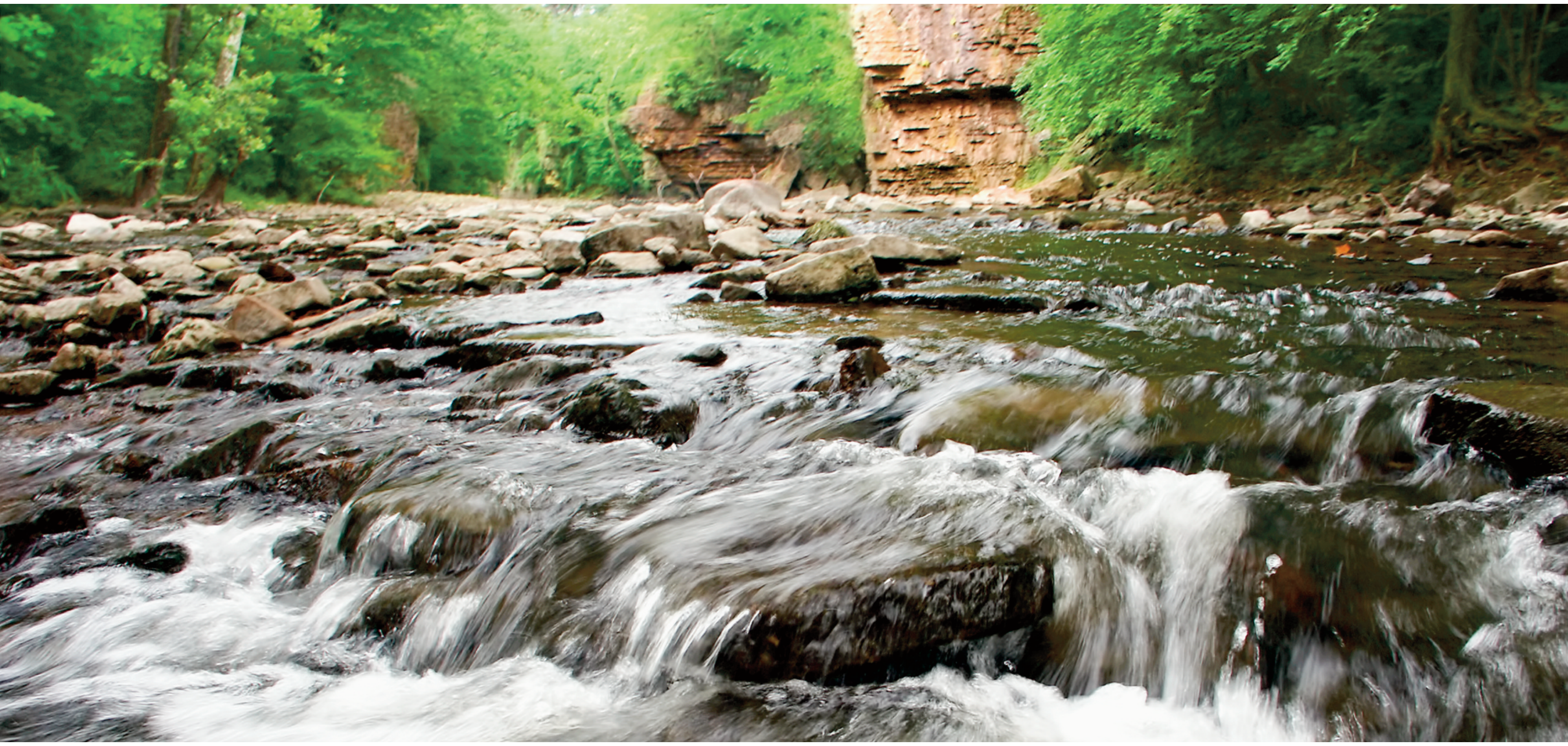
State of Illinois
Department of Natural Resources

CONTRACT REPORT 2019-01
January 2019

WATER DEMAND IN THE KANKAKEE WATER SUPPLY PLANNING REGION, 2010-2060

Scott C. Meyer, P.G. • Benedykt Dziegielewski
Zhenxing Zhang • Daniel Abrams • Walton R. Kelly



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Illinois Department of Natural Resources
Office of Water Resources

CHAMPAIGN, ILLINOIS

Printed by Authority of the State of Illinois • DNR-OWR-19-0085 • 12/18 • IOCI 19-0390

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Provisional Report

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Executive Summary

Estimates of water demand in the Kankakee River Water Supply Planning Subregion were developed for the period 2010 to 2060. The estimates were developed separately for five major water demand sectors: (1) public supply; (2) self-supplied domestic; (3) self-supplied thermoelectric power generation; (4) self-supplied industrial and commercial; and (5) self-supplied irrigation, livestock, and environmental. Estimates were developed for all sectors on a county level and for public supply at a facility level for 12 dominant public systems, including the largest systems in each county.

The techniques used to develop estimates differed by sector and included unit-demand methods and multiple regressions. These methods provided estimates of future demand as a function of demand drivers and explanatory variables for many sectors and subsectors. Explanatory variables are those that influence unit rates of water demand, such as summer-season temperature and precipitation, median household income, marginal price of water, employment-to-population ratio, labor productivity, and precipitation deficits during the irrigation season. For most sectors and subsectors, total demand was estimated by multiplying unit rates of water demand by demand drivers. Demand drivers included such measures as population served by public systems, population served by domestic wells, number of employees, gross thermoelectric power generation, irrigated cropland acreage, irrigated golf course acreage, and head counts of various livestock types.

For each sector, three scenarios were developed of future water demand that reflect different sets of plausible socioeconomic and weather conditions. These include a less resource intensive (LRI) scenario, a current trends (CT) (or baseline) scenario, and a more resource intensive (MRI) scenario. A “normal” climate, based on 1981-2010 climate “normals,” was assumed in all scenarios. Although the estimates suggest a plausible range of future demands, they do not represent forecasts or predictions nor indicate upper and lower bounds of future water demand. Different assumptions or different future conditions could result in predicted or actual water demands that are outside of this range.

Total water demand in the Kankakee subregion was an estimated 39 million gallons per day (Mgd) in 2010. The largest demand sector was public water supply. Public water demand was 18.0 Mgd in 2010, about 46 percent of the total regional demand. Most of that demand occurred in Kankakee County (14.3 Mgd).

The next largest sector was self-supplied irrigation, livestock, and environmental (ILE). ILE demands were 13.2 Mgd in 2010, with most of that in Kankakee County (9.3 Mgd). Demands for self-supplied industrial-commercial and self-supplied domestic were 5.3 Mgd and 2.6 Mgd, respectively, in 2010. As with the other sectors, the majority of the demand was in Kankakee County. Because there are no thermoelectric power-generating facilities in the region, there is currently no demand for that sector.

From 2010 to 2060, total demand in the region is estimated to increase by 1.6 Mgd under the LRI scenario, 14.6 Mgd under the CT scenario, and 36.0 Mgd under the MRI scenario. The largest increase for all three scenarios is expected in the ILE sector, primarily irrigated cropland. A smaller increase is expected in the industrial-commercial sectors for all three scenarios. Public supply demand is expected to increase under the CT and MRI scenarios, but decrease slightly under the LRI scenario. Self-supplied domestic demands decrease under all three scenarios. For the CT and LRI scenarios, there are no estimated demands for thermoelectric power generation.

For the MRI scenario, it was assumed that a single plant would come online in 2020, with a constant annual demand of approximately 11 Mgd between 2020 and 2060.

Three climate change scenarios, ranging from hot/dry to warm/wet, were analyzed to determine the impact that increasing temperature and changing precipitation patterns could have on water demands. Public water system demands were calculated to increase between 6.9 and 10.0 percent because of climate change, and increases in domestic demands were similar. Irrigation demands varied from a decrease of 2.5 percent in a wetter future environment to an increase of 10.7 percent in a drier environment. The impact of periodic droughts was also examined. For a severe drought, public water system demand was calculated to increase by 13.2 percent and cropland irrigation demand by 36.6 percent. Demands would return to normal once the drought ended.

1 Introduction

1.1 Background

Two important requirements in water supply planning and management are the knowledge of the amount of water that is currently used and that will be required in the future, and the availability of existing and potential sources of supply. Although Illinois is endowed with abundant water resources, the availability of water supplies is a concern in some regions of the state. In some areas, water demands have been increasing while water availability is limited because of court-ordered limits on water allocation, minimum flow requirements, or local hydrological conditions, especially during periods of drought.

In an effort to avert potential future water resources problems, state agencies and the Illinois State Water Survey (ISWS) prepared the *Illinois State Water Plan* reports that identified the need for long-term water supply and demand projections for the state (Illinois State Water Plan Task Force, 1984). Following these earlier efforts, a Strategic Plan for Implementation of Statewide Water Supply Planning (SWSP) was developed in 2008 in response to Illinois Executive Order 2006-01. The plan has been used to facilitate the development of three regional water supply plans to date. Recently, an updated Action Plan for Statewide Water Supply Planning was developed by the Illinois Department of Natural Resources (IDNR) in consultation with the ISWS to create a State of Illinois Water Supply Plan with all of the necessary components of regional and statewide plans. This report covers one of the regional components of the assessment of water demands.

