CDM

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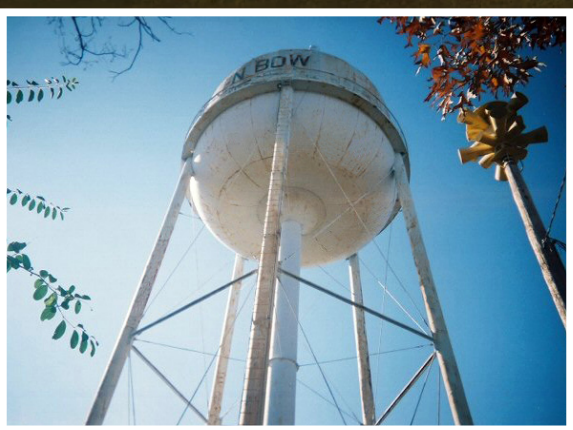
State of Oklahoma
OWRB
WATER RESOURCES BOARD
the water agency

Oklahoma COMPREHENSIVE Water PLAN

Programmatic Work Plan

MAY 2008



Contents

Overview 1

Task 1 – Demand Projections 3

Task 2 – Supply and Gap 9

Task 3 – Develop and Evaluate Supply Alternatives 20

Task 4 – Public/Policy Interaction 26

Task 5 – Implementation 27

Task 6 – Water Plan Documentation 31

Task 7 – Project Coordination and QA/QC 32

Appendices

Appendix A Programmatic Work Plan Task Schedules

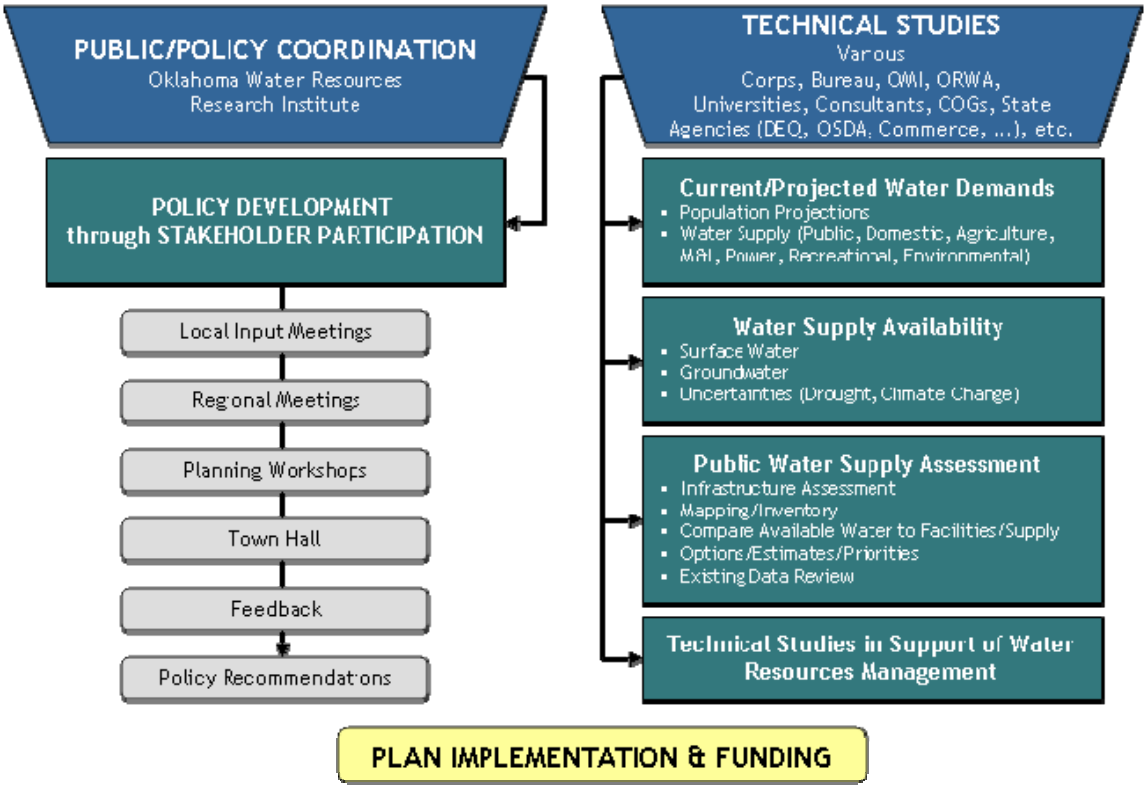
Appendix B Programmatic Work Plan Memoranda

- *Memorandum 1* – Objectives, Goals and Products for the Oklahoma Comprehensive Water Plan (December 2007)
- *Memorandum 2* – Funding Sources for the Oklahoma Comprehensive Water Plan (December 2007)
- Overview of Technical Approach for Water Supply and Demand Projections (October 2007)
- *Technical Memorandum:* Proposed Water Demand Methodologies for the Oklahoma Comprehensive Water Plan (October 2007)
- *Technical Memorandum*: Supply Availability and Gap Analysis (October 2007)

Oklahoma Comprehensive Water Plan
Programmatic Work Plan
May 2008

With strong support from the Oklahoma Legislature and broad interest in water supply planning throughout all parts of Oklahoma, the Oklahoma Water Resources Board (OWRB) has initiated a major update of the Oklahoma Comprehensive Water Plan (Water Plan). Development of the Water Plan is being conducted in two parallel but inter-related paths:

- Public/Policy Coordination
- Technical Studies



The public process was initiated in 2007 with a statewide series of local input meetings. Later in 2008, that process will move into regional meetings and planning workshops to explore the issues raised in the local input meetings.

Programmatic planning has been conducted to provide overall guidance and direction for technical elements of the Water Plan. This Programmatic Work Plan (PWP) was developed through a partnership between OWRB and the U.S. Army Corps of Engineers (USACE). It describes the major elements, timing, and sequencing associated with meeting the OWRB's objectives for the Water Plan.

The estimated timing and phasing of PWP elements are summarized in the table in Appendix A.

A series of memoranda describing the overall goals for the Water Plan and key technical approaches were developed to outline key elements of the PWP. Provided in Appendix B, these include:

- *Memorandum 1* – Objectives, Goals, and Products for the Oklahoma Comprehensive Water Plan (December 2007)
- *Memorandum 2* – Funding Sources for the Oklahoma Comprehensive Water Plan (December 2007)
- Overview of Technical Approach for Water Supply and Demand Projections (October 2007)
- *Technical Memorandum:* Proposed Water Demand Methodologies for the Oklahoma Comprehensive Water Plan (October 2007)
- *Technical Memorandum:* Supply Availability and Gap Analysis (October 2007)

Together with those memoranda, this PWP:

- Defines and documents key goals and objectives for the Water Plan
- Establishes appropriate, sound, and accepted methods for developing technical aspects of the Water Plan
- Defines priorities for the Water Plan process as a "roadmap" for phased development of the Water Plan

The proposed methodologies for demand projections draw on past OWRB analyses, updated data sets, and approaches used successfully in other statewide planning efforts. Projected demands will be evaluated in light of current and future water supplies and water quality to identify areas where water shortages are likely. Those areas will then be investigated in more detail toward identifying water supply solutions that will address Oklahomans' water needs through 2060 and beyond.

The PWP is organized into the following seven major tasks:

- **Task 1** – Demand Projections
- **Task 2** – Supply and Gap
- **Task 3** – Develop and Evaluate Supply Alternatives
- **Task 4** – Public/Policy Interaction
- **Task 5** – Implementation
- **Task 6** – Water Plan Documentation
- **Task 7** – Project Coordination and Quality Assurance/Quality Control (QA/QC)

These tasks and their various subtasks are depicted graphically in the timeline shown in Appendix A.

Work conducted under this PWP will be prioritized based on funding availability. Foundational elements critical to subsequent tasks will be prioritized in terms of both schedule and Water Plan funding, such as the following:

- **Task 1** – Demand Projections
- **Task 2A** – Statewide Physical Availability Screening
- **Task 2B** – Infrastructure/Legal Availability Screening

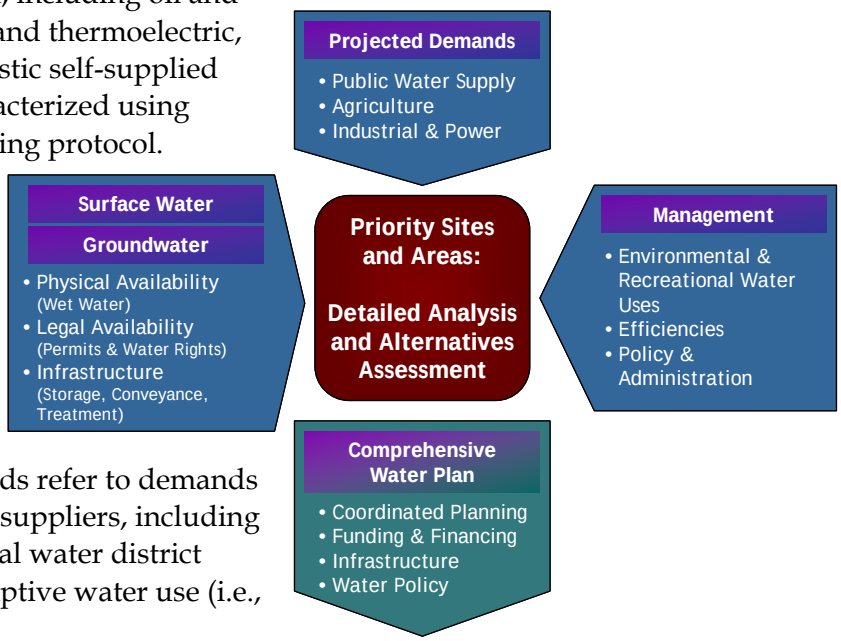
An analysis of water supply alternatives will be conducted at the regional and water provider level. If major additional funding is secured, such as appropriations under the $6.5 million 2007 Water Resources Development Act authority, more detailed alternatives will be analyzed at the water provider level. A description of the methods used to prioritize the alternatives analyses is described under Task 3 of the PWP.

This PWP should be updated approximately annually through completion of the Water Plan to reflect 1) actual funding levels, 2) current information from the public participation team, and 3) data needs and implementation priorities.

A description of the activities to be conducted under each of the PWP tasks is provided below.

Task 1 – Demand Projections

The purpose of this task is to develop statewide water demand projections for all major types of water use through 2060. Consumptive water demands will be developed for the major water use sectors: municipal and industrial (M&I), self supplied industrial (SSI, including oil and gas production needs) and thermoelectric, and agricultural. Domestic self-supplied water uses will be characterized using existing OWRB permitting protocol. Projections will be developed at the county level for all sectors and estimated at the water provider level for M&I demands. Throughout this document, M&I demands refer to demands served by public water suppliers, including both municipal and rural water district suppliers. Non-consumptive water use (i.e.,



environmental and recreational flows and lake levels) will also be investigated as part of this task.

Task 1A – Consumptive Demand Projections

1A.1 Kickoff and Data Collection and Analysis

The purpose of this subtask is to compile the necessary information for demand projections by sector, at the county level, and at the individual water service provider level.

Data will be collected from different relevant sources including previous projections developed by OWRB, USACE, and U.S. Bureau of Reclamation (USBOR). Data will also be gathered from other OWRB documents, demographic and economic projections by the 11 Councils of Government (COGs) in the state, and projections and statistics from the Oklahoma Department of Environmental Quality (ODEQ), Department of Commerce, Department of Agriculture, and other relevant state and federal agencies. These may include the U.S. Geological Survey (USGS), Department of Energy Information Administration, the U.S. Census of Agriculture, the USBOR, the 2002 USACE survey of water providers, and the ODEQ/U.S. Environmental Protection Agency (EPA) Safe Drinking Water Information System. A detailed data and information log will be developed and kept up-to-date through the completion of the demand projections task.

1A.2 Model Development and Demand Forecast

This subtask consists of two main elements—the development of the tool with which to project demands and the actual demand projections. Moreover, this subtask includes demand projections at the county level and M&I estimates at the water provider level. The objectives of this task are to:

- Develop county-level demand projections for each demand sector (M&I, SSI, thermoelectric, and agricultural)
- Develop a method to project M&I demands at a provider level
- Develop M&I demand projections at the provider level

The demand projections at the county level will be based on previous projections developed by OWRB, with any necessary adjustments based on new available data for each sector, particularly the agricultural sector.

For M&I projections, the local water provider-level estimates will be based on the county level demands and geographic information system (GIS) estimates of the proportion of each county supplied by different providers. The model will allocate the county level demands to providers in the subject county. The model will also estimate and keep track of unallocated demands and demographics (that is, demand and demographics existing in the county but not clearly served by any specific provider).

The projections will be based on the current allocation determined by the model but adjusted as necessary to account for specific planned system expansions in each county. The model will integrate information collected as part of the water provider survey described under Task 2.

Demands for SSI and thermoelectric power will be allocated to specific geographic locations within each county based on information from OWRB and the Department of Energy Information Administration. Projections for the large self-supplied demands will be kept constant at current levels unless there is specific information indicating that additional capacity or facilities will be brought online in the future. Water use associated with oil and gas production will be characterized as part of the SSI demand projections.

Agricultural demands will be projected on a county level as irrigation and livestock water use. The projections developed previously by OWRB will be used as the basis for these projections, with data updated as appropriate and required.

Both the consumptive and non-consumptive components of these sectors' use will be estimated. Non-consumptive water use by sector (M&I, SSI, and agricultural) will be estimated from the county level forecasts. Hydropower and navigational water needs will be characterized based on available information, to reflect the non-consumptive use and water needs associated with those industries. The estimates of non-consumptive use will be incorporated as return flows in the analysis of the supply/ gap in future years, and accounted for in terms of gaged stream flow.

1A.3 Interim Review

The purpose of this subtask is to perform a detailed review of the demand projections at both the county level and provider level, before additional subtasks related to water supply constraints, conservation, climate change, and provider-specific validations are initiated.

The interim review will be a two-step process. First, consultants and OWRB in a technical review committee will review the projections. This same group of reviewers will be involved in the review of the specific methods and model as part of Subtask 1A.2, and in this subtask will review the actual projections. The second step of review will be an external review with selected external reviewers.

1A.4 Provider-Level Validation

The purpose of this subtask is to review provider-level demand projections developed by specific water providers individually as part of their individual planning efforts to determine the validity and define which provider-level projections should be incorporated into the plan. Also, demand projections developed at the provider level using the allocation method described above will be "spot-checked" through direct follow-up with selected providers.

Demand projections will be reviewed in terms of methods, data and its quality, and assumptions. Many providers may have demand projections, particularly M&I projections, based on detailed planning studies developed with relevant and quality data and using valid methods and assumptions. Those projections will then be incorporated in the Water Plan demand projections (as part of Subtask 1A.7). In some cases, however, the provider-level projections may have been developed with data and or methods less reliable than the data and methods used as part of Task 1A.2. In those cases, the provider-level demands developed as part of the Water Plan will be used instead of the individually developed projections. Those evaluations and decisions will be documented.

1A.5 Assessment of Conservation

The purpose of this subtask is to assess realistic levels of potential additional conservation for each sector (with an emphasis on M&I) for the demands developed under Subtask 1A.2.

Conservation will be assessed by sector. In the case of M&I, current conservation estimates will be assessed and the level to which current conservation should be reflected in the future will be determined. Agricultural conservation opportunities will be characterized using data and costs from existing example projects and practices currently in place, and/or practices that may be anticipated to become more commonplace for agricultural water use in Oklahoma and areas with similar climates and cropping.

Planned and potential additional conservation levels will also be assessed and the resulting demand offsets will be used to refine the base demands as part of Subtask 1A.7 or to show a range of potential future demands.

1A.6 Assessment of Climate Change Impacts

The purpose of this subtask is to estimate potential changes in water demands as a result of climate change. This task will only focus on demand-side impacts. Supply-side impacts will be evaluated under Task 2.

A review of available information relevant to Oklahoma will be performed as an initial step. This information may exist from previous studies specifically. In addition to previous studies specific to Oklahoma, a review of Global Climate Models (GCM) with data relevant to the state will be performed to extract precipitation and air temperature data. A simple method to downscale GCM data on precipitation and temperature will be developed and applied and response functions will be developed to estimate the expected distribution of precipitation and temperature. These weather estimates will be translated into functions to estimate potential seasonal and annual agricultural demand increases (or decreases) and M&I increases (or decreases). The analysis will be developed probabilistically.

Results from this analysis will be used as part of the demand and supply comparisons to be performed in subsequent tasks.

1A.7 Refinements to Demand Projections

The purpose of this subtask is to incorporate any adjustments to the demand projections developed under Subtask 1A.2, based on the results of the interim review, provider-level validation, and conservation assessment (Subtasks 1A.3, 1A.4, and 1A.5).

Demand projections developed in Subtask 1A.2 will be modified at both the provider-level and county-level to incorporate any findings on conservation estimates, and the specific projections of providers that may have demand projections already developed as part of individual planning efforts.

Projections for water providers that have individually developed projections as part of their own planning efforts, validated as part of Subtask 1A.4, will be replaced and the county-level demands will be reviewed to assess the necessary modifications at that level.

Conservation scenarios assessed as part of Subtask 1A.5 may also require adjustments to the base demand projections developed as part of Subtask 1A.2. These adjustments will be made to the county-level projections by sector and, using the provider-level model, the provider-level demand projections will then be refined.

1A.8 Demand Projections Report

The demand projections subtask will be described and documented in a report that will include data sources and relevant information about the data, a description of the approach for county-level and provider-level projections, descriptions of the conservation and climate change analyses, resulting demand projections for the Water Plan, and considerations and limitations regarding the demand projections.

Task 1B – Non-Consumptive Water Use

Previous Oklahoma Comprehensive Water Plans have raised the issue of and made recommendations for evaluating non-consumptive uses including instream flows. Even though statewide supply and demand analyses will be done on the basis of current law, it seems prudent to explore emerging issues and past recommendations in this comprehensive update of the Water Plan. To that end, tasks under 1B will help evaluate existing programs within current law, what other states are doing and begin to perform technical work to more fully understand the impacts of any changes in water rights administration that may occur if such non-consumptive uses are considered: "what if" scenarios. The purpose is not to propose changes to the current law, but rather to inform discussions that may arise regarding these issues so as to ensure a fair, balanced and reasonable treatment of the subject.

