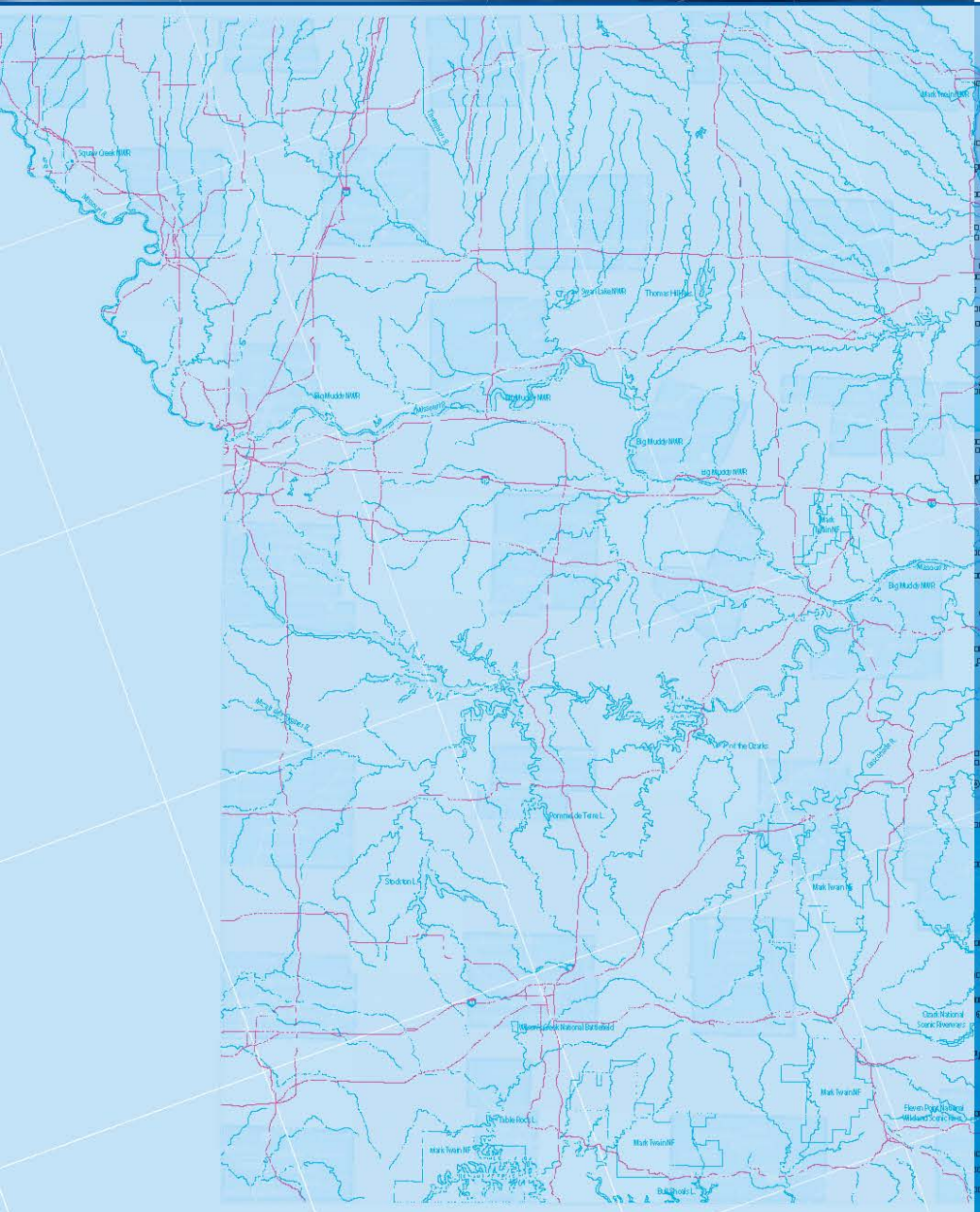

US Army Corps of Engineers ®
Kansas City District

CDM Smith

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Acronyms

ACEP	Agricultural Conservation Easement Program
ACWWC	Atchison County Wholesale Water Commission
AFY	acre feet per year
ASCE	American Society of Civil Engineers
CAFCom	Cost Analysis for Compliance
CARES	Center for Applied Research and Environmental Systems
CDBG	Community Development Block Grant
CDM Smith	CDM Federal Programs Corporation
COA	Census of Agriculture
CSR	Code of State Regulations
CU	consumptive use
CWNS	Clean Watersheds Needs Survey
CWSRF	Clean Water State Revolving Fund
DAC	Drought Advisory Committee
DBP	disinfection byproduct
DEC	Drought Executive Committee
DMR	discharge monitoring reports
DWINSA	Drinking Water Infrastructure Needs Survey and Assessment
DWSRF	Drinking Water State Revolving Fund
EIA	Energy Information Agency
EIERA	Environmental Improvement and Energy Resources Authority
EPA	U.S. Environmental Protection Agency
ERSG	Engineering Report Services Grant
FAC	Financial Assistance Center
FAO	Food and Agriculture Organization
FRIS	Farm and Ranch Irrigation Survey
GCM	general circulation model
GIS	geographic information system
GOWN	Groundwater-level Observation Well Network
Gpcd	gallon per capita per day
GPM	Gallons per minute
HUC	Hydrologic Unit Code
IBI	Index of Biotic Integrity
IUP	Intended Use Plan
MARC	Mid-America Regional Council (
MDC	Missouri Department of Conservation
MDNR	Missouri Department of Natural Resources
Mgd	million gallons per day
MHI	median household income
MoCWIS	Missouri Clean Water Information System
MORAP	Missouri Resource Assessment Partnership
MOU	Memorandum of Understanding
MS4	Municipal Separate Storm Sewer Systems
MWh	megawatt hours
NASS	National Agricultural Statistics Service

NPDES	National Pollutant Discharge Elimination System
NPS	Non-Point Source
NWIS	National Water Information System
NWQMC	National Water Quality Monitoring Council
OMW	Our Missouri Waters
PAH	polycyclic aromatic hydrocarbons
PER	Preliminary Engineering Report
PHAUCET	Pipe Hold and Universal Crown Evaluation Tool
RAD	radionuclide
RAM	Resource Assessment and Monitoring
RBP	Rapid Bioassessment Protocols
RD	Rural development
RESOP	Reservoir Operation Study Computer Program
SCO	combined sewer overflows
SDWA	Safe Drinking Water Act
SDWIS	Safe Drinking Water Information System
SEDS	State Energy Data System
SRF	State Revolving Fund
STEWARDS	Sustaining the Earth's Watersheds- Agricultural Research Database System
STORET	Storage and Retrieval
T&E	Threatened and Endangered
TMDL	Total Maximum Daily Load
TOC	total organic carbon
UIC	Underground Injection Control
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
USGS	United States Geological Survey
VIC	Variable Infiltration Capacity
WDF	Water Development Fund
WIFIA	Water Infrastructure Finance and Innovation Authority
WIMS	Well Information Management System
WQP	Water Quality Portal
WQS	Water Quality Standard
WTP	water treatment plant
WWTP	wastewater treatment plant
WY	water year

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Section 1

Purpose

The purpose of this report is to document known data and information regarding water planning within Missouri, assess the sufficiency of that data to support the Plan and any data gaps, and identify needed data for the appropriate methodologies. This report will serve as the foundation for charting the course for the next 24 months of the Missouri Water Plan development.

1.1 Introduction

By state statute, the Missouri Department of Natural Resources (MDNR) is charged with stewardship of the State Water Plan. MDNR has been successfully implementing the State Water Plan through ongoing studies, data collection, policy updates, and financing of projects where there is an identified need. Thus, the water plan and its successful execution is a compendium of multiple years of research, studies, and projects. The goal of the update to the Missouri Water Plan would be to make the plan current, comprehensive, and contemporary.

The Final Work Plan Outline (March 12, 2015) was developed by CDM Federal Programs Corporation (CDM Smith) to guide the Missouri Water Plan at the direction of MDNR in cooperation with the U.S. Army Corps of Engineers (USACE) and the Joint Committee representing the four water commissions, including (1) Clean Water Commission, (2) Safe Drinking Water Commission, (3) Soil and Water Commission, and (4) the Well Installation Board.

The Work Plan Outline identified core elements of the Missouri Water Plan and further identified major tasks. These core elements are as follows:

1. Demands – consumptive and non-consumptive
2. Supply availability
3. Gap analysis
4. Water supply and wastewater infrastructure
5. Water quality and improvements
6. Infrastructure and funding

To establish the baseline information from which to launch the Missouri Water Plan, the following major water topics were reviewed by CDM Smith.

1. Water Demand
2. Water Supply/Availability
3. Water Quality/Aquatic Species
4. Infrastructure, Financing/Funding

For each topic area, CDM Smith conducted an initial data review, developed the proposed methodology, identified data gaps and major issues, and provided recommendations regarding next steps, which are summarized in this report.

To initiate the data collection, CDM Smith conducted interviews of key MDNR staff as well as U.S. Department of Agriculture (USDA), U.S. Geological Survey (USGS) and USDA National Agricultural Statistics Service (NASS) staff. The notes from the interviews can be found in an **Appendix A** to this report.

1.2 Stakeholder Involvement Process

These data, methods, and recommendations contained within the report are based upon readily available information from the MDNR and partners. Additional regional and local data will be brought forward during stakeholder and public outreach as well as technical work group activities. The execution of the plan process is a three-pronged approach (1) interviewing key stakeholders, (2) conducting public and stakeholder outreach statewide and (3) engaging technical work groups per the four core areas of the Missouri Water Plan.

- **Stakeholder Interviews**

  Stakeholder interviews are foundational to the approach seeking to be inclusive of stakeholder concerns, issues and input upfront from the various key water sectors.

- **Public and Stakeholder Outreach**

  Public and stakeholder touch points throughout the process are critical to ensuring the plan is representative of the regional and local perspectives. The public will have opportunity for input to gain support for the Plan's implementation.

- **Technical Work Groups**

  Each water use sector has experts and practitioners in their respective fields. It is important to engage these respected professionals represented among the four core Plan elements during the data collection, methodology selection and validation of findings.

Together, the public, stakeholders and technical work groups will help set the direction of the Missouri Water Plan. The culmination of the stakeholder process will afford the Plan the best opportunity for buy-in and implementation.

1.3 Report Organization

Section 2 explores water demands followed by a review of water supply availability data and studies for both surface and ground water statewide in Section 3. Section 4 discusses water quality, aquatic species, and environmental flows data, their limitations and possible approaches. The Section 5 of the report evaluates the drivers and sources of data important to evaluate the infrastructure needs including water and wastewater treatment and supply. Section 6, Scenario Planning, will tie the previous core element discussions together in an approach for a prioritization and decision making process. In addition, this report offers an example outline of the future comprehensive Missouri Water Plan in **Appendix B**.

Section 2

Water Demand

2.1 Introduction

CDM Smith conducted an initial data review, developed the proposed methodology, identified data gaps and major issues, and provided recommendations regarding next steps, which are summarized in this section.

2.2 Data Review

This section presents an overview of key references and data resources that may be used directly or indirectly in executing the water demand methodologies for the Missouri Water Plan. For each reference or resource, a brief summary is provided along with a "resource value" on how it may be applied to the Missouri Water Plan with regard to water demand. Potentially relevant data sources reviewed included:

- Missouri State Water Plan Series Volume IV (WR48)
- Southwest Missouri Water Resource Study Phases I and II (2012, 2014)
- Northwest Missouri Regional Water Supply Phases I-VI
- Our Missouri Waters Initiative
- MDNR Major Water Users Database
- Safe Drinking Water Information System (SDWIS) and Missouri Drinking Water Watch
- Missouri Census Data Center and Cost Analysis for Compliance Census Data
- Missouri Well Information Management System (WIMS)
- U.S. Department of Agriculture (USDA) National Agricultural Statistics Service (NASS)
- University of Missouri Bootheel Irrigation Survey
- The Mississippi Agricultural and Forestry Experiment Station
- Department of Energy's Energy Information Agency (EIA)
- USGS Water Use in the United States

2.2.1 Missouri State Water Plan Series Volume IV (WR 48)

Water Use of Missouri is Volume IV of the MDNR Missouri State Water Plan Series. This volume was published in 1996 and describes Missouri's use of surface water and groundwater resources. The report covers private and public water supplies, industrial and agricultural water uses, and water use for electrical power production, navigation, recreation, fish, and wildlife. The data sources used within this report are described below and could be useful in the current Missouri Water Plan.

Applicability

While the data contained in WR 48 are dated, the methodologies and characteristics of water use are useful information for the Missouri Water Plan. Additional information within the report that will be used in development of the plan include information by sector regarding water source (surface water versus groundwater), consumptive use versus return flow, hydropower, commodity transport, recreation, fish and wildlife, and instream flow requirements.

Estimates of residential water use were derived from multiple sources including the MDNR Major Water User's Database and the USGS National Water-Use Information Program. Commercial and industrial water use estimates were derived from USGS *Estimated Use of Water in the United States*. Livestock water use was calculated by multiplying the per capita water requirements of farm animals by their population (population data were taken from the *U.S. Census of Agriculture [COA]*). Irrigation water use estimates were obtained from both the Major Water Users Database and USGS National Water-Use Information Program. Thermoelectric water use estimates were also derived from the Major Water Users Database and USGS *Estimated Use of Water in the United States*.

2.2.2 Southwest Missouri Water Resource Study Phases I and II (2012, 2014)

The *Southwest Missouri Water Resource Study Phase I* report describes the development of a long-term regional water demand forecast for 16 counties in Southwest Missouri (Barry, Barton, Cedar, Christian, Dade, Greene, Hickory, Jasper, Lawrence, McDonald, Newton, Polk, St. Clair, Stone, Taney, and Vernon Counties). The forecast estimates a projected water demand increase of 36.8 percent for the region by 2060, an increase from 339 to 464 million gallons per day (mgd) under a medium-growth scenario.

Applicability

The references and methodologies used to develop the demand forecast presented in Phase I of the study are useful in development of a statewide demand forecast.

Historical municipal water use by county was estimated using data collected from a water provider data request distributed to the 16-county region. These data were supplemented with the MDNR Census of Public Water Systems Database, where necessary. Nonresidential water use was estimated using per employee water use rates developed from the Institute for Water Resources' IWR-MAIN Water Demand Management Software. Livestock water use was estimated using per capita water requirements for farm animals, and irrigation water use was estimated using an average crop water requirement for the study area.

Phase II of this study evaluates current and future supply availability through the year 2060 for the 16-county region. A more detailed review of Phase II can be found within the Water Supply/Availability section.

2.2.3 Northwest Missouri Regional Water Supply Phases I-VI

The purpose of the Northwest Missouri Regional Water Supply study was to explore options for a regional plan to provide long-term water supply to the 12-county region of Northwest Missouri (Andrew, Atchison, Buchanan, Caldwell, Clinton, Davies, DeKalb, Gentry, Harrison, Holt, Nodaway, and Worth Counties). Phase I included an evaluation of source and treatment capacities of 83 public water systems within the study area as well as an evaluation of water demands and additional potential water supply sources for the area. Future demands through 2030 in the absence of the project were estimated by MDNR using USGS *Estimated Use of Water in the United States*. Nine of the 12 counties were manipulated to exhibit zero growth through 2030 in the absence of the project. Future growth with a project was estimated using the results of a departmental 2006 water system survey. Without the project, the Northwest Regional Water Withdrawals Forecast shows county water demands are expected to increase from 30 to 33 mgd by 2030. With the project, future water needs are expected to increase an additional 5.7 mgd above future water needs without the project. Phase II of the study provided the preliminary planning report for a regional water supply transmission system; Phase III outlined a methodology for water supply facilities to compare cost as well as identify current groundwater and surface water supplies; Phase IV provided a feasibility study update and Stage I Pipeline Preliminary Engineering Report (PER); Phase V evaluated the City of Savannah Water Treatment Plant (WTP) and Missouri-American to supply 50 percent of the GNWWC demand for 11 commission members; Phase VI provided a Cameron PER to evaluate two potential future sources of water supply; and in 2014 Phase VI was performed to further develop the Missouri-American water supply option.

Applicability

Phase I of the report is most relevant to the Water Demand element of the State Water Plan; however, future supply development should be taken into account during development of future population projections for the Northwest Region.

2.2.4 Our Missouri Waters Initiative

MDNR's Our Missouri Waters (OMW) initiative is a program designed to bring together local citizens and good science to create a path forward to improve and maintain healthy waterways. OMW includes 66 Hydrologic Unit Code (HUC)-8 watersheds, with a plan to address all watersheds within a 5-year cycle. MDNR is also working to establish Watershed Advisory Committees in more than 40 of these watersheds by the end of 2016.

Applicability

The development of the State Water Plan water demand element should use the information collected during the OMW watershed reports. This information may include a characterization of water use and water sources in the region, from both a quantitative and qualitative standpoint.

2.2.5 MDNR Major Water Users Database

According to MDNR: "Any surface or groundwater user with a water source and the equipment necessary to withdraw or divert 100,000 gallons or more per day (70 gallons per minute) from any stream, river, lake, well, spring, or other water source is considered a major water user in Missouri. Additionally, any combination of withdraws (wells, surface water pumps or diversions) that withdraw or divert 100,000 gallons or more per day (70 gallons per minute) also qualifies as a Major Water User."

The Major Water Users Database contains groundwater and surface water data by user by county. There are 10 categories of use, including: 1) municipal, 2) commercial, 3) fish and wildlife, 4) livestock, 5) agricultural irrigators, 6) electrical, 7) industrial, 8) drain and dewater, 9) recreational, and 10) other. All data contained within the database are self-reported annually by major water users.

Applicability

The Major Waters Database may be used to determine historical and baseline water use for municipal, commercial, and industrial water use. The database may also be used to evaluate historical trends in water use.

There are limitations to the data contained within the Major Water Users Database. MDNR has found that some major water users either do not report at all, or over/under estimate water use based on personal concerns of future taxation or water rationing. Thus, the overall accuracy of the database is unknown at this time, especially for self-supplied commercial and agricultural water use sectors.

Queried water use data are available by request through MDNR by sector and county.

2.2.6 Safe Drinking Water Information System and Missouri Drinking Water Watch

Missouri Drinking Water Watch serves as a public interface for SDWIS. This database contains records for approximately 5,600 public drinking water systems, of which approximately 2,700 are currently active systems. SDWIS data include a complete inventory of public drinking water systems as well as sample results, compliance activities, and water quality data. While information on individual facilities can be obtained through Drinking Water Watch, data queries can be completed via request through MDNR. Available fields, which may be useful in the demand element of the State Water Plan, include:

- Water System Detail Information: Water System Number and Name, Principal County, Federal Source
- Sources of Water
- Source Water Percentages
- Water Purchases
- Buyers of Water
- Service Connections
- Service Area
- Flow Rates: Average Daily Production, Total Design Capacity, Total Emergency Capacity

Applicability

The SDWIS database will be used to determine water sources, transfers, and production for public drinking water systems. This information may be used to establish county baseline municipal water demands.

Some SDWIS data are available in report format through the annual Census of Missouri Public Water Systems. Information contained within these annual reports, which may provide useful data for the demand element of the Missouri Water Plan, include:

- Population Served
- Percent Surface Water/Groundwater

- Supply Capacity
- Average Daily Consumption

Annual reports are available via the internet from the MDNR website at the following address: http://dnr.mo.gov/env/wpp/pdwb/census.htm. For the purposes of the Missouri Water Plan, annual report data can be queried at the county level via a data request to MDNR.

2.2.7 Missouri Census Data Center and Cost Analysis for Compliance Census Data

Population estimates and county level population projections are available through 2030 from the Missouri Census Data Center. Additionally, a social and economic database is currently maintained by MDNR for the Cost Analysis for Compliance Program, which will be valuable in collecting population and employment data at the county level for use in the demand forecast.

Applicability

Census data and projections will be used to extrapolate estimated county level water use into the future.

2.2.8 Missouri Well Information Management System

WIMS is a database on well records with data on wells installed since 1987. The database can provide location, use category, date, yield without pump, pump capacity, and static water level. For agriculture irrigation, the database will be valuable in identifying the exact locations where irrigation wells are located.

Applicability

The WIMS database may be useful in geographically assigning water use to specific regions in Missouri.

2.2.9 U.S. Department of Agriculture National Agricultural Statistics Service Census of Agriculture

NASS produces the COA every 5 years to capture a detailed picture of farms and ranches across the United States by state and county. The latest COA was conducted in 2012. Among the data collected for the Missouri COA are irrigated acres by county. The Farm and Ranch Irrigation Survey (FRIS) provides state level details on irrigation practices.

Applicability

The COA may be used to collect county-level agricultural data including irrigated acreage and livestock counts. This information will be used to develop a water demand forecast for agriculture in Missouri.

2.2.10 University of Missouri Bootheel Irrigation Survey

Conducted since 1987, this survey collects valuable information on irrigation practices and crop yields in Missouri's Bootheel where most irrigation in the state occurs.

Applicability

Data from the Bootheel Irrigation Survey may be used in development of the crop irrigation demands.

2.2.11 The Mississippi Agricultural and Forestry Experiment Station

This organization conducts research on furrow irrigation practices in the Mississippi River Valley Alluvial Aquifer that is applicable to Missouri.

Applicability

Research data from the Mississippi Agricultural and Forestry Experiment Station may be used to determine crop irrigation water requirements for the development of the agriculture forecast.

2.2.12 Department of Energy's Energy Information Agency

The State Energy Data System (SEDS), which operates under the U.S. Energy Information Administration (EIA), provides comprehensive state-level estimates of energy production, consumption, prices, and expenditures by source and sector from 1960 through 2013. These data can be used in developing the water demands for thermoelectric power generation within the state.

Applicability

EIA data for Missouri may be used in development of water demands for thermoelectric power generation.

2.2.13 USGS Water Use in the United States

Every 5 years, water use data at the county level are compiled into the USGS National Water Use Information Program Database. The most recent USGS available data are from 2010. All states provide estimates for public supply, domestic, irrigation, livestock, aquaculture, industrial, mining, and thermoelectric power. Missouri also provides estimates for water sources for each sector (groundwater and surface water).. These data can be used in estimating the proportion of population in each county that is municipally-supplied and self-supplied.

Applicability

The references and methods used to estimate USGS water use in Missouri may be used in the development of a statewide water demand forecast.

2.3 Proposed Methodology

Water demand can be estimated at the county level for most water-using sectors since demographic projections are available at this level. However, it is recommended that the water demand forecasts by sector need to be disaggregated between surface water and groundwater sources and, furthermore, associated with streams (e.g., HUC-8 areas) and aquifers. The suggested water-using sectors for the forecast include public (municipal) water supply, residential self-supply, self-supplied industrial, thermoelectric power generation, livestock, and crop irrigation. For each sector the “driver times rate of use” model will be developed as illustrated in **Figure 2-1**. The appropriate driver and corresponding representative rate of use will be identified for each sector. In addition, alternative planning scenarios will be defined, in collaboration with MDNR and in coordination with the supply and infrastructure analyses, such that variations in the sector “drivers” and/or “rate of use” can provide a likely range of potential future demand.

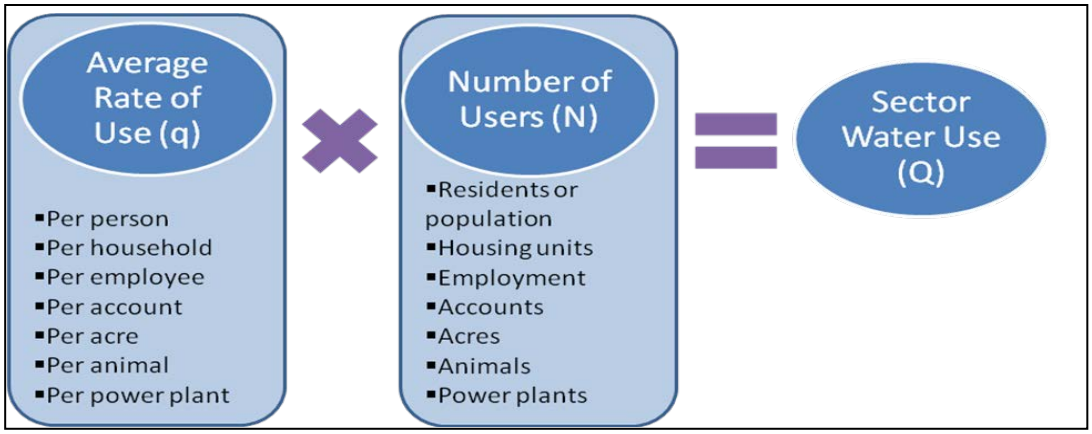

Figure 2-1. The Driver Times Rate of Use Approach

Historical water use data assembled to provide an estimate of base period use may vary by sector and data availability but generally should represent a concurrent time period such as from 2010 to 2014. The future water use of each sector is determined by the growth of a "driver" (e.g., population, employment) that is appropriate for each sector and is either available from an acceptable source or projected into the future in a manner acceptable to the sector work group.

MDNR maintains several databases that may provide valuable information regarding historic water use. The Major Water Users database may be used for annual water withdrawals by source for registered users by sector throughout the state. Since the data are self-reported, supplemental data sources for cross-checking purposes may include the SDWIS data for municipal systems, USGS Water Use in the United States estimates, EIA thermoelectric withdrawal estimates, and USDA COA data.

Historical water use can be aggregated by water use sector, county, stream/tributary or aquifer, as illustrated in **Figure 2-2**. The following discusses how the historical water use can be aligned with historical and projected demographic data to develop a water demand forecast for each sector that is compatible with the surface and groundwater availability assessments.

Sector	Base Period		Base Period MGD		2050 MGD	
	%GW	%SW	GW	SW	GW	SW
Crop Irrigation	85.4%	14.6%	7,527	1,289	8,676	1,364
Thermoelectric	0.3%	99.7%	3	1,174	3	1,351
Municipal	33.2%	66.8%	129	258	130	377
Industrial	24.5%	75.5%	71	219	52	149
Duck Habitat	35.0%	65.0%	92	171	92	171
Aquaculture	100.0%	0.0%	103	—	103	–
Livestock	39.9%	60.1%	11	16	12	17
Self-Supplied Domestic	100.0%	0.0%	13	—	14	–
Shale Gas	0.0%	100.0%	–	11	–	–
Mining	15.5%	84.5%	1	5	2	12
Self-Supplied Commercial	19.7%	80.3%	1	4	1	6
TOTAL			7,950	3,148	9,086	3,449
			71.6%	28.4%	72.5%	27.5%

Figure 2-2. Example of a Disaggregated Water Demand Forecast by Sector and Source where GW is groundwater and SW is surface water.

2.3.1 Municipal (Public-Supply) and Domestic Self-Supplied Water Use

Water use among publically supplied municipal water users by county can be projected into the future based upon the rate of growth of the county population. Estimates of residential water use are available from the Major Water Users Database maintained by MDNR as well as the SDWIS database. A survey of municipal systems may be required to determine monthly water use. The reported municipal water volume can be divided by the reported population served and/or number of connections to derive a gallon per capita per day (gpcd) rate of use for each municipality. The average per capita use for each system includes some imbedded commercial and industrial water use as well as distribution system losses.

MDNR staff have agreed to work with data provided by the Missouri Census Data Center to produce population projections by county. The rate of growth for each county can be applied to the population served for each municipal system to project the future population of each system. Where a municipal system's service area spans multiple counties, multiple growth rates may be used to project future population served by the system. The system per capita use rate times the projected population served provides an estimate of the future water demand for each municipal system. If surface water and groundwater modeling is incorporated into the State Water Plan, the municipal system demands can be assigned to the specific withdrawal nodes in these models.

USGS 2010 data on the percent of population that is publically supplied and self-supplied for each county can be used to estimate the percent of county population self-supplied and assumed to be on groundwater. Average public-supply county gpcd water use can be assigned to self-supply residential water use, or USGS data can be used to determine the self-supplied gpcd for each county. Self-supplied water use is projected into the future based upon the rate of county population growth. The self-supplied water demand can be assigned to the dominant aquifer underlying the county or proportioned among aquifers if adequate information is available.

2.3.2 Self-Supplied Industrial Water Use

Water use among self-supplied industrial water users by county can be projected into the future based upon the rate of growth of the county employment. It is assumed that any increase in water use in cases of increased employment will serve as proxy for growth in the number of self-supplied industrial users or expanded water use among existing self-supplied industrial users. County employment projections may be available from the MDNR economist or obtained from a third party vendor (e.g., Woods & Poole). Base period water use for each large water-using industrial facility can be obtained from the Major Water Users data. In addition, the 2010 USGS data have the estimated industrial water use and number of facilities by county.

Future industrial water demands can be calculated by applying the county employment rate of growth (rate of growth can be positive or negative) to the base year industrial water demand of each facility. The industrial facility water demands can be assigned to specific withdrawal nodes in the surface water and groundwater models by location.

2.3.3 Power Generation Water Use

Water use among self-supplied thermoelectric power (power) water users can be estimated for each major power-generating facility in the state and projected into the future based upon consideration of fuel type, prime mover, cooling method, and regional projections of future power generation. Plant-specific withdrawal and consumption factors can be developed using data from

MDNR's Major Water Users data and the Department of Energy EIA. Base period water use factors for withdrawals and consumption (in gallons per megawatt hours [MWh]) can be multiplied by the annual power generation (in MWh) for each unit and then converted to mgd. Thus, a withdrawal mgd and consumption mgd can be estimated for each generating unit. Most water use is from surface water sources, and the non-consumptive volume is returned to surface water. Return volume may be able to be verified using MoCWIS point source discharge data.

Future self-supplied thermoelectric power water demands can be based upon EIA projections of power generation by regional pool and fuel type. (Note that Missouri is supplied by both the Southeastern Electric Reliability Council Gateway region and the Southwest Power Pool North region.) The rate of growth in power generation by fuel type by region can be assigned to the facilities by fuel type and location. However, projections of future power generation for each facility may be limited by the maximum generating capacity of each unit. The projected power generation by facility can be multiplied by the withdrawal and consumptive use requirements of each generating unit to derive the estimated future water demand by facility. Estimated withdrawal and consumptive water demand can be summed statewide as illustrated in **Figure 2-3**.

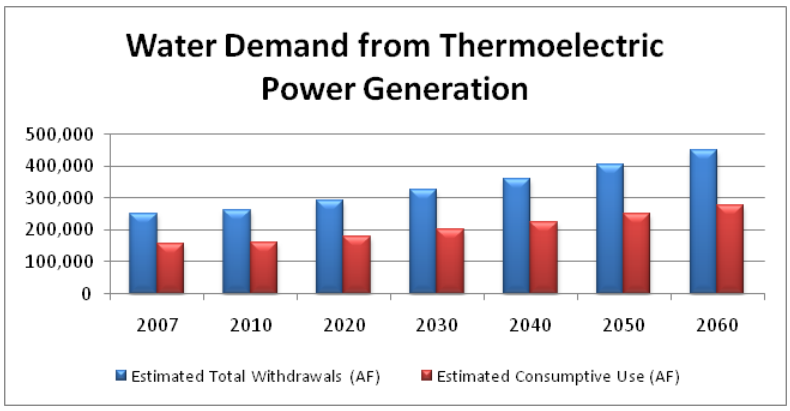

Figure 2-3. Example of Water Demands for the Thermoelectric Power Generation Sector

Hydroelectric power generation, though non-consumptive, requires adequate water supply to meet production goals. Availability of water within watersheds upstream of hydroelectric facilities will

2.3.4 Livestock Water Use

Current estimates of livestock water demand would be developed based on the major livestock groups in Missouri and their respective daily water requirements. The monthly livestock water demand is calculated by multiplying the daily water requirement (gallons) for each group by the number of livestock and then the number of days in a month, as shown in **Equation 1**.

$$\mathbf{QLS}_{n,c,m} = \mathbf{LSC}_{n,c,m} \times \mathbf{DWR}_{n} \times \mathbf{D}_{m} \qquad \textbf{Equation 1}$$

Where:

- $QLS_{n,c,m}$ = Livestock water demand in gallons for animal group (n) in county (c) in month (m)
- $LSC_{n,c,m}$ = Livestock count for animal group (n) in county (c) and month (m)
- DWR_{n} = Daily water requirement per animal (n) in gallons per day
- D_{m} = Days in month (m)

It would be assumed that daily water use is an annual average and therefore is held constant year-round for each animal group. The USGS Water Use in the United States database and MDNR Major Water Users Database would be analyzed to determine the proportion of groundwater and surface water use, and these percentages would be applied to the demands in order to assign a source to the demands. Total monthly water demand for each animal group is then summed by county to determine total daily consumption for each county.

Future livestock water demand can be based upon trends derived from the USDA NASS. Historic livestock count by animal group and county can be used to project future livestock counts. The projected livestock count can be applied to Equation 1 to derive the estimated future water demand by livestock group.

2.3.5 Crop Irrigation Water Use

The basic methodology for estimating water withdrawals for irrigated agriculture water use is developed at the county level and defined as acres irrigated times the average application rate per acre. The primary factors in this equation are defined as:

1. Number of irrigated acres
2. Percentage of acres irrigated with surface water and groundwater
3. Delivery method of the irrigation systems (e.g., furrow or pivot system)
4. Type of crops irrigated

The first two items drive the estimate of irrigation water use and is typically based on historical trends, with some type of reasonable limit placed on the growth (so that irrigated acres do not "grow" larger than what is reasonably available). **Figure 2-4** shows an example of statewide projections of future irrigated acres by crop type. These projections are typically not available statewide. However, because these projections drive the sector demand forecast, it is important that stakeholders agree to these projections for water resource planning purposes.

The last two items drive the per acre application rate. This can be forecasted based on historical or projected crop trends, improved efficiency, or, in some instances, held constant from the base year.

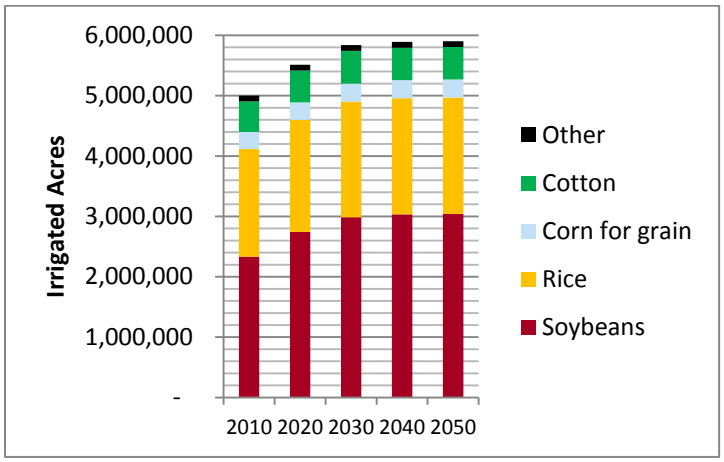

Figure 2-4. Example of Projected Statewide Irrigated Acres by Crop

The estimate of crop irrigation withdrawal for each county is defined as total irrigated acres by crop type multiplied by the average application rate for the crop(s) in that county, as shown in **Equation 2**.

$$\boldsymbol{Q_{c,i,y} = IA_{c,i,y} \times AR_{c,i,y}} \qquad \textbf{Equation 2}$$

Where:

- $Q_{c,i,y}$ = Crop irrigation withdrawal in acre feet per year (AFY) in county (c) for crop (i) in year (y)
- $IA_{c,i,y}$ = Total irrigated acres in county (c) for crop (i) in year (y)
- $AR_{c,i,y}$ = Average application rate in acre-feet per year per acre in county (c) for crop (i) in year (y)

Total water demand for all irrigated agriculture in the county is then the sum of all crop withdrawals. The estimated crop irrigation withdrawals by county are then assigned to demand nodes by location. The most probable data source is the MDNR Major Water Users Database. Equation 2 estimates the gross irrigation water requirement and thus includes what the crop requires and system losses or inefficiencies.