1.2 Purpose and Scope

The purpose of the project is to prepare future water demand scenarios for all major user sectors in the Kankakee Watershed Water Supply Planning Subregion. This subregion overlaps two of the state’s water supply regions, Northeastern Illinois and East-Central Illinois. The Kankakee subregion was supposed to be included in the Northeastern Illinois regional water supply planning process, but because of insufficient resources, the subregion was not fully evaluated during the initial study. When resources became available to study the Kankakee Watershed, it was decided to expand beyond Kankakee County and include the entire watershed, which includes northern Ford and Iroquois Counties. Because some data needed for determining water demands are only available at a county level, we decided to include the entire counties (Ford, Iroquois, and Kankakee) in the Kankakee subregion (Figure 1.1).

Water management in this region is of significant importance, partly because of the conflicts in water use during the 2012 drought. A comprehensive regional water supply assessment process to identify future water needs and viable water supply sources is essential for the future sustainable economic development of the region. Note that Kankakee County was previously investigated as part of a water demand estimation effort for the Northeastern Illinois Water Supply Planning Region (WSPR), and Ford and Iroquois Counties were previously investigated as part of the East-Central Illinois WSPR. We have concurrently developed this report, which covers the Kankakee subregion, with reports discussing water demand in two other WSPRs, the Middle Illinois and the Rock River regions (Figure 1.1).

Estimates of water demand in the Kankakee subregion from 2010 to 2060 were developed separately for each of the five major water demand sectors: (1) public supply; (2) self-supplied domestic; (3) self-supplied thermoelectric power generation; (4) self-supplied industrial and commercial; and (5) self-supplied irrigation, livestock, and environmental.

Estimates were developed for all sectors on a county level, but estimates of demand for public supply were also developed at a facility level for 12 dominant public systems, including the largest systems in each county. The future demand scenarios (defined later in this chapter) represent water withdrawals under current trends as well as under less and more resource intensive demand assumptions. The three scenarios focus only on off-stream uses of water in the region and do not include the future water needs for aquatic ecosystems or other in-stream uses.

It should be noted that this report is considered to be “provisional.” Typically during the regional water supply planning process, a regional water supply planning committee (RWSPC) is formed, consisting of major stakeholders in the region. One of the tasks of the RWSPC is to provide local knowledge on current and future water demands in the region and comments on the water demand report prepared by the ISWS. Unfortunately, an RWSPC had not been formed for the Kankakee subregion at the time of publication of this report. Therefore, it has not been reviewed by entities and individuals in the region. As a result, we have labeled this demand report “provisional” until such time that a RWSPC is formed and can review the report.

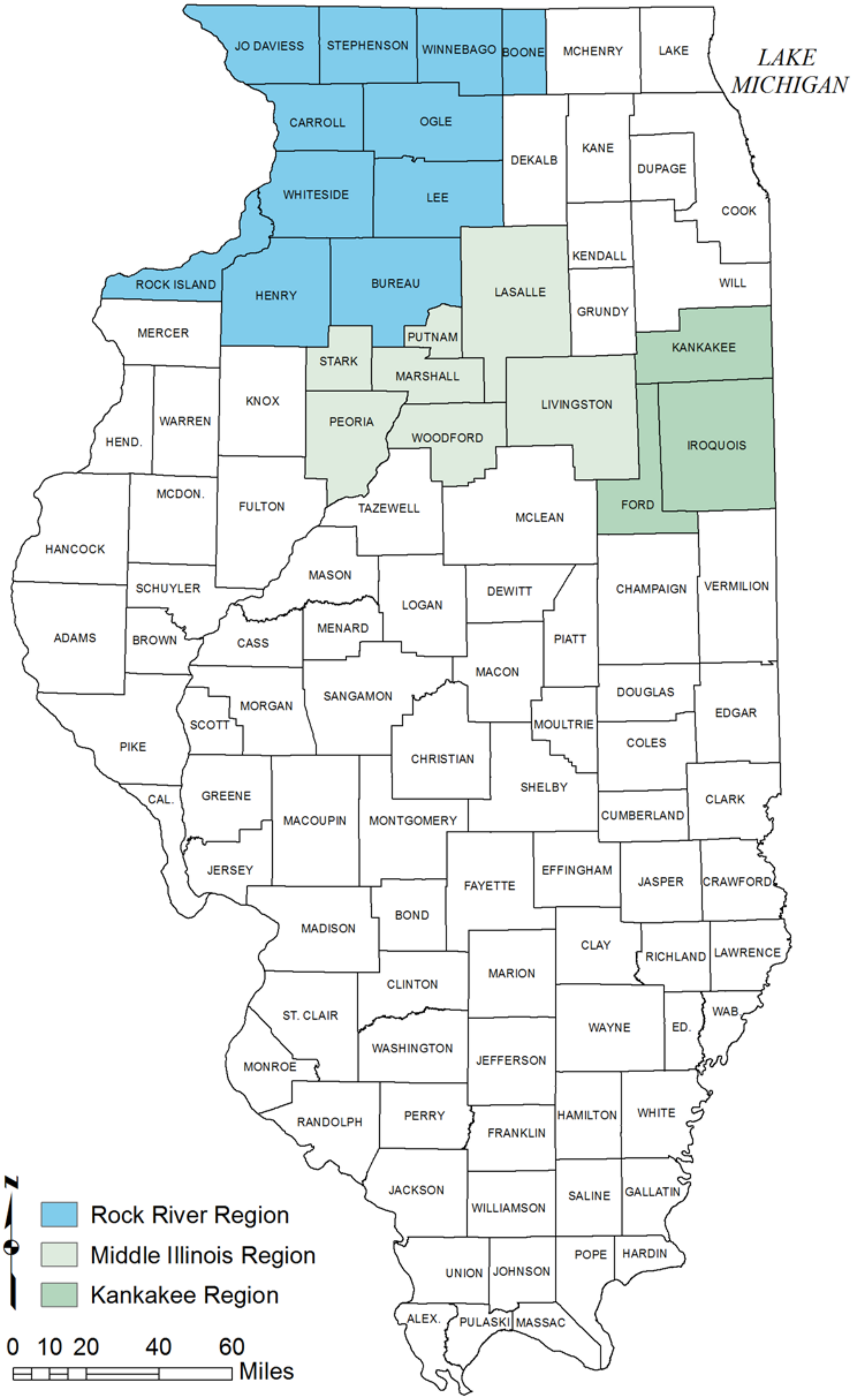

Figure 1.1 Three study regions for water demand estimation

1.3 Data Sources

Historical water withdrawal data for the benchmark years of 1990, 1995, 2000, 2005, and 2010, including the facility-level historical water withdrawal data, were obtained from the ISWS Illinois Water Inventory Program (IWIP) database. The data were compared with county-level compilations developed by the U.S. Geological Survey (USGS), which for many sectors are based on IWIP data. Counts of domestic wells were also obtained from a database maintained by the ISWS.

The data on water withdrawals in each sector were supplemented with corresponding data on demand drivers and explanatory variables for each demand area and sector. The explanatory variable data included (1) resident population and population served; (2) employment by place of work; (3) median household income; (4) marginal price of water; (5) gross and net thermoelectric generation; (6) irrigated acres of cropland and golf courses; (7) livestock counts; (8) air temperature during the growing season; and (9) growing season precipitation.

Supplemental data on historical and future values of demand drivers and explanatory variables were obtained from a variety of state and federal agencies, including the Illinois Commerce Commission; Illinois Department of Employment Security; Illinois Department of Public Health; Illinois Environmental Protection Agency (IEPA); Midwestern Regional Climate Center, Center for Atmospheric Science, ISWS; U.S. Census Bureau; U.S. Department of Agriculture; U.S. Department of Labor Bureau of Labor Statistics; and the U.S. Energy Information Administration.

1.4 Withdrawals versus Consumptive Use

This study is focused on future water needs as measured by off-stream water withdrawals. The scope of the study does not include determinations of consumptive and non-consumptive uses for each category of water withdrawals. The term *water use* is often applied using its broad meaning that denotes “the interaction of humans, and their influence on the hydrologic cycle and may include both off-stream and in-stream uses such as water withdrawal, delivery, consumptive use, wastewater release, reclaimed wastewater, return flow, and in-stream use” (Hutson et al., 2004). The term *water withdrawal* is more precisely defined as a component of water use. It designates the amount of water that is taken out from natural water sources such as lakes, rivers, or groundwater aquifers.

The difference between the amount of water withdrawn and water returned to the source (or discharge) is usually taken to represent *consumptive use*. This is the “part of water withdrawn that is evaporated, transpired, incorporated into products or crops, consumed by humans or livestock, or otherwise removed from the immediate water environment” (Hutson et al., 2004). The quantity of water “consumed” is used in calculating regional annual and monthly water budgets and represents a measure of the volume of water that is not available for repeated use.