1B.1 Develop Policy Framework and Goals

The purpose of this subtask is to establish the basis for the analysis and definition of instream flows (ISF) and recreational lake levels by agreeing on goals and the nature of the policy recommendations that may result from this analysis. Through an upfront consideration of the range of potential policy or administrative changes regarding the management of non-consumptive flows, the analysis and development of ISF goals, methods, and related work can be better focused on achieving useful and implementable results.

To help define the range of possible options, ISF and lake level programs from surrounding states will be examined and characterized. A workshop with OWRB staff and other invited parties will be held to define the goals to accomplish by this effort and to discuss and establish a policy framework for the analysis and its outcome. The results of this workshop will be presented to the Board.

A meeting with Oklahoma ISF stakeholders will be held to initialize the effort and present the overall process and policy framework options.

1B.2 Characterize Existing Programs

The purpose of this subtask is to clearly define existing programs and policy with regard to ISF and lake level management in Oklahoma by identifying and describing those programs.

Existing provisions for determining and supplying environmental flow needs, including current policies and practices, will be identified and analyzed for Oklahoma. The programs will be characterized in terms of methods for prioritizing water bodies and ecological attributes, quantifying ISF and lake level targets, and methods and protocol for implementation of those targets.

1B.3 Prioritize and Map Streams/Species for ISF Analyses

The purpose of this subtask is to establish a list of streams, lakes, and species that will be the focus of the first phases of the ISF analysis.

Working with OWRB, Oklahoma Department of Wildlife Conservation (ODWC), ODEQ, and other ISF stakeholders, a list of criteria to prioritize species and/or streams will be developed. A number of streams throughout the state will be generally characterized according to the criteria and ranked. A workshop will be held to define the list of streams for which the flow goals will be initially developed based on the ranking and other considerations.

1B.4 Review and Select Methodology for ISF Goals

The purpose of this subtask is to define the methodology to be used to establish ISF and recreational lake level goals for the prioritized streams.

The methodology proposed by ISF stakeholders will be reviewed along with the most common and accepted methods for ISF/lake level analysis used in other relevant states, including methods relying solely on hydrometric data for establishing minimum flow requirements. A simple summary matrix will be prepared and a meeting will be held to discuss the merits and drawbacks of using the different methods, specifically for Oklahoma and specifically for each of the streams prioritized for analysis.

Based on the specific nature of the streams (and/or species of interest) and the goals established in Subtask 1B.1, a methodology will be selected for use as the basis for Water Plan ISF analyses. This method may be refined or revisited after demonstrating its use on one or more priority stream segments.

1B.5 Develop Flow Goals for Initial Prioritized Areas

The purpose of this subtask is to establish flow goals and/or recreational lake levels for the streams prioritized for the initial phase. The methods selected in Subtask 1B.4 will be applied to the prioritized streams to establish flow targets. Depending on the methodology(ies) selected, these flow targets may incorporate a number of flow metrics defining a target hydrograph. The ISF goals will be presented to the OWRB in the context of the benefits they provide with respect to the criteria and goals established previously.

1B.6. Additional ISF Technical Analyses

At the discretion of OWRB and its funding partners, Water Plan funds may be used to support additional technical analyses or research identified as being critical to the development of ISF technical and/or policy issues. This may include, among other topics, further investigation of the interrelationships between ISF/recreational lake levels and other water uses such as hydropower and navigation. It may also include further analysis of the potential implications of any changes in ISF/recreational lake level protocol in Oklahoma, as well as the statutory, OWRB regulatory, and OWRB administrative changes that might be necessary to support implementation.

Task 2 – Supply and Gap

The primary objectives of Task 2 are to characterize statewide water supply availability through the 2060 planning horizon, compare these supply projections with demand projections developed under Task 1, and quantify anticipated gaps in supply.

Water supply gaps are defined as the difference between projected supplies and demands, when demands are the greater of the two. Supply availability analyses performed under this task will focus on three key components: physical availability, legal availability, and infrastructure constraints. The first subtask (2A) will focus on characterizing physical water availability ("wet water"). A second subtask (2B) will focus on characterizing the legal availability of water and infrastructure constraints,

along with water quality issues. A third subtask (2C) will focus on applying the results of the previous subtasks to screen for areas of water surplus or deficit, or "hot spots," across the state. A final subtask (2D) will refine the screening-level estimates of supply, demand, and gaps using more sophisticated water allocation models. These models will, among other things, more accurately characterize competition for supply, seasonality of supply and demand, reservoir yields, and similar aspects. The models will also allow a technical examination of possible future changes in water supplies and administration, such as conjunctive management of surface and groundwater, climate change implications, instream flow provisions, lake level management, and other societal and physical variables.

For all tasks described below, efforts will be made to recognize, minimize, and capture inherent uncertainties in calculations. Limitations associated with applied methodologies will be described in summary text. Analyses will depend on actual measured data, rather than conjecture or process-based numerical modeling. Finally, as appropriate, ranges of data and scenarios will be used to reflect uncertainty in predictions.

2A – Statewide Physical Availability Characterization

A first step in characterizing supply availability and gaps will be a statewide assessment of physical water availability. The objective of this analysis is to provide regional summaries of projected physical supplies, as compared to projected demands, at locations across the state in order to identify locations of potential surplus and shortfall (gap). Supplies, demands, and gaps for this task will be summarized on an annual basis. Graphical summaries of physical availability will also be generated as part of this subtask. Task 2A will focus on physical water availability ("wet water") only.

2A.1 Kickoff and Review of Previous Studies

The purpose of this subtask is to compile the necessary background information to guide subsequent steps in characterizing physical water availability at a subbasin level.

A meeting will be held with OWRB staff to review objectives of this task, proposed methodologies, previous studies, available data sources, and schedule for completion of Task 2A. A review of previous studies on state surface and groundwater hydrology, supply and gap projections, water quality, and reservoir yields will be conducted. The general availability and sources of data needed for this subtask, such as USGS and OWRB flow data, will be assessed.

2A.2 Gather Data: USGS Gaged Streamflows

The purpose of this subtask is to gather surface water flow data to support physical availability characterizations across the state. Each USGS gage in the state will be mapped with station name, number, and period of record. Historical mean daily

flows at each site will be downloaded from the internet or directly from USGS sources and entered into a database.

These historical flow data will be included in the GIS application deliverable described in Task 2C.

2A.3 Gather Data, Review Past Studies, and Project Yields: Groundwater

The purpose of this subtask is to characterize groundwater hydrology across the state and project future yields. Groundwater yields will be estimated using two methods. The first will involve projecting current trends of estimated usage into the future in proportion to projected population growth. The second will assume aquifer water levels are maintained at current levels (no additional "mining") so that the amount of allowable groundwater usage will equal previously published recharge rates for the given aquifer. For the latter method, annual recharge rates will be multiplied by the areas of the delineated subbasins to arrive at a volumetric rate. Current groundwater supply to the given basin will be compared to these recharge rates to arrive at a projected aquifer yield potential. Additionally, Maximum Annual Yields (MAY), where previously determined, will be noted as a cap on productivity from a given aquifer.

2A.4 Graphically Summarize Surface Water Physical Availability

The purpose of this subtask is to provide informative graphical summaries of surface water physical availability at selected locations across the state. Locations will be selected in coordination with OWRB to provide adequate spatial coverage across the state and to adequately capture gradients of supply availability. Data summaries will include time-series plots of surface water flows, both monthly and annual, to illustrate inter-annual and seasonal physical water availability fluctuations and "firm yield" plots to demonstrate the importance of storage in capturing and utilizing these fluctuating flows. Firm yield plots will show annual firm yield estimates as a function of storage capacity. These will be generated using the available timeseries of physical flows in conjunction with a simple reservoir routing and water usage model. Potential effects of climate changes, ISF, and lake levels may be taken into account in this analysis.

2A.5 Review and Summarize Compact Obligations and Interbasin Projects

The purpose of this subtask is to review and summarize interstate compact obligations and planned interbasin project yields. Note that interbasin projects may include water exports and imports on both a large river basin scale and on a smaller watershed scale. These will be reviewed and summarized for incorporation into the gap analyses described below. Obligations (demands) and supply yields will be summarized both annually and seasonally, if appropriate. Points of diversion, yield, and compliance associated with these quantities will be mapped in GIS. Interbasin projects included in the analysis will be limited to those that are already in operation, those moving through the permitting and implementation process, or those that can be reasonably expected to be implemented within the foreseeable future. Information

for this subtask will be obtained from state resources and from the water provider survey described below (Task 2B).

2A.6 Analyze Existing Public Water Supply Reservoirs for Firm Yields: Physical Availability

The purpose of this subtask is to assess the capacity for water supply yield from existing public water supply reservoirs through a series of independent analyses. Firm yields for major M&I water supply reservoirs across the state will be estimated. Firm yield is defined, for these purposes, as the minimum annual demand able to be met given a range of physical water availability, available storage, and seasonal demand patterns. These calculations will be based on a desktop evaluation of estimated physical flows at the points of diversion. Flows will be obtained from USGS gages or estimated by other means (e.g., surrogate gages, simple rainfall/runoff relationships). Only recent flow data, e.g., the past 10 years, will be used to best reflect current upstream subbasin diversions and return flows. However, if an appropriate design drought of record for these analyses is not included in recent data, then a synthetic period of flows will be created using recent data and the design drought. A collaborative approach will be used to establish the design drought. Reservoir physical characteristics, including existing bathymetry data (if any), will be obtained from individual reservoir owners and operators. In some cases best estimates will be used. In all cases, attempts will be made to reflect *current* reservoir physical conditions and capacities, which may include the results of historical sedimentation.

Numerical modeling tools, such as CDM's Water Supply Investigation Tool (WatSIT), will be used to calculate firm yields for each reservoir as a function of daily physical flows, reservoir physical characteristics, operational constraints or goals, local evaporation rates, and seasonal demands. Operational goals will include hydropower and navigational needs where relevant, and an assessment of the implications of potential recreational or fish and wildlife management targets where appropriate. Neither existing water rights (diversion or storage) for the targeted reservoir nor downstream priority water demands will be considered in these analyses. In other words, the firm yields will be based on physically available, but not necessarily legally available, flows. Firm yield estimated will be compared to previous state and water provider estimates of firm yield for each reservoir.

2A.7 Analyze Sedimentation Rates and Long-term Storage Capacity Loss for Existing Public Water Supply

The purpose of this subtask is to assess sedimentation rates and associated storage capacity loss of major existing public water supply reservoirs. Sedimentation rates will be quantified for major existing public water supply reservoirs across the state using available data or assumed sedimentation rates. Sedimentation rates will be obtained from literature, federal databases (e.g., USBOR, USACE), published analytical equations, and site-specific knowledge, as available. A range of potential storage capacity losses will be calculated using simplified spreadsheet modeling for a

50-year planning horizon. Existing data sources and existing generally-accepted models will be used to support these analyses.

2A.8 Analyze Major Federal Reservoirs for Permit Allocation Usage

The purpose of this subtask is to identify short- and long-term opportunities for additional water allocation to existing major federal reservoirs and/or opportunities to reallocate reservoir water to meet future water supply demands. The 34 major federal reservoirs in Oklahoma will be evaluated with respect to their current storage contract obligations, the current water rights and usage of individual users, and the ability to meet projected future user demands with reservoir water. This work will be screening-level only and will serve to provide guidance for future, more comprehensive, studies of federal reservoir reallocation options.

2B – Statewide Infrastructure and Legal Availability Characterization

A second step in characterizing supply availability and gaps will be a statewide assessment of water supply infrastructure capacities and constraints and water rights. Water quality considerations, with respect to constraints on supply, will also be included in this task. The objective of this analysis is to provide summaries, at the water provider level, of infrastructure and legal capacities and constraints as compared to projected demands. This characterization will be performed on an annual basis and will be largely dependent on a formal survey of the state's public water providers.

2B.1 Develop and Distribute Public Water Provider Survey

A survey will be developed for distribution to public water providers. The first objective of this survey will be to provide information on existing and planned infrastructure capacities and constraints across the state with respect to water supply. The second objective will be to gather information on diversion and storage water contracts/rights at the public water provider level. A final objective will be to provide a vehicle for direct input from the water providers to the Water Plan, specifically in the area of yield and gap projections.

The survey will include questions on existing and planned raw water and treatment infrastructure. This may include diversion capacities, major pipeline capacities, storage capacities and projected reservoir yields, water treatment capacities, and recognized water quality constraints. The survey will also give water providers an opportunity to describe planned future water supply projects, assess their own ability to meet future demands, and voice general concerns or comments with respect to state water planning. The survey will be distributed, in hard copy and/or electronic form, to all major water providers. The list of major water providers will be developed in collaboration with OWRB and other partner agencies.

2B.2 Gather Water Quality Data and Analyze Previous Work

The purpose of this subtask is to identify areas of water quality impairment that may restrict water supply development. As part of its Beneficial Use Monitoring Program (BUMP), the state has summarized water quality data for all delineated water bodies across the state and assigned beneficial use attainment designations for each based on available data (OWRB 2005). Historical water quality data used for this study were collected as part of state and federal sampling programs, including the Oklahoma Conservation Commission's Rotating Basin Monitoring Program and several water quality projects of the Oklahoma Corporation Commission.

Additionally, state environmental agencies, working with ODEQ, have described the overall state of the state's waters, and have included the Federal 303(d) List of Impaired Waters, in Oklahoma's Integrated Report. This semi-annual report submitted to EPA lists both waterbodies that have been evaluated as attaining their beneficial uses and waterbodies that, due to pollution, cannot be used for their assigned beneficial uses. ODEQ has prepared GIS map layers showing most of these waterbodies. Over 600,000 acres of lakes and over 10,000 miles of rivers and streams are listed as impaired in the 2008 Integrated Report. In addition, there are areas of the state with significant groundwater water quality problems. The Corporation Commission has a database of groundwater sampling results and other data.

The work described above will be reviewed for impairment status and trends, and results will be incorporated into the Water Plan. Waters identified as "not attaining" the designated beneficial uses of "Public/Private Water Supply" and/or "Sensitive Water Supply" will receive special consideration in the screening process described in Task 2C. In this subtask, these water bodies will be identified and mapped in GIS.

Additionally, an assessment of the BUMP study will be performed with respect to new data. New data will be incorporated into the analysis following the protocol outlined in the "Assessment Methodology" section of the *State of Oklahoma 2002 Water Quality Assessment Report*. Sources of new water quality data and information may include updated federal and state databases and the water provider survey described above.

Water quality data and beneficial use attainment designations will be included in the GIS application deliverable described in Task 2C.

2B.3 Follow Up with Providers

The purpose of this subtask is to elicit additional information from individual water providers, particularly those that did not respond to the original survey or did not provide complete responses. Gaining valuable input from public water providers is critical to the success and acceptance of this Water Plan. Therefore, direct follow up, via e-mail or phone, will be sought with providers who have not responded to the survey by the predetermined deadline. In-person follow-up visits may also be utilized. These providers will be encouraged to respond to the survey with additional

clarification on the value of the survey results to the Water Plan and further description of how the results will be used. This subtask will also be used to gain clarification on information provided in survey responses, as needed.

2B.4 Synthesize and Summarize Survey Results

The purpose of this subtask is to synthesize and summarize the results of the public water provider survey in a technical memorandum. Statistical, graphical, and tabular summaries of the responses will be included.

2B.5 Develop and Distribute Preliminary Results and Follow-up Survey

The purpose of this subtask is to provide initial results to individual water providers and gain their feedback. An abbreviated summary of the technical memorandum described above will be distributed to major water providers. Included with this summary will be a second survey, the objective of which will be to validate the findings of the first survey and seek additional detail or clarification on provider-level demands and supply constraints to support subsequent Water Plan analyses.

2C – Statewide Screening: GIS Tool Development and Application

As a third major subtask, a GIS mapping and data summary tool will be developed to provide valuable spatial summaries of supply gap or surplus projections at targeted locations. The tool will be populated with the physical, legal, and infrastructure data compiled in Tasks 2A and 2B and with demand projections generated as part of Task 1. This tool will be easily updated (e.g., with new population projections or transbasin supply projects) and may prove useful for future statewide planning efforts. This tool will be directly employed in the identification and prioritization of anticipated water supply "hot spot" subbasins for water allocation modeling under Task 2D.

2C.1 Develop and Populate GIS Tool

The purpose of this subtask is to develop a useable tool to provide quick, graphical, and informative summaries of the water supply availability characterizations described in Tasks 2A and 2B. The developed GIS application will also include projected demands (estimated under Task 1) for the appropriate subbasins and water provider service regions. The application will provide a map of the state from which users can select targeted water providers, stream "nodes," or subbasins to access straightforward summaries of projected available supplies versus demand. In this way, the application will provide for quick screening for areas of water surplus or deficit (gaps) across the state.

Water demands for this application will be based on aggregated or disaggregated projections at both the hydrologic subbasin and water provider level. Details of this methodology are provided in the description of Task 1.

The first set of supply availability calculation summaries to be included in the GIS application will target physical water availability ("wet water") and will be aggregated by hydrologic subbasin. Both surface and groundwater will be included in these estimates. Hydrologic subbasins will be delineated according to existing USGS flow gages. Each flow gage with at least 10 years of recent data will be used to define subbasins for the analysis, with supply and demand summaries provided for each associated subbasin. Groundwater estimates will draw upon the results of the analyses conducted in Task 2A.3.