The USDA NASS conducts the COA every 5 years. The COA captures a detailed picture of farms and ranches across the United States by state and county. The latest COA was conducted in 2012. Among the data collected for the Missouri COA are irrigated acres by county. Data on the type of crop irrigated by county are available for barley, corn for grain, cotton, rice, sorghum, soybeans, wheat, and vegetables harvested for sale.

NASS also produces, as a supplement to the COA, the FRIS. The latest release was in 2013. The survey is devoted entirely to collecting on-farm irrigation data for the United States. Data are only available at the state level, but can provide valuable information on irrigation practices and average water applied per acre.

The University of Missouri, through its Commercial Agriculture Program, has a great deal of supplemental information available that could prove useful in estimating irrigation demands. The program has collected data via a Bootheel Irrigation Survey since 1987. The survey results include data on the method of irrigation, common practices, and the average application rate for corn, cotton, and soybeans. The University's website offers a number of links to crop water use calculators and charts that can be used to estimate the monthly water use requirements.

The Mississippi Agricultural and Forestry Experiment Station conducts research into furrow crop production relevant to all of the producers in the Mississippi River Valley Alluvial aquifer. The results of their research may prove useful in determining the application rates for furrow crop production both currently and in the future, considering the innovative technology they test, produce, and promote such as PHAUCET (Pipe Hold and Universal Crown Evaluation Tool), soil moisture sensors, and surge valves.

2.4 Data Gaps

Currently, a source for monthly municipal withdrawals and/or consumption is not available. Monthly data would assist in verification of changes in water use due to seasonality. An electronic survey of municipal systems can be conducted to collect data to determine monthly water use patterns.

The Major Water Users Database is voluntarily self-reported per the criteria presented above in section 2.2.5. Data may be used to extrapolate water use information for the purposes of the Plan. During the Plan development process, means of improving the quantity and quality of the data within the Major Water Users Database will be explored and recommendations made in the Plan.

Initial estimates of water demand by sector and county can be developed with the available data and the proposed methodologies, as illustrated in **Figure 2-5**. Reviews of the initial estimates can be reviewed by MDNR staff, stakeholders and technical work groups to either validate assumptions or provide additional information to revise the water demand estimates.

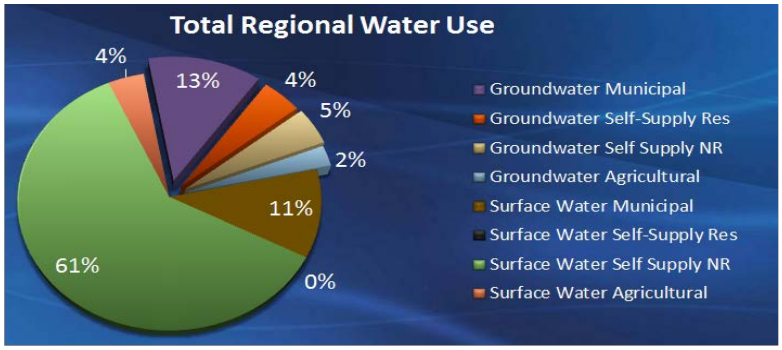

Figure 2-5. Example Graphic of Estimated Water Demand by Sector (Southwest Missouri, Phase I)

During the analysis of water use information and the development of the water demand forecasts, any shortcomings in the data will be noted. Recommendations for improving data collection methods will be included in the final report.

2.5 Major Issues

Water use in some sectors was impacted by the Great Recession from about 2008 to about 2013. Water use factors developed from this time period will need to be carefully examined to determine if recessionary impacts are reflected in the data. If so, appropriate adjustments to the data should be made to assure that water use factors used to project future water use reflect non-recessionary conditions. Similarly, some sectors and areas of the state may have been affected by drought conditions, which will effect water use information. Assumptions will need to be based on maximum daily use for the various sectors analyzed.

Potential water shortages especially during drought conditions have been established as an eminent danger statewide. Regional concerns of population growth, high water demand growth rates, localized overuse of groundwater, and future potential overuse of surface water all could lead to future water shortages throughout many portions of Missouri. Development of a statewide demand forecast will assist the state in developing sustainable alternatives to meet future demand.

2.6 Recommendations

Following development of a final methodology for the water demand forecast, review and collaboration with stakeholders and technical work groups is strongly recommended. Additional review and input from the University of Missouri Agricultural Extension is encouraged for the livestock and crop irrigation sectors of the forecast.

Define at-risk water use/demand areas along with associated risk timelines, for instance, industries of concern and associated geographic areas of concern for those industries. This will be done in conjunction with the supply evaluation as described in Section 3.6.

Three planning scenarios will be defined in collaboration with MDNR for evaluating a potential range of demands. These scenarios may reflect alternative growth or climatic conditions (e.g., normal, extreme wet and extreme dry). These three scenarios will be coordinated with the supply and infrastructure alternatives to provide a consistent range of planning scenarios.

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Section 3

Water Supply/Availability

3.1 Introduction

CDM Smith conducted an initial data review, developed the proposed methodology, identified data gaps and major issues, and provided recommendations regarding next steps, which are compiled in this section.

3.2 Data Review

This section presents an overview of key references and data resources that may be used directly or indirectly in executing the supply availability methodologies for the Missouri Water Plan. For each reference or resource, a brief summary is provided along with an "Applicability" box on how it may be applied to the Missouri Water Plan with regard to supply availability. Potentially relevant data sources identified include:

- Missouri State Water Plan Series, Volume I: Surface Water Resources of Missouri (WR45)
- Missouri State Water Plan Series, Volume II: Groundwater Resources of Missouri (WR46)
- Missouri Drought Plan (WR69, 2002)
- MDNR Water Supply Study (2011)
- USGS Stream Gage Data
- MDNR Groundwater Monitoring Network
- USGS Ozark Aquifer Models
- MDNR Major Water Users Database
- MDNR GIS Catalog
- U.S. Environmental Protection Agency (EPA) Drinking Water Infrastructure Needs Survey and Assessment
- Safe Drinking Water Intended Use Plan (IUP)
- SDWIS - MDNR Public Water Systems 2013 American Society of Civil Engineers (ASCE) Report Card for Missouri's Infrastructure
- MDNR Census of Public Water Systems
- University of Missouri Center for Applied Research and Environmental Systems (CARES)
- Southwest Missouri Water Resource Study Phases I and II (2012, 2014)
- Northwest Missouri Regional Water Supply Phases I through IV
- Howard County Regional Water Commission
- Caldwell County Commission, Little Otter Creek Reservoir

- Clarence Cannon Wholesale Water Commission, Mark Twain Lake
- North Central Missouri Regional Water Commission, East Locust Creek Reservoir
- Atchison County Wholesale Water Commission

CDM Smith performed preliminary research into each of the identified data sources and conducted in-person and telephone interviews with several key staff from MDNR and other agencies to gain a better understanding of the data available and identify potentially critical data gaps that may inhibit the production of the water supply availability portion of the Missouri Water Plan. A brief summary of the data types and expected value available from each source is provided below.

3.2.1 Missouri State Water Plan Series, Volume I: Surface Water Resources of Missouri (WR45)

Volume I of the Missouri State Water Plan was published in 1995. This report is organized by six major basins and includes an in depth statistical analysis of each basin based on selected gage records. In addition, a summary of the state's physiography, climate, hydrologic cycle, surface water quality, and general water resources such as lakes and reservoirs (over 120). The six major basins are listed here:

- Upper Mississippi River Tributaries
- Missouri River Tributaries (north)
- Missouri River Tributaries (south)
- Lower Mississippi River Tributaries
- White River Tributaries
- Arkansas River Tributaries

Applicability

WR45 provides a good baseline for evaluating the historical streamflow records within the State of Missouri. A similar approach, though with more recent gage data and modernized deliverables, is included as part of the supply availability methodology below.

WR45 concluded that, at the time of its publishing, surface water resources were sufficient to meet current needs. However, the authors note that this general conclusion, based on average flow and availability of surface water resources, does not always occur "on average." Certain portions of the state, especially those dependent upon surface water more than groundwater, are susceptible to supply availability issues during long dry periods, and these events should be carefully considered by water planners and managers across the state.

3.2.2 Missouri State Water Plan Series, Volume II: Groundwater Resources of Missouri (WR46)

Volume II of the Missouri State Water Plan was published in 1997. This report is organized by seven groundwater provinces and two sub-provinces. For each province and sub-province,

Applicability

WR46 provides a good baseline for evaluating the groundwater resources within the State of Missouri. This baseline methodology is expanded upon in the methodology section below to include more recent evaluations and investigations into Missouri's groundwater resources. Most significantly, the U.S. Geologic Survey (USGS) has developed detailed numerical models of some groundwater aquifers in the state. These models evaluate the dynamic relationship between hydrogeology, water use, and climate and can be used to establish a "safe yield" for an aquifer.

an in-depth overview of the groundwater resources is provided. This includes a description of the geology, hydrogeology (e.g., aquifer volumes), and contamination potential. In addition, a statewide summary of the state's physiography, hydrogeology, hydrologic cycle, and groundwater quality is included. The seven provinces and two sub-provinces are listed here and shown in **Figure 3-1**.

- Northwest Missouri
- Northeast Missouri
- Osage Plains
- Springfield Plateau
- Salem Plateau
- St. Francois Mountain Area
- Southeast Missouri
- Other Bedrock Aquifer Area (sub-province)
- Mississippi and Missouri River Alluvium (sub-province)

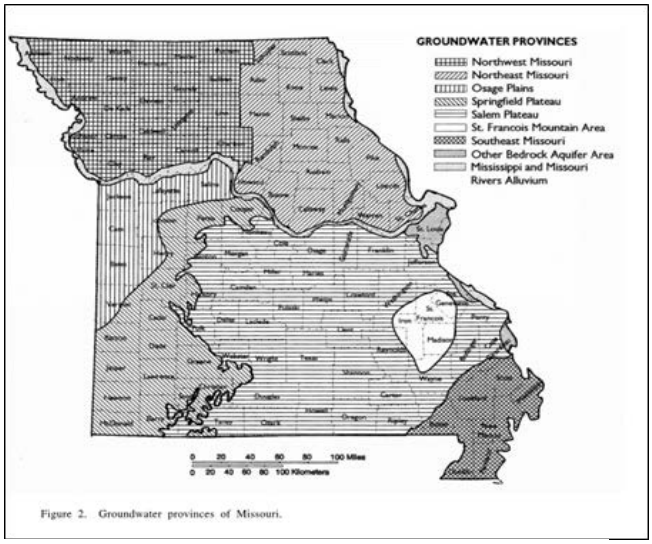

Figure 3-1. Missouri Groundwater Provinces

Groundwater Resources of Missouri - WR46 concluded that at the time of its publishing, on average, there existed approximately 7.17 billion gallons of groundwater per square mile. Though, similar to surface water, this quantity of groundwater is not evenly distributed across the state with respect to area, depth, and quality. In some cases, extraction of groundwater may not be economical for potable uses. The authors concluded that with proper management Missouri's groundwater resources are sufficient to meet the needs of various uses, including domestic, municipal, industrial, agricultural, and recreational needs. However, they noted that avoiding over-use at the local level and avoiding contamination are paramount to the long-term viability of this important resource.

3.2.3 Missouri Drought Plan (WR69, 2002)

The most current Missouri Drought Plan was published in 2002. The plan was prepared, partially, in response to a drought that occurred during the years 1999 and 2000. The 1999/2000 drought primarily impacted north central and northwestern portions of the state and was more severe for rural communities than larger municipalities. The drought plan was modeled after similar drought planning work undertaken by the State of Kentucky. Topics covered by the plan include defining drought and associated sub-categories, the state's susceptibility to drought, drought response plan operations, and organizational assignments and responsibilities. The plan defines and categorizes drought based on a number of indices, including the Palmar Drought Severity Index, Crop Moisture Index, Percent of Normal Precipitation, Standardized Precipitation Index, Reclamation Drought Index, Precipitation Deciles, and other indices. The plan also noted that active participation of an established Drought Advisory Committee (DAC) and Drought Executive Committee (DEC) is critical to the success of the drought plan and any organized drought response.

Applicability

WR69 defines and categorizes drought according to a number of recognized and accepted indices. The Missouri Water Plan can utilize these indices to help assess the risk and susceptibility of drought in the future (under historic and climate change scenarios).

3.2.4 MDNR Water Supply Study (2013)

The State of Missouri periodically publishes water supply studies focused on assisting specific communities with evaluating their water supply. The 2013 Missouri Water Supply Study evaluated the water supplies of 44 communities. Forty of these communities maintain water supply systems that are most dependent upon lakes while the other four communities maintain water supply systems that are most dependent upon direct diversion from rivers, streams, or creeks. "Lake supplied" communities were evaluated according to the abilities of their supply lakes to adequately meet demand with and without secondary supplies from rivers during the drought of record (i.e., pumping into supply lakes). The firm yield of the lakes under these two scenarios is presented and was established by use of the Reservoir Operation Study Computer Program (RESOP) model. The "direct stream supplied" communities were evaluated according to the ability of the supply streams to adequately meet demand while maintaining minimum streamflows established by the 7Q10 metric (lowest 7-day average streamflow that occurs once every 10 years).

Applicability

The Missouri Water Supply Studies are useful to the Missouri Water Plan methodology because they establish key metrics that should be considered such as 7Q10 as a low flow constraint. What is unclear is whether the relationship between the 44 evaluated communities was included. For example, if an upstream "lake supplied" city was deemed to have sufficient supplies, if pumping from a stream were to occur, is the amount of pumped water (i.e., stream depletion) taken into account when considering the supplies of downstream users? Regardless, the Missouri Water Plan will take such cause and effect relationships into account when evaluating surface water supply availability.

3.2.5 USGS Stream Gage Data

A review of available stream gage data from the USGS was conducted using the Gage II dataset (http://catalog.data.gov/dataset/gages-ii-geospatial-attributes-of-gages-for-evaluating-streamflow). In total, the USGS Gage II dataset contains streamflow records at 232 gage locations within the State of Missouri, some dating back to as early as 1900. Of the 232 gage sites, 196 were still active as of water year (WY) 2009 (the last year documented in the Gage II dataset). Water year is the 12-month period October 1, for any given year through September 30, of the following year. **Figure 3-2** and **Figure 3-3** summarize the number of gages within Missouri, binned according to their associated number of complete years of flow data between WY 1990 and WY 2009 (**Figure 3-2**) and WY 1950 and WY 2009 (**Figure 3-3**). For example, **Figure 3-2** shows over 70 gages have a full record (i.e., 20 years) during the period WY 1990 to WY 2009. A similar number of gages were found to have less than 5 complete years of flow data for the same period. **Figure 3-4** shows the same information as **Figure 3-2** in a geographic format. In addition, **Figure 3-4** also indicates which gages are classified as being in current "reference" condition (as of WY 2009). A gage is classified as being in reference condition if it is minimally affected by direct human activities.

Applicability

This review of available USGS gauge data indicates there should be sufficient data available to assess the recent and historical streamflow in the State of Missouri and supports the methodology outlined below. Though the Gage II dataset ends at WY 2009 the Missouri Water Plan will use available data through WY 2015.

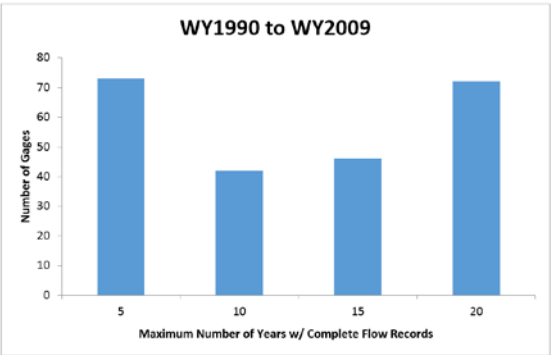

Figure 3-2. Summary of Gage Complete Flow Records, WY1990 to WY2009

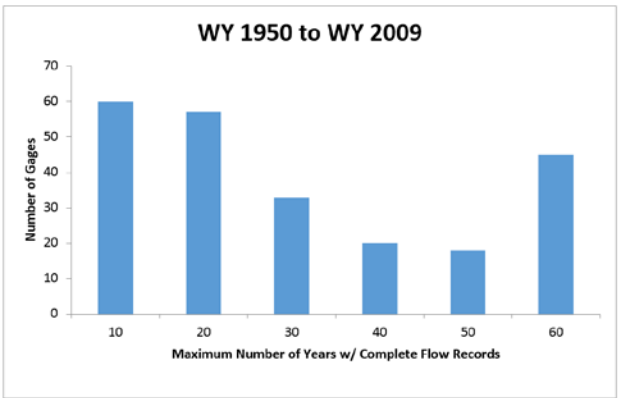

Figure 3-3. Summary of Gage Complete Flow Records, WY1950 to WY2009

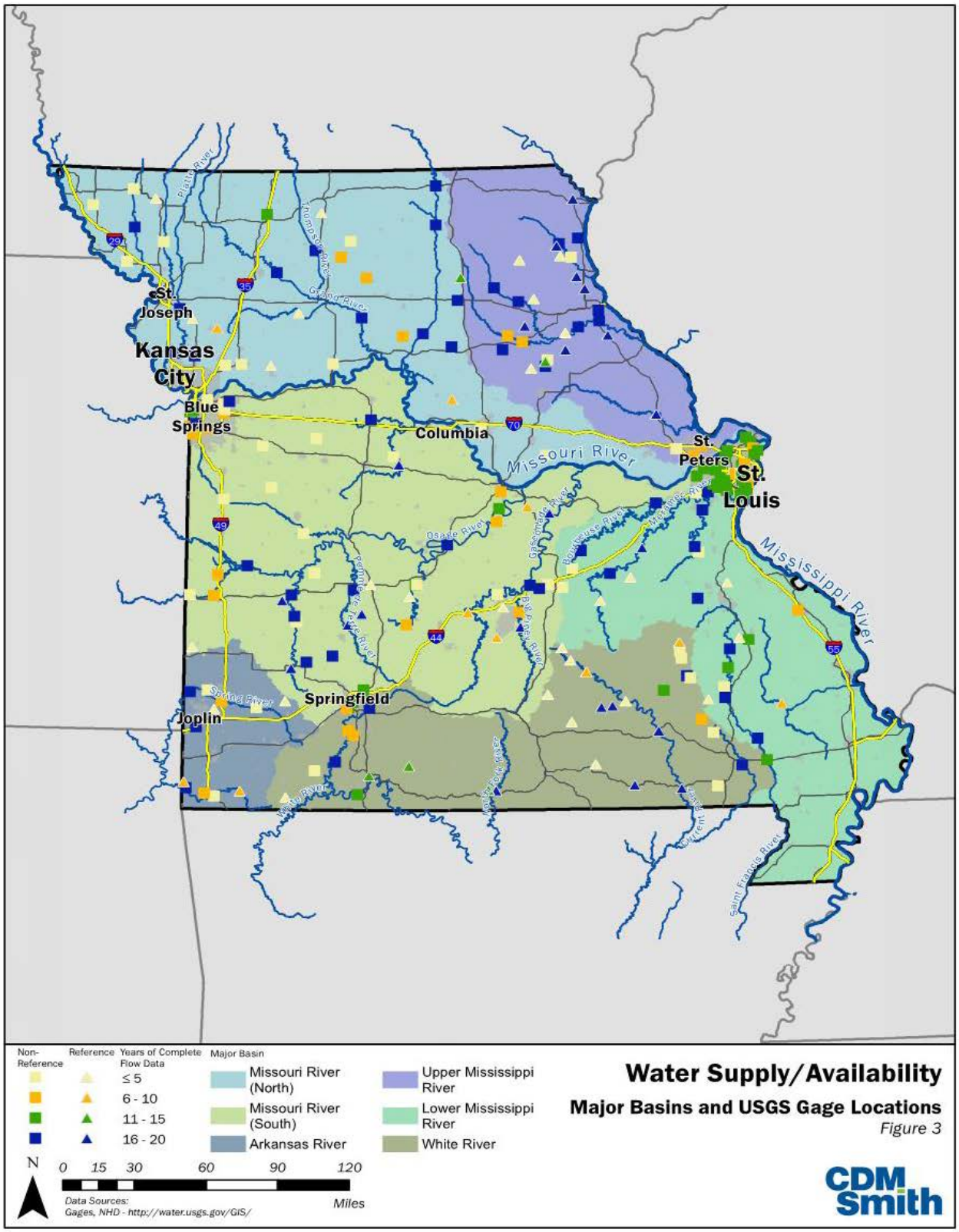

Figure 3-4. Geographic Distribution of Complete Flow Records, WY1990 to WY2009

3.2.6 Groundwater Monitoring Network

The MDNR maintains the Groundwater-level Observation Well Network (GOWN). In total, there are more than 160 observation wells in place, some dating back to the 1950s. The GOWN contains wells statewide. The following information and data are available for wells within the network. Not all wells contain all possible data (e.g., not all wells have a stratigraphy available).

- Owner
- County
- Location
- Period of Record
- Elevation
- Well Log Number
- Water Level when Drilled
- Total Depth
- Casing Depth
- Screen Length
- Producing Aquifer
- Formations Open to Production
- Long-Term Hydrograph
- Strathydrograph
- Well Log
- Real-Time Data
- Recent Daily Average or 1 year

Applicability

The GOWN provides useful information for the Missouri Water Plan. Specifically, information related to water level and associated trends over time (i.e., declining or increasing water levels) could help inform, confirm, or calibrate available groundwater models from the USGS. Specifically, correlations between water level fluxes and precipitation will help determine recharge rates.

3.2.7 USGS Ozark Aquifer Models

3.2.7.1 Greene County Model

In 2010, the USGS published a report detailing a modeling effort that focused on the groundwater resources in and around Springfield, Missouri. The primary driver behind this project was a growing cone of depression under Springfield and surrounding communities whose primary water supply is groundwater. To evaluate the sustainability of the region's groundwater supply system, a complex numerical model was constructed and calibrated. The extent of the model's area is shown in **Figure 3-5**.

Applicability

The USGS model provides valuable information related to local groundwater parameters (e.g., recharge rates, hydraulic conductivity) and also the impact of population growth, additional industrial use, and the timing of future droughts on groundwater resources. Due to the model's spatial extent (2,870 square miles, or 4 percent of the state), its application to the Missouri Water Plan is somewhat limited, though still relevant, considering the highly populated area it covers.

The model includes a historical period of record from 1907 to 2006 and a predicted period of record from 2007 to 2030. Seven future scenarios were evaluated. These scenarios varied by assumed growth rate (i.e., pumping rate), when in the projection time period a 4-year drought occurs (i.e. early of late in simulation), and whether or not an additional industrial user was an active pumper. In all, the modeling showed that water levels continued to drop under all scenarios; water level decreases were between 63 and 640 feet. Little sensitivity was observed between low and high growth rates. The model was found to be most sensitive to assumed recharge rates and hydraulic conductivity.

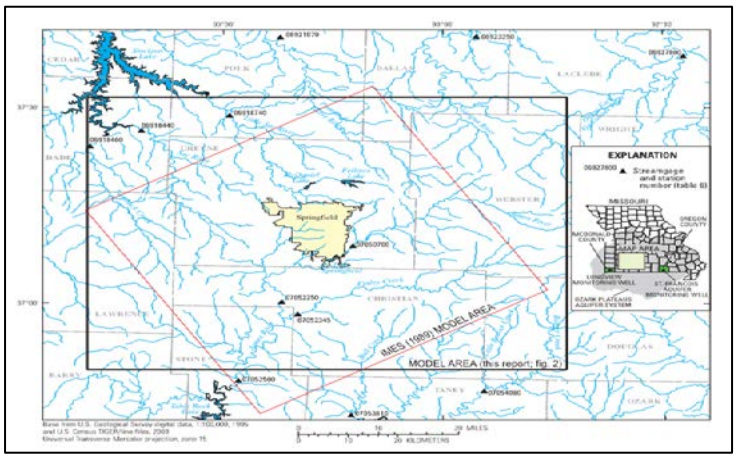

Figure 3-5. Extent of USGS Model in Greene County Study (USGS 2010)

3.2.7.2 Ozark Plateaus Aquifer Model

In 2010, the USGS published a report detailing a modeling effort that focused on the groundwater resources in and around the Tri-state area of Missouri, Kansas, and Oklahoma. The primary driver for the project was the need to assess the impacts of a growing population on groundwater resources now and into the future. To do this, a numerical model was constructed and calibrated. The extent of the model's area is shown in **Figure 3-6**.

Applicability

The USGS model provides valuable information related to local groundwater parameters (e.g. recharge rates, hydraulic conductivity) in the Tri-state region and also the impact of projected population growth scenarios on groundwater resources through 2057. Due to the model's spatial extent (7,340 square miles, approximately 50% within Missouri) its application to the Missouri Water Plan is somewhat limited, though still relevant considering the area it covers.

The model includes a historical period of record from 1950 to 2006 and a predicted period of record from 2007 to 2057. Five future scenarios were evaluated. These scenarios varied by assumed population growth rate (i.e., pumping rate), varying between 0 and 4 percent. In all, the modeling showed that continued groundwater pumping through 2057 was unsustainable under all scenarios that had growth (>0 percent).

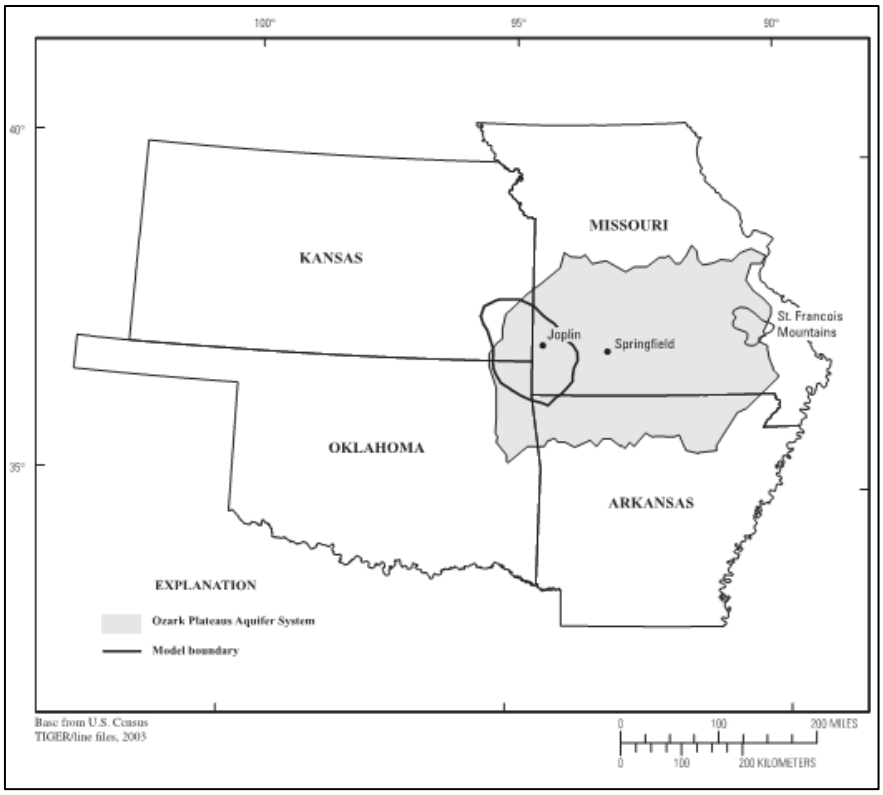

Figure 3-6. Extent of Ozark Plateaus Aquifer and Model Extent (USGS 2010)

3.2.8 MDNR Major Water Users Database

MDNR maintains a major water user database, which includes groundwater and surface water use by user and county. A major water user is defined as any surface or groundwater user with a water source and the equipment necessary to withdraw or divert 100,000 gallons or more per day (70 gallons per minute) from any stream, river, lake, well, spring or other water source. Additionally, any combination of withdraws (wells, surface water pumps or diversions) that withdraw or divert 100,000 gallons or more per day (70 gallons per minute) also qualifies as a Major Water User.

The Major Water Users Database has groundwater and surface water data by user by county. There are 10 categories of use, including: 1) municipal, 2) commercial, 3) fish and wildlife, 4) livestock, 5) ag irrigators, 6) electrical, 7) industrial, 8) drain and dewater, 9) recreational, and 10) other. All data contained within the database is self-reported annually by major water users. To date, the self-reporting framework has resulted in a low response rate.

Applicability

The Major Water Users Database, as it relates to the supply availability, provides valuable data that relate the type of water use (e.g., municipal, commercial) to the source of supply (i.e.. groundwater or surface water). However, there are concerns related to completeness of the dataset due to the self-reporting framework.

3.2.9 MDNR GIS Data Catalog

MDNR develops and maintains an extensive GIS data catalog that includes base map information, as well geological, cultural, land use, and water-related spatial data. Spatial information regarding impaired waters, point source discharges, applicable water quality standards, watershed delineation, and water quality assessments are included in the catalog. MDNR maintains an online map viewing data portal that is publically accessible. Direct access to the GIS data files is possible through direct communication with MDNR.

Applicability

MDNR's GIS data catalog will serve as a primary source of spatial data related to water and water quality during development.

3.2.10 EPA Drinking Water Infrastructure Needs Survey and Assessment

The Drinking Water Infrastructure Needs Survey and Assessment (DWINSA) summarizes the results of a nationwide survey of anticipated costs of investments to install, upgrade, or replace equipment to deliver safe drinking water and reports the results to the United States Congress. The results are also used to help determine the amount of funding each state receives for its Drinking Water State Revolving Fund (DWSRF) program, which funds the types of projects identified in the survey. The most recently available DWINSA was released in 2011. This report is available here: http://water.epa.gov/grants_funding/dwsrf/upload/epa816r13006.pdf.

According to the 2011 DWINSA, Missouri's 20-year need totals approximately $8.5 billion. This is further broken down into approximately $6.1 billion in transmission and distribution, $316 million in source, $1.3 billion in treatment, $752 million in storage, and $22 million in other drinking water infrastructure needs.

The 2015 DWINSA is currently underway during which 75 percent of all 2011 medium utilities (3,301-<99,999 population served) surveyed will be re-surveyed. The additional 25 percent will be randomly selected. Large (>100,000 population served) providers will all be surveyed in 2015. The end of survey submissions by the state is February 29, 2016. EPA is required to provide a report to Congress by February 2017.

Applicability

The 2011 and 2015 DWINSA results can be used to assess the funding needs for drinking water infrastructure for the State of Missouri. This information will be most relevant to the Infrastructure and Funding task; however, input and output data from the DWINSA process may be used to assess planned projects that can help inform assessment of future supply availability.

3.2.11 Safe Drinking Water Intended Use Plan and Annual Report (current year from Financial Assistance Center)

The DWSRF IUP is published annually by MDNR and provides an overview of the overall intended use and specific projects based on applications received which may receive funding from the SRF each fiscal year. The DWSRF annual report includes financial information regarding past spending of the SRF. Types of projects that may receive SRF funding and be identified in each fiscal year's IUP include storage (excludes reservoirs), groundwater wells, treatment, and distribution.

Applicability

The DWSRF IUP annual reports provide useful data sources for identifying areas of drinking water infrastructure concerns that have been addressed through the SRF process. The IUP can also assist in identifying current geographic areas of concern and specific infrastructure improvements that have been prioritized and may be funded by the state.

3.2.12 Safe Drinking Water Information System

The EPA maintains the SDWIS for all states and territories. This section describes the Missouri public water system violations list and the MDNR Census of Public Water System, both are subsets of the SDWIS.

3.2.12.1 Missouri Public Water Systems Violation List

This list contains information related to public water systems and drinking water violations. The list is organized by public water system identification number and includes other data fields such as name of provider, county, source of supply, date(s) of violation occurrence, name of violation, and other fields. The list can be accessed at the following web address: http://iaspub.epa.gov/enviro/sdw_form_v3.create_page?state_abbr=MO.

Applicability

The information contained in the MDNR Public Water Systems Violation List is nearly six months old and is incomplete since not all state violations are assigned value by EPA. SDWIS query is most current for the State.

3.2.12.2 MDNR Census of Public Water Systems

MDNR conducts an annual census of Missouri's public water systems based on information found in the SDWIS. The census includes information such as volume, source water type, population, types of treatments, and other characteristics of water systems. Lists of the community water systems, nontransient, noncommunity water systems, and transient, noncommunity water systems are included. In 2015, 2,722 water systems were included in the census.

Applicability

The information contained in the MDNR Census of Public Water Systems is most useful for the Demand task; however, information related to source of supply, supply capacity, and annual consumption will be useful for both the Supply/Availability task and Infrastructure task.

3.2.13 2013 ASCE Report Card for Missouri's Infrastructure

The Kansas City and St. Louis sections of the ASCE collaborated to produce the 2013 ASCE Report Card for Missouri's Infrastructure. This document includes grades for each of 11 separate infrastructure categories evaluated throughout the state, including categories for dams and drinking water. For each category, the technical committee incorporated known information regarding the capacity, condition, funding, future need, operation and maintenance, public safety, and resiliency status currently believed to be present. For dams, a grade of D- was assessed while drinking water received a score of C- in the 2013 report card, indicating significant improvements may be required.

Applicability

The information provided in the Report Card for Missouri's Infrastructure and the listed source materials for ASCE's evaluations will be assessed and incorporated into a discussion of the potential impacts of dams and drinking water infrastructure in Missouri on surface water and groundwater supply availability; however, this data source will be most applicable to the Infrastructure and Funding task.

3.2.14 University of Missouri Center for Applied Research and Environmental Systems

CARES is a mapping and data visualization center located at the University of Missouri. CARES produces and publishes a wide ranging collection of research datasets. Two programs in particular will be evaluated and potentially used as integrated datasets in the development of the water supply assessment:

- ***Missouri Map Room*** - a web-based geographic data visualization tool, which allows a user to explore and download thousands of geographic data sets for Missouri. Geographic datasets available cover a wide range of categories and feature classes related to water supply, land use, topography, and geology.
- ***Vulnerability Assessment*** - maps of public drinking wells, impoundments, intake locations and potential sources of water contamination. Reports providing more detail on the water system and potential contamination sources can be generated.

Applicability

The datasets available from CARES may be utilized directly from the public access points, or if necessary, University of Missouri staff involved in the CARES program may be contacted for additional information and data requests related to the development of the water supply assessment portion of the Missouri Water Plan.