Although a major portion of water withdrawals for public water supply, power generation, and industrial purposes represent “non-consumptive” use, these withdrawals can have significant impacts on water resources and other uses of water. For example, water withdrawn from an aquifer and then returned into a surface water body may have a positive impact on streamflow or lake water levels, but a negative impact on the groundwater source. Similarly, water withdrawn from a river for public water supply must be continuously available at the intake and is not available closely upstream or downstream from the intake for other uses, such as irrigation or industrial cooling facilities.

This study is limited to the quantification of water demand in terms of the volumes of water withdrawals from surface and groundwater sources in the study area of the Kankakee subregion. It does not quantify the water volumes being recirculated or reused within industrial facilities, discharges of treated wastewater to surface water bodies, or the infiltration of treated effluents into groundwater aquifers.

At the time of this study, data on return flows, which could be matched to withdrawals, were not readily available; therefore, the partitioning of the volume of water withdrawn into consumptive and non-consumptive use could not be determined and validated. An inventory of actual return flows should be developed in the future, and an in-depth analysis of the “matched” data on withdrawals and return flows (as well as inflows unrelated to withdrawals) should produce relationships that would be adequate for estimating consumptive and non-consumptive use of water withdrawn for each major sector.

1.5 In-stream Uses and Aquatic Ecosystem Needs

The broad definition of water use also includes environmental and in-stream uses, which are outside of the scope of this study. This study does not include water needs for aquatic ecosystems or other in-stream uses (only environmental needs of public parks and wildlife areas are considered). Some of the issues related to in-stream flow needs will be considered in other reports.

The USGS defines in-stream use as “water use that occurs within the stream channel for such purposes as hydroelectric-power generation, navigation, fish and wildlife preservation, water-quality improvement, and recreation” (Hutson et al., 2004). In-stream uses include ecosystem water needs for both in-channel and riparian uses where the streamflow supports a wide range of ecological functions of rivers and other surface water bodies.

Increasing societal recognition of ecosystem services implies that in addition to increases in future water demand to provide for new population and concomitant economic development, there will be an increasing need to manage streams to support aquatic habitat, provide for assimilative capacity to maintain water quality and also for recreational values. During the past four decades there have been an increasing public interest and growing efforts to protect environmental resources and restore ecosystems. However, the effect of in-stream flow requirements and other ecosystem needs on the availability of water supply for off-stream uses is difficult to quantify. There are some rules of thumb, such as those developed by Tennant et al. (1975); however, they are not directly applicable to Illinois streams. The actual values must take into consideration a number of hydrological and ecological factors.

1.6 Analytical Methods

Standard QA/QC procedures were used to identify, correct, and/or discard data with apparent errors caused by mistakes in collection or data input. The data checking procedures included: (1) arranging data in spreadsheets and visually inspecting for apparent anomalies; (2) calculating and examining standard ratios (i.e., per capita water quantity, per employee, or per acre water quantity); (3) graphing time-series data to identify outliers and large shifts in values over time; and (4) comparing data values against other available data sources.

The overall accuracy of the data used in this project is not ideal, but the available data and their quality are considered to be adequate for developing future scenarios of water demand.

1.6.1 Water Demand Models

The selection of analytical techniques for developing estimates of future water withdrawals (plus purchases for resale by public water systems) was dictated by the type of data on actual water quantities and the corresponding data on explanatory variables available for each sector of water demand. The two principal techniques used in this report were the unit-use coefficient method and multiple regression. The general approach to estimating future water demand can be described as a product of the number of users (i.e., demand driver) and unit quantity of water as:

$$Q_{cit} = N_{cit} \cdot q_{cit} \tag{1.1}$$

where:

Q_{cit} = water withdrawals (or demand) in user sector c of study area i in year t;
N_{cit}= number of users (or demand driver) such as population, employment, acreage, or head of livestock; and
q_{cit} = average rate of water requirement (or water usage) in gallons per capita-day, gallons per employee-day, and so forth.

The unit-use coefficient method assumes that future water demand will be proportional to the number of users, N_{cit}, and the future average rate of water use, q_{cit}, is usually assumed to remain constant or is changed based on some assumptions. Modeling of water demand usually concerns future changes in the average rate of water usage, q_{cit}, in response to changing future conditions.

Water demand relationships that quantify historical changes in q_{cit} can be expressed in the form of equations, in which the average rate of water usage is expressed as a function of one or more independent (also called explanatory) variables. A multivariate context best relates to actual water usage behaviors, and multiple regression analysis can be used to determine the relationship between water quantities and each explanatory variable. The functional form (e.g., linear, multiplicative, exponential) and the selection of the independent variables depend on the category of water demand. For example, public supply withdrawals can be estimated using the following linear model:

$$PS_{it} = a + \sum_j b_j X_{jit} + \varepsilon_{it} \tag{1.2}$$

where:

PS_{it} = per capita public supply water withdrawal within geographical area i during year t;
X_j = a set of explanatory variables (e.g., air temperature, precipitation, price of water, median household income, and others), that is expected to explain the variability in per capita use; and
ε_{it} = a random error term.

The coefficients a and b_j can be estimated by fitting a multiple regression model to historical water use data.

The actual models used in this study were specified as double-log (i.e., log-linear models) with additional variables that served to fit the model to the data and also isolate observations that were likely to be outliers:

$$\ln PS_{it} = \alpha_o + \sum_j \beta_j \ln X_{jit} + \sum_k \gamma_k \ln R_{kit} + \varepsilon_{it} \tag{1.3}$$

where:

PS_{it} = per capita public supply water withdrawals (plus purchases) within geographical area *i* during year *t* (in gallons per capita per day);
X_j = a set of explanatory variables;
R_k = ratio (percentage) variables such as ratio of employment to population;
ε_{it} = random error; and
α_o, β_j, *and* γ_j = parameters to be estimated.

Many econometric studies of water demand have been conducted during the past 50 years. A substantial body of work on model structure and estimation methods was also performed by the USGS (Helsel and Hirsch, 1992). The theoretical underpinnings of water demand modeling and a review of a number of determinants of water demand in major economic sectors are summarized by Hanemann (1998). Useful summaries of econometric studies of water demand can be found in Boland et al. (1984). Also, Dziegielewski et al. (2002a) reviewed and summarized a number of studies of aggregated sectoral and regional demand.

1.6.2 Model Estimation and Validation Procedures

Several procedures were used to specify and select the water demand models. The main criteria for model selection were (1) the model included variables that had been identified as important predictors by previous research, and their estimated regression coefficients had some statistical significance and were within a reasonable range of *a priori* values and with expected signs; (2) the explanatory power of the model was reasonable, as measured by the coefficient of multiple determination (R^2); and (3) the absolute percent error of model residuals was not excessive.

The modeling approach and estimation procedure were originally developed and tested in a study conducted by Dziegielewski et al. (2002b). Additional information on the analytical methods, estimated model, and assumptions is included in the chapters that describe the analysis of water withdrawals and development of future water demand scenarios for each major sector of use.

1.6.3 Uncertainty of Future Demands

It is important to recognize the uncertainty in determining future water demands in any study area and user sector. This uncertainty is always present and must be taken into consideration while making important water supply planning decisions. Generally, the error associated with the analytically derived future values of water demand can come from a combination of the following distinct sources:

(1) Random error: The random nature of the additive error process in a linear (or log-linear) regression model, which is estimated based on historical data, guarantees that future estimates will deviate from true values, even if the model is specified correctly and its parameter values (i.e., regression coefficients) are known with certainty.
(2) Error in model parameters: The process of estimating the regression coefficients introduces error because estimated parameter values are random variables that may deviate from the "true" values.
(3) Specification error: Errors may be introduced because the model specification may not be an accurate representation of the "true" underlying relationship.
(4) Scenario error: Future values for one or more model variables cannot be known with certainty. Errors may be introduced when projections are made for the water demand drivers (such as population, employment, or irrigated acreage) as well as the values of the determinants of water usage (such as income, price, precipitation, and other explanatory variables).

The approach used in this study is uniquely suited to deal with the scenario error. By defining three alternative scenarios, the range of uncertainty associated with future water demands in the study area can be examined and taken into consideration in planning decisions. A careful analysis of the data and model parameters was undertaken to minimize the remaining three sources of error.

1.7 Water Demand Scenarios

Estimates of future water demand were prepared for three different scenarios. The scenarios include a current trends (CT) or baseline case scenario, a less resource intensive (LRI) outcome, and a more resource intensive (MRI) outcome. The scenarios were defined by different sets of assumed conditions regarding the future values of demand drivers and explanatory variables.

The purpose of the scenarios is to capture future water demand under three different sets of conditions. The three scenarios do not represent forecasts or predictions, nor do they necessarily set upper and lower bounds of future water use. Different assumptions or conditions could result in withdrawals that are within or outside of the range represented by the three scenarios.

In all three scenarios, total population growth in the three-county study area is assumed to remain the same. Additional general assumptions used in defining each of the three scenarios are described below.