The surface water physical supply availability associated with each subbasin will simply be based on the recent (e.g., last 10 years) historical gage record at the downstream end of the subbasin. Only recent flow data will be used in order to best reflect current surface water allocations and depletions. Annual totals will be provided for wet (maximum of the 10-year period), dry (minimum), and normal (median) conditions. These conditions will be compared to longer-term data to characterize these recent flows as compared to the full period of record. Estimated groundwater yields from Subtask 2A.3 will also be included in the supply availability summaries provided for each subbasin. Projections of future yield from the two methods employed, as described under this subtask, will be included in the GIS application database. Identified transbasin supply projects (existing or reasonably anticipated), and interstate compact obligations will also be included in this application. Final summaries for a selected target year will provide a comparison of projected new demand versus physical water supplies available to meet those demands.

The "wet water" projections described above will be annualized and therefore will not reflect seasonal variations in available surface supply versus demands. Adequate storage may be needed to fully meet demands throughout a given year. To address this limitation and to provide information on capacity and water rights constraints to supply, the results of the water provider surveys (described under Task 2B) will be incorporated into the GIS application. Summaries of existing water rights and infrastructure capacities, including reservoir firm yields for each responding water provider, will be available to the user and displayed alongside projected demands for the given water provider. Additionally, a qualitative consideration of surface and groundwater quality will be included in these summaries. Areas of known water quality with a potential to significantly constrain available supplies or drive treatment costs up, such as the non-attainment water bodies described in Subtask 2B.2, will be identified in the summaries.

Consideration will also be given to the implications of OWRB's ongoing Stream Water Permit Cancellation/Reduction program on legal and physical availability of supplies.

The information described above will be incorporated as layers in the developed GIS tool and will be available to the user in concise tables for a selected location and target year. The developed GIS tool will be provided to OWRB.

2C.2 Apply GIS Tool for Quantification of Gaps and to Identify Supply "Hot Spots"

The purpose of this subtask is to identify subbasins or sites across the state with a high likelihood for future water supply gaps. Prioritized sites throughout the state will be identified using the GIS tool described above. It is anticipated that the tool will provide visual indicators on its base map of locations of projected gaps for the selected target year. Separate indicators will be provided for physical supply shortfalls versus legal and/or infrastructure driven shortfalls versus water quality and/or useability driven shortfalls. Areas of significant surplus will also be identified based on the summaries described above and may feature in the next phases as potential sources of transbasin supply water. In this way, the GIS application will provide a valuable "birds eye" spatial view of the state's water supply projections for any selected target year. Prioritized sites, either subbasins or specific demand areas, will be the focus of subsequent phases of this study, as described below.

2D – Water Allocation Modeling

As a final major subtask, water allocation modeling tools will be developed and applied to provide more sophisticated and accurate estimates of supply availability and gaps. Models will be developed to simulate the allocation, delivery, storage, consumption, and return flow of surface and groundwater at a local and/or regional level. Models will be developed for prioritized sites, or "hot spots," identified in previous tasks. Other areas considered of high importance for reasons unrelated to previous analyses may also be included in this subtask. One or more "pilot" water allocation modeling studies will be performed to gain early feedback and refine the process prior to applying the methods across the state.

2D.1 Select Modeling Tool(s)

The purpose of this subtask is to select the best available numerical modeling tool(s) for performing the studies described below. In collaboration with OWRB and other partner agencies, the most appropriate tool will be selected based on its ability to simulate all of the dynamics and physical features of a targeted system required to achieve the objectives of this subtask. The tool must be useable for a broad range of potential users with relatively transparent calculation algorithms. Finally, the expected costs and time requirements associated with development and application of the selected tool(s) must be in line with Water Plan schedule and budget constraints and priorities.

2D.2 Develop Groundwater – Stream Depletion Model Add-on

The purpose of this subtask is to develop a new model module to adequately capture the groundwater/surface water interactions germane to Oklahoma. Stream depletions

and aquifer drawdown due to groundwater pumping will be the focus of this module. Analytical solutions to fundamental hydrologic equations, such as the Glover equation for stream depletions and the Theis equation for aquifer drawdown, will likely be used. This module will be developed and integrated into the selected water allocation model(s).

2D.3 Construct and Calibrate Model(s) for Pilot Study

The purpose of this subtask is to populate a water allocation model with site-specific data for each of the pilot locations and to perform calibration exercises. One or more water allocation model(s) for selected locations will be constructed and calibrated as a pilot study of the overall approach. Models will be developed on a monthly timestep and will include infrastructure constraints, water right priorities, and seasonal variation in supply and demands. The spatial scale of each developed model will be guided by the results of the Phase 1 analysis. In some cases, models will be developed to include a single major water provider or rural subbasin only. In other cases, the spatial domain may be extended to include multiple providers to explicitly capture interdependencies among providers and/or rural users.

Rainfall-runoff calculations may be needed to support the water allocation modeling in areas where surface water data are limited. However, it is anticipated that preference for subbasin selection for this pilot study will be given to areas with adequate historical USGS flow data. Groundwater/surface water interactions will be explicitly incorporated into the model using the add-on module described above. Along with flow data, key input data for these models include projected monthly demands; physical infrastructure characteristics, such as storage and diversion capacities; aquifer and wellfield characteristics; operational practices; and water rights.

Model calibration will involve adjustment of key parameters within a reasonable range of uncertainty to better match measured data. For example, percent return flows might be modified from their original estimates to better match measured downstream flows for a historical calibration period. Alternatively, ditch losses might be adjusted to better account for discrepancies between diversion records and known irrigation water requirements. Calibration targets will be set commensurate with a planning-level degree of accuracy.

2D.4 Apply Model(s) for Pilot Study: Gap Analysis, Reservoir Firm Yields, ISF

The purpose of this subtask is to refine previous estimates of water availability and supply gaps for the selected pilot locations. The model(s) developed under Task 2D.4 will be applied to simulate the targeted systems under a range of hydrologic conditions at specified projected demand conditions. Anticipated key timeseries output for each targeted demand scenario include water supply yields, shortfalls, reservoir levels, aquifer levels, and downstream flows. This will allow for an assessment of water supply firm yields and identification of gaps to be addressed in

Task 3. Additionally, modeling results will be used to assess the impacts of future demands on ISFs with comparisons to flow goals established under Task 1B.

2D.5 Refine Methods, Approach, and Tools Based on Pilot Study

In collaboration with OWRB, both the approach and modeling tools described here will be refined based on the results of the pilot study. Feedback on the pilot study will also be sought from water providers and other stakeholders.

2D.6 Construct and Calibrate Models for Remaining Identified "Hot Spots"

Water allocation models will be constructed and calibrated for additional "hot spots" identified under Subtask 2C.2. The process will follow that described for Subtask 2D.4 (above) plus any refinements developed under Subtask 2D.6. In some cases multiple "hot spots" may be captured in a single model domain. In other cases separate models will need to be developed.

2D.7 Apply Model(s) for Remaining Identified "Hot Spots": Gap Analysis and Reservoir Firm Yields

Following the process outlined under Subtask 2D.4, the developed water allocation models will be applied to analyze for water supply yields and gaps at remaining identified "hot spots." As described above, the models will be used to generate system response to a range of hydrologic conditions under a given demand scenario (target year). Key system response output will include monthly yields, shortfalls, reservoir levels, aquifer storage, and downstream flows.

2D.8 Investigate Climate Change and ISF: "What If" Scenarios

The purpose of this subtask is to use constructed water allocation models to perform "what if" scenario analyses involving perturbations of hydrologic conditions due to climate change and potential operational policies associated with ISF, recreational lake level, and/or navigation flow goals.

Selected water allocation models developed under Subtask 2D.6 will be used to investigate the potential impacts of climate change on water supply availability and gap projections. This work will involve regionalizing (or "downscaling") of GCM predictions of temperature and precipitation changes to be relevant to Oklahoma. These predictions are publicly available and simple downscaling techniques are well-published. The uncertainties in these predictions will need to be captured with the result likely being a range of predictions. These temperature and precipitation data will then be translated into hydrologic parameters such as stream flow and evaporation rates that can be directly used in the water allocation models. Simple rainfall-runoff modeling and empirical evaporation equations will be employed to achieve this. The resulting data set will then be used as input to the selected water allocation models to quantify sensitivities of key model output to these projections, under a reasonable range of uncertainty.

Scenario analyses will also be performed with the water allocation models to investigate the impacts of water supply and demand projections on ISFs, recreational lake levels, and navigation flows. Alternatively, the impacts of prioritizing these flows on water supply yields will also be investigated using the models. ISF goals, established under Task 1B and through the work of an independent ISF group, will be used as metrics of impacts. These targets will likely include both flow magnitude and hydrograph pattern targets.

2D.9 Documentation

The work described for this subtask will be fully documented in a report and/or series of technical memoranda for review by OWRB and other stakeholders.

Task 3 – Develop and Evaluate Supply Alternatives

The primary objectives of Task 3 are to develop a series of alternatives for addressing specific future water supply shortfalls (gaps) and to evaluate these alternatives in terms of costs, yields, and feasibility. Examples of the types of alternatives to be analyzed include storage and conveyance infrastructure, supply augmentation (physical and/or legal), existing supply management (e.g., reuse), and demand management (conservation measures and drought restrictions). Additionally, as part of this task, potential water management policy changes will be analyzed.

The analyses performed under this task will initially focus on those priority areas identified under Task 2 and will utilize the tools and models developed for these areas.

3A – Infrastructure and Water Supply Alternatives

3A.1 Assess Intrabasin and Interbasin Supply Alternatives and Related Infrastructure

The purpose of this subtask is to assess the potential for projects with basins with infrastructure constraints and the potential for intra- and interbasin transfers of water to augment existing supplies in basins with projected physical supply constraints, and to identify potential projects for future consideration. Existing plans or concepts for such projects will be incorporated into the analyses.

The statewide mapping tools described under Task 2C will be used to identify areas of surplus and areas of shortfall with respect to physical availability of water. This initial screening will guide more detailed assessments of potential intra- and interbasin projects (in subsequent tasks) based on considerations of topography, geography, conceptual-level costs, non-consumptive demands, institutional constraints, water quality, and sustainable firm yields. Survey results from Task 2B will also be used to provide information on existing intra- and interbasin project plans under consideration and general interest in such projects.

For areas with sufficient water quantity but inadequate water quality, treatment for M&I uses will also be considered as funding allows. This could include:

- Treating surface or groundwater with naturally elevated TDS
- Surface waters with elevated turbidity
- Utilizing coal gas methane produced water, reuse of return frac water from wells, and oil field produced water

3A.2 Evaluate Potential for Potable and Non-Potable Reuse

This subtask will be used to broadly identify the potential for increased reuse in Oklahoma, to facilitate a more detailed assessment of return flow recapture and reuse alternatives on a basin-specific basis.

The existing nature and extent of reuse of treated wastewater effluent will be characterized based on ODEQ records and other available data sources. The evaluation will also include an analysis of Oklahoma's existing reuse-related regulations and policies, in comparison to surrounding states, to document and summarize the constraints and requirements related to reuse in Oklahoma and opportunities for potential policy changes. This will include an assessment of the degree to which water providers currently have financial and/or operational incentives to utilize reclaimed water sources. Limited outreach to selected water providers who use reclaimed water and those who do not will be used as example case studies.

The analysis will include an overview of direct potable reuse, indirect potable reuse (i.e., potable water supply source augmentation), and non-potable reuse. Implications of increased reuse on downstream flows and water supplies will be characterized. While specific decisions on water reuse are necessarily made on the basis of system-specific information and costs, this analysis will characterize and attempt to quantify the overall potential for expansion of reuse in Oklahoma, along with documentation of the constraints that may prevent that potential from being achieved in practice.

3A.3 Assess Potential Levels of Conservation

The purpose of this subtask is to assess the costs, cost-benefits, and potential implementability of additional conservation to levels identified in Task 1A.5 on a regional basis.

Drawing on national databases and resources, specific conservation measures and programs will be assessed for their regional applicability to Oklahoma. Indoor, outdoor, and commercial/industrial conservation elements will be evaluated in terms of their demonstrated effectiveness in reducing demands, costs, and longer-term trends in demands. Effects of additional conservation on M&I providers' ability to reduce demands via emergency drought restrictions will also be considered.

Interaction with the public/policy process may be used to better assess public acceptability and policy implications of mandatory and voluntary conservation measures and programs. Consideration will be given regarding the potential role and acceptability of state-directed conservation goals, guidelines, programs, and educational materials.

The potential for increased agricultural conservation, including projections of possible savings in consumptive and non-consumptive components of agricultural water use, will be characterized using information developed in Task 1A.5.

3A.4 Assess Regional Supply Alternatives for High-Priority Basins

This subtask will assess specific regional water supply alternatives for addressing projected shortages in supply for areas identified as high priority basins under Task 2. In particular, areas with anticipated supply shortages for multiple users, and areas that may require intra- or interbasin supply projects or other major infrastructure investments, will be assessed for potential regional water supply projects. The number of high-priority basins and regional supply alternatives evaluated will depend on funding levels for this subtask and the number and complexity of high-priority basins identified in previous tasks.

The water allocation modeling tools developed for specific basins under Task 2D will be used to refine and predict water management activities and yields associated with both the importing water basin and the source water basin. These alternatives may include components such as conservation, reuse, treatment, construction or enlargement of reservoirs, pipeline development or enlargement, increased groundwater pumping, aquifer storage and recovery, water rights acquisition, and intra- or interbasin transfers. Water allocation modeling tools developed under Task 2D will be used to quantify yields associated with these types of alternatives for those subbasins, and/or local water providers, with projected gaps. The tools will be used to perform "what if" scenario analyses for the various alternatives both in isolation and in concert. In addition to quantifying local yields, impacts to downstream users and on downstream flows will be assessed. Reallocation of storage pools, such as reallocation of hydropower pools or navigation pools to public water supply uses, may be assessed as appropriate relative to basin-specific conditions.

Conceptual-level costs will be identified using appropriate engineering cost factors. The conceptual analysis of regionalized water supply options will also consider issues with implementation, such as permitting, institutional issues, phasing and cash flow considerations, and management agreements. Water allocation modeling will also be used to perform "what if" scenario analyses for various conservation and reuse programs capturing both seasonal yields and the impacts on downstream water availability.

3A.5 Assess Regional Supply Alternatives for Lower-Priority Basins

This subtask will mimic Subtask 3A.4, but will assess specific regional water supply alternatives for areas identified as lower priority basins in Task 2 activities. The number of lower-priority basins and regional supply alternatives evaluated will depend on funding levels for this subtask and the complexity of the lower-priority basins identified for analysis. Water allocation modeling may be used to assist in the analyses, as appropriate based on funding availability for this subtask.

3A.6 Evaluate Relative Use of Groundwater/Surface Water in Supply Alternatives and Consider Options

This subtask will explore potential shifts in the relative use of groundwater versus surface water for specific regions around the state. This information will be used to facilitate an analysis of the long-term sustainability of Oklahoma's water resources, in order to meet the needs of water users in the state through the planning period while protecting economic, environmental, and other societal values. Water allocation modeling and an assessment of potential impacts of groundwater pumping on stream flows may be used to assess hypothetical shifts in future basin or regional supply sources from groundwater toward surface supplies and vice versa. This information will be used to provide input to the regional and provider-level alternative analyses and guide recommendations as to areas of emphasis for future sources of supply.

3A.7 Detailed Infrastructure Costing

The purpose of this subtask is to support the feasibility analysis of water supply alternatives by developing more detailed cost estimates for alternatives developed under Tasks 3A.3, 3A.4, and 3A.8. For each selected basin or water provider, more detailed capital and operation and maintenance (O&M) costs will be developed for the most feasible or attractive alternatives, with respect to yields and initial cost estimates. The detailed costs developed under this task will be useful for further comparison of alternatives and for planning purposes.

3A.8 Provider-Level Supply Alternatives

This subtask will assess specific water supply alternatives. The feasibility of alternative demand management and source of supply options will be evaluated in terms of economic and non-economic evaluation criteria. Recommendations for future sources of supply and infrastructure needs will be made for specific individual municipal or rural water systems. The degree of detail in these analyses, and the number of provider-level evaluations to be conducted, will depend on the available level of funding for this subtask.

3B – Policy and Management Alternatives

Task 3B will be developed in coordination with Task 4 described below.

3B.1 Evaluate Conjunctive Surface Water/Groundwater Management

The purpose of this subtask is to evaluate the implications of potential changes in water administration in Oklahoma related to conjunctive permitting and administration of Oklahoma's groundwater and surface water resources.

Using water allocation models developed under separate tasks, a geographically diverse set of representative watersheds will be modeled under various potential administrative conditions. Water allocation models and groundwater/stream depletion models will be used to analyze scenarios developed in consultation with OWRB and other potential stakeholders, and may include scenarios such as:

- Existing water law, in which permits are issued with no assumed impact of groundwater pumping on stream water flows
- Hypothetical changeover to complete conjunctive management, in which current and future water permits recognize the effects of groundwater pumping on stream flows
- Hypothetical change to a system where new permits are issued in recognition of groundwater pumping impacts on stream flows but existing permits are grandfathered

For each scenario in the representative watersheds, this analysis will compare permitted water use to total stream and groundwater availability to assess the effects on existing and future permitted water users, stream flows, yields, etc. A comparison of existing conditions to those under a hypothetical conjunctive use alternative will illustrate the impacts of groundwater pumping on stream flows and potential for "over-reliance" on stream flows in future planning under current administrative procedures.

3B.2 Evaluate Implications of Instream Flow Management

The purpose of this subtask is to investigate the potential impacts of various hypothetical instream flow and lake level management scenarios on stream flows and consumptive users' supply yields.

Instream flow goals and alternative flow management strategies, encompassing both flow magnitudes and seasonal patterns, will be evaluated under Task 1B. These goals, at various hypothetical priorities relative to other water uses, will be entered into developed water allocation models to quantify the impacts on M&I water supply of prioritized instream flow management schemes. Scenario analyses will be performed to attempt to develop management schemes that succeed in meeting both public water supply demands and instream flow targets. These scenarios may include demand management and/or supply augmentation alternatives developed under Task 3A. This work will be performed for selected subbasins and prioritized reaches, as agreed upon by OWRB and designated stakeholders.