3.2.15 Regional Studies

A variety of regional studies related to water supply availability have been conducted in recent years. Below is a brief summary of the regional studies reviewed as part of the data review effort.

3.2.15.1 Southwest Missouri Water Resource Study Phases I and II (2012, 2014)

The Southwest Missouri Water Resource Study was broken into two phases. Phase I focused on developing regional demand forecasts while Phase II offered a planning-level evaluation of known groundwater and surface water availability in the region. The studies' extent is defined by a 16-county region, including Vernon, St. Clair, Hickory, Barton, Cedar, Polk, Jasper, Dade, Greene, Newton, Lawrence, Christian, McDonald, Barry, Stone, and Taney. The supply availability work conducted in Phase II assessed the availability of groundwater from the Springfield Plateau and Ozark Aquifer through 2060. For surface water, reservoirs owned by the USACE were assessed along with municipally owned lakes. Four scenarios were considered in a gap analysis (difference between future demand and available supply). These management scenarios varied by assumed weather conditions (normal vs drought) and groundwater management practices (sustainable vs. continual decline). The Phase II study found that, region-wide, there is sufficient total supply to meet future demands under an assumed continuation of "normal" climatic conditions. However, a region-wide gap was observed when drought conditions were considered. Infrastructure and/or contracts for delivery of water between sub-regions were not considered as part of the gap analysis and may provide further constraints and increase the likelihood or magnitude of a regional gap.

Applicability

Regional studies offer information that is critical for an accurate assessment of Missouri's water supply availability. The water supply availability and recommended gap methodologies will rely on these studies to verify and supplement other data sources discussed in this memo, especially as it relates to water supply projects that are currently being planned to a significant degree.

3.2.15.2 Northwest Missouri Regional Water Supply Phases I through IV

Multiple studies (phases I through VI) have been completed by the Water Partnership Planning Group and the Great Northwest Wholesale Water Commission from 2007 through 2014 to develop a plan for a regional water supply source and transmission system. This series of studies focuses on a 12 county region including: Atchison, Nodaway, Worth, Harrison, Gentry, Andrew, Holt, Buchanan, DeKalb, Daviess, Caldwell, and Clinton. The studies identified current water systems that have the capacity to continue meeting the needs of their current service area while providing additional water to a regional system and evaluated alternatives for a regional water supply transmission system. Earlier phases focused on establishment of regional commissions, creation of a governance structure, and "big picture" regional water supply concepts. More recent phases of this work include the development of detailed preliminary engineering reports that describe basic design elements, opinions of probable construction costs, estimates for operations and maintenance costs, and wholesale water rates ($/1000 gallons).

3.2.15.3 Howard County Regional Water Commission

In 2013, the Howard County Regional Water Commission announced it had received funding from USDA-Rural Development (RD) to support a water regionalization project. Funding came in the form of both grants and low-interest loans and totals more than $10 million (split approximately 50/50 between grant and loan). The water regionalization project includes new groundwater wells, treatment plant, storage tower, and distribution lines. Beneficiaries of the project include the communities of Fayette and New Franklin and Consolidated Water Supply District No. 1 of Howard County.

3.2.15.4 Caldwell County Commission, Little Otter Creek Reservoir

The Little Otter Creek Reservoir is a planned reservoir located in Caldwell County in northwest Missouri. The reservoir will have a surface area of 340 acres and is estimated to have a total construction cost of $19.5 million. Currently, all required land has been acquired. Once completed, the reservoir will be used for flood protection and water supply for the county, with the capacity to provide more than 1 mgd.

3.2.15.5 Clarence Cannon Wholesale Water Commission, Mark Twain Lake

Mark Twain Lake is located on the Salt River and is owned by USACE. The lake is a multi-purpose project whose benefits include hydroelectricity, flood control, recreation, fish and wildlife conservation, and water supply. The Clarence Cannon Wholesale Water Commission and the state of Missouri hold contracts for a total of 20,000 acre-feet of storage within the lake. This storage serves as important water supply for nearly 70,000 customers of the Clarence Cannon Wholesale Water Commission.

3.2.15.6 North Central Missouri Regional Water Commission, East Locust Creek Reservoir

The East Locust Creek Reservoir is a planned reservoir located in Sullivan County in north central Missouri and will be operated by the North Central Missouri Regional Water Commission. The reservoir will have a surface area of 2,235 acres and is estimated to have a total construction cost of $97 million. Currently, more than 90 percent of the land has been purchased. Once completed, the reservoir will be used for water supply, with the capacity to provide 7 mgd.

3.2.15.7 Atchison County Wholesale Water Commission

The Atchison County Wholesale Water Commission (ACWWC) formed in 2006 with the mission to provide a safe and reliable potable water supply for all of Atchison County, Missouri, and for interested water supply districts or utilities in adjacent counties. Currently, the ACWWC member entities include the City of Fairfax, City of Rock Port, City of Tarkio, and the Atchison County Public Water Supply District #1. A primary goal of the ACWWC is to support the expansion of Atchison County Public Water Supply District #1 to encompass all of rural Atchison County. Existing facilities owned by the ACWWC include a 2.5 mgd water treatment facility, 250,000 gallon elevated water storage tank, and 750,000 gallon clear well. Future plans include expansion of treatment capacity to 10 mgd.

3.3 Proposed Methodologies

This section details the proposed methodologies for assessing the State of Missouri's supply availability for both surface water and groundwater resources in support of the Missouri Water Plan. The methodologies are derived from industry best practices that are based on available data and Missouri's current legal and administrative setting for water resources. In addition, these methodologies will integrate with the proposed scenario planning framework (see Section 6 for more detail). Alternative planning scenarios will be defined in collaboration with MDNR and in coordination with the demand and infrastructure analyses, such that variations in “drivers” such as economic and climatic conditions can provide a likely range of potential future supply.

3.3.1 Surface Water Supply Availability Methodology

The State of Missouri's surface water is administered according to riparian doctrine. Riparian land touches a lake, stream, river, or other watercourse. Riparian landowners may use water on the property, but it can be limited if their use unreasonably harms another riparian landowner’s use. This section includes an overview of the proposed methodology for evaluating surface water availability in support of the Missouri Water Plan. The methodology is intended to provide a comprehensive understanding of the historical and future availability of surface water. The following key topics are explored, and a summary of each is provided below:

1. The Natural and Legal Setting of Missouri's Surface Water
2. Existing Physical Availability of Surface Water
3. Future Physical Availability of Surface Water
4. Major Basin Water Budgets
5. Reservoir and USACE projects

3.3.1.1 The Natural and Legal Setting of Missouri's Surface Water

This section of the Missouri Water Plan will provide an overview of various factors that influence surface water supplies throughout the state. An overview of the natural and legal setting will be provided. For the natural setting, such topics as the state's physiography, climate, and land cover will be addressed. For the legal setting, a summary of Missouri's water law, major court cases, and any interstate compacts that directly or may indirectly impact surface water availability will be presented.

3.3.1.2 Existing Physical Availability of Surface Water

An assessment of physical surface water availability will be developed based on major basin/watershed boundaries. The basis of the surface water availability analysis for the Missouri Water Plan will be existing streamflow data collected by the USGS. Streamflow data collection sites within each river basin will be selected based on the availability of adequate data and relevance to the required calculations. A review of available USGS gages (described above) indicates there exist sufficient data for a meaningful assessment. Additional consideration will be given to those stations used in WR45 Missouri State Water Plan Series, Volume 1: Surface Water Resources of Missouri.

Owing to geographic, temporal, and hydrologic variability, it is instructive to look at a defined period of the recent past rather than any individual year to understand and illustrate the current status of Missouri's surface water supplies. Within a selected period of record, historical hydrologic conditions and variability of streamflow will be summarized using a variety of statistical metrics. These likely will include annual and monthly mean and median flows, minimum and maximum flows, standard deviations, a range of percentile values (e.g., 25th, 50th, 75th), and an assessment of minimum flows (e.g., 7Q10). Annual and monthly time series plots, summarizing the full period of record, will be developed to better visualize historical variability and drought periods.

For basins or sub-basins where significant data gaps exist in the USGS gage records, numerical techniques will be applied to estimate streamflows to the extent necessary. Techniques that may be used include the area ratio method and the MOVE.1 (Maintenance of Variance Extension) statistical extension methods. Both rely on the selection and use of a "surrogate" gage from a nearby basin with similar land cover features and a more complete data record. The area ratio method applies drainage area ratios to surrogate gage records to estimate flows for the study basin. MOVE.1 is a statistical flow record extension technique that fills missing data in a streamflow record (y) based on the flow at a surrogate gage (x) while preserving the statistics in-the basin with the missing data at streamflow record (y).

In addition, portions of the statistical analysis described above will be summarized in a visually appealing manner known as a "snake diagram" in which stream reaches with statistically larger flows will appear larger on a map than those with smaller flows. This allows the reader to quickly compare the physical availability of surface water across the state. An example of a snake diagram is presented in **Figure 3-7**. This statewide figure was prepared by CDM Smith in support of Colorado's Water Plan along with individual basin figures for each of the eight major basins. Individual major basin maps also include transmountain diversions, with arrows indicating the general vicinity of diversions or inflow into a given basin. A similar series of maps will be prepared for the Missouri Water Plan.

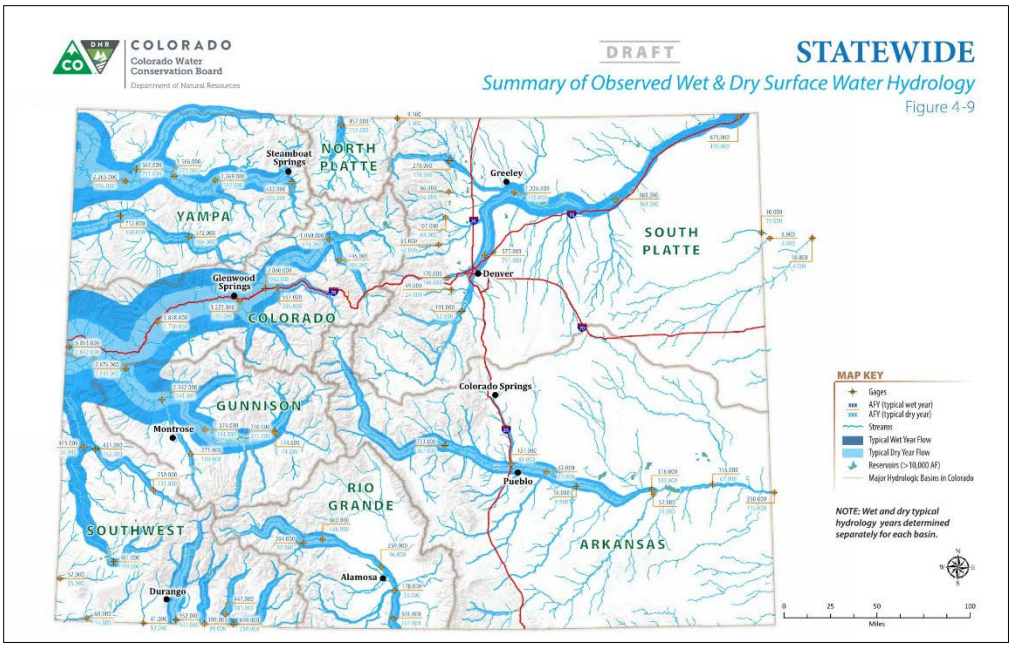

Figure 3-7. Example "Snake Diagram" from Colorado's Water Plan

Snake diagrams include river and stream centerlines overlaid with "buffer" areas indicating typical wet and dry flow volumes; the width of the buffer is proportional to the wet or dry flow in a given reach. Buffer ratios are calculated by comparing annual flow volumes for "wet" and "dry" years to average annual flow volumes. Such calculations will be performed at an appropriate number of gage sites throughout each major basin. Next, buffer ratios will be uniformly scaled so that the wet/dry buffers on each snake diagram are visually apparent. Key benefits of the development of snake diagrams include visualization of relative flow rates across the state and major basins, variability between wet and dry years, and the impacts of water supply operations. Creation of snake diagrams will rely primarily on USGS gage flow records as well the NHDPlus dataset.

3.3.1.3 Future Physical Availability of Surface Water

Future physical availability of surface water will be assessed in a similar manner to historical water but will take into account projected water demand increases (or decreases) in each defined basin as well as the impact of projected future climatic conditions as defined through the scenario planning framework. Climate change will be evaluated by developing a series of modified hydrologic flow records that capture historical patterns and variability coupled with projected future climate change trends. These new hydrologic "traces" can then be used to provide for a greater range of forecasts inclusive of uncertainty associated with climate change. In coordination with the scenario planning framework, three sets of climate change traces will be generated for each river basin reflective of a 2060 planning horizon. These traces will correspond to three distinct downscaled general circulation model (GCM) projections, spanning a range of hydrologic impacts. The proposed methodology will generally follow the following steps.

Step 1: GCM Selection

This sub-task will involve synthesis of published regional hydrologic projections to identify three specific projections for use in subsequent analysis. These projections will represent the 25th (dry), 50th (median), and 75th (wet) percentiles of the entire set of projections. Hydrologic projections out to the year 2100, in the form of gridded runoff at a 1/8th degree latitude/ longitude grid will be used for the Missouri River basin. These projections correspond to each of the 112 widely published GCM projections and were generated by routing climate predictions through a macro-scale hydrologic model (the Variable Infiltration Capacity model [VIC]). Monthly gridded runoff projections for the targeted cells and the 2060 (± 15 years) planning horizon will be downloaded from: http://gdo-dcp.ucllnl.org/downscaled_cmip_projections/dcpInterface.html. Minimum annual flows will be calculated for each 30-year data set. Percentile plots will be fitted to the ensemble of 112 minimum annual flows and the 25th, 50th, and 75th percentiles identified. The GCMs, and corresponding hydrologic projections, associated with each of these percentile values will be used in subsequent steps. The VIC model does not currently have coverage for the eastern portion of Missouri (i.e., Mississippi River basin). A separate approach for this portion of the state will be developed based the latest available datasets.

Step 2: Flow Adjustment using Delta Method

For targeted USGS flow gage locations, a "delta" method will be employed whereby monthly gaged flow records are adjusted to reflect climate change trends associated with the 2060 planning horizon. For each of the three GCM projections selected above and the selected gage locations, flow percentiles will be calculated for each calendar month using the 2060 data set of hydrologic projections. Analogous calculations will be performed using projections of the historical "overlap" period (1950-1999). Flow deltas will be defined as the difference between these two sets of projections. The deltas will be applied to actual gaged monthly flows according to relative percentiles. For example, if a given January flow in the gaged record corresponds to the 10th percentile of all January gaged flows, then the 10th percentile hydrologic projections will be used to calculate the delta (modeled future – modeled overlap). The end result of this step will be sets of three different modified monthly flow records reflective of historical variability and future climate change trends (25th, 50th, and 75th percentiles).

Step 3: Modified Analysis of Supply Availability

Using the climate change hydrologic traces generated in the above step, alternative supply availability summaries will be provided analogous to those described under "Existing Physical Availability of Surface Water." Area-weighting methods may be employed to extrapolate climate change traces to additional flow gages within a given river basin.

3.3.1.4 Major Basin Water Budgets

The information described above will be used to construct basic surface water budgets for each major basin. Budgets will be developed for dry, average, and wet conditions using an annual timescale. They will provide a high altitude, but cohesive, summary of current water use and availability within each basin. It is likely that basin inflows (un-depleted) will need to be back-calculated from the other, independently derived terms in the budget. An example hypothetical graphical depiction of such a budget is shown in **Figure 3-8**. Comparisons will be made to any previously computed water budgets developed under separate study. This effort is also closely linked to the scenario planning framework and Water Demand task, which will provide the

necessary information for calculating consumptive use (CU). Careful consideration will be given to those major basins that are influenced by natural and human activity that occur in upstream states. In addition, a summary of historical transfers of surface water from one major basin to another will be provided.

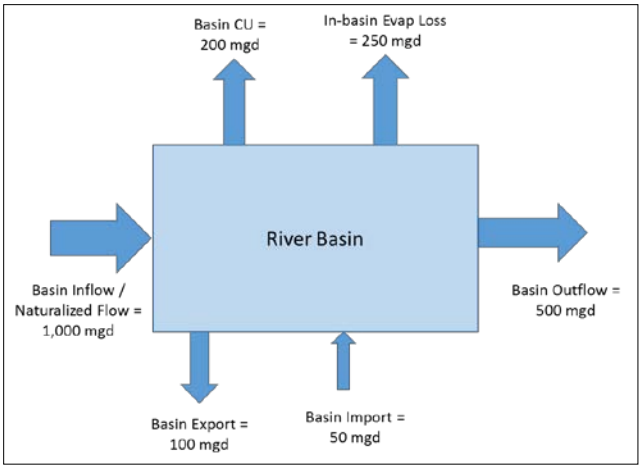

Figure 3-8. Hypothetical Basin Surface Water Budget

3.3.1.5 Reservoir and USACE Projects

An updated summary of USACE reservoir projects in the state will be prepared, including a summary of the current allocation status for each project. In addition, an analysis of potential reallocations of storage in USACE reservoirs will be included. This analysis will include a narrative of the process required for reallocation of USACE reservoir projects and which reservoirs should be considered for potential future reallocation. **Figure 3-9** shows the location of all USACE reservoirs within Missouri. Beyond USACE reservoir projects, the Missouri Water Plan will include a summary of RESOP modeling results from the Missouri Water Supply Studies (2005, 2011, and 2013). These results will be summarized by major basin and will be a key component of any shortage analysis that is undertaken.

3.3.2 Groundwater

This section focuses on the proposed approach for quantifying the groundwater supply available to meet current and future water supply demands. The methodologies described in this document will provide a means of maintaining consistency in approach with previous and ongoing studies on groundwater availability by the USGS and provide for a collaborative process that will meet the goal of understanding future supply availability. This analysis will rely on an existing numerical groundwater model developed by USGS to assess groundwater conditions under current and future water use scenarios. In addition, GOWN will be used to supplement or compliment the USGS models. This effort is also closely linked to the Water Demand task, which will provide the demand projections used to assess future groundwater use and resulting supply availability. These projected demands may differ from those within the existing USGS groundwater models, so model input revisions may be necessary. The following key assessments are explored, and a summary of each is provided below.

1. Assessment of Groundwater Resources with USGS Numerical Models
2. Assessment of Groundwater Resources without USGS Numerical Models

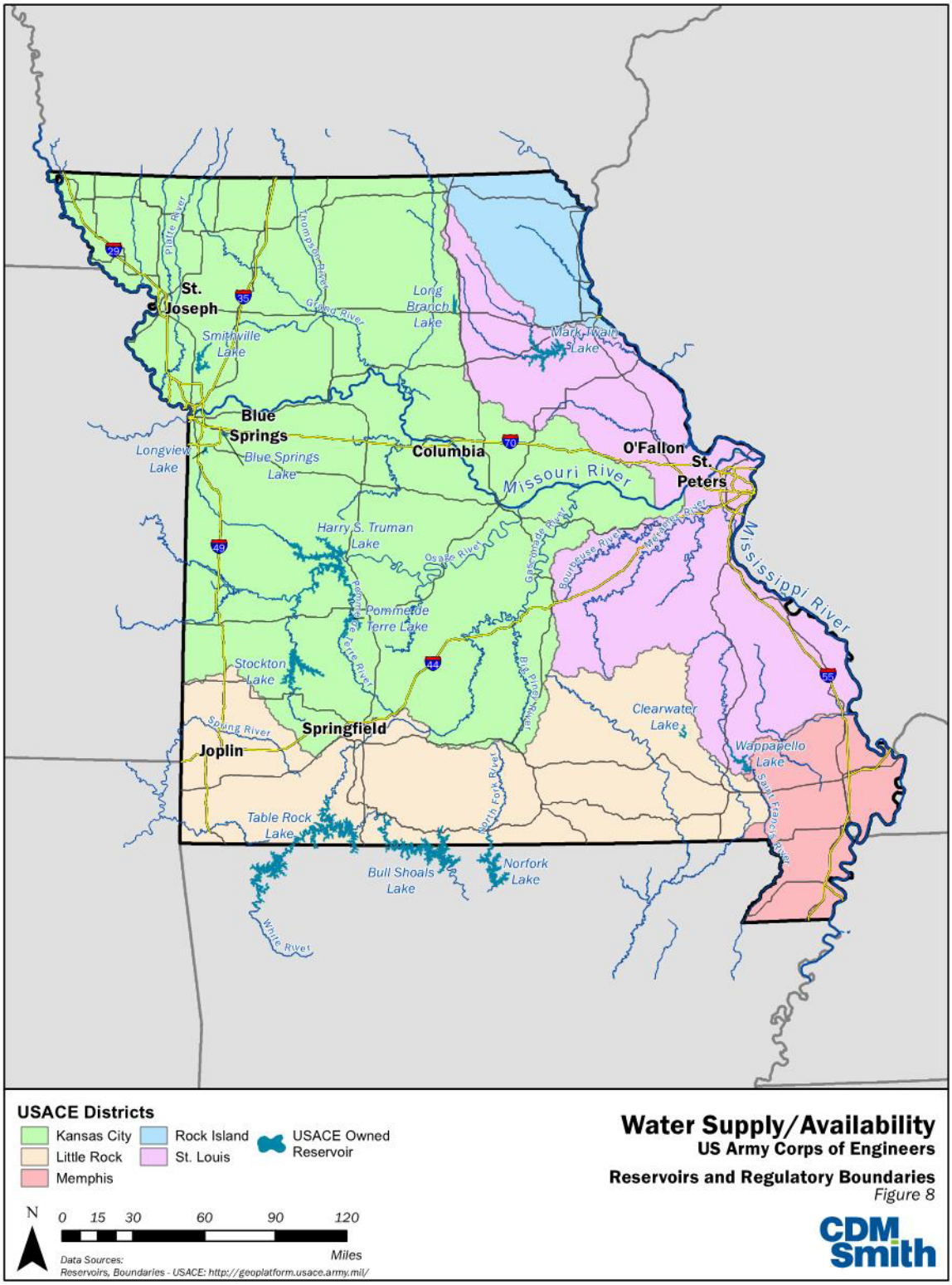

Figure 3-9. USACE Reservoirs within Missouri

3.3.2.1 Assessment of Existing Groundwater Resources with USGS Numerical Models

A large portion of Missouri's groundwater wells produce water from the Ozark Plateaus Aquifer System and are located in the southern portion of the state. This system has been the most studied, and the USGS has recently developed numerical groundwater models for certain regions of the system. This task assumes the most recent update of the USGS predictive groundwater models will be used in this study.

Current groundwater conditions will be assessed using the USGS models for those areas included in the models' extents (see Section 2 for detail on extents). Water balance information will be compiled, including pumping inputs, recharge, and flow to/from rivers and streams. Simulated water levels will be reviewed to identify patterns both spatially and temporally. No modifications will be made to model input files (e.g., water use/groundwater pumping as defined by USGS will be used). This task will include the following steps:

1. Review any available updated USGS numerical groundwater models and documentation.
2. Run model simulation and process model results.
3. Summarize model results. Information will be summarized by county and major surface water basin over the length of the simulation period for the following model output:
    - Pumping, recharge, and boundary conditions (inflow/outflow at boundaries)
    - Water elevation maps (contoured water levels) and water level hydrographs (time histories) for selected wells at which monitoring data is available
    - Available groundwater in storage

This task will serve as a baseline to compare to other water use scenarios in terms of changes in water levels and available aquifer storage. Time histories of aquifer water levels also will be used to compare against future simulations to determine potential water level trends.

3.3.2.2 Assessment of Existing Groundwater Resources without USGS Numerical Models

Numerical groundwater models are not currently available for all aquifers with significant production in the State of Missouri, so the assessment of available groundwater in these aquifers will rely on available information on the water balances of these aquifers, including estimates of yield.

This task will involve the compilation of information on baseline/current groundwater conditions. This information will include water levels, pumping/water use, geology, some estimate of recharge and loss from aquifers through inter-aquifer flows, pump test data and other information that could be used to support a planning-level water balance and estimate of yield for these aquifers. Where information is available, an assessment of whether current use of an aquifer would cause long-term drawdown impacts will be made. GOWN and the Major Water Users Database will serve as key inputs to this task; thus, data availability associated with these sources will significantly impact the outcome.

3.4 Data Gaps

This section provides a list of data gaps that were identified from the data review. In some instances, data gaps are "major" that will require additional information to execute the proposed methodology. In other instances, the data gaps are considered "minor." Minor data gaps do not need additional information to execute the proposed methodology; however, they may be beneficial by serving as a point of comparison, demonstrating increased coverage of analysis input, or providing for a more in-depth evaluation. This list will continue to evolve as the development of the Missouri Water Plan continues.

3.4.1 Major Data Gaps

- Spatial coverage of USGS groundwater models
- Coverage of RESOP modeling
- Historical data detailing annual volumes of water transferred between major basins
- Authoritative climate change adjusted hydrology dataset for the eastern portion of the state
- Comprehensive list of planned water supply projects
- Self-report response rate for the Major Water Users Database

3.4.2 Minor Data Gaps

- Lack of surface water models with reservoir/river dynamics that can help assess system yields
- Official estimate of aquifer "safe yields" across the state

3.5 Major Issues

Major issues were identified based on drivers and themes observed during the data review process. The proposed methodologies contained in this memorandum are intended to help address such major issues. These major issues likely will serve as key topics for stakeholder groups through the completion of the Missouri Water Plan. The below list is divided geographically, with Northern Missouri defined as north of the Missouri River and Southern Missouri defined as south of the Missouri River. This list will continue to evolve as the development of the Missouri Water Plan continues.

3.5.1 Northern Missouri

- Availability of surface water in groundwater poor regions (e.g., northern Missouri) during dry periods
- Reallocation of USACE reservoir storage pools
- New reservoir construction

3.5.2 Southern Missouri

- Groundwater quality can impact quantity available for potable use
- Reallocation of USACE reservoir storage pools

- New reservoir construction
- Increased groundwater withdrawals due to regional growth

3.6 Summary & Recommendations

The above tasks will provide a clear evaluation of existing surface water availability for the Missouri Water Plan. This information is very valuable; however, its value is greatly increased if taken to the next level by developing a shortage analysis in order to identify “at-risk” areas. This work is proposed as a complement to the infrastructure gap analysis to be performed under the Infrastructure and Financing task. While that effort focuses on identified provider-specific legal and infrastructure water supply gaps, this effort focuses on physical availability ("wet water"). The CDM Smith team recommends the following approach for the assessment of at-risk areas considering future surface water availability, future groundwater availability, and projected increases in demand. These methodologies will integrate with the proposed scenario planning framework that will take into account various “drivers” such as economic and climatic conditions (see Section 6 for more detail).

3.6.1 Surface Water “At-risk” Analysis

Similar to the existing surface availability assessment approach described in Section 3.1, a water budget analysis will be used to identify areas at-risk of a physical surface water shortage. For example, the northern portion of the state has limited groundwater resources and is more susceptible to supply interruptions or drought conditions. The "at-risk" areas will be evaluated by comparing projected physical availability of surface water supplies to projected surface water demand to determine if additional measures, such as secondary supplies or demand side management (i.e., conservation), would be beneficial.

This analysis relies heavily on USGS streamflow gage records to define physical availability at a sub-basin level. A key underlying assumption in the approach is that current consumptive surface water uses are approximately reflected in recent historical gage records. This effectively eliminates the need to "naturalize" flow records.

USGS gage locations will be used to delineate sub-basins for aggregated supply and demand analysis. A practical number of sub-basins will be identified within each river basin draining to gage locations with suitable periods of record.

For each sub-basin (i), the following steps will be followed:

- Projected changes (deltas) in river basin surface water consumptive demands, including municipal and industrial, agriculture, and self-supplied industrial, will be calculated using the results from the Water Demand task. These will be calculated as the difference between 2060 demands and current demands.
- Basin surface water demand deltas will be roughly disaggregated to the required sub-basin level based on economic and land use information.
- For each sub-basin, instream flow requirements will be identified.

- For each year (t) in the available period of record, the following calculation will be performed:

$$Shortage_i^t = \Delta SWDemand_i^{2060} + Q_{instream} - (Q_i^t - \sum_{j=1}^{j=i-1} \Delta SWDemand_j^{2060})$$

where:

$Shortage_i^t$ = projected surface water annual shortage associated with 2060 demands and year t surface supply in sub-basin i

$\Delta SWDemand_i^{2060}$ = projected change in surface water consumptive demand for sub-basin i and the 2060 planning horizon (relative to current demands)

$Q_{instream}$ = known instream flow requirements associated with given gage location

Q_i^t = annual river flow from gage records

The final term in the equation represents the summation of upstream annual demand deltas that will be met with the same source of supply captured by Q_i^t.

- The results of the calculations described above will be used to identify sub-basins that are considered "at-risk."

3.6.2 Groundwater "At-risk" Analysis

Future groundwater conditions and availability will be simulated using the USGS models by incorporating water use projections from the concurrent Water Demand task. This work will build directly on the models described in Section 3.2. Model files will be updated to reflect future projections of groundwater pumping. Recharge inputs and other boundary conditions will remain the same to isolate the impact of changes in pumping. It is assumed the range of recharge from precipitation included in the existing model sufficiently represents the range of future recharge. Assessment of future groundwater conditions will include the following steps:

1. Develop model files from the water demand projections that are being produced in the Water Demand task and integrated with the scenario planning framework.
2. Run groundwater model simulation(s) based on future demand projection scenarios and process model results.
3. Summarize model results. Information will be summarized by county and major surface water basin over the length of the simulation period for the following model output:
   - Pumping, recharge, and boundary conditions (inflow/outflow at boundaries)
   - Water elevation maps (contoured water levels) and water level hydrographs (time histories) for selected wells at which monitoring data is available
   - Available groundwater in storage
4. Identify "at-risk" areas that do not meet established groundwater management criteria (e.g., aquifer drawdown thresholds).

Only relative changes in streamflow and baseflow due to changes in groundwater pumping or increases in surface water diversions will be assessed using the USGS groundwater models. This relative measure of change in surface water/groundwater interaction could provide guidance on the impact of future groundwater demands or future river diversion projects.

For areas that fall outside of existing USGS groundwater model extents, “at-risk” areas will be identified based on a comparison between future demand projections from the Water Demand task and current availability of groundwater. The amount of detail incorporated into these assessments is dependent on the amount of available information.

Section 4

Water Quality/Aquatic Species

4.1 Introduction

For Water Quality/Aquatic Species, CDM Smith conducted an initial data review, developed the proposed methodology, identified data gaps and major issues, and provided recommendations regarding next steps, which are compiled in this section.

4.2 Data Review

An assessment of surface water and groundwater quality that includes detailed information regarding past, present, and future conditions across the state will be an integral part of the Missouri Water Plan. Data applicable to a statewide water quality assessment will be sourced from a broad range of agencies, programs, and other sources. Potentially relevant data sources identified include:

- Missouri State Water Plan Phase I, Volume III (WR47)
- Missouri water quality statutes and regulations
- Missouri Water Quality Assessment System
- EPA Storage and Retrieval (STORET) Data System and cooperative Water Quality Portal (WQP)
- 303(d) listings
- 305(b) reports
- Total Maximum Daily Load (TMDL) reports
- Missouri Clean Water Information System (MoCWIS)
- MDNR compliance and enforcement violations lists
- MDNR Water Quality Monitoring Strategy
- MDNR Environmental Services Program Studies
- MDNR Section 319 Nonpoint Source Implementation Program
- MDNR Biological Assessments Sampling Database
- MDNR and EPA Climate Change in Missouri Streams Project
- Missouri Outstanding Resource Waters
- U.S. Fish and Wildlife Service (USFWS) Threatened and Endangered (T&E) aquatic species list
- Missouri Department of Conservation (MDC) Special Studies and Aquatic Data
- MDC Resource Assessment and Monitoring (RAM) Program
- MDC Missouri Watershed Inventory and Assessment

- MDC Species and Communities of Conservation Concern
- Clean Water State Revolving Fund (CWSRF)
- Clean Water IUP (current year from Financial Assistance Center)
- 2013 ASCE Report Card for Missouri's Infrastructure
- MDNR GIS Data Catalog
- Missouri Resource Assessment Partnership (MORAP) Aquatic GAP Pilot Project data
- University of Missouri CARES
- USGS Missouri Water Science Center Reports

CDM Smith performed preliminary research into each of the identified data sources and conducted in-person and telephone interviews with several key staff from MDNR and other agencies to gain a better understanding of the data available. In addition, the identification of potential critical data gaps that may inhibit the completion of the Missouri Water Plan was conducted. A brief summary of the data types and expected value available from each source is provided below.

4.2.1 Missouri State Water Plan Phase I, Volume III (WR47)

In 1989, the Missouri legislature passed the Water Resources Law (Section 640.415, RSMo), which requires the MDNR to "develop, maintain and periodically update a State Water Plan for a long-range, comprehensive statewide program for the use of surface water and groundwater resources of the state, including existing and future needs for drinking water supplies, agriculture, industry, recreation, environmental protection and related needs." As a result, MDNR began developing studies, collecting data, producing reports, and engaging the public in water resources planning projects. A significant outcome of this process was the initial production of a multi-phase State Water Plan. As part of Phase I of this program, MDNR developed and published seven volumes of reports, including Volume III Water Resources Report 47 (WR47) Missouri Water Quality Assessment in 1997.

The 1997 Water Quality Assessment summarizes the quality of water throughout the state and examines natural and human-induced water quality changes as well as the effects of waste disposal on surface and groundwater quality. The water quality assessment includes discussion of key water quality issues, trends in water quality, and potential impacts to recreation, fisheries, power generation, agricultural irrigation, transportation, and drinking water.

Applicability

The 1997 Water Quality Assessment will be used to develop the basic framework and structure of the water quality section of the updated 2015 Missouri Water Plan and will provide valuable summary information regarding the State of Missouri's water quality prior to 1997. The historical data presented in the 1997 assessment can also be useful in assessing changes and trends in water quality and water quality related issues over the past 20+ years.

The assessment contains separate groundwater and surface water sections, each of which is regionally subdivided. The groundwater assessment includes seven groundwater provinces throughout the state, and the surface water assessment is organized into six categories based on the four primary watersheds in Missouri: Upper and Lower Mississippi River basins, basins north and south of the Missouri River, the Arkansas River, and the

White River Basin (**Figure 4-1**). The Missouri Water Plan will incorporate more recently developed geographic subdivisions such as eco-regions, ecological drainage units, and basin boundaries.

The assessment includes seasonal and annual data for a range of water quality parameters collected by MDNR, the Missouri Department of Health, the Missouri Department of Conservation, and the USGS at numerous locations throughout the state that can be included along with more recent data in the 2015 assessment.