In this draft report, we provide for a revision of our estimates of future demand by the self-supplied thermoelectric power generation and self-supplied industrial and commercial sectors pending receipt of information from local authorities regarding plans for addition or retirement of facilities within the study region.

1.7.1 Scenario 1 – Current Trends (CT) or Baseline Scenario

The basic assumption of this scenario is that the recent trends (past 10 to 20 years) in population growth and economic development will continue. With respect to population growth, the "current trends" are supported by official forecasts of population and employment in the study area.

The CT scenario does not rely on a simple extrapolation of recent historical trends in total or per capita (or per employee) water use into the future. Instead, the future unit rates of water usage are determined by the water demand model as a function of the key explanatory variables. The "recent trends" assumption applies only to future changes in the explanatory variables. Accordingly, the CT scenario assumes that the explanatory variables such as income and price will follow recent historical trends or their official or available forecasts. This scenario also assumes that recent trends in the efficiency of water usage (mostly brought about by the effects of plumbing codes and fixture standards, as well as actions of water users) will continue, although at a rate that is slower than in the past. The conservation trend in the historical data on water use is estimated as a part of the regression model.

1.7.2 Scenario 2 – Less Resource Intensive (LRI) Scenario

In this scenario, the efficiency assumptions include more water conservation (e.g., implementation of additional cost-effective water conservation measures by urban and industrial users), as well as higher water prices in the future.

1.7.3 Scenario 3 – More Resource Intensive (MRI) Scenario

In this scenario, the efficiency assumptions include no additional water conservation beyond that indicated by recent trends in the CT scenario. The price of water is assumed to remain unchanged in real terms, which implies that future price increases will only offset the general inflation. A higher rate of growth of median household income is also assumed.

A detailed listing of assumptions for each of the three scenarios is given in Table 1.1. Additional discussion of sector-specific assumptions for each scenario is included in the chapters that describe estimates of water demand in each sector.

Table 1.1 Factors Affecting Future Water Demands in the 21 Counties of Three Study Areas in Illinois

Factor	**Scenario 1- Current Trends (CT) or Baseline**	**Scenario 2- Less Resource Intensive (LRI)**	**Scenario 3 – More Resource Intensive (MRI)**
Total population	IDPH and trend-based projections	IDPH and trend-based projections	IDPH and trend-based projections
Median household income	Existing projections of 1.0%/year growth	Existing projections of 0.7%/year growth	Higher growth of 1.2%/years
Water conservation	50% lower rate than historical trend	Continuation of historical trend	No extension of historical trend
Future water prices	Recent increasing trend (0.8%/year) will continue	Higher future price increases (1.6%/year)	Prices held at 2010 level in real terms
Irrigated land	Constant cropland, increasing golf courses	Decreasing cropland, no increase in golf courses	Constant cropland, increasing golf courses
Livestock	Baseline USDA growth rates	Baseline USDA growth rates	Baseline USDA growth rates
Weather (air temperature and precipitation)	30-year normal (1981-2010)	30-year normal (1981-2010)	30-year normal (1981-2010)

1.8 Organization of the Report

This report is organized into an executive summary and eight chapters. The executive summary combines the results for all sectors and briefly discusses some of the implications of this study for further analysis of water demand in the Kankakee subregion.

Chapter 1 introduces the data and analytical models used to estimate future water demands. The five water use sectors are described in the five subsequent chapters (Chapters 2, 3, 4, 5, and 6). Each of these chapters begins with a brief review of the definition of the water demand sector, a summary of the historical changes in reported water withdrawals in the sector, and the procedure for deriving water demand relationships for the sector. This is followed by a description of the assumptions used to develop water demand scenarios for the sector and a summary of the scenario results. Most chapters are accompanied by one or more appendices containing detailed tables with primary data and other information used in deriving future water demand.

Chapter 7 describes the sensitivity analysis, which shows the impacts on water withdrawals under climate change scenarios, as well as the potential increase in water demands during a period of drought.

Chapter 8 provides a summary of the report. References for all chapters appear at the end of the report.

Appendices A-G give details on how various demand and population forecasts were made for different sectors and supplemental tables. Appendix H contains updates of several tables in the body of the report. This was done to provide more recent data that were not available when the initial draft of this report was completed in 2015.

2 Water Demand by Public Water Systems

2.1 Background

Public water supply is water that is withdrawn from the source, treated, and delivered to individual residential, commercial, industrial, institutional, and governmental users by public water supply systems. Some or all water can also be purchased from a nearby system and delivered to users. The U.S. Environmental Protection Agency (USEPA) defines a public water system as a public or privately-owned system that serves at least 25 people or 15 service connections for at least 60 days per year (U.S. Environmental Protection Agency, 2008).

Not all water users within the area served by a public water system rely on water delivered by the system. Some users have their own sources of supply and are therefore considered to be self-supplied. Self-supplied users include industrial and commercial establishments that rely on their own wells or surface water intakes (Chapter 5) as well as residential users who rely on private wells (Chapter 3).

2.1.1 Study Areas

According to data from the IEPA, 61 public water supply systems exist in the three counties of the study area (Table 2.1). In 2010, these systems served an estimated population of 124,659 people, as well as local businesses and institutions. A comparison of the total resident population in each county with the population served by public water systems shows that in 2010 an additional 32,544 people (or about 21 percent of the total population in the three-county area) were served by domestic wells or other sources in the self-supplied domestic sector.

To develop scenarios of future public water system use for the three-county area, we selected larger “dominant” public water supply systems from within each county as study areas for detailed investigation of historical water use (Figure 2.1). The 12 dominant systems were treated independently, with input parameters for water demand estimation based, to the extent possible, on system-level data.

We aggregated the remaining smaller systems within each county into a county-remainder (or residual) study area. This allowed us to include all public water systems in developing water demand scenarios. Water demand in the county-residual study area is computed from aggregated data. Several tables in this chapter (e.g., Table 2.2) list all study areas, including dominant systems and county-residual areas, employed in this project.

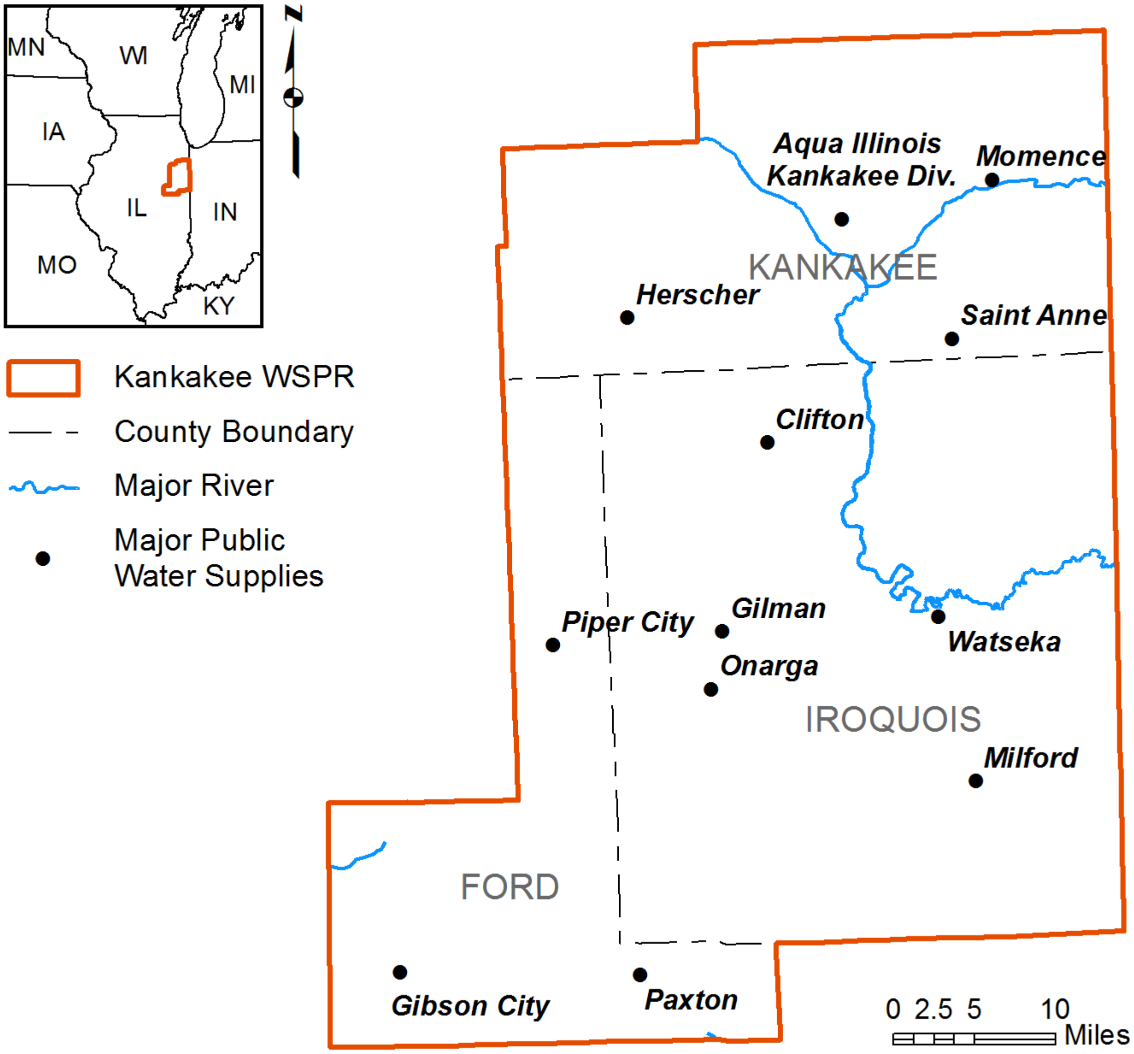

Figure 2.1 Dominant public water systems

Table 2.1 Public Water Systems in the Kankakee Subregion by County

County	Estimated Resident Population (2010)[1]	All Public Systems		Dominant Systems Used in Detailed Investigation	
		Number[2]	Population Served (2010)[2]	Number[2]	Population Served (2010)[2]
Ford	14,078	10	11,665	3	9,297
Iroquois	29,663	27	21,877	5	11,693
Kankakee	113,462	24	91,117	4	86,312
REGIONAL TOTAL	**157,203**	**61**	**124,659**	**12**	**107,302**