3B.3 Evaluate Modified Surface Water Permitting

This subtask will investigate the implications of modifying surface water permitting protocol from an annual average flow basis to a monthly or seasonal average flow basis. Statistical analyses of historical stream water flow gage data for various regions' hydrology will be used to evaluate differences between average annual and monthly/seasonal water availability. Assumed or actual historical monthly patterns of water use by major sector, coupled with projections of water use within one or more basins evaluated under this task, will be used to estimate monthly demand patterns in the basin(s). These data will be compared to annual average and monthly flows in the subject basin(s) to predict potential shortages under normal and drought conditions in peak demand months under both the annual average and the seasonal/monthly permitting approach. The results of this analysis will be used to formulate recommendations on whether and how OWRB might modify its surface water permitting protocol.

Additional analyses will consider current versus potential alternate approaches to managing hydropower water needs, navigational water needs, and water quality pools in reservoirs.

3B.4 Investigate Tribal Rights Management/Coordination

This subtask will assess the current state of interaction between tribal and state water management and permitting and identify a path forward for addressing outstanding issues. A series of workshops will be held with OWRB, stakeholders, federal agencies, and others with an interest in state/tribal water management. In coordination with the public/policy process, these workshops will be held to identify and prioritize technical issues, set assumptions for use in development of Water Plan technical analyses, and identify recommended future activities to help facilitate coordinated management of state and tribal waters within Oklahoma.

3B.5 Evaluate Potential State Roles in Regional Infrastructure/Projects

The purpose of this subtask is to identify and assess potential policy changes with respect to the state's role in regional water supply infrastructure and projects. Beyond funding/financing programs, some states participate on an institutional/authority role on major water delivery projects serving multiple users. An inventory of the types of roles played by state government in surrounding states and other western/southwestern states will be developed to further explore the range of potential roles of OWRB or other state agencies in developing, funding, financing, and/or operating major water supply projects. A variety of potential state roles will be investigated, using regional water supply projects from Task 3A to illustrate the roles. Recommendations regarding the types of roles the state should play in various types of water supply projects will be developed in coordination with OWRB, municipal and rural water provider interests, and the Water Plan's public/policy process.

Task 4 – Public/Policy Interaction

The purpose of this task is to establish and foster an interactive link between the technical elements of the Water Plan and the ongoing public participation/policy development process, and communicate and receive feedback about key technical aspects of the plan. The public participation process includes the following activities: 1) Local Input Meetings (completed), 2) Regional Input Meetings, 3) Planning Workshops, 4) Town Hall Meetings, and 5) Implementation Meetings. Additional information on these activities is located at www.okwaterplan.info.

Based on information from the input meetings, the Oklahoma Water Resources Research Institute will sponsor a series of workshops, in 2009, to formulate alternative water resource management strategies. Therefore, pertinent information from the technical studies will be an important component of the workshop process. Likewise, information generated during the workshops will be important in order to help prioritize remaining technical activities associated with completing the Water Plan.

Task 4A – Technical Interaction with Public/Policy Groups

The purpose of this task is to facilitate ongoing interaction between the technical work described in this Programmatic Work Plan and the Public/Policy process, throughout the development of the Water Plan.

At key milestones in the technical and policy evaluations, and, based on the public/policy schedule, a timeline for communicating technical information to the stakeholders will be developed. The following interactions with the Public/Policy Group meetings are anticipated:

- Local Input Meetings (completed November 2007): No technical input; members of the technical team attended a subset of the meetings.
- Regional Input Meetings: No technical input; members of the technical team may attend selected meetings to listen to the compilation and prioritization of issues, to further guide the Water Plan technical work, and to provide clarification of any technical Work Plan elements.
- Planning Workshops: Direct interaction and participation by technical team members at each workshop, to facilitate informed discussions and recommendations.
- Town Hall Meeting: Direct interaction and participation by technical team members at each workshop, to facilitate informed discussions and recommendations.
- Feedback Meetings: Technical team support of these meetings as needed.

This approach will provide information necessary to keep stakeholders informed about the technical approach and progress of the Water Plan's technical components, while facilitating informed discussions and recommendations in the public/policy process.

Task 4B – Water User Stakeholder Meetings

The purpose of this task is to establish a channel of communication with the various types of water users and related organizations regarding water use.

A series of meetings will be held with stakeholders to present information about the technical approach and discuss results and findings. Organizations and groups that may benefit from focused meetings may include municipal and/or rural water interest groups, industry groups, and environmental/recreational groups. A plan and schedule for the meetings will be developed with OWRB throughout the development of the Water Plan.

Task 4C – Technical Evaluation of Public Process Policy Concepts

The purpose of this task is to establish communication with stakeholders related to policy issues and concepts that will be assessed and considered as part of the Water Plan. Additionally, concepts identified in the public/policy forums will be technically evaluated to support policy decisionmaking.

Policy related issues, including the policy for some relevant implementation elements, will be studied as part of Task 5. Under this task, communication and feedback from stakeholders will be obtained. Additionally, results of technical evaluations related to policy issues will be communicated.

The communication is anticipated to take place in conjunction with meetings scheduled under the ongoing public/policy process.

Task 5 – Implementation

The purpose of this task is to assess and initiate implementation of various Water Plan components. Implementation strategies and guidelines will be developed based on other Work Plan elements. To the degree that funding is available, components prioritized by OWRB will be implemented as part of the Water Plan, as described below.

5A.1 Water Rights Administration System Modernization

The purpose of this subtask is to streamline and update the technological tools used in OWRB's administration of water permits across the state. OWRB's existing system maintains all water right and associated historical water use records and includes various programs to facilitate processing by staff. The OWRB Water Rights Administration System was developed in the early 1990s as a replacement to a mainframe system. Current, industry-supported hardware and software platform for

managing water rights information is essential to obtaining technical assistance in the event of a failure. Under this subtask the database system will be migrated to an Oracle system to be consistent with the platform utilized for other agency databases. A modernized and networked water rights environment will improve the storage, accessibility, manipulation and sharing of water use/supply information.

5A.2 GIS Mapping of Raw Water Infrastructure Statewide

The purpose of this subtask is to develop GIS mapping of raw water delivery systems for regional infrastructure and water providers throughout the state.

A list of water providers in the state that already employ GIS mapping for their water systems (raw and treated) will be generated drawing on feedback from the water provider survey and existing GIS databases. Water providers' raw water systems that are not mapped in GIS will be mapped, using a prioritized system defined by OWRB. It is anticipated that the majority of water providers will require some mapping assistance or will require maps to be generated in GIS for the first time. The results of a mapping pilot study will be used to scope the effort for mapping for different water providers based on size, need, and other characteristics.

Potential roles of the state in maintaining the GIS system maps will be based on criteria related to need for a centralized mapping system vs. a simple inventory of an access system with local providers keeping control and administration of their GIS geodatabases and maps.

5A.3 Evaluate Floodplain Management Codes, Statutes, and Programs

The purpose of this subtask is to evaluate flood management policies and procedures in the context of the Water Plan and identify any necessary modifications.

Floodplain management instruments in the state will be discussed with OWRB and the impact of the current floodplain management programs on water quality and water availability will be assessed. This assessment will be done in terms of any policy recommendations from the Water Plan and not on the basis of current policy.

5A.4 Evaluate Funding/Financing Programs and Needs

The purpose of this subtask is to evaluate the statewide funding requirements for implementation of projects recommended by or identified in the Water Plan, and define potential mechanisms for the funding and financing of projects.

The total costs of projects and programs to be implemented as a result of the Water Plan will be identified through the alternatives analyses conducted in Task 3. Funding needs will be categorized in terms of implementation timeline and also in terms of a general cost allocation. The plan will include costs that are associated with projects for which water providers may already have funding and financing mechanisms. At the same time, many projects may be recommended for water providers that would require some funding assistance. Additionally, some projects and programs will need

to be implemented by the state itself and OWRB will need to establish financing options and revenue streams.

Other states' funding and financing programs, together with a survey of potentially-applicable federal programs, will be summarized and considered for their applicability to Oklahoma and its identified funding and financing needs. Mechanisms to satisfy the needs, and programs to assist other project and program owners, will be drafted for OWRB review. The main considerations, advantages, and disadvantages will be presented in a policy paper for the Board.

5A.5 Evaluate Drought Preparedness

The purpose of this subtask is to use the level of drought impacts that can be anticipated based on the results of Task 2, for short-, mid- and long-term, with and without climate change effects, and compare with current drought management mechanisms to evaluate the level of drought preparedness in the state and establish policy guidelines if necessary.

In addition, consideration will be given to characterizing the inter-relationships between drought impacts on water quality, including reduced receiving water flows and assimilative capacity for dischargers, as well as the potential effects on the use of Oklahoma's surface water supplies for all major sectors of use.

The current monitoring, assessment, and response activities defined in the Oklahoma Drought Management Plan (1997) will be reviewed and updated in light of the new tools for water supply assessment developed as part of the Water Plan, and the results of the analysis of potential climate change impacts.

The current Drought Management Plan (1997) will also be updated, if necessary, in terms of the defined responsibilities for federal, state, and local players.

5A.6 Summarize Data Gaps and Provide Recommendations

The purpose of this subtask is to provide a list of the major data gaps and required data collection efforts required for Water Plan implementation. Data needs necessary for more thorough or efficient future Water Plan updates will also be identified and summarized. Under this subtask, additional actions may be identified for collection, analysis, or processing and summarizing data in support of other Work Plan tasks.

While developing the Water Plan, especially Tasks 1, 2, and 3, data gaps of significance will be listed and documented. Documentation will consist of the specific data need, where the data need was identified, relevance and anticipated beneficial use of the data, potential activities and approximate estimates of costs to compile the data or information, and recommendations for data management and updates (in the context of existing data management tools).

This task will compile the data and information gaps and documentation identified under other tasks. The system and communication protocols to compile the needs as soon as they are detected will be the most critical element of this task. Training the technical team in the use of the data needs log will take place at the beginning of the Water Plan and accessibility to the log will be widely granted to facilitate its use.

5A.7 Summarize Recommendations for Follow-on Analyses

The purpose of this subtask is to identify analyses and studies that may be needed after the completion of the Water Plan update in 2011, and summarize those as a component of the Water Plan documentation.

In executing the technical work described in this Programmatic Work Plan, the need for additional studies and/or analyses that are not included in this Work Plan may be identified. Alternatively, updates or other analyses that cannot be conducted as part of the current Water Plan may be identified for future execution. Recommendations for post-2011 analyses will be summarized, including estimates of the relative costs, role in the water planning process, and rationale for each.

5A.8 Document Projected Trends Beyond 2060

The purpose of this subtask is to document trends in water demand, supply, and quality (and other relevant variables) that can be projected into the future, up through and potentially beyond the year 2060.

The key drivers for water resources management (particularly water demands) will be projected into the future using simplified techniques and qualifying the uncertainties. The trends beyond 2060 will be documented in terms of magnitude of the variables and implications for future supply development and water resources management. Findings of the climate change evaluations will be taken into account in this task and presented as a range of potential scenarios.

5A.9 Water Conservation and Education Programs

The purpose of this subtask is to define guidelines for programs on water conservation that can be implemented on a statewide basis. To the degree that funding is available, pilot- or full-scale education programs may be developed and deployed under this subtask.

The state's role in promoting conservation and education will be compared with actual actions and programs currently in place, and any additional programs or modifications and improvements to programs will be recommended in this task.

5A.10 Pilot Water/Electric Utility Partnership

The purpose of this subtask is to define the guidelines for and implement a pilot program for a water/electric utility partnership. This effort will attempt to identify and evaluate the potential efficiencies and benefits of joint management and administration of water and electric utilities, with an emphasis on smaller

communities or rural areas. A work plan for the pilot project will be developed and implemented to assess the potential for such partnerships to be used on a broader scale. Results of the pilot project will be summarized and publicized through the OWRB or other applicable venues.

5A.11 Water Quality Management

The purpose of this subtask is to consider and document water quality management needs as they may relate to water supply and use throughout the state. This assessment will review water quality standards, assessment, permitting, and remedial programs (total maximum daily loads and their implementation) in light of projected future water supply conditions, with an emphasis on water quality standards and their implementation that are protective of the projected water needs. This effort will incorporate the state water quality management plan (CWA Section 208), as well as non-point source management plans and related water quality standards implementation plans.

5A.12 Additional Special Studies and Investigations

The purpose of this subtask is to initiate any additional studies necessary for the successful implementation of the Water Plan or for specific definition of policies or resolution of identified data gaps. The value and use of those studies and research will be described and estimates of funding required for them and timelines for completion will be established.

Subtask 5A.7 will list follow-on analyses recommended by the plan and this task will incorporate those as part of its suggestions. In addition to follow-on studies, special studies and investigations on elements not directly addressed on Tasks 1, 2, and 3 will be indentified in this task. Data needs critical to other tasks' completion, such as processing of USGS flow gaging data, will be conducted under this task consistent with identified needs and available Water Plan funding.

Task 6 – Water Plan Documentation

The primary purpose of this task is to document the methods, results, and recommendations of the Water Plan.

6A.1 2007 OWRB Water Atlas

Among the first components of the Water Plan was the 2007 development of the Oklahoma Water Atlas by OWRB. The Water Atlas provides an invaluable resource to water planners and users throughout the state.

6A.2 Draft and Final Report

The purpose of this subtask is to document the Water Plan process and outcomes in a report that will comprise the final planning document.

A generalized draft outline will be prepared and a detailed final outline will be developed for the plan and for its executive summary. This will allow OWRB to visualize the final product prior to preparation of major sections of the report.

A draft of the report and its executive summary will be prepared for review by OWRB and other designated reviewers. Peer reviews will also be conducted. Feedback will be incorporated into the final Water Plan Report.

Task 7 – Project Coordination and QA/QC

The purpose of this task is to provide project management and coordination required for the successful completion of the project.

Task 7A – Project Management and Coordination

General project management procedures will be applied to control budget, keep the project on schedule, provide the quality reviews necessary, and manage internal resources, sub-consultant resources, communications, and accounting.

Task 7B – Conduct QA/QC and Peer Reviews

Internal quality procedures for deliverables and other work products will be applied. Quality reviews will be scheduled and conducted by the consultant team, and OWRB reviews of draft deliverables will also constitute a quality review. Additionally, peer reviews will be conducted for products, methodologies, and approaches for specific tasks described above.

Appendix A
Programmatic Work Plan
Task Schedules

OKLAHOMA COMPREHENSIVE WATER PLAN
Appendix A: Programmatic Work Plan for Technical Components
May 2008

	2007				2008				2009				2010				2011			
	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q
TASK 1 – DEMAND PROJECTIONS																				
1A – CONSUMPTIVE DEMANDS																				
1A.1 Kickoff and data collection/analysis																				
1A.2 Model development and demand forecast																				
1A.3 Interim review																				
1A.4 Provider-level validation																				
1A.5 Assessment of conservation																				
1A.6 Assessment of climate change impacts																				
1A.7 Refinements to demand projections																				
1A.8 Demand projections report																				
1B – NON-CONSUMPTIVE WATER USE																				
1B.1 Develop policy framework and goals																				
1B.2 Characterize existing programs																				
1B.3 Prioritize and map streams / species for ISF analyses																				
1B.4 Review and select methodology for ISF goals																				
1B.5 Develop flow goals for initial prioritized areas																				
1B.6 Additional ISF technical analyses																				
TASK 2 – SUPPLY AND GAP																				
2A – STATEWIDE PHYSICAL AVAILABILITY SCREENING																				
2A.1 Kickoff and review previous studies																				
2A.2 Gather data: USGS gaged streamflows																				
2A.3 Gather data, review past studies, and project yields: groundwater																				
2A.4 Summarize graphically surface water physical availability																				
2A.5 Review & summarize compact obligations and inter-basin projects																				
2A.6 Analyze existing public supply reservoirs for firm yields: physical availability																				
2A.7 Analyze sedimentation rates and long-term storage capacity loss																				
2A.8 Analyze major federal reservoirs for permit allocation usage																				
2B – INFRASTRUCTURE/LEGAL AVAILABILITY SCREENING																				
2B.1 Develop & distribute public water provider survey																				
2B.2 Gather water quality data and analyze previous work																				
2B.3 Follow-up with providers																				
2B.4 Synthesize & summarize survey results																				
2B.5 Develop and distribute preliminary results and follow-up survey																				
2C – STATEWIDE SCREENING GIS TOOL DEVELOPMENT & APPLICATION																				
2C.1 Develop and populate GIS tool																				

	2007				2008				2009				2010				2011			
	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q
2C.2 Apply GIS tool for screening-level quantification of future gaps and to identify supply "hot spots"																				
2D – WATER ALLOCATION MODELING																				
2D.1 Select modeling tool(s)																				
2D.2 Develop groundwater - stream depletion model add-on																				
2D.3 Construct & calibrate model(s) for pilot study																				
2D.4 Apply models for pilot study: gap analysis, reservoir firm yields, ISF																				
2D.5 Refine methods, approach, and tools based on pilot results																				
2D.6 Construct & calibrate models for remaining identified "hot spots"																				
2D.7 Apply models for remaining identified "hot spots": gap analysis and reservoir firm yields																				
2D.8 Investigate climate change and instream flow: "what if" scenarios																				
2D.9 Documentation																				
TASK 3 – DEVELOP & EVALUATE SUPPLY ALTERNATIVES																				
3A – INFRASTRUCTURE & WATER SUPPLY ALTERNATIVES																				
3A.1 Assess intrabasin & interbasin supply alternatives and related infrastructure																				
3A.2 Evaluate potential for potable & non-potable reuse																				
3A.3 Evaluate potential levels of conservation																				
3A.4 Assess regional supply alternatives for high priority basins																				
3A.5 Assess regional supply alternatives for lower priority basins																				
3A.6 Evaluate relative use of groundwater/surface water in supply alternatives and consider options																				
3A.7 Detailed infrastructure costing																				
3A.8 Provider-level supply alternatives																				
3B – POLICY ALTERNATIVES																				
3B.1 Evaluate conjunctive Surface Water/Groundwater management																				
3B.2 Evaluate implications of instream flow management																				
3B.3 Evaluate modified surface water permitting																				
3B.4 Investigate tribal rights management/coordination																				
3B.5 Evaluate State roles in regional infrastructure/projects																				
TASK 4 – PUBLIC/POLICY INTERACTION																				
4A – TECHNICAL INTERACTION WITH PUBLIC/POLICY GROUPS																				
4B – WATER USER STAKEHOLDER MEETINGS																				
4C – TECHNICAL EVALUATION OF PUBLIC PROCESS POLICY CONCEPTS																				
TASK 5 – IMPLEMENTATION																				
5A.1 Water Rights Administration System modernization																				
5A.2 GIS mapping of raw water infrastructure statewide																				
5A.3 Evaluate floodplain mgt. codes, statutes, & programs																				
5A.4 Evaluate funding/financing programs and needs																				

	2007				2008				2009				2010				2011			
	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q
5A.5 Evaluate drought preparedness																				
5A.6 Summarize data gaps & provide recommendations																				
5A.7 Summarize recommendations for follow-on analyses																				
5A.8 Document projected trends beyond 2060																				
5A.9 Water conservation and education programs																				
5A.10 Pilot water/electric utility partnership																				
5A.11 Water quality management																				
5A.12 Additional special studies and investigations																				
TASK 6 – WATER PLAN DOCUMENTATION																				
6A.1 2007 OWRB Water Atlas																				
6A.2 Develop draft and final report, conduct peer reviews																				
TASK 7 – PROJECT COORDINATION AND QA/QC																				
7A – PROJECT MANAGEMENT/COORDINATION																				
7B – CONDUCT QA/QC AND PEER REVIEWS																				

Appendix B
Programmatic Work Plan Memoranda

Oklahoma Water Resources Board
Oklahoma Comprehensive Water Plan
Programmatic Planning

Memorandum 1 – Objectives, Goals and Products for the OCWP
December 2007

The Oklahoma Comprehensive Water Plan (OCWP) will be a long-range planning document to help Oklahoma protect and enhance the beneficial use of the state's surface and groundwater resources. The plan will reflect the continual planning process that the Oklahoma Water Resources Board leads in the state and will allow the Board to fulfill its mandate established in House Bill 2036 (1992).