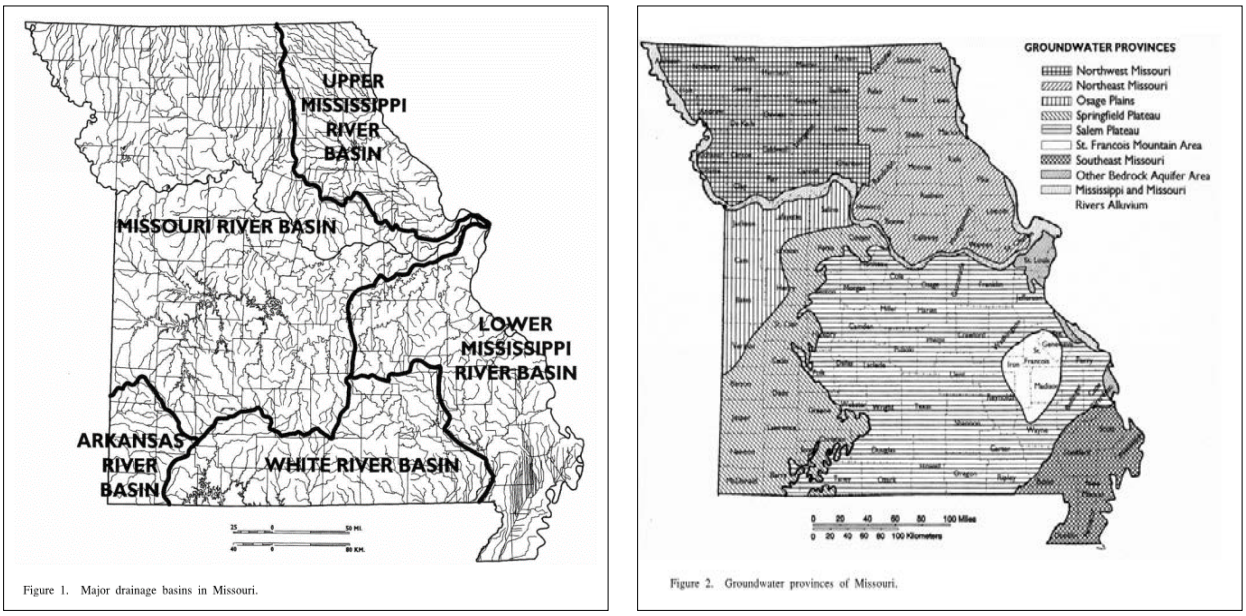

Figure 4-1. Excerpted from Volume III Water Resources Report 47 (WR47) Missouri Water Quality Assessment, showing the major surface water basins (left) and groundwater provinces (right) in Missouri.

4.2.2 Missouri Water Quality Statutes and Regulations

The Missouri water quality regulations can be found in Title 10 of the Code of State Regulations (CSR) Division 20 Clean Water Commission, Chapter 7 Water Quality (10 CSR 20-7). This portion of the CSR details statutes and rules covering effluent regulations, water quality standards, and methodologies for development of the impaired waters list. Each of these will play an important role in the development of the Missouri Water Plan. Missouri's water quality standards are reviewed and modified during the triennial review process through coordination with MDNR, the EPA, other state agencies, and concerned citizens. Water quality standards provide the regulatory framework and scientifically defensible thresholds and targets useful for assessment of the overall water quality across the state.

Applicability

A summary and explanation of the rules and regulations defined in 10 CSR 20-7 will be an integral part of the Missouri Water Plan.

Beyond providing a frame of reference for water quality assessment via the narrative and numeric water quality standards, 10 CSR 20-7 includes descriptions of the designated uses and other regulatory classifications (e.g., outstanding water, cold water fisheries, metropolitan no-discharge streams) assigned to water bodies throughout the state.

4.2.3 Missouri Water Quality Assessment System

MDNR maintains an online database of statewide water quality data known as the Missouri Water Quality Assessment System. This database houses a subset of water quality data generated by the MDNR Environmental Services Program, MDC, and other organizations that are used by MDNR to determine if a waterbody is maintaining its designated uses. This dataset is essential to MDNR's development of the biennial submittal of a 303(d) List of impaired waterbodies to EPA. A wide range of water quality, fish community, and macroinvertebrate data collected from springs, streams, rivers, and lakes throughout the state are included in the database. The dataset is publicly accessible and searchable by waterbody ID, waterbody name, and by county.

Applicability

MDNR's Missouri Water Quality Assessment System will serve as one of the primary sources of statewide surface water quality data during development of the Missouri Water Plan.

4.2.4 STORET Data System and Cooperative WQP

The EPA maintains the STORET Data Warehouse as a repository for water quality, biological, and physical data used by state environmental agencies, EPA, other federal agencies, universities, private citizens, and other agencies and organizations throughout the country. STORET is populated with water quality monitoring data collected by water resource management groups across the country. These organizations (states, tribes, watershed groups, other federal agencies, volunteer groups, and universities) submit data to the STORET warehouse to make their data publically accessible.

Applicability

STORET and the WQP will serve as valuable sources of statewide surface water quality data during development of the Missouri Water Plan.

The WQP is a similar cooperative service sponsored by USGS, EPA, USDA, and the National Water Quality Monitoring Council (NWQMC) that serves as an additional access point for data collected by over 400 state, federal, tribal, and local agencies. The WQP offers modernized access to integrated datasets housed in STORET as well the USGS's National Water Information System (NWIS) and USDA's Sustaining the Earth's Watersheds- Agricultural Research Database System (STEWARDS). The WQP system is searchable through form-based queries and can be integrated and queried through standalone web services. The WQP currently houses 265 million results from 2.2 million sampling locations throughout the country. Therefore, WQP is the largest and most comprehensive water quality database publicly available.

The STORET database and WQP include a broad range of Missouri water quality data and is searchable by a number of attributes, including waterbody name and ID, county, state, watershed, HUC, parameter, date, and sampling program.

4.2.5 303(d) Listings

Section 303(d) of the federal Clean Water Act requires that each state identify waters that are not meeting water quality standards established to protect beneficial uses of water such as whole body contact, protection of fish and other aquatic life, and drinking water for people, livestock, and wildlife. MDNR develops and updates the Missouri 303(d) list on a biennial basis to track waters that are impaired but not addressed by normal water pollution control programs.

Applicability

Missouri's 303(d) list will serve as a primary data source for assessing current water quality issues known to occur throughout the state. The existence of numerous editions of the 303(d) list going back several decades may also serve as a source for identifying broader temporal trends in water quality issues in the state, which can be incorporated into the water quality portion of the Missouri Water Plan.

To develop the 303(d) list, available and acceptable data are assessed by MDNR using listing methodology developed with a broad range of stakeholder involvement and approved by the Clean Water Commission. The methodology is used to determine if waters of the state are meeting their designated uses. Waterbodies determined to not be meeting one or more of its assigned designated uses, are placed on the 303(d) list of impaired waters. If, through ongoing assessments, a previously impaired water is determined to now be meeting water quality standards, then it is proposed for delisting. The 303(d) list is then reviewed and must be approved by the Clean Water Commission before it is forwarded to the EPA for their final review and approval. The final 303(d) list includes listings of impaired waters, the uses for which they are impaired, and the parameter or source of the impairment.

4.2.6 305(b) Reports

Section 305(b) of the federal Clean Water Act requires each state to report on the status of all waters throughout the state. In Missouri, this obligation is fulfilled via the integrated Missouri Water Quality 305(b) Report. The report, published every 2 years, summarizes water quality issues and assesses the progress made toward meeting federal Clean Water Act goals and helps direct future water quality management efforts to those waters most in need of restoration or protection. This report also includes details of the impaired waters on the 2014 303(d) list discussed previously (**Table 4-1**).

Applicability

The Missouri Water Quality Report will serve as a valuable resource for identifying water quality issues throughout the state. The report is a source of data inventory information and details on water quality controls employed in Missouri (e.g., standards, permits, TMDLs). Each biennial report also includes a summary of cost/benefit analyses conducted regarding water quality improvement programs and contains detailed descriptions of the state's broader recommendations and concerns associated with water quality issues. The existence of numerous editions of the report going back many years may also serve as a source for identifying broader temporal trends in water quality issues in the state, which can be incorporated into the water quality portion of the Missouri Water Plan.

Table 4-1 - Summary of Stream Impairments from the 2014 305(b) Report

Cause/Impairment Type	Impaired Stream Miles	Percent of Total Miles
Bacteria (Fecal coliform and E. coli)	2,490	10.17
Low Dissolved Oxygen	887	3.62
Mercury in Fish Tissue	695	2.84
Macroinvertebrate Bioassessments	350	1.43
Lead	257	1.05
Zinc	124	0.51
Cadmium	108	0.44
Sediment/Siltation	93.4	0.38
Fish Bioassessments	84.7	0.35
Temperature	46.5	0.19
Chloride	45.9	0.19
Dissolved Oxygen Saturation	35.6	0.15
pH	35.4	0.14
Cause Unknown	26.2	0.11
Ammonia	16.7	0.07
Total Dissolved Solids	15.5	0.06
Nickel	12.2	0.05
Total Suspended Solids	10.9	0.04
Nutrients	5.6	0.02
Sulfates	4.5	0.02
Chlordane in Fish Tissue	4.4	0.02
Copper	2.4	0.01

4.2.7 Total Maximum Daily Load Reports

Under the federal Clean Water Act, states are required to develop a TMDL for all impaired waterbodies included on the 303(d) list. A TMDL is a quantitative assessment of water quality impairments, contributing sources, and pollutant reductions needed to attain water quality standards. The TMDL specifies the amount of pollutant or other stressor that needs to be reduced to meet water quality standards, allocates pollutant control or management responsibilities among sources in a watershed, and provides a scientific and policy basis for taking actions needed to restore a water body.

A list of all TMDLs under development in Missouri and reports for all completed TMDLs are available online through MDNR's website at http://dnr.mo.gov/env/wpp/tmdl/. Each TMDL document includes allocations of the acceptable load for all sources of the pollutant as well as an implementation plan intended to identify how the load will be reduced to a level that will protect water quality.

Applicability

These documents will be useful in understanding how the state is addressing water quality issues and will provide insight into potential implementation concepts and possible future water quality control projects that will be discussed in the water quality portion of the Missouri Water Plan.

4.2.8 Missouri Clean Water Information System

MDNR maintains a comprehensive statewide database of water quality and discharge permitting information called MoCWIS. MoCWIS is a web-based application used by the department's Water Protection Program to maintain and manage Missouri's water quality standards, wastewater permitting and compliance, and discharge water quality monitoring and assessment programs. The application includes search functionality on publicly accessible web pages that allow a user to access information on water quality standards, permitted discharges, and discharge water quality data throughout the state through attribute and geographic searches.

Applicability

MoCWIS will serve as a primary data source during development of the Missouri Water Plan. Specific attributes of the MoCWIS system that will be used in development of the plan include information on localized applicability of water quality standards and water quality data associated with discharge monitoring reports (DMRs) from permitted discharges.

4.2.9 MDNR Compliance and Enforcement Violations Lists

MDNR is responsible for enforcing Missouri clean water laws and, as such, requires a permit for all facilities that discharge or have the potential to discharge to waters of the state. MDNR typically works with a facility to ensure that the conditions of the discharge permit are met. Enforcement actions typically consist of conference, conciliation, and persuasion, which is a statutory process for handling noncompliance. In cases where the violations are not resolved through conference, conciliation, and persuasion, MDNR may use formal enforcement actions to obtain compliance. Reports on violations and enforcement actions are posted to the MDNR Compliance and Enforcement Page and are viewable by county or facility. http://dnr.mo.gov/env/hwp/enf/index.html

Applicability

The MDNR compliance and enforcement violations lists may be used in development of the 2015 Water Quality Assessment to identify potential causes of water quality issues in localized areas throughout the state. Problem discharges can be identified easily through use of these lists as potential sources of a water quality concern in a given waterbody. Identification of pollutant sources, such as these, may prove critical to development of the Missouri Water Plan.

4.2.10 MDNR Water Quality Monitoring Strategy

MDNR's Water Pollution Control Program developed A Proposal for A Water Quality Monitoring Strategy for Missouri in 2011. This document contains a description of the present water quality monitoring program as well as a proposal for a comprehensive statewide water quality monitoring program with the overall objective of providing data sufficient to allow a water quality assessment of all waters of the state. The monitoring strategy provides a summary of previous sampling efforts and identifies 13 significant data gaps with recommendations for future monitoring. Estimated costs to implement programs to fill many of these data gaps are also included. This document remains a proposed strategy but provides a valuable summary of past efforts and future goals of the MDNR water quality monitoring program.

Applicability

The 2011 proposed Water Quality Monitoring Strategy provides a valuable summary of past efforts and future goals of the MDNR water quality monitoring program. The document also discusses numerous data gaps identified by MDNR that will be addressed in detail in the Missouri Water Plan.

4.2.11 MDNR Environmental Services Program Studies

MDNR's Environmental Services Program includes a Water Quality Monitoring Section charged with assessing the biological health of Missouri's rivers and streams, and monitoring water and sediment quality throughout the state. The section works in support of the Water Protection Program to protect clean water supplies necessary for drinking, recreation, tourism and continued economic growth. Water Quality Monitoring Section staff routinely collects and evaluates a wide variety of water, sediment, and macroinvertebrate samples and performs additional special studies. Recent studies performed include Missouri State Parks swimming area *E. coli* sampling, Lake of the Ozarks *E. coli* sampling, initial work on assessing and developing a monitoring program for headwaters, as well as comprehensive studies of sediment in large rivers.

Applicability

Sampling results and datasets associated with MDNR's Environmental Services Program studies will serve as an additional source of water quality data during development of Missouri Water Plan. An assessment of the program's reports and an understanding of the factors driving the execution of the special studies performed will provide insight into issues of interest and data gaps that may need to be addressed in the plan update.

4.2.12 Section 319 Nonpoint Source Implementation Program

Congress amended the Clean Water Act in 1987 to establish the Section 319 Nonpoint Source Management Program to help focus state and local nonpoint source pollutant reduction efforts. Nonpoint source water pollution includes all contaminants that do not originate from discharge pipes or other permitted source. Nonpoint sources of contaminants include runoff from agricultural areas, surface mines, roads, and urban areas; as well as other non-permitted sources such as septic systems.

Applicability

Nonpoint source issues are likely to be a critical component of the Missouri Water Plan and the Missouri Nonpoint Source Management Plan will serve to provide insight and detailed project and funding information regarding established nonpoint source management projects and priorities as they currently stand in the state.

Through funding provided under Section 319, Missouri receives grant funding that supports a variety of activities aimed at reducing nonpoint source pollutant loads. Grants can be used to fund technical assistance, financial assistance, education, training, technology transfer, demonstration projects and monitoring to assess the success of specific nonpoint source implementation projects. As part of the 319 Program, Missouri developed and maintains the Missouri Nonpoint Source Management Plan to describe the state program for nonpoint source management and serves as the basis for how funds are spent in addressing nonpoint source pollution. The Management Plan is revised every five years with a major revision having occurred in 2014 that reflects new state and national priorities.

4.2.13 MDNR Biological Assessments Database

MDNR initiated the process of biological criteria development in 1992 and has since developed a biological assessment (bioassessment) program based on numeric biological criteria for benthic macroinvertebrates reported in the 1997 University of Missouri document: Biological Criteria for Streams of Missouri and the 2002 Department of Natural Resources document: Biological Criteria for Wadeable/Perennial Streams of Missouri. MDNR's bioassessment program utilizes several macroinvertebrate metrics based on taxa richness, sensitive macroinvertebrate species presence, the Shannon index, and the Biotic index. Numeric criteria for these metrics have been developed for each of the 19 aquatic ecoregions (ecological drainage units) established in the state based on assessments of a total of 62 perennial reference streams. Bioassessment reports and information on metrics can be found at the Bioassessment program's website: http://dnr.mo.gov/env/esp/Bioassessment/.

Applicability

Nonpoint source issues are likely to be a critical component of the Missouri Water Plan and the Missouri Nonpoint Source Management Plan will serve to provide insight and detailed project and funding information regarding established nonpoint source management projects and priorities as they currently stand in the state.

4.2.14 MDNR and EPA Climate Change in Missouri Streams Project

In 2008, the EPA provided initial funding for MDNR to perform a 5 year pilot study intended to investigate the potential impacts of climate change on Missouri streams. Continuous data loggers have been deployed at select stream locations to provide long-term monitoring information on instream temperatures and other water quality parameters. Additional measurements of air temperature, flow, and stream type were collected at each sampling station. The project is ongoing and is scheduled to continue collecting biological and water quality data for the next 20 years. This dataset is available through MDNR directly.

Applicability

The stream water quality data compiled by MDNR as a result of the Climate Change study will serve as an additional data source during development of Missouri Water Plan. Findings from this long-term study may also provide valuable insight into potential effects climate change may have on Missouri streams.

4.2.15 Missouri Outstanding Resource Waters

Outstanding Resource Waters are listed and defined in 10 CSR 20-7 and consist of both state and national categories of outstanding resource waters that are designated to receive special protection against any degradation in quality. National Outstanding Resource Waters include all waters in the Ozark National Scenic Riverways and the Wild and Scenic Rivers system and other waters that have outstanding national recreational and ecological significance (see Figure 4-2). State Outstanding Resource Waters are specifically designated by the Clean Water Commission as high quality waters with a significant aesthetic, recreational, or scientific value.

Applicability

Outstanding Resource Waters will be identified and highlighted in each regional portion of the water plan and can be used to identify areas of special concern, potentially warranting additional protections in the future.

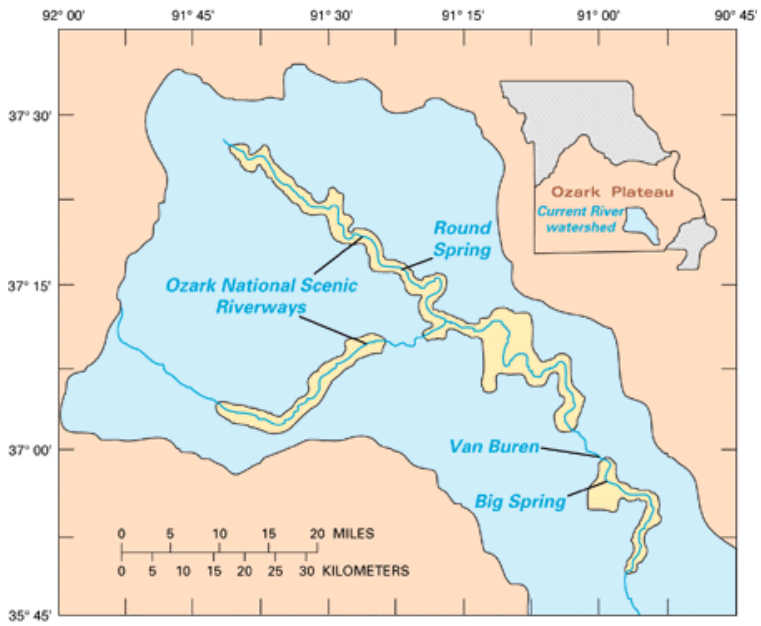

Figure 4-2. Ozark National Scenic Riverways

These waters represent the highest quality waters in the state and will merit special attention in the water quality section of the 2015 Missouri Water Plan.

4.2.16 USFWS Threatened and Endangered Aquatic Species List

The USFWS maintains an online database containing information on all species listed on the federal T&E species list. This dataset can be queried to show only those species known to occur in Missouri. A number for the listed animal species in Missouri are aquatic organisms or water fowl closely tied to aquatic systems (**Table 4-2**). The USFWS database includes links to specific information and documentation regarding the location, current status, and recovery plans for each of the listed species.

Applicability

Outstanding Resource Waters will be identified and highlighted in each regional portion of the water plan and can be used to identify areas of special concern, potentially warranting additional protections in the future.

4.2.17 MDC Special Studies and Aquatic Data

The MDC conducts a wide range of scientific studies regarding both terrestrial and aquatic habitat in all regions of the state. Although they do not maintain a statewide dataset regarding water quality, many of their studies do include significant water quality data collection. MDC also collects information to obtain a general idea of the biological health of many Missouri streams through a statewide aquatic resources monitoring program. MDC shares information with MDNR through a Memorandum of Understanding (MOU). Through direct consultation with MDC staff, any relevant MDC datasets will be identified and considered for inclusion in the production of the water quality assessment portion of the Missouri Water Plan.

Applicability

Biological and water quality data collected by MDC for specific lakes or streams may be incorporated into the water quality assessment and trend analyses, assuming the quality of the data is suitable for comparison.

Table 4-2 - Federally Listed T&E Aquatic Life and Water Fowl Species Known to Occur in Missouri.

Status	Species/Listing Name
Endangered	Cavesnail, Tumbling Creek (*Antrobia culveri*)
Endangered	Crayfish, cave (*Cambarus aculabrum*)
Endangered	Dragonfly, Hine's emerald (*Somatochlora hineana*)
Endangered	Hellbender, Ozark (*Cryptobranchus alleganiensis bishopi*)
Endangered	Higgins eye (pearlymussel) (*Lampsilis higginsii*)
Endangered	Mapleleaf, winged ; except where listed as experimental populations (*Quadrula fragosa*)
Endangered	Mucket, Neosho Neosho mucket (*Lampsilis rafinesqueana*)
Endangered	Mucket, pink (pearlymussel) (*Lampsilis abrupta*)
Endangered	Mussel, scaleshell (*Leptodea leptodon*)
Endangered	Mussel, sheepnose (*Plethobasus cyphyus*)
Endangered	Mussel, snuffbox (*Epioblasma triquetra*)
Endangered	Pearlymussel, Curtis (*Epioblasma florentina curtisii*)
Endangered	Pocketbook, fat (*Potamilus capax*)
Endangered	Sculpin, Grotto (*Cottus specus*)
Endangered	Shiner, Topeka (*Notropis topeka*)
Endangered	Spectaclecase (mussel) (*Cumberlandia monodonta*)
Endangered	Sturgeon, pallid (*Scaphirhynchus albus*)
Endangered	Tern, least interior pop. (*Sterna antillarum*)
Threatened	Cavefish, Ozark (*Amblyopsis rosae*)
Threatened	Darter, Niangua (*Etheostoma nianguae*)
Threatened	Knot, red (*Calidris canutus rufa*)
Threatened	Madtom, Neosho (*Noturus placidus*)
Threatened	Plover, piping except Great Lakes watershed (*Charadrius melodus*)
Threatened	Rabbitsfoot Rabbitsfoot (*Quadrula cylindrica cylindrica*)

4.2.18 MDC Resource Assessment and Monitoring Program

The MDC's RAM Program was primarily established to assess and monitor long-term trends in the health of Missouri's warm-water streams. Field teams collect water quality and habitat data along with fish and macroinvertebrate samples in order to assess stream health and facilitate stream restoration efforts. Stream health indicators are developed by comparing the fish and macroinvertebrate communities from the sampled stream with samples from reference sites established throughout the state. Sampling sites for health assessments are chosen at random from 17,507 miles of permanently flowing, but wadeable Missouri streams and the resulting aquatic community information is used to prioritize and focus conservation efforts in watersheds across Missouri. MDC also shares information collected throughout the state directly with MDNR as prescribed in a MOU developed between the two agencies in 2012.

Applicability

MDC's RAM database includes fish, macroinvertebrate, and water quality data collected at hundreds of locations throughout the state. Stream health indicators have been developed and assigned to each site. These data may be directly incorporated in development of the Missouri Water Plan and may aid in prioritizing watersheds of special conservation concern.

4.2.19 MDC Missouri Watershed Inventory and Assessment

The MDC has conducted an inventory and assessment for 37 of 45 watersheds in Missouri. For each watershed an overview of historic and current conditions for geology, land use, hydrology, water quality, habitat conditions, and biotic community is provided. For each watershed management problems and opportunities are outlined as goals with objectives. Strategies are provided to achieve the objectives toward meeting the goals.

Applicability

MDC's Missouri Watershed Inventory and Assessment provide significant baseline information for many watersheds as well as management problems which may advise the Missouri Water Plan.

4.2.20 MDC Species and Communities of Conservation Concern

The MDC maintains Missouri Species and Communities of Conservation Concern Checklist, a list of species and communities within the State of Missouri that are threatened, endangered, or otherwise known to be of special conservation concern. While similar to the USFWS list of federally threatened and endangered species, the Missouri list includes a greater number and wider variety of species listed on the state, federal, and global levels.

Applicability

A discussion of species listed in the *Species and Communities of Conservation Concern Checklist* will be provided on a statewide basis in the Missouri Water Plan. The species listings and any available known geographic distribution information may be used to identify regions and waterbodies within the state that may warrant special consideration when assessing the current and future water quality characteristics.

The species catalogued in the checklist represent approximately 18 percent of the native vascular plants, 14 percent of the nonvascular plants, 28 percent of the vertebrates, and an unknown percentage of the native invertebrate species known to occur in Missouri. A total of 58 species of mollusk, 42 crustacean, 14 species of amphibian, and 65 species of fish are included in the 2015 species of concern list. A large proportion of these species are aquatic in nature and/or have the potential to be significantly impacted by changes in surface water quality.

4.2.21 Clean Water State Revolving Fund

The CWSRF is designed to help communities nationwide meet the goals of the Clean Water Act by improving water quality, protecting aquatic wildlife, protecting and restoring drinking water sources, and preserving our waters for recreational use. The SRF provides low-interest loans to municipalities, counties and public sewer districts, and political subdivisions for wastewater infrastructure projects. The SRF is also used to administer the EPA's Clean Watershed Infrastructure Needs Surveys, the results of which are published by EPA. The survey results provide information regarding the capital costs required to address water quality problems.

Applicability

The available SRF data and survey information can be used to assess the current financial needs for water infrastructure projects and highlights a possible avenue to future fiscal aid for ammonia and nutrient treatment upgrades. A discussion of this relationship may be included in the conclusions or discussion section of the water quality assessment portion of the Missouri Water Plan as it relates to current and future water quality issues and concerns on a statewide level and suggest ways in which some of these concerns may be dealt with in the future.

4.2.22 Clean Water Intended Use Plan & Annual Report

The CWSRF IUP is published annually by MDNR and provides an overview of the overall intended use and specific projects that receive funding from the SRF each fiscal year based on applications received from communities wishing to proceed with projects. The SRF annual report includes financial information regarding past spending of the SRF. Types of projects that may receive SRF funding may include urban runoff, wet weather flow, stormwater and sewer overflows, water reuse and conservation, and alternative treatment projects.

Applicability

The SRF annual report may prove to be useful data sources for identifying areas of water quality concern that have been addressed through updated infrastructure projects. The SRF IUP can assist in identifying current areas of concern and specific infrastructure improvements that may be being funded by the state, which may lead to future impacts to local water quality conditions.

4.2.23 2013 ASCE Report Card for Missouri's Infrastructure

The Kansas City and St. Louis sections of the ASCE collaborated to produce the 2013 ASCE Report Card for Missouri's Infrastructure. This document includes grades for each of the 11 separate infrastructure categories evaluated throughout the state, including categories for drinking water and wastewater. For each category, the technical committee incorporated known information regarding the capacity, condition, funding, future need, operation and maintenance, public safety, and resiliency status currently believed to be present. Both the drinking water and wastewater categories received a score of C- in the 2013 report card, indicating significant improvements may need to be made.

Applicability

The information provided in the ASCE Report Card for Missouri's Infrastructure and the listed source materials for ASCE's evaluations will be assessed and incorporated into a discussion of the potential impacts of drinking water and wastewater infrastructure in Missouri on surface water and groundwater quality in the state.

4.2.24 MDNR GIS Data Catalog

MDNR develops and maintains an extensive GIS data catalog that includes base map information, as well geological, cultural, land use, and water-related spatial data. Spatial information regarding impaired waters, point source discharges, applicable water quality standards, watershed delineation, and water quality assessments are included in the catalog. MDNR maintains an online map viewing data portal that is publically accessible. Direct access to the GIS data files is possible through direct communication with MDNR.

Applicability

MDNR's GIS data catalog will serve as a primary source of spatial data related to water and water quality during development.

4.2.25 Missouri Resource Assessment Partnership Aquatic Gap Project Data

The MORAP aquatic gap project was developed to identify species, habitats, and ecosystems in Missouri's river systems that are not adequately represented among the wide range of conservation lands established in Missouri. The project was intended to provide spatially explicit data that could be used by natural resource professionals, legislators, and the public to make more informed decisions for prioritizing opportunities to fill these conservation gaps. The aquatic gap project resulted in the development of a report titled: *A Gap Analysis for Riverine Ecosystems of Missouri* in 2005. This report and the associated datasets are available via the USGS website at: http://morap.missouri.edu/index.php/aquatic-gap-pilot-project/.

Applicability

The gap analysis report and associated datasets will serve as an additional data source and will provide a baseline list of riverine systems throughout the state that have been identified as being of high conservation value. The study also provides some insight into alternative data gap identification methods potentially applicable to development of the Missouri Water Plan.

4.2.26 University of Missouri Center for Applied Research and Environmental Systems

CARES is a mapping and data visualization center located at the University of Missouri. CARES produces and publishes a wide ranging collection of research datasets, several of which will prove relevant and useful to the water quality assessment portion of the Missouri Water Plan. Three programs in particular will be evaluated and potentially used as integrated datasets in the development of the water quality assessment:

- ***Missouri Map Room*** - a web-based geographic data visualization tool that allows a user to explore and download thousands of geographic datasets for Missouri. Geographic datasets available cover a wide range of categories and feature classes related to water quality, land use, topography, and geology that may be incorporated in the water quality assessment.
- ***Vulnerability Assessment*** - maps of public drinking wells and impoundments map locations along with reports showing potential sources of water contamination developed and updated quarterly at the request of MDNRs Public Drinking Water Branch.
- ***Nutrient Management Tracker*** - a suite of tools designed to support strategic and tactical nutrient management planning for agriculture, a primary source of nutrient loading into waterbodies throughout the state.

Applicability

Three programs in particular will be evaluated and potentially used as integrated datasets in the development of the water quality assessment: Missouri Map Room, Vulnerability Assessment, and Nutrient Management Tracker.

The datasets available from CARES may be used directly from the public access points, or if necessary, University of Missouri staff involved in the CARES program may be contacted for additional information and data requests related to the development of the water quality assessment portion of the Missouri Water Plan.

4.2.27 USGS Missouri Water Science Center

USGS Missouri Water Center webpage serves as a direct link to a wide range of water-resource information compiled for the state. Information regarding surface water flows, groundwater, water quality, and other data are provided through this service. Among the data compiled and presented by the Missouri Water Science Center are numerous annual water quality summary reports for surface waters in Missouri going back to 2007. Additional resources and reports regarding quantity and quality of both surface and groundwater are also included. The Missouri Water Science Center will serve as a primary source of groundwater quality information during development of the Missouri Water Plan.

Applicability

The USGS Missouri Water Science Center webpage provides numerous resources and reports regarding quantity and quality of both surface and groundwater resources throughout Missouri. These reports will serve as a primary source for groundwater quality information and will provide additional resources and data during development of the Missouri Water Plan, particularly related to historical trends in water quality in the state.

4.3 Proposed Methodology

Development of the water quality section of the Missouri Water Plan will require accessing, organizing, and interpreting a wide range of datasets from each of the sources described above. To maintain consistency with previous efforts, the Volume III Water Resources Report 47 (WR47) Missouri Water Quality Assessment, produced as part of the initial State Water Plan effort in 1997, will be used to develop the basic framework and structure of the water quality section of the Missouri Water Plan.

A similar approach to defining groundwater and surface water regions within the state will be incorporated into the Missouri Water Plan, which will again focus on addressing the chemical, bacteriological, and radiological quality of water, historical and projected changes to water quality, and the effects of waste disposal on water. The most recent available water quality data will be assessed and summarized as part of the Missouri Water Plan along with current water quality standards and regulations. Water quality data from key water bodies and aquifers in all major sub-basins will be used to describe current conditions and changes to water quality over time. Major issues associated with water quality that have surfaced in recent years, such as changes to ammonia standards and the future development and implementation of new nutrient standards for surface waters, will be addressed in the updated plan. Maps and figures depicting the primary regions, groundwater provinces, watersheds, water quality sampling stations, geology, and land use classifications throughout the state will be included in various sections throughout the report.

A greater focus on the health and stability of aquatic communities throughout the state will be incorporated throughout the updated plan. Water quality issues and the related impacts to state and federally listed threatened and endangered species also will be a major focus of the updated plan. Significantly more water quality data have been collected and made available for surface and groundwater systems in Missouri since the development of the 1997 assessment, and these newer data sets will be used in more detailed assessments of statewide and regional water quality trends in the updated report. A discussion of the potential impacts to water quality that may be expected under each of the projected flow and water demand scenarios developed for the

overall Missouri Water Plan will be included in the water quality assessment. A summary of the overall approach to the surface and groundwater quality assessments is provided below.

4.3.1 Current Statewide Water Quality

The characterization of water quality is intended to provide an overall summary of surface and groundwater quality as well as specific water quality information that will contribute to the quantification of water availability presented in other portions of the Missouri Water Plan. The basic approach will be to use existing assessments and studies to characterize current water quality conditions associated with the available water quantities being determined through the development of the Missouri Water Plan. Priorities for both water quality protection and water quality restoration will be identified and characterized. The 2014 Statewide Missouri Water Quality Report and impaired waters list (303(d) list) prepared by MDNR will be a primary source, particularly in regard to surface water quality. This is the most current year for which approved documents are available. Information contained in the Missouri Water Quality Report will be combined with other water quality data sourced from MDNR's Water Quality Assessment System, STORET, and other potential sources of groundwater and surface water quality data to provide the most robust water quality dataset possible for the statewide water quality assessment.

Information within the water quality assessment will include comparisons to applicable surface water quality criteria that will be presented in terms of a waterbody's designated uses, similar to the sectors of use being used to evaluate water quantity in other sections of the Missouri Water Plan that are impaired by water quality conditions. Waterbodies assessed by MDNR and those with impaired and unimpaired designated uses will be displayed on maps (GIS layers provided by MDNR). In addition, information about MDNR water quality classification and designated use attainment will be summarized in tables, including the pollutants believed to be causing impairments, and identified sources of those pollutants.

Information on water quality from several other sources discussed above will also be included. Waterbodies designated as state or federal Outstanding Resource Waters will be highlighted as priority watersheds and will be identified and discussed in terms of water quality, attainment of designated uses, pollutants, and pollutant sources. TMDLs that have been, or are being prepared will also be discussed. Active fish consumption advisories, which affect the recreation use sector, will be identified. An assessment of the potential impacts of current water quality conditions on state-designated species and communities of conservation concern and federal threatened and endangered species will also be included. Finally, recent or ongoing surface water quality-related studies (including those conducted by MDNR, USGS, MDC, and universities) that have been identified and meet plan criteria for scale and data quality will be discussed.

An assessment and summary of statewide water quality standards in relation to current water quality conditions will also be included along with brief summaries of each major constituent of concern identified on a statewide level. A discussion will also be included of groundwater quality reflecting potential contaminants of concern such as nitrates, sulfates, radionuclides, chlorides, iron, manganese, brackish water, etc. Beyond the statewide assessment, subsections containing more detailed descriptions of each of the major surface waterbodies and groundwater aquifers in Missouri and the associated water quality that currently exists in each basin, region, or groundwater province will be developed. The option also exists to include more advanced

assessments of overall water quality present throughout an entire river, lake, reach, watershed, or aquifer through the use of any of a number of possible surface water or groundwater models.