[1] U.S. Census Bureau (2014c)
[2] Illinois Environmental Protection Agency (2014)

2.1.2 Historical Water Demand Data

Data on public system water demand were obtained from IWIP, administered by the ISWS. Under this program, a questionnaire is sent to all of the nearly 1740 community water systems (i.e., public water systems that supply water to the same population year-round; these systems serve a population of 12,008,700) in the state (Illinois Environmental Protection Agency, 2015). The questionnaire includes questions about water sources, withdrawals, and water deliveries to residential, commercial, and industrial customers (Illinois State Water Survey, 2018). If system representatives do not complete the survey, IWIP staff estimate water withdrawals by extrapolation from data submitted in previous years. The water demand and population served data collected by the ISWS together constitute our database on historical water usage by the 12 dominant-system and three-county residual study areas.

The IWIP database contains data on annual withdrawals and purchases of water by public water supply systems. Not all public water systems rely entirely on withdrawals from surface water and groundwater sources. Some systems rely entirely on water purchased from a neighboring system or combine self-supplied withdrawals with purchases. For the purpose of this study, the reported self-supplied withdrawals were adjusted by adding reported water purchases and subtracting water sales to compute water demand in each system’s retail service area. This computation was necessary to develop forecasts of future water demand because the socioeconomic data correspond to water demand areas.

Table 2.2 shows the estimated historical (1990-2010) population served by the 12 dominant public water systems and by public water systems in the three-county residual study areas. The 12 dominant systems served a population of 107,302 people in 2010, and public water systems in the county residual study areas served 17,357 people. Therefore, the total estimated population served by public water systems in the three-county study area is 124,659.

Table 2.3 shows the historical water demand by the 12 dominant public water systems and by public water systems in the three-county residual study areas. Water demand by the dominant systems totaled 16.4 million gallons per day (Mgd) in 2010, with an additional 1.6 Mgd used by public water systems in county-residual study areas. The combined public system demand in 2010 was 18.0 Mgd, and, dividing by the total population served of 124,659 people, this total demand is equivalent to a per-capita demand of approximately 144 gallons per capita per day (gpcd). Between 1990 and 2010, total public system use increased by 2.5 Mgd, or 16 percent. During the same period, the total population served increased by 8 percent. Although per-capita demand varied within the period from 1990 to 2010, it is 7.5 percent greater in 2010 (144 gpcd) than in 1990 (134 gpcd), an increase that implies an average annual growth rate of 0.4 percent.

Table 2.2 Estimated Population Served by Public Water Systems

Study Area	**1990**	**1995**	**2000**	**2005**	**2010**
Ford County					
Gibson City	3,700	3,660	3,466	3,523	3,572
Paxton	4,473	4,539	4,725	4,800	4,725
Piper City	900	800	1,000	1,000	1,000
Ford County Residual	2,334	2,233	2,248	2,265	2,368
Iroquois County					
Clifton	1,390	1,440	1,452	1,400	1,400
Gilman	2,000	2,000	1,813	1,813	1,813
Milford	1,728	1,545	1,512	1,369	1,380
Onarga	1,300	1,360	1,425	1,425	1,600
Watseka	5,700	5,700	5,670	5,500	5,500
Iroquois County Residual	9,384	9,455	9,691	9,954	10,184
Kankakee County					
Aqua IL – Kankakee Division	60,000	55,000	65,000	67,000	80,000
Herscher	1,400	1,525	1,753	1,680	1,680
Momence	3,350	3,400	3,450	3,650	3,420
St Anne	1,552	1,350	1,200	1,200	1,212
Kankakee County Residual	16,170	18,799	15,337	10,642	4,805
REGIONAL TOTAL	**115,381**	**112,806**	**119,742**	**117,221**	**124,659**

Table 2.3 Historical Public Supply Water Demand (Mgd)

Study Area	1990	1995	2000	2005	2010
Ford County					
Gibson City	0.602	0.773	0.860	0.773	0.698
Paxton	0.490	0.614	0.701	0.559	0.510
Piper City	0.108	0.121	0.085	0.139	0.073
Ford County Residual	0.197	0.224	0.218	0.203	0.180
Iroquois County					
Clifton	0.170	0.205	0.153	0.125	0.147
Gilman	0.202	0.242	0.294	0.240	0.238
Milford	0.282	0.170	0.177	0.232	0.164
Onarga	0.128	0.153	0.162	0.169	0.160
Watseka	0.600	0.720	0.660	0.582	0.645
Iroquois County Residual	0.853	0.894	0.951	0.893	0.876
Kankakee County					
Aqua IL – Kankakee Division	9.336	10.992	12.023	12.888	12.683
Herscher	0.112	0.132	0.160	0.148	0.132
Momence	0.797	0.673	0.850	0.771	0.765
St Anne	0.167	0.158	0.143	0.195	0.209
Kankakee County Residual	1.467	1.838	1.410	1.195	0.530
REGIONAL TOTAL	**15.510**	**17.910**	**18.847**	**19.111**	**18.009**

2.2 Water Demand Model

2.2.1 Explanatory Variables

Substantial data collection and processing were required to estimate explanatory variables to formulate a water demand model. We defined the dependent variable for the public supply sector as gross water demand per capita; in addition to including residential deliveries, this parameter includes deliveries to commercial, industrial, and institutional establishments within the service areas of public water systems (as well as water losses in the transmission, treatment, and distribution systems). Based on preliminary statistical analysis and previous water demand studies, we employed five independent variables to explain the variability of per-capita water demand across study sites and at different time periods: summer-season air temperature, summer-season precipitation, ratio of local employment to local population, marginal price of water, and median household income. Weather data were obtained from the Midwestern Regional Climate Center, Center for Atmospheric Science, ISWS. Data employed for characterizing weather included observations of monthly temperature and precipitation. To characterize weather conditions at each dominant public system and county-residual study area, we sought to employ observations only from within the county, but in some cases we were required to use data from outside the county to develop comprehensive datasets (Table 2.4).

We estimated historical employment-to-population ratios for public system service areas using 1990-2010 municipal population data available from the U.S. Census Bureau (U.S. Census

Bureau, 1995, 2004, 2014c) and employment totals aggregated by zip code (U.S. Census Bureau, 2015b). Data on median household income were obtained from the U.S. Census Bureau (U.S. Census Bureau, 2014b) and from the U.S. Census Bureau's 2006-2010 American Community Surveys (U.S. Census Bureau, 2014a). Data on historical prices of water were obtained by contacting all individual public water systems and from a survey of Illinois water prices conducted in 2003 (Dziegielewski et al., 2004).

One additional variable was included to account for unspecified changes in water use that will likely influence water demand over time, and it represents general trends in water conservation behavior. This variable accounts for such influences as the increase in water use awareness programs, implementation of federal laws mandating adoption of conservation technologies, and a recent emphasis on adoption of full-cost water pricing. The conservation trend variable was specified as zero for 1990, 5 for 1995, 10 for 2000, 15 for 2005, and 20 for the year 2010.

Table 2.4 Stations Used for Weather Characterization in the Kankakee Subregion

County	**Station Used for Weather Characterization**	
	Name	**Number***
Ford	Paxton	116663
Iroquois	Watseka 2 NW	119021
Kankakee	Kankakee Metro WWTP	114603

*National Weather Service (NWS) Cooperative Observer Program (COOP) number (National Climatic Data Center, 2015)

2.2.2 Per-Capita Water Demand Equation

A log-linear regression (see Equation 1.3 in Chapter 1) was applied to capture the relationship between per-capita demand and the explanatory variables. The statistical model explains per-capita water demand as a function of average maximum daily air temperature during the summer landscape irrigation season (May to September), total precipitation during the summer season, the ratio of employment to residential population, the marginal price of water, median household income, and the conservation trend variable.

The estimated coefficients and some statistics of the regression model are shown in Table 2.5. A more detailed description of the estimation procedure and regression results is included in Appendix A.