This memorandum summarizes the objectives and goals of the plan, and the potential products resulting from the plan.

Relationship between Objectives and Products

This memorandum includes a discussion of both objectives for, and products of, the OCWP. The objectives of the plan are the overarching goals for the OCWP. Those objectives will generally dictate the products that will be developed as part of the plan.

Examples of products are demand projections, water allocation models, GIS maps and geodatabases, facility inventories, etc. They will be developed as part of the overall planning effort and will be required at different stages in the planning process. The analyses and results of the OCWP planning process will be documented in the final OCWP report.

Goals and Objectives for the OCWP

The Strategic Planning Meeting held on August 20, 2007 and the Goals and Objectives Workshop held on September 13, 2007 resulted in the identification of several general objectives:

- One of the OCWP priorities will be understanding and addressing municipal and industrial (M&I, often referred to as public water supply) needs, in light of projected growth in population and the fact that some areas have already exhibited limitations in supply. Development of the OCWP should consider how it can assist public water supply systems that do not have solid plans for meeting future water demands.

- Agricultural demands will continue to comprise a significant portion of the state's water use, indicating a need to thoroughly understand and project agricultural water demands and the sources of supply that will be used to meet those demands.

- Existing policy and administrative procedures necessarily form the baseline of all analyses. However, technical analyses conducted under the OCWP will investigate the need for, and potential implications of, policy changes in a number of areas. Policy areas to be considered in development and execution of the OCWP include:
    - Conjunctive administration of surface water and groundwater supplies
    - Municipal water system regionalization and the State's role in regional systems and projects
    - Environmental flow management
    - Other facets of water permitting and administration, such as permitting based on annual average surface water yields
    - Revenue generation and financing sources, instruments and institutions for project implementation
    - Other policy elements identified as part of the ongoing public/policy process
- Public water supply systems should be evaluated for their 50-year demands and supply plans, with an assessment of whether current local plans provide a method for supplying 50-year demands. To the degree possible, the OCWP should consider water demands and needs beyond the base planning horizon (2060), ideally looking ahead 100 years.
- Results of municipal supply analyses should be summarized to highlight areas where future demands may not be met, whether due to infrastructure or firm supply issues. Priorities should be placed on addressing areas where current demands are not being met, followed by those areas where projections indicate future demands will not be met.
- The OCWP should summarize statewide and community level infrastructure needs.
- The OCWP should consider additional interbasin transfers within the State of Oklahoma to support resolution of any identified (or projected) supply shortfalls.
- Environmental flows will also be considered in light of existing administration of water supplies and potential future water management policies. Of note are the state's existing scenic rivers statute and domestic water allocation procedures. These programs, plus mandatory compliance with interstate compact deliveries, should be taken into account when considering instream flow programs and policies.

Desirable Attributes for the Final OCWP and its Interim Products

One overarching goal of the OCWP will be to achieve a plan that has the following attributes and characteristics:

- Reliable information
- Consistent methods and comparable results
- Defensible
- Practical and useable
- Understandable
- Consistent with existing policy
- Forward-looking
- Balanced management of supplies
- The "go-to" source of water information for water users, planners, and media

OCWP Potential Products based on the Objectives

The objectives and considerations listed above will require the following outcomes and products:

- Accurate assessment of water demands, using demand projection models
- Accurate assessment of water supply, using supply estimate and allocation models
- Recommendations to local public water supply agencies on alternatives to meet future demands
- Evaluation of potential regional water supply systems
- Evaluation of the state's role in regional supply systems
- Local public supply system survey
- Summary of statewide and community level infrastructure needs
- Evaluation of interbasin transfers
- GIS mapping of regional and local infrastructure
- Policy concepts regarding environmental flows

- Inventory of existing intrastate water transfer capacities and historical transfers
- Policy and tools regarding surface and groundwater interaction and impacts
- Models, databases, technical memoranda and documents associated with these products and tasks

Related steps as part of this programmatic planning support effort include the development of methodologies for demand and supply and ultimately the development of a Programmatic Work Plan.

The Programmatic Work Plan will prioritize and establish phasing for these potential products, using the objectives and goals as a guideline for the OCWP effort. An additional consideration regarding the planning products is the level of funding required to develop those products and the level of funding available at different stages in the planning process. The Programmatic Work Plan will take funding and its timing into consideration when phasing the OCWP efforts and associated products.

Oklahoma Water Resources Board
Oklahoma Comprehensive Water Plan
Programmatic Planning

Memorandum 2 – Funding Sources for the OCWP
December 2007

The Oklahoma Comprehensive Water Plan (OCWP) will provide long-range planning to help Oklahoma protect and enhance the beneficial use of the state's surface and groundwater resources. This memorandum summarizes information regarding current and potential funding for the OCWP, including state and federal sources. The OWRB envisions that, combined with federal cost-shared funds, the OWRB will work with local water suppliers and other water users in evaluating their current water supplies, assessing long-term needs and sources of water, and developing strategies to meet needs over a 50-year time horizon.

Oklahoma's Governor and Legislature, during special session in June 2006, displayed an unprecedented show of support for water resources planning in the form of specific funding for a substantial update of the OCWP over a five-year time frame. State legislative funds have been committed to develop the most critical foundational elements of the OCWP through its anticipated completion in 2011. However, federal funds can only be appropriated one year at a time, and therefore, the probability and amount of future federal appropriations that may be available for the development of the OCWP cannot be identified with certainty beyond current (federal fiscal year 2008) appropriations.

An overview of the possible range of state and federal funds that could be used to develop the OCWP to varying end points is provided in the sections below. The components, estimated costs, priorities, and schedule of technical work under the OCWP are being developed separately in the OCWP Programmatic Work Plan.

State Funding Sources

Recognizing the importance of comprehensive statewide water planning, Oklahoma's Governor and Legislature have committed a substantial level of gross production tax funding to the development of OCWP. State legislative appropriations for the OCWP include approximately $1.25 million per state fiscal year over a five-year period. Starting in state fiscal year 2007 and continuing through state fiscal year 2011, these legislative appropriations will total about $6.24 million.

Additional state funds have not been secured at this time. Among the possible avenues for increasing state appropriations for the development of the OCWP are the following:

- Legislative removal of the cap on gross production taxes
- Reallocation of a portion of state legislative appropriations of gross production tax funds from the OWRB's water and wastewater financing programs to the OCWP

OWRB will continue to investigate the feasibility of these additional state funding sources, while also pursuing federal partnerships and other funding opportunities.

Federal Partnership Opportunities

The Oklahoma Water Resources Board (OWRB) has a long history of successfully developing water supply plans and related studies. OWRB has worked with federal and local agencies as partners in these efforts to leverage the use of state investments and augment them with the expertise and resources of agencies such as the U.S. Army Corps of Engineers (USACE), Bureau of Reclamation (Reclamation), and others. Participation by the USACE and Reclamation is particularly relevant, given those agencies' significant roles in water storage and development projects throughout the state.

OWRB is actively pursuing federal partnerships to leverage the use of its state appropriations, in order to maximize the value of the OCWP to the water users and uses in Oklahoma. Below is a summary of the most relevant and potentially available sources of federal funding for the OCWP.

USACE

While the USACE is not a granting agency, it does have the authority to technically and financially support water resources projects. USACE generally participates in locally-sponsored projects generally through two programs: the Continuing Authorities Program (CAP) and the Planning Assistance to States (PAS). Large projects are the subject of specific Congressional authorization under the periodic Water Resources Development Act (WRDA). In instances where needs or projects are smaller in scope, the USACE has authority to act without further authority under the CAP. Here, the USACE has the general authority to study, and if proven feasible, approve and construct certain water resources development projects.

Planning Assistance to States

Under Section 22 of the 1974 WRDA (Public Law 93-251), USACE has authority to provide technical assistance to support state preparation of comprehensive plans for the development, utilization, and conservation of water and related land resources. Commonly referred to as Planning Assistance to States (PAS), these projects are conducted on a 50/50 federal/non-federal cost-share, and 50% of the non-federal share can be in-kind services.

Since 1996, PAS funds have been capped at $500,000 per state per year. While this cap was raised to $2 million per state per year in the recently-passed 2007 WRDA bill, overall appropriations for the program by the U.S. Congress will govern the

availability of these funds, and it can be expected that competition between states will result in many states' allocations being far less than the annual $2 million maximum.

In June 2007, the OWRB entered into a $300,000 agreement with the USACE's Tulsa District for programmatic planning support for the OCWP under PAS authority. OWRB's $150,000 non-federal cost share under this agreement is being provided as a combination of in-kind services and cash contributions.

OWRB is actively pursuing additional PAS funding to support ongoing water planning needs. Initial requests for federal fiscal year 2008 (FFY 2008) appropriations bills included $500,000 of PAS funds for Oklahoma. However, the recently-passed final federal appropriations bill for FFY 2008 included $246,000 in PAS funds for Oklahoma. Initial indications are that most or all of these funds will be allocated to support OWRB's water planning efforts, and there is a potential that additional FFY 2008 funds could be allocated to these efforts at the discretion of USACE. OWRB will continue to support future appropriations of PAS funds, with a target federal funding level of $500,000 per federal fiscal year through the 2011 completion of the OCWP. Doing so will require modification of the existing USACE/OWRB agreement for PAS support, or preparation of a new agreement, to increase the overall amount of the agreement and extend its schedule.

General Investigation Studies

Two existing USACE general investigation/feasibility studies are charged with evaluating water supply issues in portions of Oklahoma, and could be used to support the goals and end products of the OCWP. These include the Southeast Oklahoma Water Resource Study and the Washita River Basin Study. Both studies include a 50/50 federal/non-federal cost share requirement, and the non-federal share can be in cash or in-kind. Because of the potential for significant water development in these areas of the state, technical studies are needed to support informed water resources management decisions.

The Southeast Oklahoma Study is an environmental restoration study of a 29-county area in southeast Oklahoma, including the Kiamichi River Basin and other tributaries of the Red River. The Tulsa District of USACE and OWRB signed a Feasibility Study agreement on July 10, 2001. The OWRB later requested that the study be deferred pending legislative review of water development options being considered for the study area. OWRB is now seeking to continue the study, at a target federal funding level ranging from about $300,000 to $900,000 per year through FFY 2011.

The initial reconnaissance studies under the Washita River Basin Study identified a federal interest for flood damage reduction and ecosystem restoration. The OWRB is interested in participating as the local sponsor and has provided a letter of intent to cost share a feasibility study. The study area covers portions of the southwest corner of the state and adjacent areas. The scope of the feasibility study would be broadened to evaluate water supply and demands in the study area and to identify, evaluate and

recommend implementable watershed management alternatives to meet future water demands while preserving the ecosystem of the Washita River Basin. This activity, similar to the Southeast Oklahoma Study, would be complementary to Oklahoma's five-year comprehensive water resources planning and management initiatives. OWRB has identified a target federal funding level ranging from about $300,000 to $750,000 per year through FFY 2011.

Water Resources Development Act
The 2007 WRDA bill includes authorization for $6.5 million for USACE participation in the development of the OCWP, at a 75/25 federal/non-federal cost share. OWRB is actively pursuing federal appropriations under this new authority, starting immediately and continuing through FFY 2011. If the full $6.5 million is appropriated and evenly distributed over three FFYs, the annual federal funding under the WRDA 2007 authority would be nearly $2.2 million.

Reclamation Grants

In June 2007, Reclamation published a request for proposals under its Geographically Defined Programs (GDP) authority for Oklahoma Investigations, as part of the Oklahoma State Comprehensive Water Plan (Funding Opportunity No. 07SF600018). The Oklahoma Investigations Program, a GDP, is administered in accordance with Section 205 of Public 109-103, Energy and Water Development Appropriations Act of 2006. This funding opportunity covers potential Reclamation support through FFY 2011, and offers up to $300,000 of federal funding, contingent on availability of appropriations.

Section 205 authorizes Reclamation "to enter into grants, cooperative agreements, and other agreements with irrigation or water districts and States to fund up to 50 percent of the cost of planning, designing, and constructing improvements that will conserve water, increase water use efficiency, or enhance water management through measurement or automation, at existing water supply projects….. [and] to enter into grants or cooperative agreements with universities or non-profit research institutions to fund water use efficiency research."

OWRB submitted a proposal for Reclamation funding under this funding opportunity and was awarded a grant. The initial amount of the grant was for $20,000, with possible additional funds to be made available if adequate appropriations are made available to Reclamation. OWRB will continue to pursue this opportunity, with a goal of reaching the full $300,000 federal grant amount between now and 2011.

Other Opportunities

The OWRB is continuously in search of additional partnership and funding opportunities to leverage the state's investment in the OCWP. Additional opportunities may become available as the development of the OCWP progresses. For example, the USGS and other state and federal partners are actively engaging in the study of instream environmental flows, and it is anticipated that they will

contribute some level of in-kind support toward those investigations. Similarly, the Oklahoma Water Resources Research Institute is contributing in-kind services and identifying other financial partnering opportunities as it conducts its public and policy work under the overall umbrella of the OCWP.

Summary

Significant state funding has already been committed to the development of the OCWP, and it is anticipated that federal funding and support will play an important role in enhancing the analyses and results of the OCWP. A summary of federal and state funding goals is provided in Table 1 below. The Programmatic Work Plan is being developed as a phased, prioritized plan for conducting the technical and public/policy elements of the OCWP, such that the work can continue in a logical manner under any of the range of possible funding levels.

Table 1 Potential Range and Timing of Federal and State Funding

Calendar Year	**CY 2007**	**CY 2008**	**CY 2009**	**CY 2010**	**CY 2011**	**Total Potential Funding**	**Local Match Required***
State Fiscal Year (Jan-Dec)	**SFY 2007**	**SFY 2008**	**SFY 2009**	**SFY 2010**	**SFY 2011**		
Federal Fiscal Year (Oct-Sep)	**FFY 2007**	**FFY 2008**	**FFY 2009**	**FFY 2010**	**FFY 2011**		
Southeast Oklahoma Water Resource Study		$290,000	$700,000	$800,000	$900,000	**$2,690,000**	$2,690,000
Washita River Basin Study		$270,000	$500,000	$750,000	$750,000	**$2,270,000**	$2,270,000
WRDA Appropriations		$0	$2,166,667	$2,166,667	$2,166,667	**$6,500,000**	$2,166,667
Reclamation GDP Grants		$20,000	$100,000	$100,000	$80,000	**$300,000**	$300,000
Planning Assistance to States	$150,000	$500,000	$500,000	$500,000	$500,000	**$2,150,000**	$2,150,000
Total Federal Funding Potential by Calendar Year	**$420,000**	**$1,801,700**	**$4,054,200**	**$4,336,700**	**$3,297,500**	**$13,910,100**	**$9,576,667**
Oklahoma Legislative Appropriations	$1,248,250	$1,248,250	$1,248,250	$1,248,250	$1,248,250	**$6,241,250**	N/A
Potential Additional State Appropriations	$1,248,250	$1,248,250	$1,248,250	$1,248,250	$1,248,250	**$6,241,250**	N/A
Total Funding Potential by Calendar Year	**$2,916,500**	**$4,298,200**	**$6,550,700**	**$6,833,200**	**$5,794,000**	**$26,392,600**	

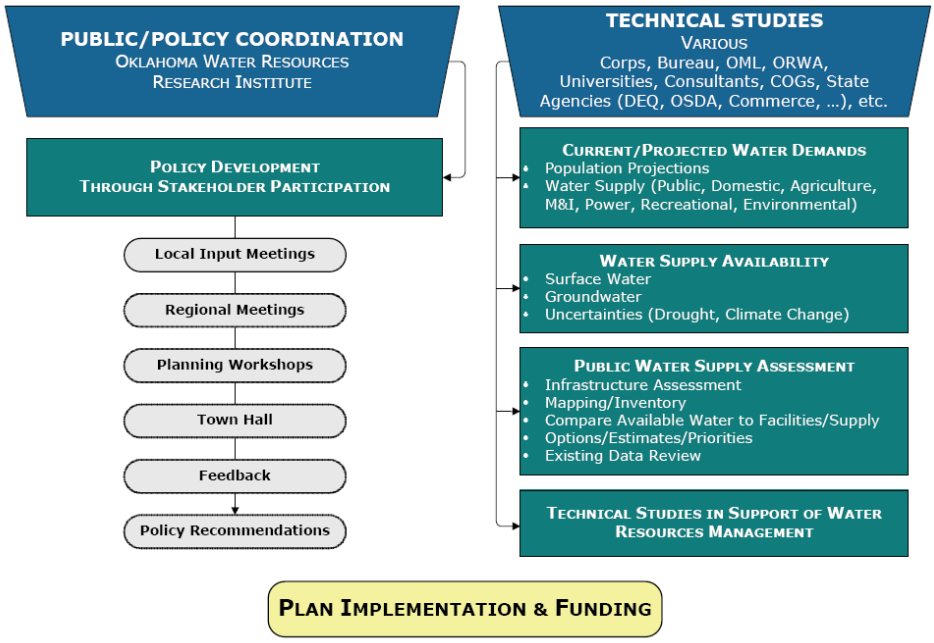
** In-kind and/or cash, depending on specific federal source*

While the timing and amounts of the funding listed in this table may vary depending on the ability to appropriate federal funds, the OWRB has clearly established a roadmap for funding a thorough analysis of statewide water supplies, demands, and solutions to meet Oklahomans' needs through 2060.