4.3.2 Long-term Trends in Water Quality

MDNR, MDC, USGS, and potentially other state, federal, and local entities have maintained numerous surface and ground water monitoring stations with data records that go back at least to the 1970s. Groundwater monitoring has primarily been focused on groundwater levels, not quality. Groundwater quality data may be available from individual systems or regional water suppliers. Likewise, MDNR regional and Water Resources staff will have insights. These long-term stations will be identified through evaluation of station periods of record and discussions with MDNR and other agencies' staff. Water quality records from any additional sources with data for 30 years or more also will be identified. Long-term trend evaluations will be focused on water quality stations with 30 years of data or more that are associated with, or located in proximity to, the sites (i.e., flow gages) being used in the available water quantity assessment. Where available, data from more than one source agency (e.g., MDNR and USGS) will be evaluated. All selected water quality stations will be shown on maps.

Time series of long-term data records from the selected surface and groundwater water quality monitoring stations will be plotted and analyzed for trends (**Figure 4-3**). Depending on the character of the data, the trend analysis may consist of simple linear regressions or seasonal Kendall tests. The water quality parameters that will be evaluated may include dissolved oxygen (fish and wildlife and domestic use), nutrients (fish and wildlife use), bacteria (domestic and recreational use), and sediment (fish and wildlife, nondomestic, commercial and industrial, and navigational use).

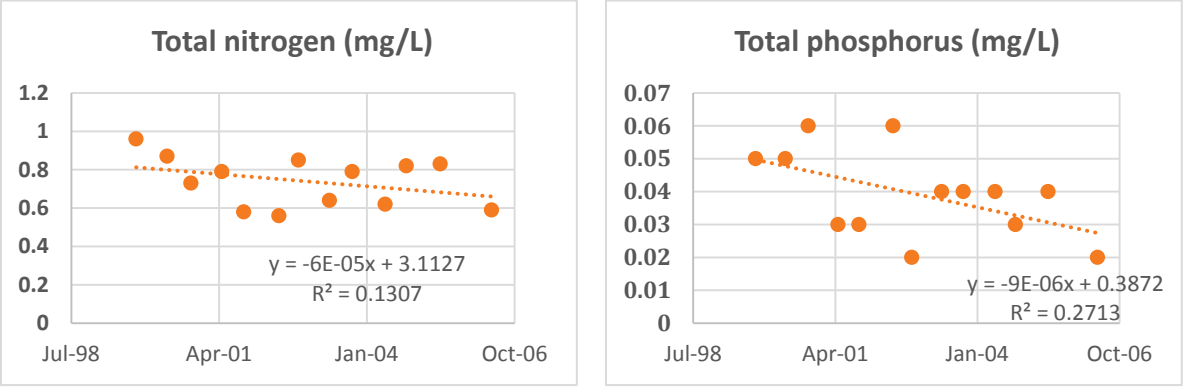

Figure 4-3. Example of simplified long-term trend regression analysis – Current River at Montauk State Park

4.3.2.1 Changes since the Missouri State Water Plan Series Phase I Volume III 1997 Water Quality Assessment

Changes in water quality since the 1997 Water Quality Assessment will be evaluated based on data from the water quality stations selected for long-term trend analysis and information reported in the 2014 Missouri Water Quality Report. In addition, any other available studies of water quality changes during the period from 1997 to 2015 that meet plan criteria for scale and data quality will be summarized. Information on possible causes for any observed changes will be gleaned from resources such as TMDLs, 303(d) listings, permitted discharge violation lists, nonpoint source management plans, and special studies that meet plan criteria for scale and data quality.

A discussion of MDNR listings of water body impairments during the period from 1997 through 2014 will also be included. During this period, the water quality standards, water quality assessment and impairment determination methodologies, and geographic distribution of listed waters likely have evolved and changed. A summary of changes that have occurred in the protocols for assessing and classifying water body water quality since 1997 will be provided. This will include a discussion of the increased importance and focus on the assessment of aquatic communities.

The number of segments and/or miles of streams and number of lakes listed as impaired for each assessment year will be listed in a table along with the use(s) impaired, the pollutant(s) identified as causing the impairment, and any source(s) of the pollutant(s) identified. This information may also be presented in graphs. In addition, for each assessment period, the number of new impairments, old or continued impairments, and removed impairments will be identified. Reasons for the removal of stream segments or lakes from the list of impaired water bodies will also be identified. The influence of changes in water quality standards and assessment methodology on the comparability of the numbers and types of water quality impairments reported will be included in the discussion of the impairments over time.

4.3.3 Existing and Projected Water Quality Issues

Discussion of current water quality issues in each major watershed and groundwater province throughout the state will grow out of the discussion of current water quality conditions. Water quality issues will be categorized in terms of the use sector(s) impacted and whether associated pollutants might be attributed to point and/or nonpoint sources.

Water quality issues identified in the 1997 Water Quality Assessment will be revisited, summarized, and compared to the current issues discussed above. Drivers of any changes in major surface water or groundwater quality issues will be identified and discussed. In addition, if any issues identified in the previous assessment are no longer considered a primary issue, reasons behind this situation will also be identified and discussed.

Existing information will be reviewed to identify any outstanding or emerging water quality issues that could affect water availability over the next 5 years. The importance and major drivers of each of the issues will be discussed in terms of the water resources and the use sectors that could be affected. Some of the primary issues expected to warrant significant discussion in the Missouri Water Plan include:

- Changes to ammonia criteria and the potential impacts to water quality
- Recent changes to bacteria criteria and permitted discharge requirements
- Expected future implementation of new nutrient criteria
- Outstanding Resource Waters
- Groundwater quality
- The state of water quality and ecological flows as it relates to aquatic species
- Emerging contaminants of concern (polycyclic aromatic hydrocarbons (PAHs), endocrine disruptors, pharmaceuticals, etc.)

Any additional emerging issues in water quality that come to light through the water quality assessment development process will also be discussed.

4.3.4 Methodology for Aquatic Species

4.3.4.1 Environmental Flows

An assessment of environmental flows can be utilized in the water planning process to help address non-consumptive water demands for sustaining aquatic communities. Typically, assessments of environmental flows have focused on critical low flow periods as the primary source of impacts from changes in stream flows to aquatic life. Critical low flow conditions are primarily defined through either hydrologically-based or biologically-based statistical assessment. Hydrologically-based low flows are used to assess critical low flow conditions in most states, including Missouri. This method, developed by the USGS, isolates the single lowest flow event from each year of record and then examines these flows for a series of years. The hydrologically-based method is used to examine extreme values such as the lowest 7-day average flow in a 10-year period (7Q10). The advantage of this method is that it utilizes extreme value analytical techniques that are well supported by past engineering and statistical practice. However, this method is generally not conducive to assessing site-specific durations and frequencies sometimes specified in aquatic life criteria.

The EPA has developed biologically-based critical low flow assessments that are designed to examine all low flow events within a given period of record, even if several events occur in a single year. This approach is intended for assessment of the frequency of biological exposure to critical low flow levels and captures the cumulative nature of effects of low flow events on aquatic biota. The biologically-based method uses site-specific averaging periods and frequencies of occurrence that are specified in aquatic life criteria such as the EPA's National Recommended Water Quality Criteria. Recommended averaging and occurrence intervals, such as 1 day in 3 years (1B3) or 4 days in 3 years (4B3) used in the national recommended criteria, are based on the available biological, ecological, and toxicological information concerning the stresses that aquatic organisms, ecosystems, and their uses can tolerate.

As discussed in EPA's document, *Technical Guidance Manual for Performing Wasteload Allocation. Book IV: Design Conditions, Chapter 1*, there are advantages and disadvantages to incorporating analysis of both hydrologically and biologically-based critical low flows and the rationale for the use of each method differs. The hydrologically-based design flow method was initially developed to answer questions relating to water supply and is effective at answering water supply related questions. The biologically-based method was developed specifically to facilitate the use of two averaging periods specified in the application of aquatic life criteria and more directly related to the impacts to an aquatic community that have been shown to occur at various low flows. For example, the once-in-3-year low flow statistic recommended by EPA is based on how long it would take the aquatic community to recover (approximately 3 years) after such low flow conditions occurred. Calculation of hydrologically based critical low flows is currently a regulatory requirement for certain applications in Missouri, while implementation of biologically-based critical low flows as any sort of regulatory requirement in the State would necessitate a rule change.

4.3.4.2 Bioassessment

Biological assessments (bioassessments) are evaluations of a waterbody through direct measurement of the biotic community in the waterbody, including fish, macroinvertebrates, and aquatic plants or algae. Bioassessments can be used to directly determine if a waterbody is meeting its designated aquatic life uses by determining if it is supporting the survival, growth, and reproduction of the appropriate aquatic species. EPA's Rapid Bioassessment Protocols (RBPs) for Use in Streams and Wadeable Rivers (EPA 841-B-99-002) was developed, in part, based on prior work done in Missouri in the 1980s and 1990s, and provides technical guidance on refined and revised methods for conducting cost-effective biological assessments of periphyton (algae), benthic macroinvertebrates, fish communities, and quality of the physical habitat in streams and small rivers. The document has been used as a framework for development of additional biological monitoring programs by MDNR and state water resource agencies in many other states. These protocols have proven to be readily revised and updated to reflect a wide range of regional differences in aquatic habitats and communities.

As discussed in Section 4.2.13 of this report, MDNR has a bioassessment program in place that utilizes numeric biological criteria for benthic macroinvertebrates originally developed in MDNR's Biological Criteria for Wadeable/Perennial Streams of Missouri. The bioassessment program currently in place in Missouri focuses on benthic macroinvertebrates and habitat metrics. However, bioassessment protocols have been developed in several states to assess fish communities through the use of indices such as Index of Biotic Integrity (IBI). While bioassessment of fish communities can provide greater insight into the potential for a waterbody to meet its designated aquatic life uses, the necessary fish assemblage and reference data is not always readily available. Although collection of fish community data has not historically been a major focus for MDNR, fisheries data collection has been performed in the state by MDC, USGS, USFWS, and through various University programs. Collaboration with these entities may provide significant sources of fish assemblage data that could be used to develop bioassessment criteria for fish communities moving forward.

4.3.4.3 Nonconsumptive Needs Toolbox

MDNR may consider the use of an environmental Planning Region Toolbox to support efforts of the Planning Regions and other stakeholders to develop projects to meet nonconsumptive needs. This can serve as a guide for Planning Regions as they develop the Missouri Water Plan. The tools and resources can help stakeholders develop and execute the nonconsumptive portions of the State Water Plan and specific projects in a strategic fashion to meet the nonconsumptive needs identified.

This is not a policy document for the MDNR. The intent of the approach is to provide a compilation of information for use by the Planning Regions and others as they address nonconsumptive needs and implementation of nonconsumptive projects. As the Planning Regions or project proponents consider use of the tools described in this document, they will need to consider the applicability and limitations of the tools that may apply to the issue they are addressing.

Using the Toolbox consists of four fundamental actions. Each action outlines a step in producing a comprehensive state water plan. These actions are discussed in more detail below and in **Figure 4-4**:

Step A. **Basinwide Goals:** Develop goals at the appropriate basin-level or alternative spatial scale and map attributes for each Planning Region identified.

Example: Maintain population of native fish species so that none are listed as threatened or endangered in our basin.

Step B. **Measurable Outcomes:** Establish quantifiable, measurable outcomes for nonconsumptive targets and attributes.

Example: Sustain 10 populations of Niangua darter in 10 different river locations.

Step C. **Needs and Opportunities:** Identify needs and opportunities for protecting targets and attributes and strategically plan to meet those nonconsumptive needs.

Example: Based on analysis of existing levels of protection and where attributes occur, only five populations of Niangua darter are protected. As a result, we need to protect an additional five populations to meet our established measurable outcomes.

Step D. **Decision Process:** Use the decision template to determine what actions need to be taken to meet nonconsumptive needs and implement projects.

Example: For one of the five locations where protection of Niangua darter populations is limited, moving through the decision template may lead to the determination that reservoir reoperation could achieve desired outcomes.

Figure 4-4. Overview of the Nonconsumptive Portion of the Water Plan

While these actions are called "steps," not every Planning Region will start at the top and work their way down the list sequentially. For some regions it may be appropriate to focus on one or two of the steps. Also, each of the steps may inform the other three and there may be interaction between the steps. This process is designed to serve as a guide, but is not prescriptive in its approach. Instead, as projects are assessed, this framework may offer consistency in determining needs, goals, and outcomes. If projects are already assessed or ongoing, then this framework may not need to be utilized.

The Toolbox can be utilized to help develop near-term and long-range plans for meeting goals and implementing projects on the ground. At the Planning Region scale, the tools can be used to help develop a basinwide strategic approach for meeting nonconsumptive needs and developing specific measurable outcomes for environmental attributes.

Step A. Basinwide Goals and Focus Area Mapping

The first step toward developing a State Water Plan is to develop Planning Region-wide goals that specify environmental and recreational targets. These goals will serve as the foundation for a strategic framework to guide current and future nonconsumptive project planning.

Examples of basin-scale goals and objectives include:

- Improve conditions in the basin for all fish species on the federal candidate species list to prevent additional threatened and endangered species listings
- Maintain all habitat for fish species on the state's Species and Communities of Conservation Concern list in the basin
- Maintain important fishing and recreational opportunities in the basin

To improve conditions may entail a restoration project. These projects are often more expensive than projects that protect or maintain existing conditions, but may be needed for high priority attributes or locations. In areas with competing water needs, management actions or limited protection may be the only way to balance multiple uses of a river or stream.

The focus area maps can be developed by each Planning Region based on a common set of environmental and recreational attributes and represent where Missouri's important water-based environmental and recreational attributes are located. The maps can be reflective of stakeholder input for the focus areas and also reflect stream reaches and subwatersheds with higher concentrations of environmental and recreational qualities. These maps will be generated to provide information to the Planning Regions on important environmental and recreational areas in their basins but are not intended to dictate future actions. The MDNR can use the environmental and recreational focus area mapping for the following purposes:

- The maps are intended to serve as a useful guide for water supply planning to enable coordination on future projects and to help avoid future conflicts between meeting consumptive, environmental, and recreational needs
- The maps can assist in identifying the status of environmental and recreational water needs, including reaches where needs are being met, where additional study is needed, and where proposed implementation projects in the basin have been identified
- The maps can help basins plan for the water needs of species of special concern so that they do not become federally listed as endangered or threatened in the future
- The maps can provide a basis for collaborative efforts for future multi-objective projects

Step B. Measurable Outcomes

Once environmental and recreational attributes have been identified and planning area goals established, the next step for the nonconsumptive portion of the Planning Region implementation plans is to formulate measurable outcomes for environmental and recreational attributes based on the Planning Region goals. A measurable outcome is a statement that articulates—in measurable or quantifiable terms—the desired state of an attribute as a result of an action or decision, such as:

- Maintain 80 percent of smallmouth bass habitat or population levels in subbasin Y
- Increase habitat or population levels for candidate species by 15 percent in the basin
- Protect the two populations of northern redbelly dace in subbasin X
- Increase acres of wetlands for waterfowl by 500 acres by 2015
- Maintain 90 percent of boatable days at select recreation locations

Measurable outcomes should be identified at both the local scale (project level) and at the Planning Area (regional strategy). The process of developing measurable outcomes should involve stakeholders with a diverse range of interests. Projects should be planned both proactively and strategically to address current and future issues.

Step C. Needs and Opportunities

Once attributes have been assessed for the basin and measurable outcomes established, the next step is for planning areas to survey existing and planned projects and methods and identify needs and opportunities to meet measurable outcomes. This step in the planning process is focused on conducting analyses to identify gaps in nonconsumptive needs, determine protection statistics, and consider project funding sources to devise comprehensive implementation plans. Planning areas may want to explore the existing and planned projects and methods for a given attribute before determining measurable outcomes.

Step D. Decision Process

The decision tree in **Figure 4-5** can be used to identify what should be done to ensure the long-term maintenance of an environmental or recreational attribute on a specific stream reach, which may have been identified through Step C. These actions should support planning area goals (Step A) and measurable outcomes (Step B).

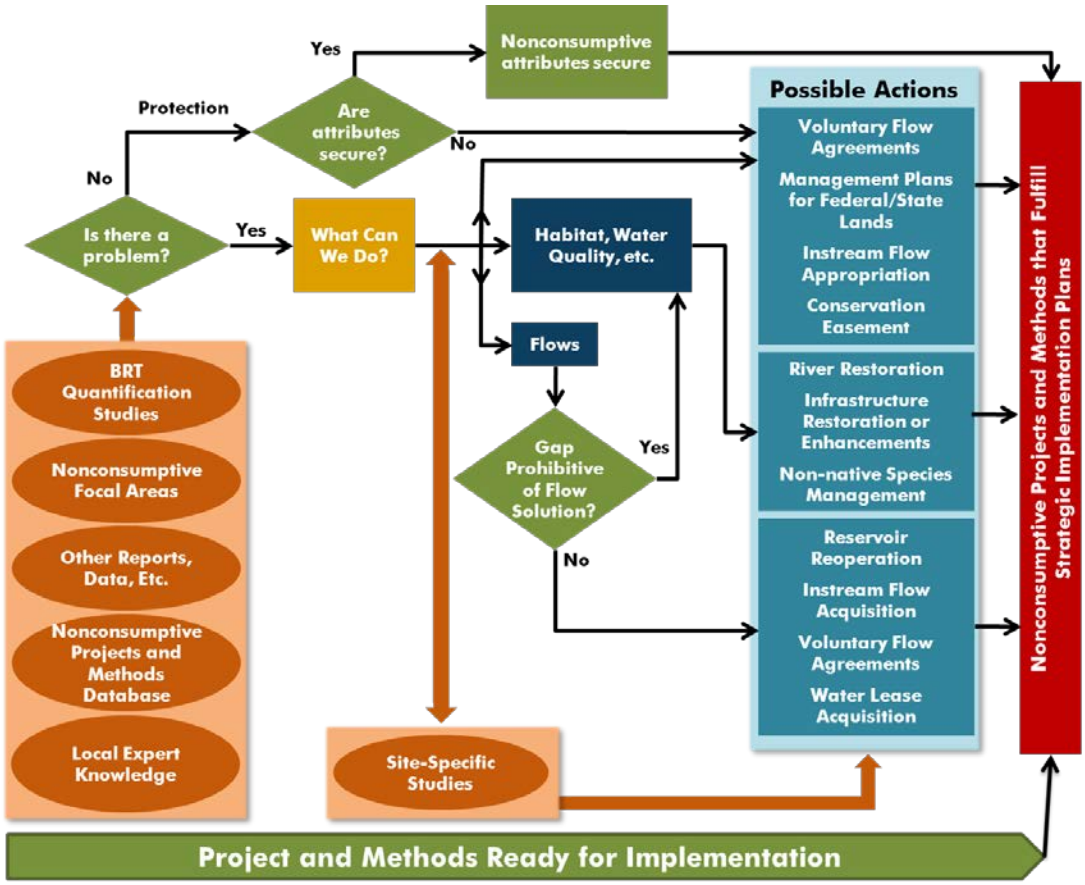

Figure 4-5. Decision Tree for Planning and Implementing Nonconsumptive Projects

If a Planning Area chooses to develop its implementation plan, this decision tree might be applied to a mapped focus area where an environmental or recreational attribute is present. In this case, the decision tree could guide the understanding of what actions are needed in relevant focus segments or locations across the entire watershed. Alternatively, the decision tree can be used on an individual stream segment to identify what should be done in that segment.

Although significant information has been gathered, there may be segments or locations with environmental or recreational attributes where there remains insufficient information to answer the first question in the decision tree: Is there a problem? In this case, the science tools can be used to understand what attribute(s) may be at risk, but actual monitoring of ecological and recreational indicators may be required to identify the extent to which an attribute exists, if an attribute is of concern, and the actual factors impacting the attribute.

4.4 Data Gaps

A relatively large number of data sources will be used in the development of the water quality assessment portion of the Missouri Water Plan. Many of these data sources are readily available and can be accessed via public data portals. In some cases, the accessibility of available data sources may be improved through direct interaction and cooperation with the host agencies (e.g., MDNR, MDC). Access to back-end search and query functionality within some of the large water quality datasets produced by state agencies may be necessary and potentially even essential to the data analysis process.

The statewide water quality assessment will necessarily be based on the water quality data available at the time of production, but major data gaps will be identified and detailed within the Plan Update along with recommendations for future data collection that may benefit future editions of the Missouri Water Plan. A potential starting point for identifying major data gaps may be found in MDNR's A Proposal for A Water Quality Monitoring Strategy for Missouri. This 2011 document provides a summary of previous sampling efforts and identifies 13 significant data gaps with recommendations for future monitoring and estimated costs of the recommended programs. Additionally, based on the current and previous Missouri Water Quality Reports and a brief inspection of the Missouri Water Quality Assessment System database, it appears likely that statewide sampling and assessment of some parameters, particularly in light of new, expected, and recently revised water quality standards (i.e., nutrients, ammonia, bacteria), has historically been limited, and insufficient data currently exist for a comprehensive evaluation of these parameters. Increased sampling and analysis efforts for these and other emerging parameters of concern may be warranted in the future. A discussion of the data gap issues and potential impacts to this and future statewide water quality assessments will be included in the Missouri Water Plan.

4.5 Major Issues

Development of a comprehensive statewide water quality assessment as part of the Missouri Water Plan will be fundamentally dependent upon the successful integration of available surface water and groundwater quality, land use, infrastructure, biological, and other data types from a wide range of data sources. Successful integration of this array of data sources will require significant coordination and cooperation between project staff and key personnel from MDNR, MDC, and other state and federal agencies and organizations. As part of the current data acquisition and scoping process, initial lines of communication with various key individuals and agencies have already been opened. A series of short interviews with numerous staff have been conducted as a means of developing a preliminary assessment of the available data types and understanding key issues as seen from a variety of perspectives. An ongoing dialogue between project staff and key personnel and maintaining the current level of coordination will be essential to successful production of the Missouri Water Plan.

The Missouri Water Plan will be a dynamic and evolving document as conditions and priorities may shift on various levels during the production period. As such, it is essential that changes in policy, regulation, prioritization, and other critical issues are identified as they occur so that they may be integrated into the water plan in a timely fashion.

4.6 Summary & Recommendations

A comprehensive assessment of the current water quality conditions, issues, concerns, and trends is an integral part of the overall Missouri Water Plan. Maintaining good water quality is a local, state, and national environmental concern that has been increasingly moving to the forefront of environmental policy over the past several decades. Detailed statewide descriptions and summaries of both surface and groundwater water quality that will be incorporated in the Missouri Water Plan will serve to document conditions and concerns and highlight issues that will need to be addressed to maintain and improve water quality in Missouri over the next several decades.

The Water Plan Update is intended to be a starting point for an iterative and collaborative process that will result in the determination of a path forward in addressing water quality issues in the state. Among other fundamental goals of the Missouri Water Plan, the Plan will aim to help the state and all stakeholders through identification and determination of:

- Potential gaps in the current water quality standard and biological criteria that may be limiting the effectiveness of protecting designated uses for waters in the state.
- Data availability and possible under-utilization of existing data.
- Areas where additional state and local efforts are needed for adequate monitoring, assessment, or protection of waters.
- The adequacy and efficacy of the current magnitude, duration, location and frequency of monitoring efforts in the state to maintain trend analysis and change detection.
- Means of prioritizing the potential efforts to fill data gaps and fulfill water quality monitoring, assessment, and protection needs.
- Appropriate metrics for the scale of effort/assessment. (e.g., specific fish populations dependent on the stream size)

It is likely that future updates and editions of the Missouri Water Plan will be inextricably linked to the upcoming Plan Update and will build upon the framework established during this effort. An accurate, thorough, and detailed assessment of the current state of water and water quality that includes detailed analyses of current critical data gaps and provides reasonable suggestions for addressing these gaps moving forward should be a fundamental goal of the Missouri Water Plan.

Section 5

Infrastructure, Financing/Funding

5.1 Introduction

For Infrastructure, Financing/Funding, CDM Smith conducted an initial data review, developed the proposed methodology, identified data gaps and major issues, and provided recommendations regarding next steps, which are compiled in this section.

5.2 Data Review

An assessment of the available water infrastructure that includes detailed information regarding existing and planned future conditions and capacity across the state will be an integral part of the Missouri Water Plan. Understanding the funding constraints is another important part of this process. Determination of infrastructure needs and applicable financing to meet corresponding project needs requires the concerted effort of federal and state government agencies. Data applicable to a statewide infrastructure assessment and funding mechanisms will be derived from a broad range of agencies and programs. CDM Smith performed preliminary research into the identified data sources and conducted in-person and telephone interviews with several key staff from MDNR and other agencies to gain a better understanding of the data available. In addition, potential critical data gaps that may inhibit the completion of the Missouri Water Plan have been identified. A brief summary of the data types and expected value available from each source is provided below.

5.2.1 Infrastructure Needs and Funding Process

Infrastructure improvements consist of new infrastructure and upgrades, rehabilitations, and replacement of existing infrastructure. The need for infrastructure improvements is based on any one or a combination of reasons, including increased population; loss of resource (depleted surface or groundwater supplies); stricter regulatory standards; and age, condition, and capacity of existing infrastructure. Potentially relevant data sources identified include:

- Missouri SRF
- EPA's Clean Watersheds Needs Survey (CWNS)
- EPA's DWINSA
- MDNR PERs
- USDA-RD
- Missouri Department of Economic Development, Community Development Block Grant (CDBG) Program
- EPA’s Clean Water 319 Grants
- Environmental Improvement and Energy Resources Authority (EIERA)
- Agricultural Conservation Easement Program (ACEP)

- Watershed Protection and Flood Prevention Act (PL-566)
- MoCWIS Database
- Mid-Missouri Regional Planning Commission
- Missouri SDWIS
- Natural Resources Conservation Service (NRCS)

5.2.1.1 MDNR Financial Assistance Center

The MDNR Financial Assistance Center (FAC) provides low-interest loans and partial grants to municipalities, counties, public water and public sewer districts, and political subdivisions for wastewater and drinking water infrastructure projects. The FAC's primary method of financial assistance is through the federally capitalized SRF low-interest loan program. Eligible projects may be new construction or the improvement or renovation of existing facilities. The Missouri FAC uses and manages an internal database containing projects and project-level data in various stages of planning and funding including: planning, fundable, under construction, and completed. EPA initiates need surveys on a national level to determine infrastructure needs nationally and subsequently assigns portions of SRF funds to states. The federal SRF does not meet national infrastructure cost needs, creating a need for additional funding sources. Drinking water and clean water funds are applied for and awarded separately as described below.

Applicability

The SRF FAC database provides data for projects in planning, those that are funded, under construction, and completed which will be useful in determining capacity and condition of existing facilities.

5.2.1.1.1 Clean Water SRF Funds

CWSRF funds are distributed statewide by percentage of large metropolitan areas and districts (population greater than 75,000), Outstate Missouri (population less than 75,000), combined sewer overflows (CSOs), and department initiatives. CWSRF funds are used for wastewater pipe and treatment facilities, CSOs, and stormwater management projects.

5.2.1.1.2 Drinking Water SRF Funds

DWSRF funds are distributed as follows: 20 percent very small communities (<3,300 population), 15 percent small communities (>3,301-9,999 population), and 65 percent general communities (>10,000 population). DWSRF funds are used for drinking water associated projects.

5.2.1.2 Clean Watershed Needs Survey

The CWNS report summarizes capital costs required to address water quality or water quality related public health issues. Data from the 2012 survey have been collected, but the report has not yet been released. The previous CWNS report was released in 2008, and the link is available on the last page of this section.

Applicability

The CWNS provides data regarding known funding needs and funding for Clean Water projects.

According to the 2008 CWNS report, Missouri's total documented need over a 20-year period, was approximately $5.75 billion. The results of this report are also used to allocate CWSRF funds to individual states. According to MDNR, current needs are estimated at $9.5 billion for necessary clean water improvements, primarily wastewater related projects. Missouri is generally allocated approximately $30 to $40 million in CWSRF funds. That amount combined with the matching funds provided by MDNR and repayment from prior loans totals approximately $100-$200 million available funds per year to loan out to eligible projects.

5.2.1.3 Drinking Water Infrastructure Needs Survey

The FAC handles DWSRF funding applications as well as DWINSA distribution and collection. The survey is distributed every 4 years with the assistance of state agencies such as MDNR. The DWINSA report summarizes anticipated capital costs required to address infrastructure and eligible equipment improvements and replacements needed to deliver safe drinking water. The DWINSA report is submitted to Congress along with recommendations for a 20-year planning period. The survey results are also used to help determine the amount of funding each state receives for its DWSRF program.

Applicability

DWINS looks at source, treatment, storage, transmission, and other factors requiring improvement for facilities in the state.

There are two primary goals of the DWINSA assessment:

1. Determine the national need and inform Congress
2. Determine the needs by state per allotment

There are five categories of need:

1. Source – includes wells, surface water intakes, and springs
2. Treatment – includes treatment plants
3. Storage – includes finished water tanks
4. Transmission and distribution – includes appurtenances
5. Other – includes emergency power generators, system security, and computer and automation costs

According to the EPA 2011 DWINSA – Fifth Report to Congress, Missouri's 20-year need totals approximately $8.5 billion. This is further broken down into approximately $6.1 billion in transmission and distribution, $316 million in source, $1.3 billion in treatment, $752 million in storage, and $22 million in other drinking water infrastructure needs. The 2011 DWINSA report link is available on the last page of this section.

5.2.1.4 Water Quality Related Infrastructure Challenges for Wastewater

There are challenges associated with clean water facilities meeting recent bacteria/E. coli discharge limits. Bacteria/E.coli discharge is a major issue in the Northeast Region during the summer months due to low flow conditions. Discharges to low flow streams during the summer and during drought periods can heavily impact water quality due to lack of sufficient dilution from streamflow.

Applicability

Understanding of current and future regulations provides insight into possible future infrastructure and funding needs.

Area-specific requirements can present additional challenges. Wastewater treatment plants (WWTPs) in portions of the southeast and southwest regions are held to higher standards due to their proximity to Ozark Scenic Riverways, known for their pristine condition.

Additionally, there is currently an ammonia water quality standard (10 CSR 20-7.031, November 30, 2005) for fish criteria from the EPA issued in 1999. New ammonia standards based on the 2013 EPA guidance will require some communities and public water providers to upgrade their wastewater infrastructure to comply with new discharge requirements. Additionally, effluent limitations are expected to become significantly more restrictive under new ammonia criteria for mussels, though it is believed that overall treatment plant technologies are the same. Therefore, while increased financial burdens to comply with the new ammonia criteria are still expected for many systems, the technology being used by some facilities has the capacity to meet new ammonia standards based on 1999 ammonia criteria for fish. A fact sheet created by MDNR, explaining the new EPA recommended ammonia criteria is located online (link provided at the end of this section).

Part of the process for determining how to meet these stricter standards is to determine affordability. The new ammonia guidelines and the costs to meet them are run through the Cost Analysis for Compliance (CAFCom) process. Currently, calculations are being completed based on the 1999 standards. It is anticipated that statewide upgrades to plants will be necessary when the new guidelines are enacted for the state. Mechanical and land application facilities, for which MDNR estimated the costs based on 1999 standards, should be able to meet the 2013 EPA ammonia criteria.

The overall goal of the CAFCom process is to determine an adequate schedule of compliance that will mitigate the financial burden resulting from the new permit requirement for ammonia. The goal for the estimated residential user costs, considering new permit requirements, is not to exceed 2 percent of the area median household income. If this goal is not achievable, the permit is placed on hold until further investigation can be done to determine the best and most affordable option for the facility.

The number of years allowed for compliance is assigned based on CAFCom results. If compliance with a new standard is determined to be a high burden, the system generally would be granted 10 years to comply with the standard. Medium burdens are allotted 7 to 9 years, and low burdens are allotted 5 to 7 years.

Area-specific requirements can present additional challenges. WWTPs in portions of the southeast and southwest regions are held to higher standards due to their proximity to Ozark Scenic Riverways, known for their pristine condition.

5.2.1.5 Water Quality Related Infrastructure Challenges for Drinking Water

Disinfection byproduct (DBP) criteria cause some of the greatest drinking water treatment concerns for public drinking water systems in the MDNR Northeast and Kansas City regions. Many facilities in northern Missouri have issues meeting DBP and total organic carbon (TOC) limits.

Additionally, there are several treatment facilities in the Southwest MDNR Region experiencing violations in radionuclide (RADs) levels in drinking water sources, particularly in McDonald and Barton Counties. The source of this contamination is unknown and often requires construction of new wells.

5.2.1.6 Infrastructure Project Examples

MDNR provides funding to public drinking water supplies for infrastructure improvement projects through the state's SRF loan program and federal SRF set-asides. Competitive engineering report grants are available to community public drinking water systems (regardless of application status to the DWSRF program) and provide up to 90 percent of the cost to hire an engineer and develop a preliminary engineering report (not including plans and specifications). Community drinking water systems are required to develop engineering reports for all major infrastructure improvements and as a first step toward implementing changes to help the system achieve and maintain capacity and comply with drinking water regulations. Engineering reports are required to accompany construction loan and grant applications for community drinking water system facility upgrades.

Applicability

Access to PERs provides understanding of community water supply/ infrastructure needs as well as possible methods to resolve them.

Recently developed PERs have been scanned into an electronic format and are available upon request from MDNR. Access to reports completed since 1999 may be available; however, the majority of PERs available are from 2009 to present. The reports generally contain the following sections: Introduction, Project Planning, Existing Facilities, Project Need, System Improvement Alternatives, and Estimates of Cost.

In addition to PERs, the project areas and studies described below are exemplary of regional water planning efforts. This approach decreases individual costs, often merges funding sources to achieve project completion, and provides a variety of options for establishing water supply sources.

5.2.1.6.1 Northwest Missouri Regional Water Supply Studies, Phases I-VI

The Great Northwest Wholesale Water Commission project is an example of a combination of large and small regional utilities working together to find a reliable source of water for multiple entities. The water source for this project is the Missouri River. Some proposed projects have moved forward, the remaining entities have not resolved their long-term water concerns.

The six studies performed for this region of the state have been conducted in cooperation with the MDNR and the USACE under six Planning Assistance to States agreements and in coordination with the Great Northwest Wholesale Water Commission. Funding for the different phases of this project has been received from local, state, and federal entities in addition to funds provided by the commission. During development of the sixth study, the USDA-RD was approached and funding for the construction of the Cameron Pipeline was generated through a USDA-RD grant/loan. The funding covers development of design documents, survey, legal, land acquisition, construction, engineering services during construction, and expenses for startup.