The estimated elasticities of the explanatory variables in the structural model have the expected signs and magnitudes, although the statistical significance of the coefficients for the two climatic variables is marginal. The variables with low significance are retained in the model because the signs and magnitudes of the regression coefficients are close to expected values, and low significance is caused primarily by high variance (i.e., noise) in the data. The constant elasticity of the summer-season average maximum air temperature variable indicates that, on average, a 1.00000 percent increase in temperature increases per-capita water demand by 1.13185 percent. The negative constant elasticity of the summer rainfall variable signifies that, on average, a 1.00000 percent increase in total summer precipitation decreases per-capita water demand by 0.05946 percent. Similarly, a 1.00000 percent increase in the marginal price of water is associated with a 0.19770 percent decrease in per-capita water demand, and a 1.00000 percent increase in median household income results in a 0.12183 percent increase in per-capita demand.

The coefficient of the variable representing the employment-to-population ratio (0.50331) indicates that in study areas with higher commercial/industrial employment relative to resident population, per-capita water demand is greater.

The estimated coefficient of the conservation trend variable is -0.00412. It indicates that historical data exhibit a significant declining trend in per-capita water demand, which we attribute to water conservation, of approximately 0.4 percent per year.

The regression model explains 34 percent of time-series and cross-sectional variance in log-transformed per-capita water demand. This level of explanation is consistent with results of similar regional studies of municipal water demand in Illinois and other regions in the U.S. The level of explanation is often found to be less than 50 percent when regression models are fitted to cross-sectional time series data. An additional measure of the performance of the regression model is the mean absolute percent error (MAPE) of the model's estimation of the data used to estimate the regression equation. The MAPE of the log model is 4 percent (19.2 percent when predictions are converted back to the linear scale).

Table 2.5 Estimated Log-Linear Model of Per-Capita Water Demand (gpcd)

Variables*	**Estimated Coefficient**	**t Ratio**	**Probability >|t|**
Intercept	-0.42031	-0.10	0.9208
Ln (Max. Summer Temperature)	1.13185	1.21	0.2271
Ln (Total Summer Precipitation)	-0.05946	-1.05	0.2961
Employment/Population Ratio	0.50331	8.01	<0.0001
Ln (Median Household Income)	0.12183	1.35	0.1793
Ln (Marginal Price of Water)	-0.19770	-5.75	<0.0001
Time (Conservation) Trend	-0.00412	-1.40	0.1616

*Other model parameters are listed in Appendix A.

2.2.3 Estimated and Reported Water Demand in 2010

We used the water demand equation to estimate both historical and future per-capita water demand in each of the 15 study areas (including 12 dominant public water systems and three county-residual study areas). In order to assess the performance of the model (shown in Table 2.5), the reported and estimated (uncalibrated) per-capita water demand in 2010 in each dominant public water system and in combined public systems within county-residual study areas were compared (Table 2.6). In most cases, the differences between the model-estimated and reported values were relatively small.

In some cases, mostly for county-residual areas, the differences between the model-estimated and reported values were significant, contributing to the MAPE across all 15 study areas of 15.4 percent (when results are converted back to linear scale). Before using the model to generate predictions for all future years, the model was "calibrated" by adjusting its intercept to match exactly the estimated water usage in 2010 with the reported water demand in 2010. From a statistical perspective, the calibration involved adding back the model residuals for 2010 to the predicted values for 2010 and all future years.

Table 2.6 Estimated (Uncalibrated) and Reported Per-Capita Water Demand in 2010

Study Area	**Estimated Demand (gpcd)**	**Reported Demand (gpcd)**
Ford County		
Gibson City	153.2	195.3
Paxton	110.5	108.0
Piper City	100.8	72.6
Ford County Residual	97.4	75.8
Iroquois County		
Clifton	112.0	105.3
Gilman	117.2	131.0
Milford	119.1	119.1
Onarga	100.1	99.7
Watseka	121.1	117.2
Iroquois County Residual	94.5	86.1
Kankakee County		
Aqua IL – Kankakee Division	113.7	158.5
Herscher	97.8	78.8
Momence	159.7	223.5
St Anne	136.2	172.7
Kankakee County Residual	101.6	110.3

2.2.4 Water Withdrawals by Source

Table 2.7 shows the percentages of demand satisfied by groundwater and surface water in 2010 by the dominant public systems and by public systems in the county-residual areas. Although the majority of public water systems in the Kankakee subregion rely completely on groundwater to satisfy demand, the relatively large demand of the Aqua-Illinois Kankakee system, which relies entirely on surface water, causes surface water to predominate as the principal source of water for public supply in the region. Overall, surface water satisfied 71 percent of regional public system demand in 2010.

Table 2.7 Source of 2010 Reported Water Demand

Study Area	Groundwater		Surface Water	
	Mgd	%	Mgd	%
Ford County				
Gibson City	0.698	100	0	0
Paxton	0.510	100	0	0
Piper City	0.073	100	0	0
Ford County Residual	0.180	100	0	0
Iroquois County				
Clifton	0.147	100	0	0
Gilman	0.238	100	0	0
Milford	0.164	100	0	0
Onarga	0.160	100	0	0
Watseka	0.645	100	0	0
Iroquois County Residual	0.876	100	0	0
Kankakee County				
Aqua IL – Kankakee Division	0	0	12.683	100
Herscher	0.132	100	0	0
Momence	0.765	100	0	0
St Anne	0.209	100	0	0
Kankakee County Residual	0.500	94	0.031	6
REGIONAL TOTAL	**5.296**	**29**	**12.713**	**71**

2.3 Characterization of Future Water Demand Scenarios

2.3.1 Future Change in Population Served

The main driver of future water demand in the public supply sector is population served. As discussed in Appendix B, we developed estimates of future county resident population from historical county-level population counts (1920-2000) (U.S. Census Bureau, 1995, 2004), estimates of 2010-2014 population on July 1 of each year (U.S. Census Bureau, 2015a), and available projections of 2015-2025 county population developed by the Illinois Department of Public Health (Data.Illinois.gov, 2018). Table 2.8 shows county resident population, both reported and projected, in the Kankakee subregion between 2010 and 2060.

The results in Table 2.8 show that for the three-county region, total resident population is expected to increase from 157,203 to 174,037 during the period 2010 to 2060, an increase of 16,834 people, or 11 percent. A population increase is projected for Kankakee County and decreases are projected for Ford and Iroquois Counties. Changes in resident population will result in changes in population served by public water systems.

To estimate the future population served by public water systems, we employed an approach similar to the approach we used to estimate future county resident population. For each study area, including county-residual study areas, we plotted 1990-2005 counts and estimates (U.S. Census Bureau, 1995, 2004, 2015a) and 2010-2014 estimates (U.S. Census Bureau, 2015a) of municipal resident population, and we fit a linear trend line to these data. If this trend line displayed an upward trend that was statistically significant ($R^2 \geq 0.2$), we employed the trend line equation to estimate a 2060 resident population. From this value, we estimated the 2060 population served using the proportionality of 2010 resident population to 2010 population served. We then used the 2010 and 2060 population-served estimates as input values to estimate the population served for intervening years, on a five-year basis, using the *Home/Fill/Series …/Linear* utility in Microsoft Excel 2013 (Microsoft Corporation, 2003), assuring that the *Trend* box was checked. For public systems in which the historical counts and estimates displayed a downward trend or an upward trend with $R^2 < 0.2$, we maintained the population served at the 2010 level to 2060. We employed the difference between county sums of resident population and population served to estimate each county's population served by domestic wells (Chapter 3), validating this estimate by dividing it by an estimate of the total number of active domestic wells in the county to ensure that the computation yields a value of about two to four persons per domestic well. In a few cases, this validation procedure suggested that our computation of the self-supplied domestic population was too low, so we used an alternative approach of computing the population served by individual systems in which we assumed that the population served from 2015 to 2060 was maintained at the 2010 proportion of county resident population.

Table 2.9 shows projected changes in future population served by the 12 dominant (community) public water supply systems included in the study. The values in Table 2.9 show that for the combined 12 systems, total population served is expected to increase between 2010 and 2060 from 107,302 to 146,103, an increase of 38,801 people (approximately 36 percent). Estimates of population served by public water systems in county-residual areas are shown in Table A.3 (Appendix A).