Oklahoma Comprehensive Water Plan
Overview of Technical Approach for Water Supply and Demand Projections
October 2007

The Oklahoma Water Resources Board (OWRB) has initiated a major update of the Oklahoma Comprehensive Water Plan (Water Plan). Development of the Water Plan is being conducted in two parallel but inter-related paths:

- Public / Policy Coordination
- Technical Studies



The public process was initiated in April 2007 with a statewide series of local input meetings. Upon completion of these listening sessions in late 2007, the process will move into regional meetings and planning workshops to explore ways to address the issues raised in the local input meetings.

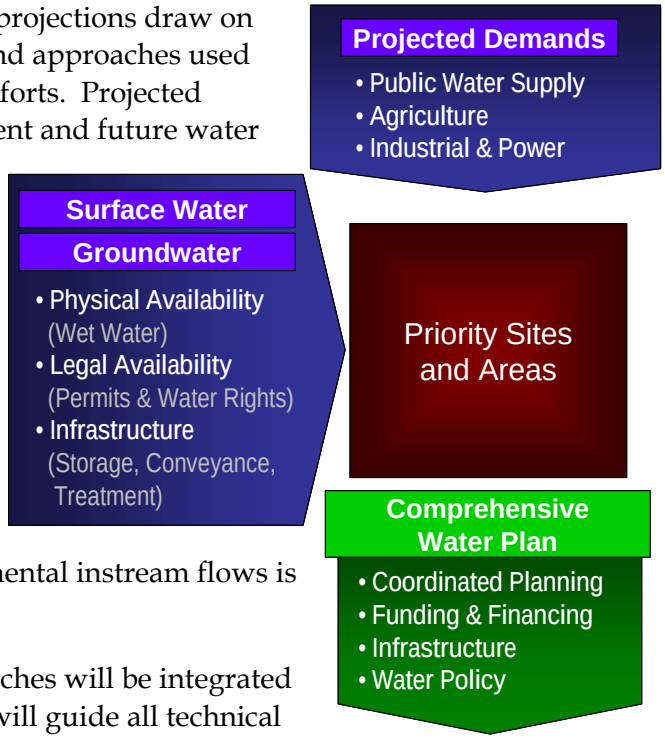
The technical component of the Water Plan is underway as well. A Programmatic Work Plan, scheduled for completion in late 2007, is being developed to:

- clearly define and document key goals and objectives for the Water Plan
- establish appropriate, sound, and accepted methods for developing technical aspects of the Water Plan
- define priorities for the Water Plan process and define a prioritized "roadmap" for phased completion of the Water Plan

Attached to this overview are two technical memoranda that describe proposed methods for the following two key aspects of the Water Plan:

- projections of future water demands (public water supply, agricultural, self-supplied industrial, and power generation)
- water supply availability

The proposed methodologies for demand projections draw on past OWRB analyses, updated data sets, and approaches used successfully in other statewide planning efforts. Projected demands will be evaluated in light of current and future water supplies to identify areas where water shortages are likely. Those areas will then be investigated in more detail, toward identifying water supply solutions that will address Oklahomans' water needs through 2060 and beyond.



The methods proposed are to be refined with input from stakeholders in the planning process. A separate technical memorandum describing the policy and technical approach to evaluating environmental instream flows is under development.

Upon confirmation, these technical approaches will be integrated into the Programmatic Work Plan, which will guide all technical activities associated with the update of the Water Plan. Initiation of major technical work consistent with the Programmatic Work Plan will commence in late 2007 and early 2008.

<u>Attachments:</u>

- *Technical Memorandum – Oklahoma Comprehensive Water Plan: Supply Availability and Gap Analysis*
- *Technical Memorandum – Proposed Water Demand Methodologies for the Oklahoma Comprehensive Water Plan*

Technical Memorandum
Proposed Water Demand Methodologies for the Oklahoma Comprehensive Water Plan
October 2007

This memo describes the proposed methodology for developing water demand forecasts for the Oklahoma Water Resources Board's (OWRB) Update of the Oklahoma Comprehensive Water Plan (Water Plan). The water demand forecasts are to be estimated for three primary water use sectors: municipal and industrial (M&I) use (public water supply systems, including rural residential use), self-supplied industrial and thermoelectric power use, and agricultural use. These sectors and their subsectors are listed in Figure 1.

Figure 1 Water Use Sectors and Subsectors

The OWRB has initiated a refinement of the county-level water demand forecasts since the 1995 Water Demand Update. This "refinement" demand forecast is in draft form and is discussed in detail in the memorandum as a potential source for use in the current Water Plan Update. The refinement, water demand forecast was estimated for M&I, thermoelectric power, and agriculture. This memo includes a preliminary review of the methodology of the refinement water demand forecast. Portions of the refinement draft forecast may be used for the current water demand forecast contingent upon a more thorough review of the refinement forecast input data.

Overview of Water Demand Forecasting Approach

The underlying methodology to be used in estimating future water demand is the *Driver Times Rate of Use* approach. This approach defines the water use of a given sector as some quantity of water use, such as gallons per day, per demographic unit multiplied by the number of demographic units, or drivers. As shown in Figure 2, the driver, or demographic unit, and the corresponding water use factor, can be defined independently for each sector. The selection of the appropriate unit and the water use factor depends upon the data available for each sector.

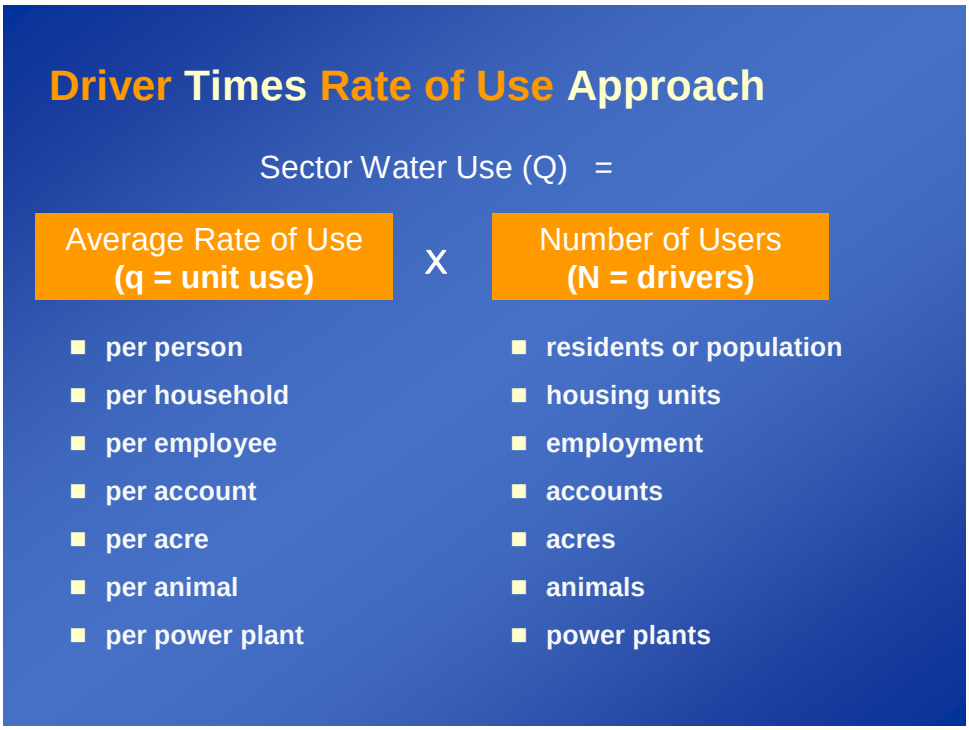


Figure 2 Driver Times Rate of Use Approach

The per unit rate of water use, or "little q," can be derived in a number of ways, as illustrated in Figure 3. The first projection methodology shown in Figure 3 which assumes a constant rate of use is often applied as the per capita method in which water use divided by population provides a constant per capita water use factor, which is then multiplied by future population. Similar per unit water use factors can be developed for most sectors given historical, or current, water use value and a defined demographic unit. Projection of future water demand then requires having projected values of the defined demographic unit. This method assumes that per unit water use is constant over time. This constant rate of use is the typical approach used in forecasting agricultural water demand where the per unit use is the water use per animal or water use per irrigated acre and the number of units is the number of livestock or acres of irrigated crop.

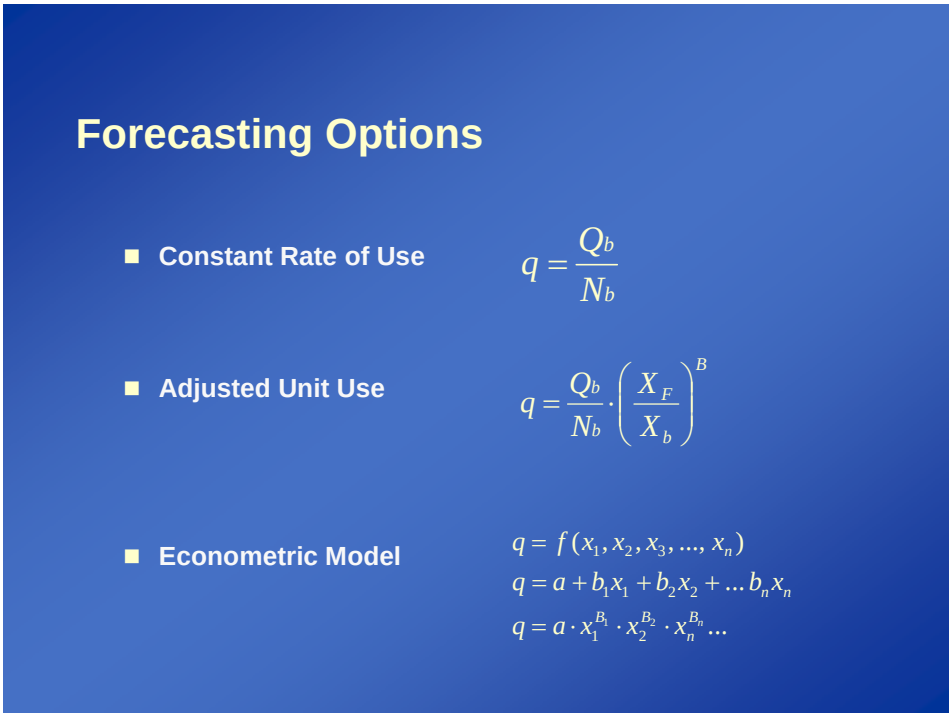


Figure 3 Forecasting Options

The second projection methodology shown in Figure 3 is a modified version of the constant rate of use in which "little q" varies in response to the variation in factors that could include temperature, precipitation, income, or the price of water. One such factor is represented in Figure 3 as X where X_b is the base year value, X_f is the future year value, and *B* is the elasticity of X. This model can be set up to provide variation in per unit use on a monthly basis, or over time throughout the forecast period.

The third forecast methodology shown in Figure 3 is one in which the per unit use is a function of an econometric model. This type of demand model can account for a variety of factors (represented in Figure 3 by *x* and coefficients) that affect the average rate of per unit use. The econometric model requires extensive historical data to develop the demand model, and requires projected future values of the individual explanatory variables.

As described below, county-level data were collected and used with the IWR-MAIN version 6.0 residential water demand models and nonresidential water use coefficients to estimate the M&I county water demands in the refinement draft forecast. The residential water use models of the IWR-MAIN water demand forecast software typically use well-defined econometric models to estimate the average water use per household. Alternatively, one can estimate a unique water demand model from site-specific historical data. Developing a custom set of econometric models of per unit water use for water use sectors in Oklahoma is not necessary for the purposes of the Water Plan update.

Municipal and Industrial (M&I) Water Use

Water demand for municipal and industrial use, also referred to as public water supply, is to be estimated at the system level. That is, current water demands are to be identified and future water demands are to be estimated given the service areas of public and rural water supply systems. There are more than 700 M&I (both public and rural) systems in the state.

Previous Forecast Approaches

M&I water demand in the OWRB refinement forecast was estimated at the county level using the Forecast Manager component of the IWR-MAIN Water Demand Management Suite, which is copyrighted software of Camp Dresser & McKee Inc. (CDM). The application of the IWR-MAIN software to estimate the county water demands was conducted by the U.S. Army Corps of Engineers, Tulsa District (USACE) with technical support provided by CDM. The water demand forecast used a base year of 2000 with projections at 10-year intervals to the year 2060.

The M&I water demand forecast was estimated for residential, commercial, and industrial water use sectors. The residential water use was driven by projected number of households per county and an average rate of water use (gallons per household per day) as estimated as a function of housing density, median household income, marginal price of water and sewer service, maximum monthly temperature, and total monthly precipitation.

Water use forecasts for the commercial and industrial sectors were driven by the projected number of employees within 3-digit employment groups for each county. The employment within each 3-digit employment group was multiplied by a corresponding water use coefficient in gallons per employee per day (ged). Figure 4 illustrates ged water use coefficients for the major employment groups. Note that the coefficients in Figure 4 are grouped by Standard Industrial Classification (SIC) codes, which were replaced by the North American Industrial Classification System (NAICS) codes in 1997.

The number of households per county, and number of employees per county, was derived from a special tabulation of county population projections prepared by the Oklahoma Department of Commerce (ODOC) in 2002, which extended the population projections to the year 2060. Table 1 shows the ODOC projections for Atoka County as an example. Note that the ODOC projections include populations for municipalities within each county in addition to the county total population. Also, in many counties there is a significant portion of the county population not identified with a particular municipality.

Selected Nonresidential Coefficients

Major Industry Group	SIC Codes	Water Use Coefficient (gallons/employee/day)*	
Construction	15-17	20.7	(244)
Manufacturing	20-39	132.5	(2,784)
Transportation, communications, utilities (TCU)	40-49	4.3	(225)
Wholesale trade	50-51	42.8	(750)
Retail trade	52-59	93.1	(1,041)
Finance, insurance, real estate (FIRE)	60-67	70.8	(233)
Services	70-89	137.5	(1,870)
Public administration	91-97	105.7	(25)

Source: Planning and Management Consultants, Ltd. (1996) IWR-MAIN©.
*The numbers in parentheses represent the sample number of establishments from which the water use coefficient was calculated.

Figure 4 Selected Nonresidential Coefficients

Table 1 Population Projections by City by County

	2000 Pop.	Projections											
		2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060
Atoka County	13,879	14,600	15,500	16,500	17,400	18,300	19,300	20,200	21,200	22,200	23,300	24,300	25,400
Atoka City	2,988	3,140	3,340	3,550	3,750	3,940	4,160	4,350	4,570	4,790	5,020	5,240	5,470
Caney Town	199	210	220	240	250	260	280	290	310	320	340	350	370
Stringtown	396	420	440	470	500	520	550	580	600	630	660	690	720
Tushka Town	345	360	390	410	430	450	480	500	530	550	580	600	630
Remainder of County	9,951	10,470	11,110	11,830	12,480	13,120	13,840	14,490	15,200	15,920	16,710	17,430	18,210

Oklahoma State Data Center - Oklahoma Department of Commerce
Special run of extra years for the Oklahoma Water Resources Board-November 2002

The USACE estimated the number of households by assuming the 2000 Census persons per household would remain constant through the year 2060. Total employment by county was estimated by assuming the 2000 ratio of employees to population would remain constant and that employment at the 3-digit level for each county would follow the same distribution as found in the 2000 County Business Patterns for each county. Table 2 shows the USACE estimates of housing and total employment for the Atoka County example.

Table 2 Atoka County Population, Housing, and Employment Projections

County		Year						
		2000	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Atoka	Population	13,879	15,500	17,400	19,300	21,200	23,300	25,400
	Housing	4,964	5,544	6,223	6,903	7,582	8,334	9,085
	Employment	3,259	3,822	3,992	3,793	4,344	4,726	5,101

Source: OWRB refinement draft Appendix 2 (Population), 3 (Employment) and 4 (Housing)

In addition to residential, commercial, and industrial subsector water use estimated from the projected housing and employment for each county, the refinement M&I demand for each county includes an estimate of water for unaccounted-for water (UAW). The UAW water use is estimated as a percent of total M&I water demand, which is derived from survey data for each county. Note that the American Water Works Association (AWWA) recommends that the terminology "unaccounted-for water" be replaced by the term "non-revenue water" since the introduction of the International Water Association/AWWA water audit format for accounting for all water within a system including real and apparent water losses.

The refinement draft report provides the resulting estimate of M&I water demand by county. As an example, the M&I demand for Atoka County is shown in Table 3.