5.2.1.6.2 Atchison County Wholesale Water Commission (2010)

The Atchison County Wholesale Water Commission (ACWWC) was formed in 2006 and was initially part of the Northwest Missouri Regional Water Supply Study. The newly constructed 2.5 mgd water treatment plant with a 250,000 gallon elevated tank and 750,000 gallon clear well serving the cities of Fairfax, Rock Port and Tarkio as well as Atchison County Public Water Supply District #1. The plant is capable of future expansion to 10 mgd and the ACWWC is exploring other customers in the tri-state area.

5.2.1.6.3 Southwest Missouri Water Resource Study Phases I and II (2012, 2014)

Phase I of this study performed a regional demand forecast by water use sector (i.e., residential, commercial, industrial, livestock, and agriculture) through 2060. Phase II performed a planning-level evaluation to analyze the known groundwater and surface water availability of southwest Missouri to determine if current sources are sufficient to meet future regional demands. The two phases are built on studies performed in 2003, 2006, 2009, and 2010 which identified water supply and needs. Currently, an area of great concern is the Joplin metro area in Jasper and Newton Counties. This area is experiencing significant growth in population and seeking alternative water sources to supplement their Shoal Creek supply. The area is projected to need an alternate supply source by the year 2020 and is looking at alternatives, including a reallocation of Table Rock, Pomme de Terre and Stockton Lakes or construction of a new reservoir. Both Phase I and Phase II of this study have been conducted in cooperation with the MDNR and the USACE under Planning Assistance to States agreements and in coordination with the Tri-State Water Resources Coalition.

5.2.1.6.4 Little Otter Creek Reservoir, Caldwell County

The Little Otter Creek Reservoir is a planned reservoir located in Caldwell County in northwest Missouri. The reservoir will have a surface area of 340 acres and is estimated to have a total construction cost of $19.5 million. Currently, all required land has been acquired. Once completed, the reservoir will be used for flood protection and water supply for the county, with the capacity to provide more than 1 mgd.

5.2.1.6.5 East Locust Creek Reservoir, Sullivan County

The East Locust Creek Reservoir is a planned reservoir located in Sullivan County in north central Missouri and will be operated by the North Central Missouri Regional Water Commission. The reservoir will have a surface area of 2,235 acres and is estimated to have a total construction cost of $97 million. Currently, more than 90 percent of the land has been purchased. Once completed, the reservoir will be used for water supply, with the capacity to provide 7 mgd.

5.2.1.6.6 Howard County Regional Water Commission

In 2013, the Howard County Regional Water Commission announced it had received funding from USDA-Rural Development (RD) to support a water regionalization project. Funding came in the form of both grants and low-interest loans and totals more than $10 million (split approximately 50/50 between grant and loan). The water regionalization project includes new groundwater wells, treatment plant, storage tower, and distribution lines. Beneficiaries of the project include the communities of Fayette and New Franklin and Consolidated Water Supply District No. 1 of Howard County.

Applicability

Access to local community commissions provides the resource of experienced individuals in regards to local water supply/infrastructure issues, establishing community involvement and project planning.

5.2.1.6.7 Clarence Cannon Wholesale Water Commission (Mark Twain Lake)

Mark Twain Lake is located on the Salt River and is owned by USACE. The lake is a multi-purpose project whose benefits include hydroelectricity, flood control, recreation, fish and wildlife conservation, and water supply. The Clarence Cannon Wholesale Water Commission and the state of Missouri hold contracts for a total of 20,000 acre-feet of storage within the lake. This storage serves as important water supply for nearly 70,000 customers of the Clarence Cannon Wholesale Water Commission.

5.2.1.7 Funding Issues

Specific funding issues occur at the smaller community level. There is a funding gap for small non-municipal systems such as residential subdivisions. The northeast region has some of the state's highest water rates. For example, many people are paying $10/1,000 gallons in addition to the $20 to $25 monthly service charge (MNDR Regional Office Interviews, see Appendix A).

Additionally, SRF funds are available to cover funding for development of engineering design documents (e.g., plans and specifications) but not an engineering report. USDA-RD funding allows systems to get a bridge loan for design and USDA will refund the lender once the project is ready for construction. There is also a gap in funding for small systems who are out of compliance, have aging infrastructure, and inadequate funds to pay for planning, design, and construction over longer periods of time.

Many communities are applying for USDA-RD funding though it means having a higher interest rate than the SRF. A caveat for the USDA-RD is that it has longer loan terms. The SRF programs currently offer a 20-year loan (the department is evaluating loan terms out to 30 years), and USDA's is a 35-year loan. Although the overall annual payment may be lower for the USDA-RD loan, the total paid back is greater than for the SRF loan. In addition to annual payment considerations, communities are looking to both USDA and SRF for grant funding availability to determine which funding program to pursue.

Drinking water reservoirs are not eligible for funding under the SRF programs.

5.2.2 Additional Funding Sources

Additional funding can be found for projects depending on the size of communities, location, and project cost.

5.2.2.1 USDA Rural Development

USDA oversees the *Water & Waste Disposal Loan & Grant Program* designed to assist state, local government, and private non-profits with improving water for rural areas and towns (population fewer than 10,000). This program provides funding for clean and reliable drinking water systems, sanitary sewage disposal, sanitary solid waste disposal, and stormwater drainage for households and businesses in eligible rural areas. When available, grants can be combined with long-term, low-interest loans for rural water and waste disposal projects.

5.2.2.2 Missouri Department of Economic Development

The CDBG offers grants to small Missouri communities to improve local facilities, address critical health and safety concerns, and develop a greater capacity for growth. Each application is reviewed based on community need, including the extent of poverty, population, housing, and population growth lag in relationship to other metropolitan areas.

Applicability

Knowledge of possible funding sources and available funding is pivotal in determining project possibilities.

5.2.2.3 Clean Water 319 Grant Project

Clean Water Act Section 319 Grants are available for implementation of best management projects to control nonpoint source pollution. The program was implemented as a result of violations in bacteria limits. Section 319 grants are funded by EPA and administered by the MDNR.

5.2.2.4 Environmental Improvement and Energy Resources Authority

EIERA is administered through MDNR and assists communities by providing environmental solutions through finance, research, and technical assistance. This assistance is primarily related to both the providing of bonds for infrastructure projects and the selling of bonds to support water and wastewater infrastructure needs through the SRF. EIERA also provides assistance to businesses and communities producing products made from recycled materials, provides funds for the cleanup of contaminated properties, and supports low-income weatherization funding.

5.2.2.5 Non Infrastructure Funding Programs

5.2.2.5.1 Agricultural Conservation Easement Program

The ACEP provides financial and technical assistance to help conserve agricultural lands and wetlands and their related benefits. Under the Agricultural Land Easements component, NRCS helps Indian tribes, state and local governments, and non-governmental organizations protect working agricultural lands and limit non-agricultural uses of the land. Under the Wetlands Reserve Easements component, NRCS provides financial and technical support to landowners to protect, restore, and enhance wetlands on their property.

- Through ACEP and its predecessor programs, NRCS holds permanent and 30-year conservation easements on over 154,000 acres in Missouri.
- Each of these easements is monitored annually.
- Many easements provide habitat for threatened and endangered species.

5.2.2.5.2 NRCS Watershed Protection and Flood Prevention Act

The Watershed Protection and Flood Prevention Act (PL-566) authorizes NRCS to help local organizations and units of government plan and implement watershed projects. PL-566 watershed projects are locally led to solve natural and human resource problems in watersheds up to 250,000 acres (less than 400 square miles). Projects can include flood prevention and damage reduction, development of rural water supply sources, erosion and sediment control, fish and wildlife habitat enhancement, wetland creation and restoration, and increased recreational opportunities.

- The U.S. Congress stopped funding the Watershed Program in 2011, but did not de-authorize the program.
- NRCS continues to serve as the lead federal agency on the Little Otter Creek and East Locust Creek projects, and is providing a large portion of the funding.

Additional information about Missouri NRCS programs is available on the NRCS Missouri website; the link is provided on the last page of this section.

5.2.3 Additional Data Sources

Potential data sources include current databases and proposed studies.

5.2.3.1 Missouri Clean Water Information System Database

There are approximately 11,700 wastewater permits. The data and information for these permits is reported in the MoCWIS and is available online. The link is available on the last page of this section.

Applicability

MoCWIS will serve as a valuable source of statewide wastewater permitting data during development of the Missouri Water Plan.

MDNR is currently issuing permits on a 5-year cycle; however, the department is working toward a watershed permitting approach in which permits will be renewed as an entire watershed. This watershed-based permitting approach will allow MDNR to monitor and determine effluent guidelines based on water quality of the entire watershed.

Permitted facilities are required to submit discharge monitoring reports. These are required on varying timeframes (e.g., monthly, annually) based the type of facility and discharge. Data from these reports from 2008 to present are stored in the MoCWIS data portal. The link is available on the last page of this section. Queries of the MoCWIS database also can be completed for topics such as violations and schedules of compliance.

5.2.3.2 Mid-Missouri Regional Planning Commission Wastewater Treatment Plant Summaries

The 604(b) Community Wastewater Assessment was performed in 2011 by communities and regional planning commissions along with MDNR and the Missouri Association of Councils of Government. This assessment surveyed community wastewater treatment systems in the state. The goal of this project is to assess and inventory public wastewater systems, develop a wastewater improvement needs summary for interested communities and watersheds, identify potential funding opportunities for improvements, and work with communities as appropriate to anticipate needed improvements to maintain and improve water quality. This summary report is

designed to provide a "snapshot" of existing systems and a comparison of systems to others in the region and the state as well as to forecast future system capacity needs, options, and costs. Each system is summarized in a two-page report. This report is available in hard copy form at MDNR headquarters. Only portions of the document are available online. The link is provided on the last page of this section.

The 604(b) Statewide Water Assessment, performed in July 2011, provides general conditions and needs for municipal wastewater treatment facilities in communities with populations less than 5,000. The four objectives of this project are to create an inventory of needed wastewater system improvements, develop a needs summary for the participating entities, develop a financing guide for the systems, and work with the state and federal agencies to amass financing tools to address the needed improvements in the State of Missouri. A link to this report is provided on the last page of this section.

Additional domestic wastewater data sources:

- MDNR National Pollutant Discharge Elimination System (referred to as NPDES) domestic wastewater permitted facilities dataset with locations, treatment type, and population served
- Geology and topography data layer (link provided on last page of this section)

5.2.3.3 Safe Drinking Water Information System

SDWIS data include a complete inventory of public drinking water systems as well as sample results, compliance activities, and water quality data. Missouri Drinking Water Watch serves as a public interface for SDWIS. This database contains records for approximately 5,600 public drinking water systems, of which approximately 2,700 are currently active systems. While information on individual facilities can be obtained through Drinking Water Watch, data queries can be completed via request through MDNR. Available fields, which may be useful in the demand element of the State Water Plan, include:

- Water System Detail Information: Water System Number and Name, Principal County, Federal Source
- Sources of Water
- Source Water Percentages
- Water Purchases
- Buyers of Water
- Service Connections
- Service Area
- Flow Rates: Average Daily Production, Total Design Capacity, Total Emergency Capacity

Applicability

The SDWIS database will be used to determine water sources, transfers, and production for public drinking water systems. This information may be used to establish county baseline municipal water demands.

Some SDWIS data are available in report format through the annual Census of Missouri Public Water Systems. Information contained within these annual reports, which may provide useful data for the demand element of the Missouri Water Plan, include:

- Population Served

- Percent Surface Water/Groundwater
- Supply Capacity
- Average Daily Consumption

Annual reports are available via the internet from the MDNR website at the following link: http://dnr.mo.gov/env/wpp/pdwb/census.htm. For the purposes of the Missouri Water Plan, annual report data can be queried at the county level via a data request to MDNR.

5.3 Proposed Methodology

This section describes the methodology that will be used for assessing the infrastructure gap in support of the Missouri Water Plan Update. Two distinct infrastructure gaps are discussed: one for water supply infrastructure (e.g., storage, pipelines, treatment plants, agriculture) and the other for wastewater infrastructure. In addition, alternative planning scenarios will be defined in collaboration with MDNR and in coordination with the demand and water supply tasks, such that variations in "drivers" such as economic conditions and future water supply can provide a likely range of potential infrastructure gaps described below in further detail.

5.3.1 Water Supply Infrastructure Gap

The proposed approach for assessing the water supply infrastructure gap in Missouri is a two-step process. The first step is to calculate the 2060 total new water needs, which is described in the Water Demand Technical Memorandum. The second part of the 2060 water supply infrastructure gap analysis is to determine the anticipated yield from each planned project that will be operational in 2060, assuming 100 percent success rate. Both of these components will be assessed using units of mgd and are related in the following governing equation:

$$\sum_i Infrastructure\ Gap = \ Net\ New\ Water\ Needs_i - Net\ New\ Yield\ from\ Planned\ Projects_i$$

Where,

i = demand/supply sector (e.g. municipal, irrigation, etc.)

The governing equation above will be calculated for each demand/supply sector (e.g., municipal, irrigation). The *Net New Yield from Planned Projects* is subtracted from the *Net New Water Needs* (i.e., demand increases above existing supplies). The assumed spatial units for this analysis likely will be county and/or major basin while the assumed planning horizon is 2060. Where the total project yield for a water provider exceeds the projected 2060 demand, the extra water will be assumed to be unavailable for redistribution to other areas of the state unless otherwise noted.

Information on project yields will be obtained through an outreach approach focused on interviewing key staff for water providers across the state and a review of relevant documentation such as master plans, regional studies, integrated resource plans, and federally funded studies such as environmental impact statements. This outreach will be used to determine what projects and/or methods water providers are pursuing to meet their future needs along with confirmation of water demand data. It is expected that in some instances project information will not include a quantified estimate of yield. In these circumstances, professional judgment will be used to assign predicted yield. Projects will be classified into general categories such as:

- Growth utilizing existing supplies
- Regional in-basin projects
- New transbasin projects
- Reallocation of USACE reservoirs
- Reuse of existing supplies
- Demand side management practices (e.g., active conservation)

Based upon the data review process, it is likely that insufficient information is available. This will be confirmed by reviewing all available relevant documentation once the Missouri Water Plan Update is underway. In the likely event that more project information is needed, a statewide water provider survey will be initiated as part of the outreach effort. Survey responses will be solicited using online tools. A sample outline for the survey is as follows:

- General Information (name, location)
- Project Sponsor (i.e., funding source)
- Project Yield and Supporting Analysis (supporting information submitted under separate cover)
- Project Cost and Supporting Analysis (supporting information submitted under separate cover)
- Project Timing (e.g., construction, phasing)

Note that this methodology does not in any way preclude water providers from planning or developing projects in excess of their 2060 needs. Rather, it is beyond the scope of this gap analysis to present data for individual water providers whose demand projections, planning horizon, and system reliability may differ from the regional analysis presented here. Any "excess" yield quantified for a particular county is assumed to not be available to meet water supply gaps in other counties, unless specified otherwise.

The projected cost of the water supply infrastructure gap in Missouri will be compared to the latest statewide DWINSA results (most likely 2015). Any differences, and reasons for these differences, will be documented in a technical memorandum.

5.3.2 Wastewater Infrastructure Gap

Assessment of a wastewater infrastructure gap will also be included in the Missouri Water Plan Update. This assessment will focus on two aspects:

1. The infrastructure needs related to meeting future wastewater capacity requirements associated with growth in the municipal and industrial demand sectors
2. The infrastructure needs related to meeting anticipated increases in effluent water quality regulations for ammonia, phosphorus, and nitrogen

The wastewater infrastructure gap will require an outreach similar to the water supply infrastructure gap described above, including review of relevant documentation and a wastewater service provider survey. A sample outline of such a survey is provided below:

- General Information (name, location)
- Project Sponsor (i.e., funding source)
- Project Capacity, Effluent Water Quality, and Supporting Analysis (supporting information submitted under separate cover)
- Project Cost and Supporting Analysis (supporting information submitted under separate cover)
- Project Timing (e.g., construction, phasing)

The projected cost of the wastewater infrastructure gap will be compared to the latest Clean Watersheds Needs Survey results. Any differences, and reasons for these differences, will be documented in a technical memorandum.

5.3.2.1 Additional Possible Source of Wastewater Data

Another potential data source could come from performing a statewide pre-feasibility study for wastewater system regionalization as part of the water plan projects. This study would be the first step in an important task shared among small rural communities to comply with statewide discharge standards, particularly new ammonia standards. The proposed pre-feasibility study would be used to identify systems that could benefit from regionalization. Subsequently, Community Services Program staff could work with identified systems to develop a process for regional compliance.

5.4 Data Gaps

This section provides a list of data gaps that were identified by the data review process in support of the Infrastructure and Funding task. This list will continue to evolve as the development of the Missouri Water Plan Update continues.

- Database for infrastructure systems needs associated with watersheds, assigned to match MDNR permitting system watershed layout.
- Status of plant and projected capacity for both WWTPs and WTPs.
- Planned project yields.
- Status of infrastructure (e.g., pipes), especially as relates to age, material type, and condition.
- Due to the large number of unregulated dams in the state of Missouri, there is not a definitive measure of the condition or potential for repairs on all dams in the state.
- There is not a comprehensive list of levees in the state, their design protection level, or condition.
- Water usage based on propane and diesel powered water withdrawals
- Likely only 10 percent of water users reporting agricultural water use in the Bootheel of Missouri
- Unaddressed/unknown infrastructure needs not captured within existing programs due to funding thresholds and limitations or caused by unforeseen system failure.

5.5 Major Issues

Issues for infrastructure include condition of infrastructure (both known and unknown) and limited funding.

5.5.1 Condition of Infrastructure

Currently, all of Missouri's water infrastructure is in less than average shape according to the 2013 ASCE report as shown on **Table 5-1**. All water infrastructure categories are of concern as each can have detrimental effects on overall water quality for both groundwater and surface water.

Table 5-1 - Missouri's Water Infrastructure Grades

Infrastructure	Grade
Dams	D-
Drinking Water	C-
Inland Waterways	D
Levees	C-
Wastewater	C-

Source: 2013 Report Card for Missouri's Infrastructure by ASCE

5.5.2 Areas of Concern

There are multiple areas of concern for water and wastewater infrastructure including dams, reservoirs, levees, waterways, treatment systems, supplies, and distribution and collection systems.

5.5.2.1 Dams and Levees

Ninety-eight percent of regulated dams are in compliance with dam safety regulations. However, the vast majority of Missouri's dams are unregulated and aging. Funding for increased inspection and regulation of our high hazard dams will be necessary to address safety issues and raise the current grade of D-. MDNR has assisted in the completion of Emergency Action Plans for approximately 84 percent of regulated high hazard dams in the state and approximately 57 percent of all regulated dams. It is estimated that the total cost to upgrade Missouri's dams to national standards of repair and operation, including development of an Emergency Action Plan for all high hazard dams, over the next 10 years is $225 million, or $22.5 million per year.

As reservoirs age, siltation can become a significant issue to the point of reducing critical water supply storage during periods of drought. Solutions to this problem may include construction of additional reservoirs, raising dams and/or dredging current reservoirs. Dam raising and dredging have been found to be extremely cost prohibitive.

In Missouri, there are roughly 10,000 miles of levees the majority of which are under private control. Many if not all these levees will require maintenance in the next 20 years.

5.5.2.2 Inland Waterways

Inland waterways infrastructure is aging and as such suffers from degradation. USACE has partnered with the Mid-America Regional Council (MARC) to study the degradation of the Missouri River bed. They are studying the causes of this degradation and how it will affect the infrastructure and economy of the Midwest. Most of the Mississippi River's locks and dams were constructed in the 1930s and are in need of repair or replacement.

5.5.2.3 Water Infrastructure

Missouri typically has sufficient water for serving its communities, but its aging water treatment and distribution systems are struggling to keep up with current demand for operations and maintenance. According to the EPA 2011 DWINSA – Fifth Report to Congress, Missouri's 20-year need totals approximately $8.5 billion. Current funding provided by federal and state SRF programs for capital infrastructure investment is inadequate to fund both current and future public drinking water systems' needs. Specific examples include:

- In the region of McDonald County, there are some issues with industries depleting groundwater.
- Another problem faced by Missouri utilities is that aging populations and aging infrastructure in many regions leave many towns unable to afford system upgrades, especially in rural areas. This especially a problem in southwest Missouri.
- In the northeastern portion of the state, many areas are declining in population, and towns are no longer functional as no one wants to take over responsibilities for the current systems.
- Farmington is a growing community in St. Francois County with 14 active wells all with RADs. An administrative order to resolve concerns with RADs has been signed by the community.

Missouri is annually allocated approximately $40 million dollars in federal SRF to fund drinking water projects. According to MDNR, current needs for drinking water projects are estimated at $8.5 billion dollars. As can be seen, there is inadequate funding for drinking water projects.

5.5.2.4 Wastewater Infrastructure

According to MDNR, current needs are estimated at $9.5 billion for clean water projects. Missouri is generally allocated approximately $30 to $40 million annually in CWSRF funds. Current funding provided by federal and state programs for capital infrastructure investment is inadequate to fund both current and future wastewater systems' needs.

Efforts have been made toward regionalizing wastewater treatment to reduce the need for septic systems. However, the topography and rocky subsoil makes the costs of running pipelines extremely high.

5.5.3 Limited Funding

While there are multiple sources of funding available for water and wastewater projects, the quantity of funding needed is greater than the amount of available public funds (loans and grants). In addition, many small communities and rural areas are looking to finance projects with large amounts of grant funding in order to avoid significant rate increases and will often not pursue a project through loan funding only. Possible methods of meeting funding needs would be to seek funding from different funding mechanisms and sources.

Possible funding sources for infrastructure projects include:

- USDA-RD.
- Missouri Water Development Fund (WDF).

- Small Communities Small Borrowers Loan – criteria is population under 1,000 and project cost of less than $100,000.
- CDBGs, with approximately $500,000 in funding per year.
- EIERA provides environmental solutions through finance, research, and technical assistance.
- Department of Economic Development Direct Loan and Grant Program, also with limited funds.
- EPA's proposed Water Infrastructure Finance and Innovation Authority (WIFIA) funding
- Private sources

More information on these other funding sources is available through the MDNR Financial Assistance Center. The link is available on the last page of this section.

Another funding concern is the reduction in revenue due to the adoption of conservation measures. A typical residence previously used 4,700 gallons per month; this has now been reduced to 3,700 gallons per month. The result of lower water use is less revenue.

Smaller systems frequently meet political resistance to raise rates to improve degrading systems. Additionally, small non-municipal systems (e.g., subdivisions) may not be eligible for many of the public funding programs.

5.5.4 Agriculture Irrigation

Irrigation occurs throughout the state with over 1,000,000 acres of irrigated cropland, the majority of which occurs in six counties in southeast Missouri. Nearly 100 percent of irrigation in this region is from groundwater wells in the alluvium of the Mississippi, St. Francis, and Black Rivers. Well depths in this region are approximately 100 feet, and water yields are high. As irrigation becomes more prevalent in the southern states of the Mississippi Alluvial Aquifer (Arkansas, Louisiana), water supply concerns could be an issue in the region due to high volumes used for agriculture irrigation.

In other regions of the state, irrigation occurs primarily from groundwater in the major alluvial valleys or relies on collecting ponds. There are currently very few surface water diversions for irrigation. Outside of alluvial valleys, the depth to water table limits the feasibility of irrigation due to the increased costs associated with new well construction and pumping. Additionally, salinity is an issue in some areas of the state affecting the capability of using groundwater.

5.6 Recommendations

A comprehensive assessment of current water and wastewater infrastructure conditions, issues, and concerns is an integral part of the overall Missouri Water Plan. Maintaining infrastructure is a local, state, and national environmental concern that has been increasingly moving to the forefront, especially as systems age and populations increase. Detailed statewide descriptions and summaries of both water and wastewater infrastructures will be incorporated into the Missouri Water Plan. This will serve to document conditions and concerns and highlight issues that will need to be addressed in order to maintain and improve water and wastewater infrastructure in Missouri over the next several decades.

In addition, it is likely that future updates and editions of the Missouri Water Plan will be linked inextricably to the upcoming publication and will build upon the framework established during this effort. Therefore, an accurate, thorough, and detailed assessment of the current state of water and wastewater infrastructure that includes detailed analyses of current critical data gaps and provides reasonable suggestions for addressing these gaps moving forward should be a fundamental goal of the Missouri Water Plan.

Also, it is recommended that strong working relationships with federal, state, and local stakeholders are maintained to create an atmosphere that promotes combining technical resources and available funds and funding mechanisms wherever possible.

Specific tasks that should be performed include:

- Perform outreach (e.g., surveys, interviews) for water infrastructure data. Interview key staff of water providers across the state and review relevant documentation such as master plans, regional studies, integrated resource plans, and federally funded studies such as environmental impact statements.
- Create a technical memorandum documenting any differences and reasons for differences between projected cost of the water supply infrastructure gap in Missouri and the latest statewide DWINSA.
- Perform outreach (e.g., surveys, interviews) for wastewater infrastructure data. Interview key staff of wastewater treatment providers across the state and review relevant documentation such as master plans, regional studies, integrated resource plans, and federally funded studies such as environmental impact statements.
- Create a technical memorandum documenting any differences and reasons for differences between projected cost of the wastewater infrastructure gap in Missouri and the latest CWNS results.
- Perform a statewide pre-feasibility study for wastewater system regionalization.
- Evaluate funding for development of engineering design documents.
- Evaluate the Missouri WDF future funding need.
- Identify process improvements to address such needs as unaddressed/unknown infrastructure costs.

5.7 Links

Clean Watersheds Needs Survey
http://water.epa.gov/scitech/datait/databases/cwns/upload/cwns2008rtc.pdf

Drinking Water Needs Survey and Assessment (2011)
http://water.epa.gov/grants_funding/dwsrf/upload/epa816r13006.pdf

Environmental Improvement and Energy Resources Authority http://eiera.mo.gov

EPA recommended ammonia criteria http://dnr.mo.gov/pubs/pub2481.htm

Geology and topography data layer http://dnr.mo.gov/geostrat/

Mid-Mo Regional Planning Commission Summaries

604(b) Community Wastewater Assessment, 2011
http://boonslick.org/wp-content/uploads/2011/05/Boonslick-604b-reports.pdf

604(b) Statewide Water Assessment, July 2011
http://mmrpc.org/plans/604%28b%29/604-b-Statewide-wastewater-assessment-report-draft-1%20web%20version.pdf

Missouri Clean Water Information System
http://dnr.mo.gov/mocwis_public/permitSearch.do

MDNR Financial Assistance Center http://dnr.mo.gov/env/wpp/srf/index.html

MDNR Financial Assistance Center – Additional Resources

http://dnr.mo.gov/env/wpp/srf/additional-resources.htm

MDNR's Drinking Water Watch Interface https://www.dnr.mo.gov/DWW/landing_MO.jsp

MOCWIS data portal http://dnr.mo.gov/mocwis_public/dmrDisclaimer.do

Missouri NRCS programs http://www.nrcs.usda.gov/wps/portal/nrcs/site/mo/home/

USDA Rural Development http://www.rd.usda.gov/

Section 6

Scenario Planning and Adaptive Management

6.1 Introduction

Scenario Planning and Adaptive Management can be utilized in state water planning to evaluate and accommodate future uncertainty with respect to demands, supply and social conditions. An outline of this approach is presented below.

6.2 Scenario Planning

Missouri and states across the country have utilized traditional predictive water planning processes in the past. These processes have relied on the past as the key to extrapolate the most likely future water planning scenario. Due to the very long timeframe that it takes to build water and wastewater projects, and the planning horizon for the Missouri Water Plan being 2060, a wide range of uncertainties may present themselves between now and then; therefore, scenario planning may be an option for addressing Missouri's water supply future. Uncertainties such as Missouri's future economy and how that will impact population growth, and climate variability and how that may affect water supply levels, are important to consider. Scenario planning helps explore a broader range of future possibilities and acknowledges uncertainties.

The scenario planning framework described below is designed to integrate with all other components of the Missouri Water Plan, including the water demand, water availability, water quality/aquatic species, and infrastructure analyses. Furthermore, this section also includes an optional adaptive management framework which can be used to determine what actions may need to be implemented over time, depending on several "signposts." This adaptive framework will allow for Missouri to:

- Be flexible so that it can address critical planning issues in a strategic fashion;
- Identify and prioritize key planning uncertainties; and
- Develop a consensus vision for how Missouri can meet the challenges and opportunities of the future.

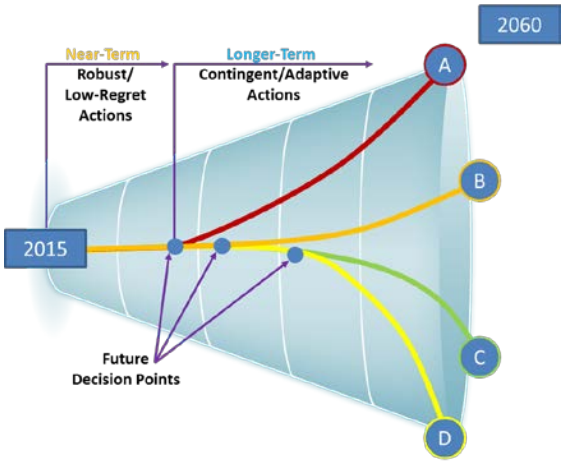

Figure 6-1. The cone of uncertainty helps define the range of water supply futures

Figure 6-1 depicts the "cone of uncertainty," which indicates that from today's vantage point, the future is unknown, and increasingly so as planners try to look further and further into the future. When exploring uncertainty, it is important to look at the edges of the cone to ensure that a full range of futures is being considered. Scenario planning and adaptive management is the process where these scenarios are developed, near-term actions are defined that need to be implemented no matter what future Missouri faces, and

additional actions are identified that may need to be implemented in the future for one or more particular scenarios.

Planning decisions must balance a wide range of risks, given the uncertainties that may occur in the future. The following definitions are used to describe the planning concepts used in this overall framework to incorporate risk and uncertainties:

- ***Scenario Planning*** – A planning process that defines complete, plausible scenarios of the future. This concept differs from traditional planning, in which one future is defined without taking into account uncertainties. Scenarios are formulated by assessing key drivers of uncertainty (e.g., economic/demographic growth, climate, environmental regulations, and social values and perspectives) and combining the outcomes of these drivers into a complete picture of what the future might look like.
- ***Adaptive Management*** – A process that develops alternative paths to each one of the future scenarios. Adaptive management reduces the risk of underperforming or over investing as it provides a framework for incremental monitoring of future trends and phased implementation of strategies over time.
- ***Signposts*** – Represent decision points by which future drivers of the scenarios will be assessed and actions taken to determine which path of strategies should be implemented. The signposts are directly related to the drivers used to develop the scenarios, but are fewer in number and may represent an aggregate of multiple drivers.

Planning for the future is uncertain and change is continuous, requiring a thoughtful consideration of uncertainty and risk. These uncertainties can be examined to allow for better tracking and enable adaptive management. Some of the factors that can be considered may include:

- Risk and Uncertainty
- Demand Uncertainty
- Supply Uncertainty
- Natural Disasters (Flood, Drought, Wildfire, etc.)
- Climate Variability
- Political Drivers

Scenarios represent complete, plausible futures that are defined by major drivers that can impact municipal and industrial water demands and water supply availability, and are designed to capture a full range of uncertainty.

Listed below are example drivers that may be considered in State Planning:

- Population Growth / Economic Growth
- Climate Status / Water Supply
- Agricultural Demand and Agricultural Water Demand
- Social / Environmental Values

- Regulatory Constraints
- Municipal and Industrial Water Demands

As part of the Missouri Water Plan, these drivers can be developed. Once these drivers are determined, Missouri will need to develop scenarios for 2060. These scenarios will represent plausible futures that depend on many assumptions. Having multiple future scenarios helps to identify management responses that perform well when compared across a wide array of baseline conditions that could occur in the future.

6.3 Adaptive Management Framework (optional)

An adaptive management framework can also be used to determine if and when additional strategies should be implemented. Adaptive management has three main elements: (1) signposts, (2) outcomes, and (3) actions.

Signposts are decision points based on the most critical drivers that were used in the development of the future scenarios. Missouri will need to develop sign posts as part of the Missouri Water Plan. The following example signposts represent an aggregation of multiple drivers for State water planning, and are defined as follows:

- ***Municipal and Industrial Water Demands*** – Based primarily on the tracking of economic and demographic growth. Water demands will be assessed as being lower or higher than the mid-level water demand.
- ***Water Supply Availability*** – Based on a tracking of climate, hydrology, and environmental regulations affecting availability of water. Water supplies will be assessed as being lower or higher than the mid-level water supply availability.
- ***Social Values*** – Based on the tracking of values towards land-use development, energy use, water use efficiency, agriculture, environment, and recreation, an overall assessment will be made to define social values as being more "green" or more "resource utilization." Green values will dictate more dense, low-impact development; higher reliance on water use efficiency; greater protection of the environment and recreational resources; more energy efficiency; and preservation of agriculture and open space. Resource utilization values will dictate a full use of water supply resources, including new supplies, to meet municipal and industrial demands.

Outcomes represent alternative paths for the signposts. For example, the outcome of the municipal and industrial Water Demand signpost may be that demands are greater than mid-level forecasts because economic and demographic growth is tracking higher than expected.

Actions represent the strategies to be implemented based on the outcomes of the signposts. Actions may include: staying the course, acceleration of a previous strategy, or implementation of a new strategy (e.g., new water supply).

This process of developing plausible scenarios of the future and using signposts to determine when additional actions are needed has the following benefits:

- It captures a range of uncertainties and risks that can affect the ability to meet water demands in the future

- It identifies near-term actions that will provide benefits under a range of uncertainties as a foundation to longer term planning
- It provides a framework for incremental implementation beyond near term actions that uses signposts to determine when such additional actions are needed

Appendix A

Interview Notes

Interviews were conducted to inform the Missouri Water Plan process. Statements made in interviews are the opinions of the interview participants.

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Interview Notes

Agricultural Irrigation

Introduction

CDM Smith interviewed Joe Henggeler, Irrigation Engineer based at the T.E. "Jake" Fisher Delta Center in Portageville, MO associated with the University of Missouri.

The following are notes from the one hour interview. The notes follow main topics of discussion not necessarily in order of discussion.

Crop Production and Irrigation in Missouri

Jessica Fritsche, CDM Smith, provided an introduction to estimating irrigation demands in state water planning.

Joe provided background information on the Missouri Irrigation Surveys. The Bootheel region survey started in 1988, and currently data is available through 2011. Survey reports are available from 1997-2005 at the following link: http://agebb.missouri.edu/irrigate/survey/index.php, however, Joe stated that he is able to provide the 1997-2011 report that is currently not available online.

Joe discussed the quality of the survey data. He stated that he is most confident in center pivot irrigation data. Center pivot users generally know water use per pass and the number of passes made. On the other hand, furrow water use reporting is less reliable and Joe does not feel nearly as confident, as this use is not metered. Furrow irrigation water use is estimated by inches applied/acre. There is a subset within the furrow data called poly pipe, which is low weight garbage bag tubing. Joe finds this subset of data to be more reliable. When Phaucet is used to determine hole sizes in the poly pipe, the data is more reliable.