Table 2.8 Reported and Projected Resident Population (2010-2060)

County	Estimated Population	Projected Population			2010-2060 Change	2010-2060 Change (%)
	2010[1]	2020[2]	2040[3]	2060[3]		
Ford	14,078	13,448	13,448	13,448	-630	-5
Iroquois	29,663	27,686	27,686	27,686	-1977	-7
Kankakee	113,462	117,167	125,013	132,903	-19,441	17
REGIONAL TOTAL	**157,203**	**158,301**	**166,147**	**174,037**	**16,834**	**11**

[1] U.S. Census Bureau (2015a)
[2] IDPH projection (Data.Illinois.gov, 2018)
[3] See Appendix B

Table 2.9 Reported and Projected Population Served by Dominant Public Water Supply Systems

Public Water System	Reported Population Served	Projected Population Served*			2010-2060 Change	2010-2060 Change (%)
	2010	2020	2040	2060		
Ford County						
Gibson City	3,572	3,572	3,572	3,572	0	0
Paxton	4,725	4,725	4,725	4,725	0	0
Piper City	1,000	1,000	1,000	1,000	0	0
Iroquois County						
Clifton	1,400	1,444	1,532	1,620	220	16
Gilman	1,813	1,813	1,813	1,813	0	0
Milford	1,380	1,380	1,380	1,380	0	0
Onarga	1,600	1,600	1,600	1,600	0	0
Watseka	5,500	5,500	5,500	5,500	0	0
Kankakee County						
Aqua IL – Kankakee Division	80,000	87,212	101,637	116,061	36,061	45
Herscher	1,680	1,792	2,017	2,242	562	33
Momence	3,420	3,779	4,497	5,215	1,795	52
St Anne	1,212	1,245	1,310	1,375	163	13
REGIONAL TOTAL	**107,302**	**115,062**	**130,583**	**146,103**	**38,801**	**36**

*Projections for the systems are estimates based on historical trends and IDPH population projections (Data.Illinois.gov, 2018) as described on page 22.

2.3.2 Future Changes in Explanatory Variables

We employed the future values of six explanatory variables (temperature, precipitation, employment/population ratio, price, income, and conservation trend) to estimate future rates of per-capita water demand in the public supply sector in each study area. As a prerequisite for computing future water demand, we estimated the future values of these variables based on assumptions as specified below.

2.3.2.1 Summer-Season Temperature and Precipitation

Per-capita water use is affected by summer (May through September) weather conditions. A higher or lower average of monthly maximum daily summer temperatures results in higher or lower per-capita water use, respectively, as determined by an elasticity of +1.13. Similarly, higher or lower total summer precipitation results in a lower or higher per-capita water use, respectively, as determined by an elasticity of -0.06. We assumed future values of summer-season (May through September) maximum daily temperature and total precipitation that are averages from each of the weather stations listed in Table 2.4 for the 30-year period from 1981 to 2010. Thus, we assumed that “normal” 1981-2010 summer weather conditions will prevail in the future. The maximum daily temperature values are shown in Table 2.10.

Summer precipitation totals are shown in Table 2.11. The data show that total summer-season precipitation in 2010 was generally greater than 1981-2010 normal conditions. On the other hand, total precipitation during summer 2005 was affected by drought and was much less than normal.

Table 2.10 Average of Maximum Monthly Summer-Season (May-September) Temperature at Weather Stations in the Kankakee Subregion

County	**Station Used for Weather Characterization**		**Average of Monthly Maximum Summer (May-September) T (°F)**		
	Name	**ID**[1]	**2005**	**2010**	**1981-2010 Average (“Normal”)**
Ford	Paxton	116663	81.58	81.38	79.26
Iroquois	Watseka 2 NW	119021	81.92	81.46	79.68
Kankakee	Kankakee Metro WWTP	114603	82.15	81.82	79.62

*NWS COOP number (National Climatic Data Center, 2015)

Table 2.11 Summer Precipitation at Weather Stations in the Kankakee Subregion

County	**Station Used for Weather Characterization**		**Total Summer (May-September) Precipitation (inches)**		
	Name	**ID**[1]	**2005**	**2010**	**1981-2010 Average (“Normal”)**
Ford	Paxton	116663	18.42	21.37	18.90
Iroquois	Watseka 2 NW	119021	16.55	21.47	19.43
Kankakee	Kankakee Metro WWTP	114603	14.42	23.31	20.1

*NWS COOP number (National Climatic Data Center, 2015)

2.3.2.2 Employment-to-Population Ratios

We assumed that employment-to-population ratios in 2010 are maintained through 2060.

2.3.2.3 Marginal Price of Water

Future changes in retail water prices will result in changes in per-capita water usage as determined by the estimated price elasticity of -0.20. The marginal price of water in the historical data was calculated as the incremental price per 1,000 gallons at the level of consumption between 5,000 and 6,000 gallons per month.

Future values of marginal prices will depend on the adoption of pricing strategies by retail water suppliers as well as the frequency of rate adjustments. Water rate structures often remain unchanged for several years, thus resulting in a decline of the real price with respect to inflation. An expectation in the water supply industry, however, is that several factors will cause future retail water prices to increase faster than the rate of inflation. These include an increased investment in treatment processes to address water quality concerns, increasing energy costs, and increasing infrastructure replacement costs.

Recent trends in water prices were determined from a survey of water rates in Illinois (Dziegielewski et al., 2004). Data for 219 water systems in Illinois show only a 3 percent increase in the median value of a total water bill at the consumption level of 5,000 gallons per month between 1990 and 2003 (increasing from $18.18 to $18.70 in constant 2003 dollars). During the same period, the median value of the marginal price of water increased from $2.59 to $2.90, which represents an increase of 12 percent (in constant 2003 dollars), or 0.9 percent per year. This modest increase in median price reflects the fact that a number of systems kept their nominal price of water unchanged. Real water prices decreased in 112 systems (due to inflation) and increased in 107 systems. The average increase in the 107 systems in terms of the total bill was 25 percent, and the average marginal price increased by 39.6 percent (or 2.6 percent per year).

Other published sources have reported increases in the price of municipal water. NUS Consulting (2007) reported that the average price of water in 51 systems located throughout the United States increased by 6 percent during the period from July 1, 2006 to July 1, 2007. The Earth Policy Institute (2007) reported an increase of 27 percent in the United States during the past five years. Adjusting for inflation during the period (CPI 2000 = 172.2, CPI 2005 = 195.3), this increase is equivalent to an increase in real prices of approximately 12 percent (or 2.3 percent per year).

For this study, we assumed trends in marginal prices that range from (1) no trend; to (2) gradually increasing water rates following the recent trend in Illinois of an increase in marginal price of 0.8 percent per year; to (3) a more dramatic increase in marginal price by 1.6 percent per year.

2.3.2.4 *Median Household Income*

Future changes in median household income will result in changes in per-capita water demand as determined by the estimated income elasticity of +0.12. Historical data from 1990, 1995, 2000, 2005, and 2010 suggest an average trend in median household income (expressed in constant 2010 dollars) of 0.15 percent per year. Although forecasted economic growth in the study area suggests that future income is likely to grow, official projections of future income growth at county and public water system levels are not available.

One relevant estimate of income growth for the State of Illinois is provided by the Illinois Regional Econometric Input/Output Model (IREIM) (Regional Economics Applications Laboratory, 2014), which indicates that personal income will increase at a rate of 1.5 percent per year between 1997 and 2022. Because the growth in median household income is generally less than the expected growth in total personal income, we have assumed rates of growth in median household income of 0.7, 1.0, and 1.2 percent, all values that are less than the 1.5 percent annual rate of growth in personal income suggested by the IREIM.

2.3.3 *Scenarios of Water Demand*

We have developed three scenarios of future public water system demand that reflect three different sets of plausible socioeconomic conditions (Table 2.13). These include a less resource intensive scenario, a current trends (or baseline) scenario, and a more resource intensive scenario. Although our estimates suggest a plausible range of future demand, they do not represent forecasts or predictions, and they do not indicate upper and lower bounds of future water demand. Different assumptions or different future conditions could result in predicted or actual water demand that is outside of this range.

Some assumptions of future socioeconomic and weather conditions do not differ between scenarios. In all scenarios, employment-to-population ratios for individual study areas are maintained at 2010 levels, and summer temperature and precipitation remain at “normal” values for the 30-year period from 1981 to 2010. The population served by public systems in each study area either increases at a rate reflecting historical trends or is maintained at the 2010 level, depending on our analysis of historical trends in population served (page 22); population served is not varied between scenarios.

2.3.3.1 Current Trends (Baseline) Scenario (CT)

This scenario characterizes conditions during the period from 2010 to 2060 as an extension of recent trends in the principal factors influencing water demand. The specific assumptions of the CT scenario are the following:

1. Employment-to-population ratios are maintained at 2010 levels.
2. Marginal price of water increases at an annual rate of 0.8 percent.
3. Median household income increases at an annual rate of 1.0 percent.
4. Per-capita water use is affected by a “conservation trend” of -0.206 percent per year, which is half the trend suggested by historical data.
5. Summer temperatures and precipitation remain at “normal” values for the 30-year period from 1981 to 2010.

2.3.3.2 Less Resource Intensive Scenario (LRI)

This scenario assumes socioeconomic conditions during the period from 2010 to 2060 that would result in less water use by the public supply sector. Other conditions, not included in this analysis, could also lead to less water usage. The specific assumptions of the LRI scenario are the following:

1. Employment-to-population ratios are maintained at 2010 levels.
2. Marginal price of water increases at an annual rate of 1.6 percent.
3. Median household income increases at an annual rate of 0.7 percent.
4. Per-capita water usage is affected by a “conservation trend” of -0.412 percent per year, which is the trend suggested by historical data.
5. Summer temperatures and precipitation remain at “normal” values for the 30-year period from 1981 to 2010.