Table 3 Projected M&I Water Use in Acre-Feet per Year

County		Year						
		2000	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Atoka	M&I	2273	2557	2799	2954	3287	3603	3917

OWRB refinement Update draft, Table 3.

Proposed Approach for Water Plan Update

CDM proposes that the refinement draft M&I water demand forecast by county be reviewed and used as a basis for estimating the M&I water demand forecasts by systems within each county. It is proposed that a detailed review of the water demand inputs be reviewed and compared with more recent data if available. The per unit estimates of gallons per household per day from the refinement forecast should be reviewed and compared with available system-level information on average residential water use. If the draft forecast inputs are deemed to be out-of-date, the demand forecast inputs will be revised and new estimates of county water demand will be generated.

A methodology for allocating the county-level water demand forecast to a system-level water demand forecast is outlined below. If available, system information provided in response to the USACE 2002 survey of water providers should be reviewed for information that may assist in refining the allocation of the county demand forecasts to the system level.

Figure 5 illustrates the water systems for Atoka County as shown in the OWRB Rural Water System Atlas. Note that the (yellow) corridor through Coal and Atoka Counties is the City of Oklahoma City access to both Atoka Reservoir and McGee Creek Reservoir in Atoka County and does not directly serve customers in Atoka County. The Rural Atlas also lists portions of water systems located in adjacent counties with service lines extending into small portions of Atoka County. Note that in the example of Atoka County, there are unserved portions of the county.

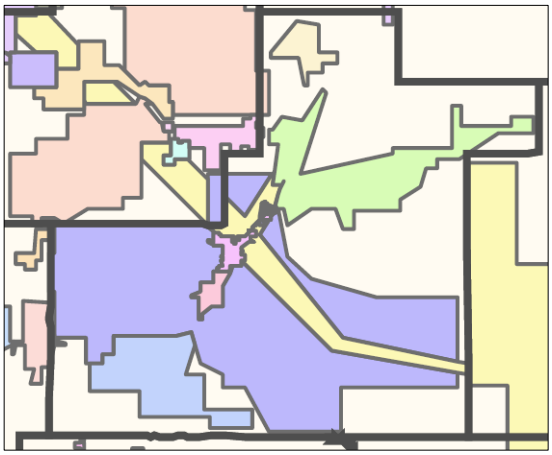


Figure 5 Atoka County Water Systems

Table 4 lists the community water systems listed in the OWRB/U.S. Environmental Protection Agency (EPA) Safe Drinking Water Information System (SDWIS). The SDWIS data includes the approximate population served by each system. In the example of Atoka County, the served population for the Town of Atoka Public Water System matches the 2000 population for the Town of Atoka shown in Table 1 above. In this example, the population served by the water systems listed in the SDWIS represents about 68 percent of the 2000 population for the county.

Table 4 SDWIS Data for Atoka County Community Systems

Water System Name	County(s) Served	Population Served	% of County Pop
ATOKA CO RWD # 1 (WARDVILLE)	ATOKA	125	0.9%
ATOKA CO RWD # 3 (CANEY)	ATOKA	506	3.6%
ATOKA CO RWD #2	ATOKA	225	1.6%
ATOKA COUNTY RWS & SWMD #4	ATOKA	3000	21.6%
ATOKA PWS	ATOKA	2988	21.5%
HOWARD MCLEOD CORR CENTER	ATOKA	550	4.0%
MACK ALFORD CORR. CENTER	ATOKA	1000	7.2%
STRINGTOWN PWA	ATOKA	1105	8.0%
sub-total		9,499	68.4%
County Total		13,879	
Remainder		4,360	

As illustrated in Table 5, the refinement draft M&I water demand forecast for each county can be distributed among systems within the county based on the percent of county population served by each system. However, as in the example of Atoka County, there is a significant portion of the county M&I water demand remaining after allocating water demand to the individual systems.

Table 5 County M&I Water Forecast in Acre-feet per Year by System

Water System Name	Year						
	2000	2010	2020	2030	2040	2050	2060
ATOKA CO RWD # 1 (WARDVILLE)	20.5	23.0	25.2	26.6	29.6	32.5	35.3
ATOKA CO RWD # 3 (CANEY)	82.9	93.2	102.0	107.7	119.8	131.4	142.8
ATOKA CO RWD #2	36.8	41.5	45.4	47.9	53.3	58.4	63.5
ATOKA COUNTY RWS & SWMD #4	491.3	552.7	605.0	638.5	710.5	778.8	846.7
ATOKA PWS	489.4	550.5	602.6	636.0	707.7	775.7	843.3
HOWARD MCLEOD CORR CENTER	90.1	101.3	110.9	117.1	130.3	142.8	155.2
MACK ALFORD CORR. CENTER	163.8	184.2	201.7	212.8	236.8	259.6	282.2
STRINGTOWN PWA	181.0	203.6	222.8	235.2	261.7	286.9	311.9
Sub-total	1,556	1,750	1,916	2,022	2,250	2,466	2,681
Remainder	717	807	883	932	1,037	1,137	1,236
Total M&I	2,273	2,557	2,799	2,954	3,287	3,603	3,917

The allocation of the county water demand among systems as illustrated in Table 5 assumes that the percent of county population served by each system remains constant into the future through 2060. This may not be true in cases where systems plan to expand their service areas, or new systems may be established in the future. Thus, the allocation methodology must be carefully reviewed given the projected populations of municipalities (see Table 1) and existing plans for system expansion within each county. Note that the county-level average water use per household will be assigned to each system within the given county.

It is important to note that the resulting OWRB estimates of future water demand by system are not intended to replace any water demand projections prepared by an individual water provider. The resulting OWRB estimates of future water demand by system are for regional planning purposes only and should not be construed as adequate for individual provider planning without further review.

To the extent possible, CDM will collect available water demand projections developed by individual water providers throughout the state for comparison purposes. If the OWRB update system projections are found to be significantly different than the existing individual provider projections, CDM and OWRB will examine these differences and determine if an adjustment to the OWRB system projections is warranted.

Self-supplied Industry and Thermoelectric Power

Available data for self-supplied industries, large water users, and thermoelectric power facilities provide information on the location of each facility. The refinement draft forecast identifies water demand for thermoelectric power facilities by county, based upon EPA, ODEQ, and the DOE Energy Information Administration (EIA) data. The EIA data include forecasts of power production and water usage for power production at the national level. The refinement estimates of water demand for

thermoelectric power assume that water use increases in constant (linear) proportion to increases in power demand.

The data and methodology used in the refinement estimates of thermoelectric power water demand should be reviewed in detail and updated if more recent data are available.

In addition, OWRB/EPA SDWIS data, OWRB permit data and other available information will be reviewed by county to identify large industrial water users not accounted for in the estimation of M&I water demand. Future water use for these facilities may be held constant at the current level, unless there is specific information indicating that additional capacity or facilities will be brought online in the future.

The water use projections for thermoelectric power facilities and large self-supplied industries can be located as specific points within a county.

Agriculture

Water use in the agricultural sector is typically separated between irrigation water use and livestock water use. Irrigation water use is estimated as the number of irrigated acres by crop type times the water use, typically in acre-feet per acre, by crop type. There are standard crop irrigation requirements that provide the water use requirements by crop type. The U.S. Census of Agriculture provides data on irrigated crop acreage by county.

The refinement draft water demand forecast incorporates agricultural water demand by county prepared in March 2003 for the State of Oklahoma by the Bureau of Reclamation (BOR) Great Plains Regional Office. The BOR agricultural water demand forecasts use a base year of 2000 and project agricultural water demand to the year 2060. The water demands are developed by livestock groups and crop irrigated acres. The irrigated acres are based on the 1997 Census of Agriculture. The highest number of irrigated acres by county from 1978 to 1997 was assumed as the 2060 future number of irrigated acres. The BOR crop water demand estimate used a crop irrigation requirement (CIR) factor that does not include delivery losses and on-farm losses. The USACE added an irrigation efficiency factor to the BOR irrigation demand to account for these water losses.

It is proposed that a detailed review of the BOR/USACE agriculture water demand forecasts by county be reviewed and updated if more recent data are available.

Unlike the M&I water demand forecast which is associated with system service areas or self-supplied users that can be associated with a specific point within a county, the agricultural water demand is associated with a general county area. It may be possible to utilize land use maps and geographic information system (GIS) to identify the agricultural areas of a county and thus more accurately allocate the county-level acreage and livestock data to respective areas of a county in order to align with

supply geographies (watersheds or aquifers). These land use maps and GIS can also be used to identify potential reductions in irrigated acres as the result of M&I or other development of these lands, to the extent that the land use maps identify future land use.

Average and Peak Water Use

It is not known at this time whether peak water use data were collected in the USACE system survey conducted in 2002. If data are available regarding system peak water use and average annual water use, then peak water demand for M&I use can be estimated. If monthly water withdrawal data are available, the seasonality of withdrawals can be inferred upon the demand forecast to provide estimates of peak month water demand by sector.

Consumptive and Nonconsumptive Water Use

Nonconsumptive water use by sector (M&I, self-supplied industry, and agriculture) will be estimated from the county level forecasts. The estimates of nonconsumptive use will be incorporated as return flows in the analysis of the supply/gap in future years.

Similar Statewide Planning Efforts

The proposed approach to developing the water demand forecast for the Water Plan Update is similar to the approach used in previous OWRB Water Plans in that M&I, self-supplied and agricultural water demands are estimated separately. The proposed approach is different in that the M&I water demand is to be estimated at the system-level rather than at the county-level.

A similar, but less refined approach was used to develop the statewide water demand forecast for the recent Colorado Statewide Water Supply Initiative (SWSI). The approach used in the SWSI estimated county-level M&I water use on a per-capita basis, with the addition of known self-supplied water use (including thermoelectric power use), and county-level agricultural water use estimates. The county demand forecasts were aggregated up to major basin-level water demands for comparison with available and future supply at the basin level.

A similar approach was also developed for the State of Pennsylvania in which M&I water demand is estimated at the system level with estimates of self-served domestic use estimated for the unserved portions of each county. Thermoelectric power water use is location specific and agricultural water use is estimated at the county level. The M&I, power and agricultural water demands were allocated to relatively small hydrologic units using GIS for comparison with USGS streamflow data. The approach was piloted in one major basin of the state.

Technical Memorandum
Oklahoma Comprehensive Water Plan: Supply Availability and Gap Analysis
October 2007

The Oklahoma Water Resources Board (OWRB) has initiated the development of a major update to the Oklahoma Comprehensive Water Plan (Water Plan). Primary among OWRB's goals for the Water Plan is to forecast water uses and supplies through 2060, which in turn will facilitate identification of future water supply shortages and methods to address those shortages.

The Water Supply Availability and Gap Analysis component of the Water Plan will be critical to achieving those objectives. The Water Supply Availability and Gap Analysis uses and builds upon demand forecasts that will be developed in separate Water Plan tasks. This technical memorandum describes the proposed approach for the Water Supply Availability and Gap Analysis, which in turn will be used in the development of the Programmatic Work Plan.

Background and Objectives

Since the 1995 Water Plan Update, OWRB has developed preliminary updates to statewide water supply and demand projections. These updates provide an excellent overview of known data and past studies with respect to supply availability in the state, as well as updated County-level demands. Surface water supply availability for future growth was estimated based on a series of independent reservoir yield studies for the major reservoirs in the state. Groundwater availability was quantified based on estimates of current recoverable yields and recharge rates associated with the major aquifers in the state using parameter values applied uniformly across each major aquifer.

While the approaches employed in recent work provide adequate characterization of supply availability at a gross level, they do not provide sufficient information to meet OWRB's goals for the Water Plan update in a number of areas, as listed below.

1. Independent reservoir yield estimates fail to account for competition and dependencies among water providers and stream basins. In other words, the projected growth of water provider A may affect the future water supply available to water provider B, and this is not captured in the recent estimates.
2. Independent reservoir yield estimates did not account for interstate compacts.
3. Consistency in methods and key assumptions, such as the historical drought record used for firm yield calculations, from the independent reservoir yield studies.
4. Supply versus demand analyses were performed at a coarse spatial resolution (planning district or county level).

5. The groundwater recoverable yield analyses do not take into account current groundwater levels which in many cases will reduce recoverable yield estimates.

6. A number of important elements were omitted from the supply availability planning estimates, including:
   - Decline in groundwater levels over time, reducing future recoverable yield estimates
   - Surface-groundwater interactions (e.g., stream depletions from groundwater pumping)
   - Potential impacts of climate change on surface supplies
   - Environmental flow considerations.

The proposed approach will address the items listed above and provide an accurate and comprehensive forecast of the state's water resources through 2060. The Water Plan will identify future water supply "gaps" (demand exceeding supply) at a water provider level, develop and apply a common approach for system yield and reliability estimates, identify areas of future competition for surface and groundwater, and quantify significant surface-groundwater interactions. Even though Oklahoma water law does not consider the impact of groundwater pumping on surface water flows for purposes of permitting, prudent planning of future water supply availability must consider the physical interconnection of these sources.

The Water Plan will also provide screening level evaluations of project alternatives to address identified gaps, including yield calculations and costing. The results of this study will provide guidance to OWRB on policy change investigations, funding prioritization, and identification of opportunities for regional and inter-basin cooperation and planning. Finally, a key component of this study will be the development of tools and methodologies that can be employed by OWRB and individual water providers for future use.

Methods

The flow chart presented in Figure 1 summarizes the proposed approach for analyzing supply availability and quantifying supply gaps at a statewide level. The guiding principles for this effort will be that the work is:

- Data centered, when possible (as opposed to conceptual)
- Publicly accessible and transparent
- Peer and stakeholder reviewed
- Consistent in methodology
- Well-documented and reproducible
- Adaptable for future considerations

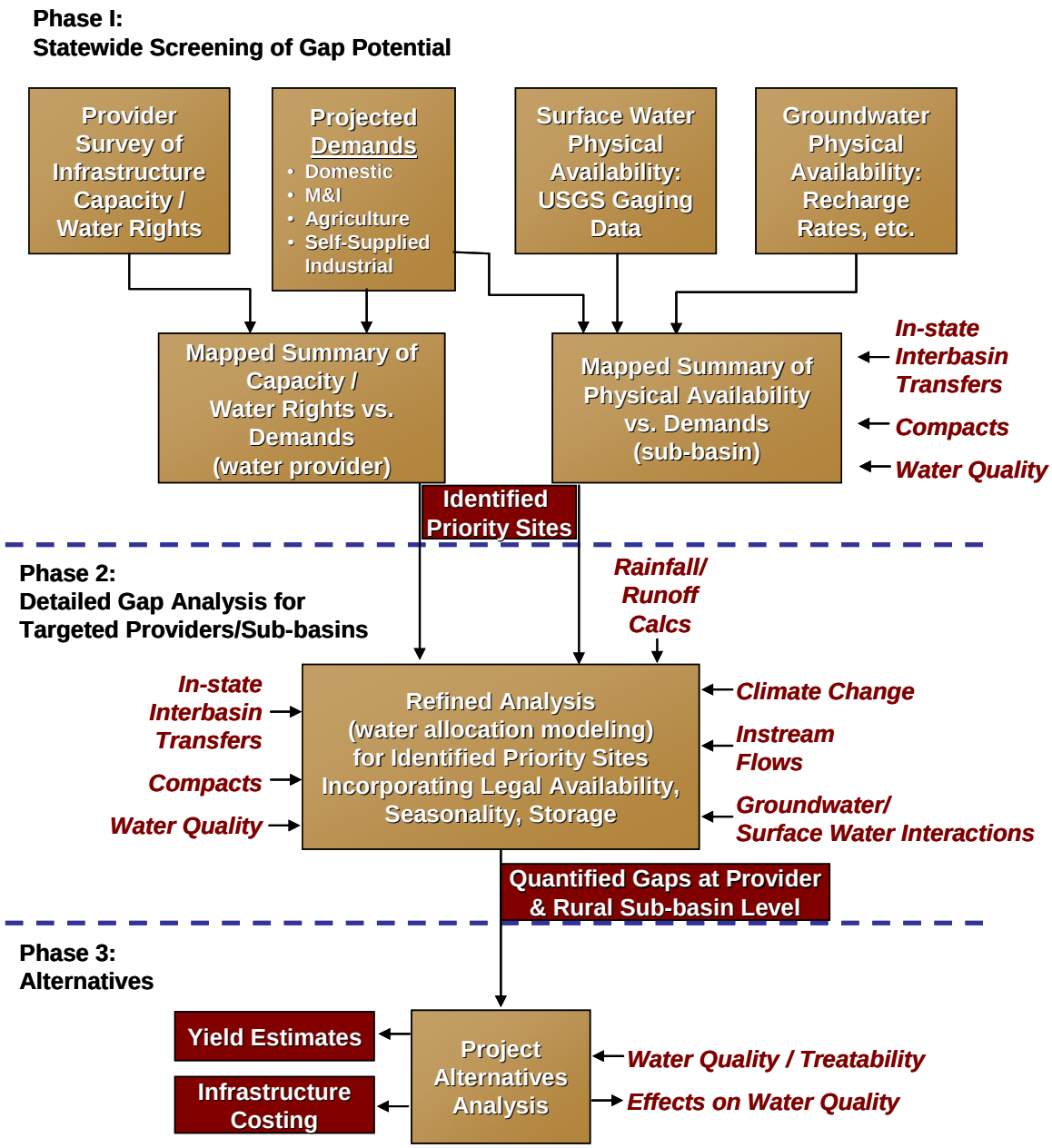


Figure 1
Summary of Overall Technical Approach

A phased approach is proposed as a way of effectively executing this challenging study, as well as focusing efforts and funding during the process. As shown in Figure 1, the three proposed major phases consist of:

- Statewide screening assessment and survey
- Detailed gap analysis by water provider
- Water provider project alternatives and scenario analyses

Each phase is discussed in detail below.