The methodology for the survey was discussed. Approximately 1200 two page surveys are distributed to farmers. Response is voluntary and varies each year. The exact response rate is unknown. In comparison to NASS survey data, the numbers align closely.

Joe stated that nearly 100-percent of irrigation in the Bootheel region is from groundwater wells pulling from the Mississippi River Alluvial Aquifer. Well depths in this region are approximately 100 feet and water yields are high. Other regions of the state rely more on collecting ponds, with only a small amount of surface water diversion from streams.

Joe recommended a data source from the Mississippi Agricultural and Forestry Experiment Station, where water use for irrigation is recorded electronically by calculating flow based on electrical usage (kWatt hr). This data is being meticulously collected for all crops and catfish, and is further broken down into irrigation methods. Joe indicated that he is attempting to make this data applicable to Missouri by adjusting for climate and evapotranspiration losses. This data has been collected over a period of at least 10 years.

There was a brief discussion regarding the county level information available from NASS including the Ag Census and the Farm and Ranch Irrigation Survey (FRIS). The FRIS is broken down into state specific and national reports, both of which contain general information regarding irrigation water use in Missouri.

Joe provided an overview of Missouri's Crop Water Use Calculator, available at the following link: http://agebb.missouri.edu/weather/reports/cwu/. He mentioned in a later email that in the Bootheel region wells irrigate 85-100 acres. He suggested taking new well registration data to determine how many new acres are added per year.

Jessica asked questions on determining irrigation use efficiency. Joe suggested using the pivot data found within the survey to calculate efficiency using the following equation:

Irrigation use efficiency = irrigated yield – dryland yield/inches of water applied

This calculation results in bushels/acre/inch; which would allow one to determine the inches of water applied per acre. Seasonal application is difficult to determine without utility data. It is also important to take into account the variation in water year types (wet vs dry). For example, 2011 and 2015 were wet years and 2012 was a dry year – this can be mitigated by calculating percentage yield differences by yield type. Joe completed a study on this and will send the paper with that data.

There is also a tool created by Food and Agriculture Organization (FAO) – Joe will send this if he is able to find it.

Future Trends

- Wireless water sensors will continue to expand in use; although Joe is not sure that this will actually impact water use for farmers. There is actually potential for an increase in water use as farmers realize they may not have watered enough in the past. Mississippi has found (United Soybean Board) that use of these sensors on soybean farms has decreased water use, however yields are not impacted. Jason Krutz is working on this project in Mississippi. Joe will try and find this data for us. Data should be available from demonstration farms in the next few years.

- Microirrigation: the problem with use in Missouri is the amount of iron in the groundwater is clogging subsurface drip irrigation. Benefit is that is fits corners/various field shapes.

- Overall: Energy costs are currently and will continue affecting farming practices. Outside the Bootheel the water table is deep and the cost of a new well is limiting ag production. Ponds are also becoming more common for this region. Salinity north of I-70 is also a significant issue with the exception of the Missouri River area. The Bootheel region is prime for farmland, but space is limited for additional farmland. One huge factor is the difference between land ownership vs leasing land. Wells would have to be constructed by land owners, and land leveling expenses fall on owners, but pivot system expenses fall on farmers. Fifty-five percent of farmland in the Bootheel region is leased, which impacts the decision to add additional irrigation systems.

Data gaps

- Joe feels that there is a significant need for a study similar to that in Mississippi using kWatt hours to determine water use. This could also be used for propane and diesel powered water withdrawals.
- Joe expressed concerns regarding water use in the Mississippi River Valley Alluvial Aquifer. The aquifer is the source for all irrigation water in the Bootheel – and the aquifer extends through Arkansas and Mississippi and into Louisiana. There has been a significant increase in farmland in Arkansas and Mississippi within this aquifer and Joe has concerns that there may be future lawsuits against Missouri because Missouri is not imposing penalties for lack of documentation of agricultural water use (Major Water Users Data). He noted that he believes only 10% of ag users in the Bootheel are reporting water use. He believes these lawsuits could easily allege that Missouri is not following the concept of reasonable use.

Action Items

Joe has agreed to provide, if available:

- A copy of the Irrigation Survey ending in 2011. Additional surveys beginning in 1988 are available through Joe if needed (completed 7/23/2015)
- A link to the studies being completed in Mississippi regarding water use per kWatt hr
- A link to the Missouri FRIS report
- A study completed on irrigated and dryland crop yields (completed 7/23/2015)
- data from Jason Krutz regarding wireless irrigation sensors (completed 7/23/2015)
- A study he completed regarding changes in ag water use due to salinity in groundwater (completed 7/23/2015)
- A link to the water use tool available through the FAO

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Interview Notes

CAFCom and Community Services

Introduction

CDM Smith interviewed MDNR staff responsible for CAFCom and the Small Community Assistance Program.

- Lacey Hirschvogel, Affordability and CAFCom, Jefferson City, Missouri
- Sreedhar Upendram, Economist, Jefferson City, Missouri
- Hannah Humphrey, Community Services, Jefferson City, Missouri

The following are notes from the one hour interview. The notes follow main topics of discussion not necessarily in order of discussion.

Affordability and CAFCom

Lacey Hirschvogel began the interview with an explanation of MDNR's Affordability Tool, CAFCom. The program was started in 2012, consistent with Section 644.145, RSMo, which states:

> *When issuing permits under this chapter that incorporate a new requirement for discharges from publicly owned combined or separate sanitary or storm sewer systems or treatment works, or when enforcing provisions of this chapter or the Federal Water Pollution Control Act, 33 U.S.C. Section 1251, et seq., pertaining to any portion of a publicly owned combined or separate sanitary or storm sewer system or treatment works, the department of natural resources shall make a finding of affordability on the costs to be incurred and the impact of any rate changes on ratepayers upon which to base such permits and decisions, to the extent allowable under this chapter and the Federal Water Pollution Control Act.*

In order to comply with this program, Lacey and her team use national indices found in Hydromantis based upon Capdet Works (concern is primarily east coast costs) to calculate costs for communities and public water providers to comply with any new discharge requirement. These costs include four mechanical compliance options (over a 20-year period) including aeration, extended aeration, oxidation and sequencing batch reactor as well as high and low estimates for land application (over a 30-year period). High estimate is the construction and land cost to build a new storage basin, low cost is using the existing lagoon as a storage basin (reduces construction, material, and land costs). Costs are calculated based on the facilities' design flow. Overall costs include capital costs, annual operations and maintenance, annual debt retirement, and total present worth (assume 5 percent interest rate). The user costs/month is also calculated as percent of median household income.

The overall goal of the CAFCom process is to determine an adequate schedule of compliance that will mitigate the financial burden resulting from the new permit requirement(s). The estimated residential user costs for the upgrade are not to exceed two percent of the area median household income (MHI). If this goal is not achievable, the permit is placed on hold until further investigation can be done to determine the best and most affordable option for the municipality. The number of years allowed to comply are assigned based on CAFCom results. If compliance with a new standard is determined to be a high burden, the system would generally be granted 10 years to comply with the standard. Medium burdens are allotted 7-9 years, and low burdens are allotted 5-7 years. For example, high burden have 16 years to comply - generally 5 years to raise rates, 10 years to get the funds and 5 years to bond.

Lacey stated that MDNR currently has a spreadsheet with CAFCom data starting in September 2014. However, this spreadsheet is not useful because they did not issue permits with a new requirement for ammonia. There is also data from 2012-September 2014, but this data set is not as accurate as the current spreadsheet and is not currently in a useful format. They believe by 2018 all compliance alternatives, costs, and schedules for the 1999 ammonia standard will have been calculated for publically owned systems.

The new ammonia guidelines were discussed as they relate to CAFCom. Currently calculations are being completed based on the 1999 standards, but Lacey anticipates statewide upgrades to plants will be necessary when the new guidelines are updated for the state. Mechanical and land application facilities that MDNR estimates the costs for based on 1999 standards can meet 2013 EPA ammonia criteria.

Sreedhar Upendram maintains and updates a database with social and economic data for CAFCom. Sreedhar stated that he is available to analyze population and employment data and prepare projections for the next 50 years. The projections will be at the city and county level, including but not limited to population, employment, and water demand. He noted he is updating the database with 2013 Census data. There are 1,032 communities in Missouri.

Community Services

Hannah Humphrey provided the group with a proposal for a Statewide Pre-Feasibility study for Wastewater System Regionalization. Hannah stated that this study could be used as the first step in an important task of shared responsibility among small rural communities in reaching compliance with statewide discharge standards, particularly new ammonia standards. Hannah believes that regionalization of services for small communities is an important next step that should be included in a Missouri Water Plan. The proposed pre-feasibility study would be used to identify systems that could benefit from regionalization. Subsequently, the Community Services division could work with identified systems to develop a process for regional compliance. The program would be similar to the Public Drinking Water PER grants but for wastewater.

Hannah provided a list of potential data sources for small community data. These include:

- 604(b) Community Wastewater Assessment, 2011. Communities and Regional Planning Commissions, along with MoDNR and the Missouri Association of Councils of Government, surveyed small community wastewater treatment systems in the state. The goal of this project is to assess and inventory public wastewater systems, develop a wastewater improvement needs summary for interested communities and watersheds, identify potential funding opportunities for improvements, and work with communities as appropriate to anticipate needed improvements to maintain and improve water quality. This summary report is designed to provide a "snapshot" of the existing system, a comparison of this system to others in the region and the State, and to forecast future system capacity needs, options, and costs. Each system is summarized in a two page report. This report is available in hard copy form at MDNR headquarters. Only portions of the document are available online. Mid-Mo Regional Planning Commission summaries are available at: http://boonslick.org/wp-content/uploads/2011/05/Boonslick-604b-reports.pdf.

- 604(b) Statewide Water Assessment, July 2011. The assessment provides general conditions and needs for municipal wastewater treatment facilities in communities with populations less than 5,000. The four objectives of this project are - to create an inventory of needed wastewater system improvements, to develop a needs summary for the participating entities, to develop a financing guide for the systems, and to work with the state and federal agencies to amass financing tools to address the needed improvements in the State of Missouri. This report is available at: http://mmrpc.org/plans/604%28b%29/604-b-Statewide-wastewater-assessment-report-draft-1%20web%20version.pdf.

- MDNR NPDES domestic wastewater permitted facilities dataset with locations, treatment type, and population served

- Geology and topography data layer. Available at: http://dnr.mo.gov/geostrat/

Action Items

- Lacey Hirschvogel will send costs for the land application and least cost mechanical alternative upgrades to systems for ammonia compliance for 2014 and 2015.

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Interview Notes

Groundwater

Introduction

CDM Smith interviewed several MDNR staff responsible for groundwater management and monitoring in the State.

- Scott Kaden, Groundwater Section Chief, MDNR - Rolla
- Cynthia Brookshire, Public Drinking Water Assistance Unit Chief, MDNR - Rolla and Springfield
- Brian Fredrick, Hydrologist, MDNR - Springfield

The following are notes from the one hour interview. The notes follow main topics of discussion not necessarily in order of discussion.

Major Water Users Database

Brian Fredrick is the coordinator of the Major Water Users reporting and database. By statute, there is to be not more than three staff responsible for facilitating the Major Water User data. The State Statute requesting Major Water Users report their use was created in the 1980s. Major Water Users are defined as follows:

> *"Any surface or groundwater user with a water source and the equipment necessary to withdraw or divert 100,000 gallons or more per day (70 gallons per minute) from any stream, river, lake, well, spring or other water source is considered a major water user in Missouri. Additionally, any combination of withdraws (wells, surface water pumps or diversions) that withdraw or divert 100,000 gallons or more per day (70 gallons per minute) also qualifies as a Major Water User." (Pub2337 FAQ 2014)* http://dnr.mo.gov/pubs/pub2337.htm

Per the riparian doctrine, there are generally no limitations on the surface and groundwater withdrawals in the State.

> *"There are no state laws, regulations or policies that specify how much water may be used. Missouri is a riparian water law state, which means, all landowners touching or lying above water sources have a right to a reasonable use of those water resources. Recent case law has established the reasonable use criteria that the State Supreme Court has been following. Reasonable use requires that other users and landowners not be overly adversely impacted." (Pub2337 FAQ 2014)*

In 2014, there are 1,970 active users of which 1,213 have reported water use or about 60 percent, thus of the active registered users 757 have not reported 2014 water use as of the date of this meeting. The number of major users not registered at this time is unknown. While reporting is required by statute, it is not enforced. A user may have more than one "withdrawal point" and on

average users have 4.5 withdrawals points. Municipalities, counties and water districts are well represented in the database since they report their quantities already. Agricultural Irrigation water use reporting may not be as well represented in the system. There was a recent amendment to the statute that would encourage greater participation in Major Water Use registration in Southeast Missouri counties. This statute addresses agricultural irrigation use, particularly when there is an impact of one user on another's groundwater withdrawals. The amendment is as follows:

> *"Notwithstanding any provision of law to the contrary, no major water user shall convey water withdrawn or diverted from within the southeast Missouri regional water district created under section 256.643 when such withdrawal or diversion and subsequent conveyance to a location outside such district unduly interferes with the reasonable and customary activities of a major water user registered under section 256.410 located within such district. If such conveyance occurs, the attorney general or the party or parties affected may file an action for an injunction, however, in no case shall an injunction be issued if the injunction would be detrimental to public health or safety." (RSMo 256.433.1)*

This amendment is governed by the Southeast Missouri Regional Water District as established by Statute RSMo 256.643.1.

> *"There is hereby established a public corporation to be known as the "Southeast Missouri Regional Water District". The district may include all or part of the following counties: Scott, Mississippi, Stoddard, Butler, New Madrid, Pemiscot and Dunklin."*

There are no fees associated with reporting annual water use in Missouri. It is prevalent in Southeast Missouri to have property ownership and well use from Arkansas residents and farmers because the lack of enforcement mechanisms and fees in Missouri. Brian noted that some major users fail to register or report based on fear of future taxation of recorded water use. On the flip side, some agricultural irrigators believe that reporting high water use annually will ensure their water rights for the future if water rationing is enforced. Since all data is self-reported, the overall quality of the data is unknown, especially for the unmetered agricultural users.

Other means to encourage self-reporting during the past decade were the use of online reporting and a current upgrade to a more user friendly and better functioning interface that will allow end users and MDNR staff to have better access to water use data. A benefit of voluntarily reporting is if ever there is a discrepancy or water use challenge, past use has been documented to defend future water use.

The Major Water Users Database has ground- and surface water data by user by County. There are 10 categories of use including (1) municipal, (2) commercial, (3) fish and wildlife, (4) livestock,(5) ag irrigators, (6) electrical, (7) industrial, (8) drain and dewater (9) recreational, and (10) other. Brian provided a hardcopy of all users by county for all categories except irrigation, which he sent to CDM Smith on July, 7th 2015. Cynthia Brookshire noted a study conducting door-to-door interviews in Taney and Stone Counties indicating limited knowledge of reporting by golf courses with overall only about 19 percent of major water users registered. It is unclear, statewide, what percent of industrial water users are registered.

A means to crosscheck Major Water Users irrigated acres, particularly agriculture, is to compare current USDA Agricultural Census reported irrigated acres to irrigated acres reported to the Major Water Use Database annually. Also MDNR's WIMS is GIS based and has certified high production wells since 1987. WIMS can provide location, use category, date, yield without pump, pump capacity and static water level. https://www.dnr.mo.gov/mowells/wimsSearchLanding.do Cynthia and Scott noted that this data is generally reported by well drillers and there may be discrepancies in the yield data (yield without pump vs pump capacity). They noted that the most useful data within WIMS are location, use category, and date.

Groundwater Monitoring Network

Scott Kaden discussed the groundwater monitoring network in Missouri. There are 168 wells throughout the State. MDNR only measures water levels, not water quality. Forty of the wells have corresponding rain gages. Six of the rain gage sites collect additional data on various wetland parameters. The oldest monitoring well began collecting data in 1956. http://dnr.mo.gov/env/wrc/groundwater/gwnetwork.htm

Thirteen different aquifers are monitored by one or more of these wells. Some wells monitor one specific aquifer while others collect data from multiple aquifers. The well locations may be near communities or away from influences to reflect ambient conditions. http://dnr.mo.gov/env/wrc/groundwater/index.html

Cynthia Brookshire noted there are 10 paired wells in the Springfield Plateau and Ozark Aquifer of southwest Missouri. Cynthia also noted that Missouri is second in the country in number of monitoring wells.

There are mineral issues (brackish) near and north of the Missouri River.

The groundwater table in the alluvial aquifer of southeast Missouri is near the surface (generally 5 to 15 feet below the surface) wells provide high yield for agriculture. Agriculture in this region includes mainly corn, soybeans, rice, and cotton. In southeast Missouri Bootheel area, eight monitoring wells measured record levels of decline but only 10 percent of the major users reported declines.

Scott noted that MDNR is updating a database of springs that could be queried for water quality. It is relevant in areas of karst topography with sinkholes and loosing streams. This database is not yet available to the public.

Scott, Cynthia, and Brian felt that gaps in the current groundwater network for Missouri included mandatory reporting requirements for major water users and a water quality monitoring data set.

Action Items

- Brian will provide the Major Water Users Database Agriculture Irrigators data. (completed July 7th)
- Brian can query the Major Water Users Database as needed.
- Brian noted providing to CDM Smith the data dictionary for reference of all MDNR data. (Completed July 7th)

Interview Notes

Wastewater Permitting

Introduction

CDM Smith interviewed MDNR staff responsible for MoCWIS permitting.

- Rebecca Cripe, Permitting – Water and Wastewater Permits, Jefferson City, MO

The following are notes from the one hour interview. The notes follow main topics of discussion not necessarily in order of discussion.

MOCWIS

Rebecca explained that there are approximately 11,000 water and wastewater permits. The data for these permits is reported in the Missouri Clean Water Information System, available online at the following link: http://dnr.mo.gov/mocwis_public/permitSearch.do

Wastewater permits are referred to as clean water permits. Of the approximately 11,700 permits, there are approximately 7,500 site specific permits, with the remainder covered under general permits. MDNR is currently operating under a 5-year permit cycle; however, the department is working towards a watershed permitting approach, in which permits will be renewed as an entire watershed. This watershed approach will allow MDNR to monitor and determine effluent guidelines based on water quality of the entire watershed.

Permitted facilities are required to submit DMRs. These are required on varying timesteps (monthly, annual, etc.) based on the discharge history of the facility. Data from these reports from 2008 to present is stored in the MoCWIS data portal, available here: http://dnr.mo.gov/mocwis_public/dmrDisclaimer.do . Queries of the MoCWIS database can also be completed for topics such as violations and schedules of compliance through a Sunshine Law Request. Rebecca stated that she is confident in the quality of this dataset overall. Definitions to assist in using the database are available through the following link: http://dnr.mo.gov/env/wpp/mocwis/definitions.htm.

If there is mapping or GIS needs for the permitting data, Rebecca suggested contacting Ken Tomlin or Mike Kruse of MDNR.

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Interview Notes

MU Extension – Water Quality

Introduction

CDM Smith interviewed Bob Broz, Extension Water Quality Program Director at the University of Missouri College of Agriculture, Food, and Natural Resources.

The following are notes from the one hour interview. The notes follow main topics of discussion not necessarily in order of discussion.

Source Water Protection and Educational Programming

Bob explained that his role with the University of Missouri involves educational programming as it relates to source water protection. Main priorities within this program are water quality, specifically as related to pesticide and other agricultural pollution, as well as watershed management.

Bob began with a discussion of water quality in drinking water reservoirs in Missouri. He indicated that there are 10 reservoirs that have high levels of atrazine (based on 1996 standards). As a result, a plan of action is currently being developed to reduce the potential of agricultural pollution to drinking water reservoirs. This plan is being developed as part of the TMDL and 303(d) program. Bob stated that agricultural pollution in the form of nutrients, sediment, bacteria, and or pesticide runoff plays a role in all 303(d) listed impairments (may not be primary source, but very likely some contribution is from ag). Bob attributes this to not only the large amount of ag production in the state (both crop and livestock), but also to the slope and soil types of Missouri land. The state has over 2 million acres of heavy clay pan soils which cause minimum absorption and large amounts of run-off. Additionally many farmers are switching to No Till methods which increase pesticide runoff. There are currently studies being completed on Variable Rate Application or Precision Ag strategies that would allow farmers to precisely apply fertilizer as needed and reduce leaching. Additional information on this technique is available here: http://extension.missouri.edu/p/WQ451. Cropland is especially prevalent in the southeast Bootheel region of the state where yields are generally 300 bushels/acre for corn and 85 bushels/acre for beans. Cattle production in Missouri is a contributor to water quality issues (specifically bacteria) especially in southwest and south central Missouri. This is in part due to thin rocky soils with significant slopes. This is less of an issue in north central Missouri where soils are thicker.

There are over 200,000 acres of irrigated cropland in the state, of which the majority is in southeast Missouri. There is some irrigation in Southwest Missouri in Barton County particularly and in Central Missouri in the Kingdom City area east to Martinsburg. Nutrient loading and irrigation work hand in hand – as irrigation increases, nitrification of receiving waterbodies increases. Irrigation data from the Crop Water Use Calculator is available from Joe Henggeler at 573-225-7986. Joe has been collecting 15 years of irrigation indicator data (Erin will work to set up a call with Joe). Advancements in irrigation are reducing the amount of water required for

irrigation. These advancements include wireless water sensors which are drastically increasing yields while reducing the amount of water required for irrigation. They are also reducing nitrogen leaching and soil erosion. Bob indicated that he has seen studies that show that these sensors will pay for themselves in 3 years. There is also a move towards subsoil poly tubing to irrigate. Bob pointed out the following article which provides an overview of this system: http://www.deere.com/en_US/docs/html/brochures/publication.html?id=e9d79ab9#14. He noted, however, that this system will not work in the heavy claypan areas of the state.

There was discussion of the breakdown of groundwater versus surface water usage in ag. Bob stated that surface water usage is generally not reported because there is no enforcement of reporting regulations. Groundwater usage would be easier to track through well records. He stated that the best source of surface water data would be irrigation distributors due to the quick replacement cycle of irrigation equipment.

Bob discussed the approximately 40 watershed plans that have been written. Most of these have been written in collaboration with NRCS and MDC as part of the 319 program. Watershed plans are available at the following link: http://mdc.mo.gov/your-property/greener-communities/missouri-watershed-inventory-and-assessment and include information such as watershed size, land use, soil types and slopes. While some of these plans were written prior to the EPA required 9-element plan, there are a number of them that have been written recently under these criteria (identification of impaired waters with causes and sources, load reductions, financial and technical assistance, educational components, schedules, monitoring criteria, etc).

Watershed modeling is being completed on two watersheds. Black Creek is undergoing final review, but is available from John Johnson at MDNR. The Spring River Watershed Initiative was completed by the Harry S Truman Regional Planning Commission and is available here: http://www.hstcc.org/#!spring-river-watershed/c1bx7.

When asked about TMDLs in Missouri, Bob stated that while efforts including modeling are aimed at targeting current TMDLs there are a number of TMDLs that are difficult to entirely address, or that simply cannot be addressed in their entirety due to lack of source information. These generally include mine tailings and the atmospheric deposition of mercury.

The topic of watershed management from a stakeholder perspective was addressed. Bob stated that 93 percent of land in Missouri is privately owned, and as a result, local buy-in to water quality and watershed planning is important. OMW is one element of the local buy-in process. Bob stated that in his experience one should expect at least a 1 to 1.5 year timeline to get people interested in working together towards a common goal.

When asked about water quality issues moving forward Bob pointed out a number of issues:

- Blue-green algae blooms from ag production are the source of several law suits nationwide. Nitrates are generally causing these blooms and individuals are suing the states for lack of regulation. There is currently blue-green algae blooms in Smithville Lake and Truman Lake. Additionally, a magnesium spike in Maysville may be linked to a nutrient issue. Nutrient limits and organics caused by nutrient loading are going to be an important issue in the near future. There are currently no nutrient limits for streams in Missouri; and varying

limits for lakes depending on their location in the state (lower in the south and higher in the north)

- Watershed targeting needs to be used as a means to utilize funding
- Public involvement is important and there need to be efforts to help people realize causes and effects relating to water quality issues
- A wide range of data has been collected without realization of the full extent of its application. For example, there has been research on the use of buffer strips (25 feet for sediment, 40 feet for nutrients, and 60 feet for wildlife) – but buffer strips can be used for additional water quality issues with some additional research and application of past research

Potential data gaps Bob indicated are:

- Endocrine disruptors
- Antibiotics in wastewater (human and livestock sources)
- Soil moisture research

Notes/Follow-Up

- Erin will reach out to Joe Henggeler regarding a possible interview with Jessica Fritsche (CDM Smith)

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Interview Notes

Permitting

Introduction

CDM Smith interviewed MDNR staff responsible for the Permitting Program.

- Chris Wieberg, Operating Permits Section Chief, Jefferson City, Missouri

The following are notes from the one hour interview. The notes follow main topics of discussion not necessarily in order of discussion.

Permits

Chris provided a general overview of MDNR permitting section. Issued permits include (1) general NPDES permits, (2) state specific permits, and (3) combination state/federal permits. Chris estimated that there are currently 4,000 general permits and 3,800 state specific discharge permits issued statewide. While NPDES permits pertain to point source discharges to surface waters, groundwater (i.e., subsurface waters per revised statute) is also considered a Water of the State in Missouri, therefore Underground Injection Control (UIC) Permits, approximately 50 statewide, and other groundwater discharge state operating permits are also issued through the MDNR permitting section. Groundwater discharge permits are issued to sites with the potential to discharge (such as around coal ash ponds), however, these are not considered UIC permits. MDNR also handles land disturbance permits for construction sites. Municipal Separate Storm Sewer Systems (MS4) permits are also handled through MDNR permitting. These permits include minimum control standards. There are four site specific MS4 permits in Missouri, the remainder are regulated under general permits.

Additionally, the permitting section works with rural residential housing developments to handle subdivision waste control by developing methods for septic tank installation. This program is completed in partnership with the Department of Health and Senior Services.

Permit limitations can be technology (effluent) based (10.CSR 20-7.015) or water quality based (10.CSR 20-7.031) whichever is more stringent. Water Quality Standard (WQS) criteria are developed by the Watershed Protection Section, supervised by John Hoke. The recent WQS rulemaking resulted in the expansion of the Waters of the State as discussed by Watershed Protection. A new statutory requirement recently passed (House Bill 28 – Rep. Miller) requires that if the change in WQS is 25 percent or more an evaluation of economic and environmental need on a watershed basis must be conducted. Any WQS amendment after HB 28 is subject to this requirement. The last WQS amendment had a fiscal note that was very high due to more facilities having to comply with bacteria and other requirements. John Hoke can provide the fiscal note for the past WQS rulemakings. This is discussed further with respect to ammonia standards in the following section.

Permit data is accessed through the MoCWIS data portal. The system includes water quality monitoring data for all dischargers. This data is initially submitted to regional offices, which enter the data into the MoCWIS system. Self-generated reports of water quality violations are generated by MoCWIS and follow-up is completed by regional office officials. MoCWIS is available at: http://dnr.mo.gov/mocwis_public/permitSearch.do

Ammonia Criteria

Ammonia is often a required water quality constituent sampled during monitoring. Chris discussed ammonia toxicity standards as they relate to seasonal variations. Ammonia varies by temperature and pH (e.g., 7.8 pH is typical parameter of permit) of the water. Therefore, Missouri includes two seasons of ammonia effluent limitations. While effluent limitations are expected to be significantly smaller under new ammonia for mussels criteria, Chris stated that overall treatment plant technologies are the same. Therefore, while financial burdens to update systems to comply with new ammonia criteria are still expected for many systems, the technology being used by many facilities to treat ammonia already exists based on 1999 ammonia for fish criteria. A fact sheet created by MDNR that explains the new EPA recommended ammonia criteria is located at: http://dnr.mo.gov/pubs/pub2481.htm

Chris stated that any new requirement included in a Publicly Owned Treatment Works permit must be accompanied by a CAFCom/Affordability analysis to determine the potential cost for compliance as it pertains to user rates. Permits are also subject to HB 28 as it pertains to limit increases over 25 percent and have to establish or document economic and environmental need on an HUC-8 scale similar to WQS. No CAFCom analysis is completed for private facilities.

Action Items/Notes

- Chris is available to discuss the integration of watershed based permitting and regulations (time was limited during interview)

Interview Notes

Public Drinking Water

Introduction

CDM Smith interviewed MDNR staff responsible for the public drinking water program.

- Megan Torrence, Engineering Reports, Jefferson City, Missouri
- Tom Adams, Public Drinking Water, Jefferson City, Missouri

The following are notes from the one hour interview. The notes follow main topics of discussion not necessarily in order of discussion.

Public Drinking Water Engineering Reports

MDNR provides funding to public water supplies for engineering projects through the state's SRF program. Grants are available to all community water systems (regardless of application status to the DWSRF program) and provide up to 90 percent of the cost to hire an engineer and develop an engineering report. Engineering reports are required by community water systems as a first step towards implementing changes to help the system achieve and maintain capacity and comply with drinking water regulations. Megan Torrence provided a stack of PERs for review. She explained that these reports accompany applications for grant funding from community water systems seeking to upgrade facilities.

PERs have been scanned, and are available upon request from MDNR. Access to reports since 1999 is available. However, the majority of data available is from 2009-present. The reports contain the following sections: Introduction, Project Planning, Existing Facilities, Project Need, and System Improvement Alternatives.

Following the meeting, Megan provided three spreadsheets:

- Project Request Spreadsheet: a list of applicants to the Engineering Services Grant Project from 2008, 2009, 2011, and 2013. Contains information about recommendations included in the report, whether funding for the improvements was obtained, and if the project has started construction.
- 2013 Engineering Report Services Grant (ERSG) program Master List: a list of 2013 grants by system, which includes total project costs and financial awards.
- ERSG Info: an example of fields available from the ERSG system, which are available for query.

SDWIS

Tom Adams provided an introduction to the SDWIS, an EPA provided drinking water database. The Missouri SDWIS system contains records for 5,600 water systems. Of these, 2,700 are currently active systems.

The SDWIS system for Missouri is currently available to the public through MDNR's Drinking Water Watch Interface, available here: https://www.dnr.mo.gov/DWW/landing_MO.jsp

SDWIS data includes a complete inventory of public drinking water systems as well as sample results, compliance activities, and water quality data. While information on individual facilities can be obtained through Drinking Water Watch, data queries can be completed via request through MDNR. Available fields include:

- Water System Detail Information: Water System Number and Name, Principal County, Federal Source
- Water System Contacts
- Sources of Water
- Source Water Percentages
- Water Purchases
- Buyers of Water
- Annual Operating Period
- Service Connections
- Service Area
- Regulating Agencies
- Flow Rates: Average Daily Production, Total Design Capacity, Total Emergency Capacity

Data is updated during regional office inspections. Drinking water violations are available upon request from MDNR. It is important to note, however, that these violations include both system and operational violations.

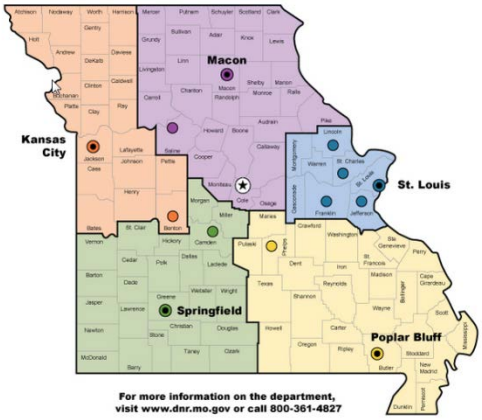
Interview Notes

Regional Offices

Introduction

CDM Smith interviewed several individuals representing MDNR Regional Offices via a phone interview on July 21, 2015. Regional Office attendees included:

- Everett Baker – Northeast Region: Macon, MO – Engineering Section Chief, Drinking Water and Wastewater
- Jack Baker – Southeast Region: Poplar Bluff, MO – Drinking Water and Wastewater Manager
- Brad Ledbetter – Southeast Region: Poplar Bluff, MO – Drinking Water Unit Chief
- Dan Daugherty – Kansas City Region: Lee's Summit, MO – Drinking Water Environmental Scientist
- Kristen Pattinson – Southwest Region: Springfield, MO – Drinking Water Compliance



The following are notes from the two hour interview. The notes follow main topics of discussion not necessarily in order of discussion. A regional map is provided to illustrate regional boundaries.

Infrastructure

Everett Baker stated that disinfectant by-products are the greatest treatment concern in northeastern Missouri and the Kansas City region. Dan Daugherty stated that several Kansas City regional facilities also have issues meeting disinfection-by-product and TOC limits. There was also concurrence amongst all interviewees regarding the challenges associated with recent ammonia and bacteria/E. coli discharge limits. Everett stated that ammonia and bacteria/E.coli discharge is a major issue in the Northeast Region during the summer months due to low flow conditions. Discharges to low flow streams during the summer and during drought periods can heavily impact water quality due to lack of sufficient dilution from streamflow.

Brad Ledbetter explained that wastewater treatment plants in portions of the Southeast and Southwest Regions are held to higher standards due to their proximity to Ozark Scenic Riverways, known for their pristine condition.

Kristen Pattinson mentioned that several treatment facilities in the Southwestern Region are experiencing violations in Radionuclide (RADs) levels, particularly in McDonald and Barton Counties. She indicated that the source of this contamination is natural, and often requires construction of a new well, however, drilling a new well in the same area may not work, as treatment is cumbersome.

It was noted that there is a funding gap for small non-municipal systems such as residential subdivisions. Everett noted that the northeast region has some of the State's highest water rates for example many paying $10/1,000 gallons and on top of that paying a $20-$25 monthly service charge. It was noted that many are applying for USDA funding. Although it is higher interest rate than SRF, it has a longer term to pay it back. SRF is 20 year loan and USDA is 35 year loan. Thus, the overall monthly payment is cheaper for the USDA loan though the total payed back is greater than the SRF loan.

Water Quality

Everett explained that in northern Missouri lakes and streams are often highly turbid, especially during summer months. Lake turbidity rises from 10 to 20 ppm to as high as 200 to 300 ppm. He added that turbidity in rivers in this portion of the state can quickly rise into the thousands.

Kristen discussed the many lakes located throughout the Southwest Region. She indicated that lake limits on pollution are becoming tighter in recent years, and phosphorus and nitrogen limits are currently in development for Missouri lakes in an effort to reduce nitrification. Mike Beezhold asked about septic regulations in the region, and Kristen indicated that septic regulations fall under the Department of Health. She also indicated that there are current efforts towards regionalizing wastewater treatment to reduce the need for septic systems; however, the topography and rocky subsoil make costs of running pipelines extremely high. Kristen noted that the 1999 phosphorous limits greatly improved Table Rock Lake. Brad mentioned that there is a 319 grant project on the Current River in Missouri to identify and replace failing septic systems. The program was implemented as a result of violations in bacteria limits.

The group discussed siltation, especially as it relates to drinking water reservoirs throughout Missouri. As these reservoirs age, siltation has become a significant issue to the point of reducing critical water supply during periods of drought. Brad indicated siltation concerns in the Southeastern Region are also tied to heavy metal pollution from historical mining activities such as at Fredericktown at the foothills of the St. Francois Mountains. While there are few heavy metal violations at this time, it is becoming a major concern as lake levels decline. The group discussed the importance of including this issue in the state water plan with a discussion of causes and potential solutions.

Non-point source pollution is an issue across the State. Solutions suggested by the team included implementation of best management practices for agricultural producers including no till techniques on cropland and elimination of access to waterways for livestock. A potential concern in Missouri regarding proper management and conservation practices on agricultural lands is that much of the farmland throughout the state is leased by farmers. Brad indicated that there are efforts in Southeastern Missouri to determine funding sources for dredging of lakes in this region. However, Everett cautioned that dredging may not be a cost-effective option.

Aquatic Species

Everett pointed out that aquatic species vary throughout the state due to the tremendous differences in topography between northern and southern Missouri. In northern Missouri streams and pools tend to dry up and/or become highly turbid due to muddy conditions during the summer months. Many of the stream have been channelized. He stated that the availability of water in the north is limited, in turn limiting aquatic species in this portion of the state.

Brad noted that there are also significant differences in streams within southern Missouri. The southeastern portion of the Southeast Region is characterized by man-made channelized streams constructed to drain alluvial agricultural fields in the Bootheel area. Aquatic species within this portion of the region include catfish, carp, and buffalo fish. In the western portion of the region, streams are known for their pristine quality as part of the Ozark Scenic Riverways. This area is home to trout, walleye, and bass. Since 1979 there have been no discharge limits in place unless grandfathered in.

Both Brad and Everett noted that in some instances wastewater discharges are a positive contributor to the low flow needs of aquatic species.

In the Southwest, Kristen noted concern with nitrification and the Niangua Darter.

Water Supply

Dan noted that there are several areas south of Kansas City building low water dams to allow for back-up reservoir storage during periods of drought like 2012.

There was also discussion of supply issues related to siltation of drinking water reservoirs throughout the state. As reservoirs age, particularly those in northwest and southwest Missouri, they can experience a decrease in storage due to significant siltation. Solutions to this problem may include construction of additional reservoirs, and/or dredging of current reservoirs. Both have been found to be extremely cost prohibitive. Everett provided the example of a reservoir in Vandalia, Missouri that was dredged using funding from an EPA demonstration grant in the late 1970s. Everett indicated that the costs of dredging and disposal of dredged material were extremely high, and that the reservoir has nearly returned to the amount of siltation it was in prior to dredging. Steve McIntosh may have additional information regarding bathymetric studies on this project and others in the region. Additional discussion of siltation in Missouri lakes can be found in the Water Quality section of the notes.

Kristen led a discussion regarding additional supply issues in the Southwest Region. She stated that the current area of greatest concern is the Joplin metro area in Jasper and Newton Counties. This area is currently experiencing significant growth in population and is seeking alternative storage to supplement their Shoal Creek supply. The area is projected to need an alternate supply source by the year 2020, and is currently looking at alternatives including a reallocation of Table Rock Lake and Stockton Lake or construction of a new reservoir. Additionally, Branson has a surface water treatment plant which had issues during the last flood (June, 2015) in which lines were broken by boulders. However, groundwater wells were able to keep up with supply during this time. Kristen indicated that she expects that as the tourist and seasonal population continues to increase in Branson there will be water supply issues. There are already some peak season supply issues as population triples during tourist season. Groundwater is declining drastically in

this area during peak usage. In McDonald County (Noel), Liberty Utilities (Water) had to lower a pump approximately 100 feet to 270 feet likely due to Tyson Foods drawing down the groundwater table in that area. Throughout this region there are some issues with industries depleting groundwater, and drought conditions could exacerbate this issue.

Everett stated that the northern part of the Northeast Region has limited groundwater. However, there are some issues with deep well drawdown in Mexico, Missouri during heavy agricultural irrigation in Audrain County. Shallow wells go dry when deep irrigation wells start drawdown. Personal wells were going dry due to ag usage. However, at this time it is only an issue during drought.

Dan stated that Jefferson County (St. Louis Region) is experiencing high urban growth which is causing significant drawdown of wells. Jefferson County Consolidated District #1 is currently buying water from Missouri American Water, St Louis to supplement supply. This transfer was accomplished through purchase of an abandoned railroad right of way to pipe water from the Meramec River. Groundwater levels in this area have decreased quite a bit over the past few decades. Crystal City/Festus/ Herculaneum are having issues with collector wells that cannot get adequate water during certain times of the year.

Clarence Cannon Wholesale Water Commission pulling out of Mark Twain Lake is helping to reduce drawdown issues especially during drought. However, the central part of the Northeast region is always on the edge of drought according to Everett.

In the southeast: Madison, Iron, and Wayne Counties – There are granite formations and low yielding wells (50 gpm resulting in communities needing multiple wells to keep up with demands). The Bootheel region wells are generally about 125 feet deep or less producing 500 to1000 gpm. More ag wells are being built that produce 2,000 to 3,000 gallon per minute (gpm) in Bootheel following the 2012 drought which may impact future supplies. There are also RADs MCLs in some wells where there were no previous issues in St Francois, Perry and Cape Girardeau Counties. In the Northeast region RAD issues are found in Boone, Cole, and Calloway Counties where new wells have been drilled to address the problem. The source of this contamination is unknown.

Water Demands

Another problem faced by southwest Missouri utilities especially in rural areas is that aging population and aging infrastructure leaves many towns without the ability to afford system upgrades.

Aside from Boone, Cole and Calloway Counties, in the northeastern portion of the state many areas are declining in population and towns are no longer functional as individuals do not want to take over responsibilities for the current systems. Everett also believes that per capita usage was previously highest in the northeast; however, more efficient appliances are helping to reduce per capita usage. Dan agreed that average water usage has declined due to low flow fixtures and appliances. Recent droughts have initiated the downward trend with the adoption of conservation measures and replacement with low flow fixtures. Everett noted that a typical residential use was 4,700 gallons per month which has now fallen to 3,700 gallons per month. The result of lower water use is less revenue.

In the Southeast Region, there has been some growth in Cape Girardeau County in the past 5 to10 years. This growth has led to the construction of small community wells and individual WWTPs. Ft Leonard Wood in Pulaski County has had significant growth and land disturbance in the 1990s; but this has affected wastewater more than drinking water. Farmington is a growing bedroom community of St. Louis with 14 active wells, all with RADs. An administrative order is expected soon which will cost millions of dollars to resolve.

Water districts are being urged to connect to regional public water supplies, but are struggling with removing revenue sources despite aging infrastructure. Rates in the Northeast Region are already at or near 2 percent of MHI and therefore there is little room for additional rate increases to maintain the system. Small systems really struggle with these costs. The primary solution is regionalization. There is resistance from small communities which rely on this as revenue but few reserve revenues to maintain and upgrade the water systems. For example Trenton, MO recently abolished their water utility board allowing the Council to have control of the revenues.

Other Issues

The Regional Offices noted a few issues to consider.

1. There is a lot of turnover of operators of small systems who cut their teeth on small systems before moving to larger communities. They also face the political resistance to raise rates to improve degrading systems and find it futile.

2. The Public Service Commission licensed a few small systems (e.g. Hickory Hills near California, MO) that were too small to ever afford to pay back loans.. It was noted that these will likely be in enforcement for the foreseeable future.

3. Small non-municipal (e.g., subdivisions) systems are not eligible for SRF. Erin Lepper noted a small borrower loan program but it has limited funds. Likewise, the Department of Economic Development has a “sister” loan program also with limited funds.

4. Inspection data need to be supplied and applied by the Drinking Water Branch.

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Interview Notes

SRF Drinking Water and Wastewater

Introduction

CDM Smith interviewed MDNR staff responsible for SRF drinking water and wastewater needs data.

- Jeff Starr, Drinking Water and Wastewater SRF, Jefferson City, MO
- Darleen Groner, Drinking Water SRF, Jefferson City, MO

The following are notes from the one hour interview. The notes follow main topics of discussion not necessarily in order of discussion.

State Revolving Fund

Darleen Groner is the MDNR chief of the drinking water SRF, and handles SRF drinking water funding requests and survey distribution and collection for EPA's Drinking Water Infrastructure Needs Survey. Jeff Starr handles reporting requirements for both the DWINSA and the CWNS. The SRFs provide low-interest loans to municipalities, counties, public water and public sewer districts and political subdivisions for wastewater and drinking water infrastructure projects. The SRF is a federally capitalized, low-interest loan program. Projects may be new construction or the improvement or renovation of existing facilities.

Both Jeff and Darleen began our interview with an explanation of each of these surveys. Both surveys are completed every four years, with the assistance of state agencies such as MDNR. The DWINSA summarizes the results of a survey of anticipated costs of investments to install, upgrade, or replace equipment in order to deliver safe drinking water and reports the results to Congress. The results are also used to help determine the amount of funding each state receives for its DWSRF program, which funds the types of projects identified in the survey. The most recently available DWINSA was released in 2011. This report is available here: http://water.epa.gov/grants_funding/dwsrf/upload/epa816r13006.pdf

Darleen summarized the methodology for the survey. EPA distributes to public drinking water suppliers surveys based on population served. Surveys are provided to all large providers which serve populations greater than 100,000. Distribution of additional surveys is explained in the needs survey document at the end of this summary. Each utility is asked to document drinking water infrastructure needs over a 20-year timeline. Results are extrapolated to account for statewide totals. According to the EPA 2011 DWINSA – Fifth Report to Congress, Missouri 20-year need totals approximately $8.5 billion. This is further broken down into approximately $4.8 billion in transmission and distribution, $325 million in source, $1.3 billion in treatment, $636 million in storage, and $43 million in other drinking water infrastructure needs.

Darleen provided an excerpt from the recent EPA report accessed via the link provided above. Survey distribution is currently underway for 2015, during which 75 percent of all 2011 medium utilities surveyed will be re-surveyed. The additional 25 percent will be randomly selected. Large providers will all be surveyed in 2015. The end of survey submissions by the state is February 29, 2016. EPA is required to provide a report to Congress by February 2017.

The results of this survey are used to allocate SRF drinking water funds to individual states. Jeff and Darleen indicated that Missouri is generally allotted approximately $40 million in SRF drinking water funds (this include approximately $17.8 million in capitalization grants from EPA and recycled funds).

Jeff introduced the CWNS, which summarizes the results of EPA's survey of capital costs to address water quality or water quality related public health problems. Data for 2012 have been collected but the report has not been released yet. The CWNS was last released in 2008, and is available here: http://water.epa.gov/scitech/datait/databases/cwns/upload/cwns2008rtc.pdf

According to the 2008 CWNS report, Missouri's total documented needs over a 20-year period are approximately $5.75 billion. The results of this report are also used to allocate SRF clean water funds to individual states. Jeff indicated that current needs are estimated at $9.5 billion for Clean Water and $8.5 billion for drinking water. Missouri is generally allocated approximately $30 to $40 million in clean water SRF funds. That amount combined with the matching funds provided by MDNR and repayment from prior loans totals approximately $150 million in the fund. SRF funds are distributed statewide by percentage of (1) large metropolitan areas and districts (population greater than 75,000), (2) Outstate Missouri (population less than 75,000), (3) CSO, and (4) department initiatives.

The Missouri State Revolving Fund System is an internal database managed by MDNR. The database contains project level specific data for projects under the following categories: planning, fundable, under construction, and completed.

National Information Management System (NIMS)

The EPA NIMS collects high level (not by project) drinking water and clean water information that provides a record of statewide SRF funding. The data dates back to the inception of each program: 1989 for Clean Water and 1998 for Drinking Water. This includes data on federal and state investments, set-asides, fund assistance, project type data, and fund information. Data are due to be input into NIMS by the end of August and are published and shared at the annual Council of Infrastructure Financing Authorities (CIFA) conference in November. cifanet.org.

The Missouri Drinking Water NIMS Report is available here:

http://www.epa.gov/ogwdw/dwsrf/nims1/modw10.pdf

The Missouri Clean Water NIMS Report is available here:

http://water.epa.gov/grants_funding/cwsrf/upload/CWNIMS_MO.pdf

Tanya Roth has details by region.

Other Funding Sources

- USDA-RD
- Small Communities Small Borrowers Loan – criteria is less than 1,000 population and project cost of less than $100,000.
- CDBG. Approximately $500,000 in funding per year.
- EIERA. Eiera.mo.gov

More information on these other funding sources are available through the MDNR Financial Assistance Center. http://dnr.mo.gov/env/wpp/srf/index.html

Action Items

- Jeff Starr will provide CDM Smith the Needs survey links and subsequent reports (completed via e-mail on 6/22/15)

Attachment from Jeff Starr:

Summary of Drinking Water Infrastructure Needs Survey

The DWINSA is an assessment of the 20-year infrastructure needs of state-regulated and tribally-regulated water systems that are eligible for DWSRF funding. The DWINSA is used to allocate capitalization grant funds. States and regions with greater need get a greater percentage of the funding.

The 1996 Safe Drinking Water Act (SDWA) Amendments established the DWSRF. The 1996 SDWA Amendments also directs EPA to conduct drinking water infrastructure needs assessment every four years.

There are two primary goals:

1) Determine the national need and to inform Congress; and
2) Determine the needs by State per allotment.

There are five categories of need:

1) Source – to include wells, surface water intakes and springs
2) Treatment – to include treatment plants
3) Storage to include finished water tanks
4) Transmission and Distribution to include appurtenances and
5) Other to include emergency power generators, system security and computer and automation costs.

The five categories of need are used in the Report to Congress to describe the contribution of each of the categories to the total national needs. For example, transmission and distribution needs have represented over half of the total needs in previous surveys.

State Survey Strata	Population		
LARGE	**>100K**		Census – All Systems Receive Questionnaire (2011 MO had 8 large systems-**2015 MO has 7 large systems**)
MEDIUM	**50,001-100K**		MO has **7 systems to survey for the 2015** in this strata (all were surveyed in 2011)
	25,001-50K	**10,001-50K**	25,001-50K: MO has **4 systems to survey in this strata** (1 system was not surveyed in 2011)
	10,001-25K		10,001-25K: MO has **24 systems to survey in this strata** (3 are new and were not surveyed in 2011)
	3,301-10K		3,301-10K: MO has **52 systems to survey in this strata** (11 are new and were not surveyed in 2011)
SMALL	**1001-3,300**		National Small System Sample-not being surveyed this time
	101-1000		
	≤ 100		

Allowable Projects must be:

- Capital improvement needs for 20 years.
- Eligible for SRF funding.
- In furtherance of public health goals of the SDWA

Violation or regulatory requirement is not necessary.

- Reflects the most cost-efficient investment strategies.
- Within the Assessment timeframe 2015 – 2034.

Key Dates for States are as follows and are subject to U.S. Office of Management and Budget approval:

U.S. Office of Management and Budget Review	Fall 2014
Pre-Surveying Training	Fall 2014
Field Surveying Starts	July 2015
1st Third Deadline	August 31, 2015
2nd Third Deadline	November 30, 2015
End of Submissions	February 29, 2016
End of Modifications	February 2016- Don't rely on mods
Analysis and Quality Control	Spring/Summer 2016
Report Writing and Clearance	Fall 2016
Report to Congress	February 2017

The Final Report is due to Congress in February 2017. Allow for six months of data crunching and report draft, three months at EPA Management and three months for U.S. Office of Management and Budget review.

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Interview Notes

USGS

Introduction

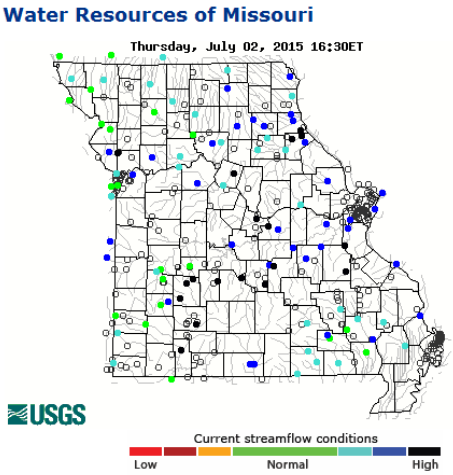
CDM Smith interviewed USGS staff responsible for water quality data.

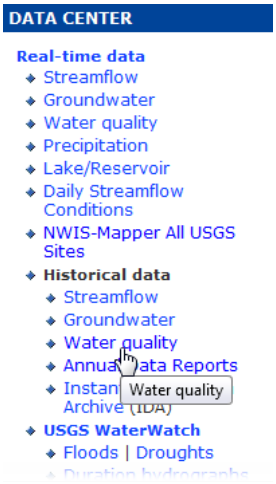
- Miya Barr, USGS Water Quality Specialist, Rolla, Missouri

The following are notes from the one hour interview. The notes follow main topics of discussion not necessarily in order of discussion.

Water Quality Data

Miya began the interview by guiding the team through the website for the USGS Missouri Water Science Center, available at http://mo.water.usgs.gov/. From this website users can access current streamflow conditions, real time data, and historical data.





Queries of historical data can be completed by using the menu bar located on the left side of the screen. As shown in the image to the left, a query is started by selecting "water quality" from the "historical data" category. This will launch a second screen in which the user should select "Field/Lab Samples". This will allow access to the NWIS, which currently includes data from field and/or laboratory analysis from 5,995 sites. http://waterdata.usgs.gov/nwis

Miya explained that there are currently 72 ambient network sites in Missouri that are recording monthly water quality parameters. Data are tab delimited. There is a parameter code dictionary available to query specific contaminants (e.g., temperature is 00010). Steve McIntosh noted that USACE releases are required on the Missouri River when temperatures exceed 70 to 80 degrees Fahrenheit for fish species. This is particularly important downstream of powerplant cooling water discharges. Missouri River gages are located at:

- 06893060 Missouri River at Randolph
- 06818000 Missouri River at St. Joseph
- 06906500 Missouri River at Glascow

- 06910450 Missouri River at Jefferson City
- 06934500 Missouri River at Hermann
- 06935550 Missouri River at Labadie
- 06935965 Missouri River at St. Charles

There are joint gages between USGS and USACE at Table Rock and Lake Taneycomo for dissolved oxygen.

Of great interest is ammonia and whether that is specifically measured by USGS. Of concern is NH3, free ammonia. It was discussed that it may be calculated using temperature and pH. We used an example at Wilson Creek at Springfield on the James River (codes for location are 71845, 71846). The code for nitrate and nitrite is 00625. Was only able to access NH4. So USGS has NH4 and organic nitrogen as well as nitrate and nitrite for computing Total nitrogen. Data can be download in delimited format and put into a spreadsheet to perform the calculation.

For information on groundwater, Miya suggested using the MDNR Groundwater-Level Observation Well Network, available at: http://dnr.mo.gov/env/wrc/groundwater/gwnetwork.htm.

USGS does some local independent monitoring: for instance, remediation monitoring in Independence, MO where they are looking at nutrients, bacteria and macro-invertebrates on the Little Blue River. A similar study has been published on the Blue River in Kansas City.

Reports

For additional water quality data and information for Missouri, Miya suggests the USGS report, *Quality of Surface Water in Missouri, Water Year 2013*. The report is available at http://pubs.usgs.gov/ds/0886/pdf/ds886.pdf. USGS (John Ford) has monitored long-term trends from 1993 – 2008 on six watersheds including the Grand River, Wilson Creek, Elk River and Gasconade River. More on the program can be found at this link. http://mo.water.usgs.gov/fact_sheets/wtrqual/Ambient/FS062-01.pdf

Interview Notes

Water Protection Program

Introduction

CDM Smith interviewed MDNR staff responsible for the Watershed Protection Program.

- John Johnson, 319 Non-Point Source (NPS) Program, Jefferson City, Missouri
- Trish Rielly, Monitoring and Assessment, Jefferson City, Missouri
- John Hoke, Chief of Watershed Protection, Jefferson City, Missouri

The following are notes from the one hour interview. The notes follow main topics of discussion not necessarily in order of discussion.

319 NPS Implementation Program

John Johnson provided a brief overview of 319 NPS Implementation Program which uses grant funding to support monitoring efforts and load reductions. All Section 319 NPS projects must include information, education, prevention, or corrective activities to reduce NPS impacts. The current Missouri Nonpoint Source Management Plan (2015-2019) is available at: http://dnr.mo.gov/env/wpp/nps/mgmtplan/docs/missouri-nonpoint-source-management-plan-042215-final.pdf

A NPS Program funding request has a three-fold purpose to (1) address 303(d) listed streams, (2) create a watershed plan using the EPA 9 Elements and (3) meet water quality standards and TMDLs. Cities, counties, states, schools and colleges, and not-for-profits (501(c)3 like watershed and water conservation districts may apply. The match is 60/40 with in-kind counted as match. Funding is not available to address items of a permit but can be applied for for practices that go above and beyond the permitted actions. Current funding support statewide is $3 million.

Currently, the MDNR NPS program is working in partnership with the SRF program to reduce NPS loading from failing septic systems. In areas where septic systems have been identified as potential sources of pollution, SRF funds are utilized to complete feasibility studies to connect communities and/or individuals to public clean water systems. 604b funds are also being utilized through Regional Planning Systems.

Priority projects include those within the *Our Missouri Waters* pilot watersheds, particularly those in waters identified by EPA approved TMDL reports.

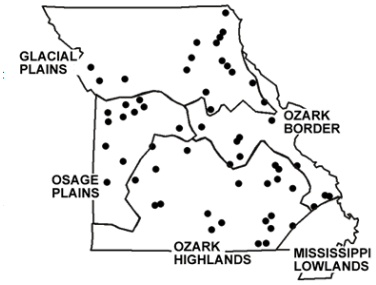
Watershed Protection

John Hoke oversees Missouri's TMDL/303(d) water quality standards program and Trish Rielly oversees the surface water monitoring network. Unless otherwise noted, data is housed in the MDNR Water Quality Assessment System, located here: http://dnr.mo.gov/mocwis_public/wqa/waterbodySearch.do

The 303(d) listed waters are on a two year cycle with EPA.

The watershed protection division works with USGS on an extensive surface water monitoring network which includes:

- 71 ambient water quality stations (approximately 10 plus years of data)
  - Data is collected 4-12 times per year
  - Bacteria, pesticides, nutrients, etc.
  - 2 stations are located on the Missouri River
    - *Collect continuous DO on the Missouri River at Hermann and St. Joseph.*
- Wadeable Stream Monitoring
  - Takes place in priority areas for TMDL monitoring, water quality standards development, and watershed management plan development
- Targeted Monitoring
  - Generally used to adjust WWTP dischargers or to gather information relating to nonpoint concerns
- Lake Monitoring
  - Statewide Lake Assessment Program
    - *Completed in cooperation with the University of Missouri, School of Natural Resources – Limnology (Jack Jones)*
    - *monitors 75 lakes 4 times per year*
    - *Focus is recreation and aquatic life*
    - *Data are provided to DNR annually where it is uploaded into MDNR Water Quality Assessment System,*



Lakes monitored as part of the Statewide Lake Assessment Project in 2004. State physiographic regions are labeled. Northwestern lakes are monitored in a separate project.

  - The Lakes of Missouri Volunteer Program (partnership with MDNR and the University of Missouri) – monitors 66 lakes with sampling approximately 4 to 6 times per year
    - *2014 Summary Report: http://lmvp.org/Data/2014/2014ColorBooklet.pdf*
    - *2014 Public Data: http://lmvp.org/Data/2014/2014PublicData.pdf*
- Missouri Stream Team
  - Volunteer water quality monitoring program is an activity of the Missouri Stream Team program

- *Depending upon the level of training, volunteer data can be used to screen conditions for preliminary standards where follow-up may be necessary to document findings (Introductory to Level 3 training), or used to supplement departmental data collection efforts in priority areas for watershed management planning or TMDL development (trained at Level 2 or higher to collect field samples following department protocols).*
- *There are over 5,000 Stream Teams and more than 3,600 trained water quality monitors.*
- *Additional information about the Volunteer Monitoring Program can be found at this web site: http://dnr.mo.gov/env/wpp/VWQM.htm*

Biological sampling is completed in partnership with Missouri Department of Conservation and includes:

- Fish tissue sampling
  - 20 sites are monitored for constituents such as mercury (primarily), PCBs, DDT, pesticides, herbicides
  - 13 sites are long term trend monitoring sites previously established by the EPA
  - Other waters may be monitored by MDC based on fishing interest. The data is provided to MDNR annually where it is uploaded into MDNR Water Quality Assessment System.
- Macroinvertebrate sampling
  - Approximately 45-50 samples are collected per year from wadeable streams during spring and fall to provide a community profile
  - The majority of this type of monitoring is completed by MDNR's Environmental Services Program. However, MDC as part of the RAM program also conducts macroinvertbrate monitoring during the fall months.
- Fish Community RAM
  - Completed at 100 sites/year (warm water wadeable streams) with Matt Combs of MDC
  - MDC is developing a fish IBI for the 3 major faunal subregions of Missouri (Central Plains, Ozarks, Mississippi Alluvial Basin (Bootheel)

Additional monitoring activities include low flow (visual) surveys completed as a screening level tool at point source dischargers, sediment monitoring (primarily in historical and current mining areas), and bacterial monitoring at all Missouri state park beaches.

With the new expanded clean water rule, the miles of stream to be monitored have gone up from 24,000 miles of streams to 110,000 miles, and lakes increased to 3,100. The expanded rule includes bacteria limits for which a benefit/cost analysis was completed.

Self-reported point source discharge data is currently housed separately within the MoCWIS, although MDNR is currently moving towards a more integrated system. MOCWIS data is available here: http://dnr.mo.gov/mocwis_public/permitSearch.do

Future monitoring may include emerging contaminants such as pharmaceuticals, and monitoring PAHs in sediment in urban areas.

Ammonia

The group discussed current and future ammonia criteria as it relates to watershed protection. In 2005, Missouri instituted the 1999 EPA ammonia standard. Permits with effluent limits were granted with 8 to 13 year timelines to allow compliance with an ammonia end-point. Permit changes based on the 2013 EPA ammonia standard (sensitive mussels, gill breathing snails and fauna) will likely be included in the next rule change package, scheduled for release in the fall of 2016. The new rules will undergo affordability analysis and would be expected be final in 2018. Based on the statewide prevalence of sensitive mussels, these standards will likely be enforced statewide. The new standards will likely require significant upgrades to systems, and funding is likely to be an issue in most cases. (In an interview with the Affordability (CAFCom) staff they noted that the cost of meeting the upcoming ammonia standard is likely not that much more than meeting the 2005 (EPA 1999) standard as facilities come into compliance. The results of the affordability analysis will determine the schedules of compliance, which will range from 3 to 10 years. It is expected that systems upgrades will cause increased nitrogen in discharge, possibly leading to increases in nutrients. Nutrients will be the next rulemaking.

Data

In addition to the monitoring links provided above, information is also available through:

- USGS National Water Information System: http://waterdata.usgs.gov/mo/nwis/
- GIS links:
  - 303(d) Listed Waters: http://dnr.mo.gov/env/wpp/waterquality/303d/index.html
  - Stream and Lake Classification and Use Designations: http://www.dnr.mo.gov/simplemap/construct.do?config=wclsuse
  - Water Quality Assessment: http://www.dnr.mo.gov/simplemap/construct.do?config=wqaviewer

Action Items

- Colleen Meredith should be able to provide a spreadsheet of 319 NPS funded projects (name, amount funded, project type).
- MDNR will provide the University of Missouri Lake Monitoring data link (see addition/comment above).

Appendix B

Example Water Plan Outline

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Volume 1 – Summary Report

Outline Example

Foreword

Executive Summary

1 Introduction
- 1.1 History of Water Planning in Missouri
- 1.2 Missouri Water Plan Vision, Mission, and Goals

2 Key Findings
- 2.1 Demand Projections
- 2.2 Water Availability
- 2.3 Water Quality
- 2.4 Infrastructure
- 2.5 Scenario Planning

3 Issues and Recommendations
- 3.1 Priority Issue No. 1
- 3.2 Priority Issue No. 2
- 3.3 Priority Issue No. 3
- 3.4 Priority Issue No. 4
- 3.5 Etc.

4 General Description of the State
- 4.1 Physical Environment
  - 4.1.1 Landforms and Geology
  - 4.1.2 Climate
  - 4.1.3 Ecology
- 4.2 Hydrologic Environment
  - 4.2.1 Surface Water
  - 4.2.2 Groundwater
- 4.3 Socioeconomic Environment
  - 4.3.1 Demographics
  - 4.3.2 Land Use
- 4.4 Water Resources Management
  - 4.4.1 Legal Framework
  - 4.4.2 Water Agency Authorities and Missions

5 Framework for Water Management
- 5.1 Statewide Overview
  - 5.1.1 Water Demand Forecasts
  - 5.1.2 Surface Water Availability
  - 5.1.3 Groundwater Availability
  - 5.1.4 Water Quality
  - 5.1.5 Infrastructure Gap Analysis
  - 5.1.6 Scenario Planning

5.2 Regional Water Resource Planning Areas
- 5.2.1 Region No. 1 Overview
- 5.2.2 Region No. 2 Overview
- 5.2.3 Region No. 3 Overview
- 5.2.4 Region No. 4 Overview
- 5.2.5 Etc.

6 References

7 Appendices

Appendix A Regional Stakeholder and Technical Work Group Notes
Appendix B Public Meeting Notes

Volume 2 – Demands

Outline Example

1 Introduction and Overview
- 1.1 Sectors of Water Use
- 1.2 Geographic Planning Areas: Countries, Basins, & Regions
- 1.3 Overview of Water Use Data
- 1.4 General Methodology
- 1.5 Planning Scenarios

2 Summary

3 Demographic Projections
- 3.1 Population Projections
- 3.2 Employment Projections

4 Municipal (Public-Supply) Water Use
- 4.1 Data Sources
- 4.2 Methodology
- 4.3 Base Period Water Use
- 4.4 Future Water Use
- 4.5 Alternative Scenarios

5 Self-Supplied Domestic Water Use
- 5.1 Data Sources
- 5.2 Methodology
- 5.3 Base Period Water Use
- 5.4 Future Water Use
- 5.5 Alternative Scenarios

6 Self-Supplied Industrial Water Use
- 6.1 Data Sources
- 6.2 Methodology
- 6.3 Base Period Water Use
- 6.4 Future Water Use
- 6.5 Alternative Scenarios

7 Thermoelectric Power Water Use
- 7.1 Data Sources
- 7.2 Methodology
- 7.3 Base Period Water Use
- 7.4 Future Water Use
- 7.5 Alternative Scenarios

8 Livestock Water Use
- 8.1 Data Sources
- 8.2 Methodology
- 8.3 Base Period Water Use

8.4 Future Water Use
8.5 Alternative Scenarios

9 Crop Irrigation Water Use
9.1 Data Sources
9.2 Methodology
9.3 Base Period Water Use
9.4 Future Water Use
9.5 Alternative Scenarios

10 Conclusion
10.1 Summary of Findings
10.2 Major Data Gaps

11 Recommendations
11.1 Key Water Demand Issues and Concerns
11.2 Recommendations for Future Updates

12 References

13 Appendices
Appendix A Regional Stakeholder and Technical Work Group Notes
Appendix B Public Meeting Notes

Volume 3 – Supply

Outline Example

1 Introduction and Overview
- 1.1 Geographic Planning Areas
- 1.2 Overview of Water Availability Data
- 1.3 General Methodology
- 1.4 Planning Scenarios

2 Summary

3 Natural and Legal Setting of Missouri's Water Supply

4 Groundwater Availability
- 4.1 Data Sources
- 4.2 Methodology
- 4.3 Base Period Groundwater Availability
- 4.4 Future Groundwater Availability
- 4.5 Alternative Scenarios

5 Surface Water Availability
- 5.1 Data Sources
- 5.2 Methodology
- 5.3 Base Period Surface Water Availability
- 5.4 Future Surface Water Availability
- 5.5 Alternative Scenarios

6 U.S. Army Corps of Engineers Projects
- 6.1 USACE Reservoirs in Missouri
- 6.2 Contracting with USACE for Reservoir Storage

7 Regional "At-Risk" Analysis
- 7.1 Overview of Methodology
- 7.2 Groundwater "At-risk" Area Analysis
- 7.3 Surface Water "At-risk" Area Analysis

8 Conclusion
- 8.1 Summary of Findings
- 8.2 Major Data Gaps

9 Recommendations
- 9.1 Key Water Supply Issues and Concerns
- 9.2 Recommendations for Future Updates

10 References

11 Appendices
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- Appendix B Public Meeting Notes

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Volume 4 – Water Quality

Outline Example

1 Introduction and Overview

2 Summary

3 Physiography

4 Surface Water Quality and Aquatic Species
- 4.1 Data Sources
- 4.2 Surface Water Quality Standards
- 4.3 Surface Water Quality Data Assessment
- 4.4 Aquatic Species Data Assessment
- 4.5 Nonconsumptive Needs Toolbox
- 4.6 Surface Water Quality Data Gaps

5 Groundwater Quality
- 5.1 Data Sources
- 5.2 Groundwater Quality Standards
- 5.3 Groundwater Quality Data Assessment
- 5.4 Surface Water-Groundwater Interface
- 5.5 Groundwater Quality Data Gaps

6 Water Quality Trends
- 6.1 Surface Water Quality and Aquatic Species Trends Analysis
- 6.2 Groundwater Quality Trends Analysis

7 Conclusion
- 7.1 Summary of Findings
- 7.2 Major Data Gaps

8 Recommendations
- 8.1 Key Water Quality Issues and Concerns
- 8.2 Recommendations for Future Updates

9 References

10 Appendices
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Volume 5 – Infrastructure

Outline Example

1 Introduction and Overview
- 1.1 Geographic Planning Areas
- 1.2 Overview of Infrastructure Data
- 1.3 General Survey Methodology
- 1.4 Planning Scenarios

2 Summary

3 Infrastructure Survey
- 3.1 Methodology
- 3.2 Summary of Response
- 3.3 Water Supply Infrastructure Survey Results
- 3.4 Wastewater Infrastructure Survey Results

4 Infrastructure Gap
- 4.1 Data Sources
- 4.2 Methodology
- 4.3 Infrastructure Gap Results
- 4.4 Alternative Scenarios

5 Infrastructure Gap Cost Estimate
- 5.1 Data Sources
- 5.2 Methodology
- 5.3 Infrastructure Gap Cost Estimate
- 5.4 Alternative Scenarios

6 Funding the Infrastructure Gap
- 6.1 Financial Strategies
- 6.2 Statewide Versus Regional Benefits

7 Conclusion
- 7.1 Summary of Findings
- 7.2 Major Data Gaps

8 Recommendations
- 8.1 Key Water Supply Infrastructure Gap Issues and Concerns
- 8.2 Key Waste Water Infrastructure Gap Issues and Concerns
- 8.3 Key Infrastructure Funding Issues and Concerns
- 8.4 Recommendations for Future Updates

9 References

10 Appendices
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- Appendix B Public Meeting Notes

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