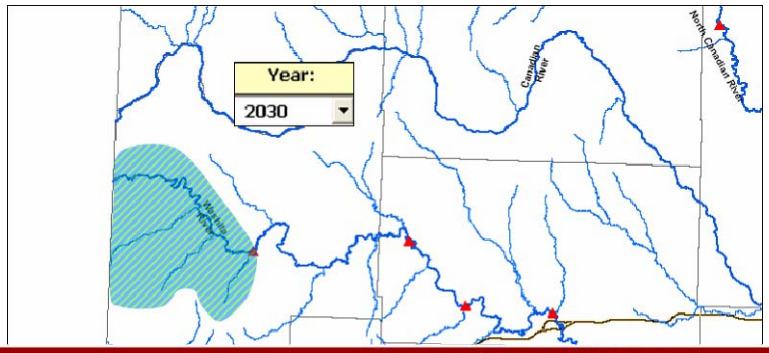
Phase 1: Statewide Screening
The objective of the Phase 1 screening analysis is to provide regional summaries of projected supplies and demands at locations across the state in order to identify locations of potential surplus and shortfall (gap). The key end product of the statewide screening analysis will be coarse projections of supply gap or surplus at the targeted locations. There will be two sets of projections—one based on physical water availability ("wet water") and the other based on infrastructure and water rights constraints. Both sets will be summarized on an annual basis. Examples of the types of tabular summaries that might be generated from this analysis are provided in Figure 2. Graphical summaries of this type of information will also be generated.

As part of this work, we envision developing a GIS mapping tool that is both visual and interactive and provides these types of summaries for any user-selected available target point. This tool will be easily updated (e.g., with new population projections or trans-basin supply projects) and may prove useful for statewide planning beyond this study. Details of the calculations are provided below.

Water demands for this phase of the analysis will be based on aggregated/disaggregated projections at both the hydrologic sub-basin and water provider level. Details of this methodology are provided in a separate document.

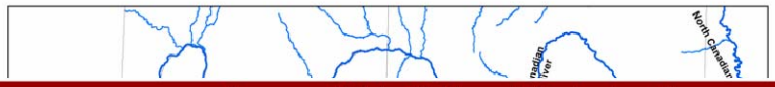
The first set of surplus/gap summaries, aggregated by hydrologic sub-basin, will be based on physical water availability ("wet water"). Both surface and groundwater will be included in these estimates. Hydrologic sub-basins will be delineated according to existing USGS flow gages. Each flow gage with at least 10 years of recent data will be used to define sub-basins for the analysis, with gap/surplus summaries provided for each associated sub-basin. In other words, if all 186 of the active USGS flow gages currently identified for Oklahoma meet the specified period of record criteria, then 186 sub-basin summaries will be developed.

a) Wet Water



USGS Gage XXXXXX Example River Headwater											
	Available Surface Supply (AFY)	*2030 Groundwater Supply (AFY)*	*Current Groundwater Supply (AFY)*	*Planned Interbasin Transfer (AFY)*	*Compact Obligation (AFY)*	*Tribal Rights (AFY)*	*Gross 2030 Demand (AFY)*	*Current Demand (AFY)*	*Total Available Supply (AFY)*	*New 2030 Demand (AFY)*	*2030 Wet Water Gap / Surplus (AFY)*
Avg Year	10,000	1000	1000	+500	0	100	16000	8000	10,400	8000	(+)2400
Wet Year	15,000	1500	1000	+500	0	100	15200	7600	15,900	7600	(+)8300
Dry Year	4000	500	1000	+500	0	100	17600	8800	3900	8800	(-) 4900

b) Infrastructure and Water Rights



Summary of Water Rights and Infrastructure Gap Water Provider A						
Projected Annual Demand (AFY)	*Current Water Rights (AFY)*	*Current Infrastructure Firm Yield (AFY)*	*Projected Peak Day Demand (MGD)*	*Current Infrastructure Hydraulic Capacity (MGD)*	*Current Infrastructure Treatment Capacity (MGD)*	*Water Quality Constraint?*
5000	6000	4000	10	8	15	No

Figure 2
Hypothetical Statewide Water Availability Screening Summaries

The surface water physical availability associated with each sub-basin will simply be based on the recent (last 10 years) historical gage record at the downstream end of the sub-basin. Recent flow data will be used in order to reflect current surface water allocations and depletions. Annual totals will be provided for wet (maximum of the 10-year period), dry (minimum), and average (median) conditions. These conditions will be compared to longer-term data to characterize the recent flows compared to the full period of record. Additionally, OWRB will coordinate with the Grand River Dam Authority to obtain information about river diversions in the Grand River sub-basin.

The analysis will account for demands outside the sub-basin satisfied by sources within the sub-basin and demands within the sub-basin satisfied with water "imported" to the sub-basin. In Figure 2a this is captured by the " interbasin transfer" column.

Estimated groundwater yields will also be included in the summaries for each sub-basin of physical supply availability. The capacity for future groundwater yield will be estimated using two methods: based on current trends of usage that will increase in proportion to projected population growth, and based on maintaining aquifer water levels at current levels so the amount of allowable groundwater usage will equal previously published recharge rates for the given aquifer. For the latter method, annual recharge rates will be multiplied by the areas of the delineated sub-basins to arrive at a volumetric rate. Current groundwater supply to the given basin will be compared to these recharge rates to arrive at a projected aquifer yield potential, which in some locations will mean a reduction in groundwater use. Identified trans-basin supply projects (existing or planned), and interstate compact obligations will be included in this analysis. Final summaries for a given target year, will provide a comparison of projected new demand versus physical water supplies available to meet those demands (Figure 2 a).

It is important to note that the "wet water" projections described above are annualized and therefore do not reflect seasonal variations in available surface supply versus demands. Adequate storage may be needed to fully meet demands throughout a given year. To address this limitation and to provide useful capacity information at a water provider level, statewide summaries of infrastructure and legal (water rights) constraints will be developed. A survey of all major public water supply providers will serve as the basis of this analysis. Based on the survey response, summaries of existing water rights and infrastructure capacities, including reservoir firm yields, for each responding water provider will be developed in relation to projected demands (Figure 2 b). Additionally, a qualitative consideration of surface and ground water quality will be included in these summaries. Areas of known water quality with a potential to significantly constrain available supplies or drive treatment costs up, particularly with respect to total dissolved solids in surface waters and nitrates in groundwaters, will be "flagged" for additional investigation. The identification of these areas will be based on the results of the water provider surveys, previous studies and knowledge, and review of available water quality database.

All of this information will be incorporated as another layer in the developed GIS tool. For those water providers with surface storage that report their firm yield as "unknown," firm yield calculations will be performed by the state as part of this work plan. We will assume that water providers that do not respond to the survey do not need further investigation, with respect to water rights and infrastructure capacity, as part of this study. However, we envision a second, follow-up, survey to be sent out after draft completion of Phase 1, with summaries of preliminary results, to give water providers a second opportunity to respond.

Finally, as part of this sub-task, prioritized sites will be identified throughout the state with respect to identified potential shortfalls. These sites, either sub-basins or specific water providers, will be the focus of the next phases of the study described below. Areas of significant surplus will also be identified based on the summaries described above and may feature in the next phases as potential sources of trans-basin supply water. Subsequent analyses (Phases 2 and 3) may also include areas considered of high importance for reasons unrelated to this analysis.

In addition to the gap analyses and tool development described above, informative graphical summaries of physical water availability, both groundwater and surface water, at selected locations will be developed for the Water Plan. These summaries will likely include time-series plots of surface water flows, both monthly and annual, to illustrate inter-annual and seasonal physical water availability fluctuations and "firm yield" plots to demonstrate the importance of storage in capturing and utilizing these fluctuating flows.

The approach outlined here for Phase 1 represents a refinement of past planning approaches. Specifically, surface water availability estimates will be improved by:

- Relying on stream gage data, which reflect the networked competition for supplies in the state
- Incorporating compact obligations
- Applying a consistent methodology at a smaller spatial scale (sub-basin).

Groundwater availability estimates will be improved by applying refined techniques for estimating future recoverable yields using historical water level data and trend analyses. Finally, specific water provider supply constraints will be identified through the proposed survey.

Phase 2: Detailed Gap Analysis

Phase 2 of the study will involve more refined calculations of the projected water supply gaps identified in Phase 1. Specifically, this level of analysis will incorporate seasonality in supply availability and demands, infrastructure, and legal availability. This will primarily be achieved through the use of water allocation models. Models will be developed to simulate the allocation, delivery, storage, consumption, and

return flow of surface and groundwater at a local and/or regional level. Simulations will be performed on a monthly timestep and will include infrastructure constraints, water right priorities, and seasonal variation in supply and demands. Models will be developed for each of the prioritized sites with shortfalls identified in Phase 1. The spatial scale of each developed model will be guided by the results of the Phase 1 analysis. In some cases, models will be developed to include a single major water provider or rural sub-basin. In other cases, the spatial domain may need to be extended to include multiple providers to explicitly capture interdependencies among providers and/or rural users.

Rainfall-runoff calculations may be needed to support the water allocation modeling in areas where surface water data are limited. Groundwater-surface water interactions will be explicitly modeled, where the potential is deemed significant, as part of this sub-task. If these interactions are not explicitly included in the selected water allocation modeling software (described below), a form of the Glover analytical equation will likely be applied outside of the model. Additionally we recommend a subset of the modeled systems be used to investigate and demonstrate the potential range of impacts of climate change and environmental flow prioritization on gap projections. Climate change perturbations will likely involve modifications to existing stream hydrographs based on gross approximations of climate change impacts as described in the scientific literature. The proposed approach for evaluation and quantification of environmental (instream) flow targets as part of the Water Plan is described in a separate document. Incorporating these targets will likely involve adding hypothetical priority instream flow rights, based on the established targets, to the given water allocation model.

A summary of available water allocation modeling software is provided in Table 1. A preliminary "scoring" of these models, as they might be applied to the Phase 2 evaluations, is provided in Table 2. Scoring is based on a scale of 1 to 5 (least to most desirable, respectively) assigned to specific model features and a "weighting" of the relative importance of each category of feature (using the same scale). It should be noted that all values shown are preliminary and were assigned based on CDM's experience and professional judgment, without input from OWRB, stakeholders, or technical peer review. Scores were based on several factors, focused on meeting OWRB's goals and objectives for the Water Plan update.

Table 1 Comparison of Water Allocation Modeling Software

	SWAM[1]	RiverWare[2]	WEAP[3]	WRAP[4]	MODSIM[5]
License Cost	Free	$6,500 + $2,500/year	$2,500/ project	Free	Free
Relative Cost of Model Construction	Low	High	Medium	High	High
Technical Support	High	High	High	Low	Low
Graphical User Interface	Yes	Yes	Yes	No	Yes
Level of Sophistication	Low	High	High	Medium	High
Ease of Use	High	Low	Medium	Low	Low
Flexibility	High: Can easily adapt code	High: Rule-based simulation	Medium	Low	Medium: Reservoir targets / PERL scripts
Timestep	Monthly	Hourly to annual	Daily to monthly	Daily to monthly	Daily to monthly
Permitting/Operational Support	No	Yes	Yes	Yes	Yes
Operational Support	No	Yes	No	No	Yes
Max Spatial Scale	Reach/sub-basin	River basin	River basin	River basin	River basin
Rainfall-runoff	No	No	Yes (but can also use gage data)	No	No
River Routing	No	Yes	No	No	Yes
Water Rights	Yes	Yes	Yes	Yes	Yes
Groundwater	Stream depletions in development	Storage only	Recharge/ seepage/ depletions	No	Glover equation for return flows (infiltration)
Water Quality	No	Yes: temp, TDS, DO	Yes: DO, BOD, conservative, first order	Yes: salinity	Yes: salinity
Instream Flows	Yes	Yes (rule-based simulation)	Yes	Yes	Yes
Demand Management	Yes: conservation & reuse	No	Yes: conservation & reuse	No	No
Suitability for Water Provider Use	High	Low	Medium	Low	Low

[1] Simplified Water Allocation Model, CDM
[2] CADSWES / U.S. Bureau of Reclamation (USBR)
[3] Water Evaluation and Planning System, Tellus Institute, Boston, Massachusetts
[4] Water Rights Analysis Package, State of Texas
[5] CSU / USBR

TDS = total dissolved solids
DO = dissolved oxygen
PERL = Practical Extraction and Report Language (a simple user programming language)

Table 2 Comparison of Water Allocation Modeling Software: Relative Scoring (scale of 1 to 5, feature score x feature weighting)

Feature Weighting	SWAM	RiverWare	WEAP	WRAP	MODSIM
License Cost(4)	5	1	3	5	5
Relative cost of model construction (5)	5	1	3	1	1
Technical Support (5)	5	5	5	1	1
Graphical User Interface (5)	3	5	5	1	3
Level of Sophistication (2)	1	5	5	3	5
Ease of Use (5)	5	1	3	1	1
Flexibility (4)	5	5	3	1	3
Timestep (0)	1	1	1	1	1
Permitting / Operational Support (3)	1	5	5	5	5
Operational Support (1)	1	5	1	1	5
Max Spatial Scale (4)	3	5	5	5	5
Rainfall-runoff (2)	1	1	4	1	1
River Routing (1)	1	5	1	1	5
Water Rights (0)	1	1	1	1	1
Groundwater (4)	3	1	4	1	2
Water Quality (2)	1	5	5	4	4
Instream Flows (4)	5	4	4	4	4
Demand Management (4)	5	1	5	1	1
Suitability for Water Provider Use (4)	5	1	3	I	1
TOTAL:	**225**	179	**233**	125	159

The highest scoring models of those reviewed are WEAP and SWAM. We recommend that these two modeling tools be used jointly in this study. WEAP is recommended for developing models where:

- System components exceed the intended limit in SWAM (e.g., large number of users, large spatial domain required)
- Specific system complexities (e.g., hydropower calculations, explicit aquifer simulations) are better represented, as compared to SWAM
- Rainfall-runoff calculations are needed

The developed WEAP models will be licensed to OWRB and may serve as the foundation for future water permitting and appropriations model development. The simplified model, SWAM, is recommended where:

- Smaller spatial domains with fewer components are appropriate
- Groundwater supply and impacts on surface water can be adequately simulated using indirect methods external to the model
- Measured flow records are adequate (rainfall-runoff calculations are not needed)

- System complexities exist that are not currently included in either SWAM or WEAP (SWAM will be adapted to address the specific need)

Models developed as part of the Water Plan may be reviewed by targeted technical review teams. SWAM will be available for distribution to OWRB and other state agencies, individual water providers, and rural districts for their own future planning studies.

Phase 3: Alternatives Analysis
The water allocation models developed in Phase 2 will be used to investigate supply alternatives to meet quantified shortfalls. For each of the water providers with a projected shortfall, simulations will be performed to quantify the yields associated with project alternatives such as:

- Increased storage
- Increased delivery/diversion capacity
- Improved treatment capability/capacity
- Trans-basin water supply projects
- Water rights acquisition
- Conservation programs
- Reuse programs
- Water transfers and other market-based options.

Screening level costs will also be developed for each project alternative. Water quality, especially that of the surface waters in the western portion of the state, may feature significantly in this analysis due to treatment costs. As part of this subtask, it is recommended that a subset of the investigations include quantification of the impacts of new projects on environmental flows and/or the impacts of new projects on water quality. SWAM appears to be better suited for the former, while WEAP is better suited for the latter. These exercises will serve both to provide insight into the relationships and dependencies among these differing water resource goals and as demonstrations of potential methods for future work.

It is recommended that a single sub-basin undergo the Phase 2 and Phase 3 analyses in the first year of study. Implementing the full range of proposed analyses on a single basin will highlight issues needing additional effort or refinement prior to applying the methods on a statewide level.

Comparison to Other Statewide Planning Efforts

The 2007 Texas State Water Plan focuses on fifteen major river basins and thirty major aquifers with respect to quantifying regional water supply availability. Both surface and groundwater regional availability estimates are based largely on statewide numerical models developed over a number of years. Surface water summaries are provided for each of the fifteen major river basins. Summaries include average annual gaged river flow (downstream end of basin), major reservoir capacities and yields,

and projections of future total supplies (existing yields + future projects + available unused resources) under the drought of record. River basin water allocation models, given current and planned infrastructure and permitting, were used to estimate reservoir yields and predict future supplies. Groundwater supplies are handled with separate analyses that used previously-developed groundwater models for each major aquifer to predict future trends in groundwater levels and total supply availability. Water needs (or gaps) are summarized according to sixteen geographic planning regions by comparing projected supplies to projected demands for these regions. Projected supplies for these planning regions appear to be estimated using independent reservoir yield calculations and groundwater yield projections, given current and planned infrastructure.

The 2004 Colorado Statewide Water Supply Initiative (SWSI) quantified supply availability in eight major river basins. Surface supply availability estimates rely heavily on previously-developed river basin water allocation models, where available. For those basins with models, average annual surface supplies (physically and legally available) were summarized at five or six selected locations within the basin. In addition, annual and monthly timeseries plots of predicted legally available river flows were generated. For those basins without developed models, surface supply summaries rely heavily on USGS stream gage data. Groundwater supplies are discussed only with respect to the physical and hydraulic characteristics of the major aquifers in the state. Key issues associated with both confined and unconfined aquifers are identified and briefly discussed, including stream depletions and declining water table levels. Future water needs (or gaps) were estimated based on projected additional demands and specific planned water provider projects (additional future demands – planned supply projects = gap).

Many of the components of both the Texas and Colorado water supply planning methods are common to the supply availability and gap analysis methodology proposed here for Oklahoma. All three methods rely on available regional surface and groundwater historical data, significant input from individual water providers, particularly with respect to existing and planned supply projects, and some form of water allocation modeling. However, neither the Texas nor Colorado plans integrate their basin supply availability analyses (physically and legally available water) with current and planned infrastructure and projected demands in the form of alternatives analyses. Part of this reason behind this was undoubtedly the lack of useable and simplified tools to achieve these types of analyses at the water provider level within budget and schedule. In this respect, the phased approach, and development of tools, proposed here represents a significant improvement on these studies that is directed toward achieving OWRB's goals for the Oklahoma Comprehensive Water Plan.