2.3.3.3 More Resource Intensive Scenario (MRI)

The intent of this scenario is to define future conditions that would lead to more water usage by the public water supply sector. The specific assumptions for the More Resource Intensive (MRI) scenario are:

1. Employment-to-population ratios are maintained at 2010 levels.
2. Marginal price is maintained at 2010 levels (in real terms).
3. Median household income increases at an annual rate of 1.2 percent.
4. Per-capita water use is unaffected by a “conservation trend.”
5. Summer temperatures and precipitation remain at “normal” values for the 30-year period from 1981 to 2010.

Table 2.12. Summary of Demand Scenario Assumptions

Assumption	Water Demand Scenario		
	CT	LRI	MRI
Population served (2015-2025)	Assumed Illinois DPH Projections	Assumed Illinois DPH Projections	Assumed Illinois DPH Projections
Population served (2030-2060)	Trend Projections*	Trend Projections*	Trend Projections*
Employment-to-population ratio	2010 value	2010 value	2010 value
Marginal price of water growth rate	0.8%/year	1.6%/year	2010-level constant
Median household income growth rate	1.0%/year	0.7%/year	1.2%/year
Water conservation trend	-0.206%/year	-0.412%/year	No conservation trend
Weather conditions	1981-2010 Normal	1981-2010 Normal	1981-2010 Normal

*See Section 2.3.1

2.4 Scenario Results

2.4.1 Total Public Supply Demand

We estimated per-capita demand using the regression model, and we computed total demand by multiplying future populations served by the model-generated per-capita water demand estimates. Scenario results for the total study area are summarized in Table 2.13. Table A.4 to Table A.9 in Appendix A show future total and per-capita water demand at the system level for the scenarios. There are only small differences between the reported demand in 2010 and weather-normalized demand in 2010.

The overall changes in total future water demand are a direct result of the projected population and the combined effects of three assumptions: marginal price of water, growth in median household income, and the assumed trend in water conservation.

Under the CT scenario, weather-normalized demand for public water supply increases from 17.69 Mgd in 2010 to 21.81 Mgd in 2060, a 23.3 percent increase. This 4.11 Mgd increase reflects a 31.1 percent increase in population served and a 9.6 percent decrease in weather-normalized per-capita water demand. The change of per capita use is a result of reductions in use due to price increases and conservation trends that exceed the increases in use caused by growth in income.

Under the LRI scenario, weather-normalized demand for public water supply decreases by 2.2 percent from 2010 to 2060, from the weather-normalized demand of 17.69 Mgd in 2010 to 17.29 Mgd in 2060. This 0.40 Mgd decrease reflects a 31.1 percent increase in population served between 2010 and 2060 and a 25.4 percent decrease in per-capita water demand during the same period. This decrease in per capita use is a result of reductions in use because of price increases and conservation trends that exceed the increases in use caused by low rate of growth in income.

Finally, under the MRI scenario, weather-normalized demand for public water supply increases by 54.7 percent, from the weather-normalized demand of 17.69 Mgd in 2010 to 27.38 Mgd in 2060. This 9.68 Mgd increase is predicted because of a 31.1 percent increase in population served between 2010 and 2060 and a 9.2 percent increase in per-capita water demands during the same period. The increase in per capita use is caused by growth in income without price and conservation effects.

2.4.2 Implications for Sources of Public Water Supply

For this project we have estimated future demand from surface water and groundwater sources based on the proportion of the 2010 demand that is satisfied by water from these sources. In other regions, a portion of public system demand is sometimes imported from another county. Available data indicate that no public system in the Kankakee subregion satisfies demand through such imports.

2.4.2.1 Demand for Local Surface and Groundwater

Assuming that each public water system maintains its 2010 ratio of groundwater to surface water demand, the overall ratio of water supply sources will change from 2010 to 2060 owing to differential growth among water systems having differing ratios of supply sources in 2010. Under the CT and LRI scenarios, we project that demand for locally sourced groundwater will decrease, although under the CT scenario the reduction in demand is relatively small. Under the MRI scenario, demand for locally sourced groundwater increases. Reflecting growth of the Aqua Illinois–Kankakee Division system, demand for locally sourced surface water increases under all three scenarios.

Under the CT scenario, weather-normalized demand for locally sourced groundwater decreases by 1.7 percent (0.9 Mgd) from 2010 to 2060. Under the LRI scenario, weather-normalized groundwater demand decreases by 19.9 percent (1.05 Mgd) during this time period, and under the MRI scenario it increases by 20.3 percent (1.07 Mgd). In contrast, weather-normalized demand for locally sourced surface water in the study area under the CT scenario increases by 33.8 percent (4.21 Mgd) from 2010 to 2060. Weather-normalized demand for locally sourced surface water under the LRI scenario increases by 5.2 percent (0.65 Mgd) during this time period and increases by 69.3 percent (8.61 Mgd) under the MRI scenario.

2.4.2.2 Demand for Imported Water

We have assumed that water will continue to be supplied from the county where it is ultimately used for public supply, with no county imports required through 2060; hence Table 2.13 shows no imported water under any scenario.

Table 2.13 Public Supply Water Demand Scenarios

Year	Population Served	Demand		Locally Supplied[1] (Mgd)		Imported[2] (Mgd)
		gpcd	Mgd	Ground Water	Surface Water	
Current Trends (Baseline) Scenario (CT)						
2010 (Reported)[3]	124,659	144.5	18.01	5.30	12.71	0
2010 (Normal)[4]	124,659	147.5	18.39	5.26	12.43	0
2015	128,539	146.3	18.81	5.43	13.38	0
2020	132,419	143.8	19.04	5.25	13.78	0
2025	136,299	142.5	19.42	5.24	14.18	0
2030	140,179	141.2	19.80	5.23	14.56	0
2035	144,060	139.9	20.16	5.22	14.94	0
2040	147,940	138.6	20.51	5.21	15.30	0
2045	151,820	137.3	20.85	5.20	15.65	0
2050	155,700	136.0	21.18	5.19	15.99	0
2055	159,580	134.7	21.50	5.18	16.32	0
2060	163,460	133.4	21.81	5.17	16.64	0
2010 (Normal)-2060 Change	38,801	-14.1	3.42	-0.09	4.21	0
2010 (Normal)-2060 Change (%)	31.1	-9.6	18.6	-1.7	33.8	0
Less Resource Intensive Scenario (LRI)						
2010 (Reported)	124,659	144.5	18.01	5.30	12.71	0
2010 (Normal)	124,659	141.9	17.69	5.26	12.43	0
2015	128,539	138.1	17.76	5.17	12.58	0
2020	132,419	133.1	17.62	4.91	12.71	0
2025	136,299	129.4	17.64	4.82	12.82	0
2030	140,179	125.8	17.63	4.73	12.91	0
2035	144,060	122.3	17.61	4.64	12.98	0
2040	147,940	118.8	17.58	4.55	13.03	0
2045	151,820	115.4	17.53	4.46	13.06	0
2050	155,700	112.1	17.46	4.38	13.09	0
2055	159,580	108.9	17.38	4.29	13.09	0
2060	163,460	105.8	17.29	4.21	13.09	0
2010 (Normal)-2060 Change	38,801	-36.1	-0.40	-1.05	0.65	0
2010 (Normal)-2060 Change (%)	31.1	-25.4	-2.2	-19.9	5.2	0
More Resource Intensive Scenario (MRI)						
2010 (Reported)	124,659	144.5	18.01	5.30	12.71	0
2010 (Normal)	124,659	153.3	19.11	5.26	12.43	0
2015	128,539	154.9	19.91	5.70	14.21	0
2020	132,419	155.1	20.54	5.61	14.93	0
2025	136,299	156.7	21.36	5.70	15.66	0
2030	140,179	158.3	22.19	5.79	16.40	0
2035	144,060	159.8	23.02	5.87	17.15	0
2040	147,940	161.4	23.87	5.96	17.91	0
2045	151,820	162.9	24.73	6.05	18.68	0

Year	Population Served	Demand		Locally Supplied[1] (Mgd)		Imported[2] (Mgd)
		gpcd	Mgd	Ground Water	Surface Water	
2050	155,700	164.4	25.60	6.14	19.46	0
2055	159,580	166.0	26.48	6.23	20.25	0
2060	163,460	167.5	27.38	6.33	21.05	0
2010 (Normal)-2060 Change	38,801	14.1	8.26	1.07	8.61	0
2010 (Normal)-2060 Change (%)	31.1	9.2	43.2	20.3	69.3	0

[1]Locally Supplied: Water is supplied from within the county
[2]Imported: Water is supplied from outside the county
[3]2010 (Reported): reported demand in 2010
[4]2010 (Normal): weather-normalized demand in 2010 (obtained by substituting normal weather conditions in the regression model)

2.4.3 Differences between Scenarios

Table 2.14 and Table 2.15 compare estimated 2060 water demand under the CT scenario with those under LRI and MRI scenarios, respectively. The tables show that the differences between the CT scenario and the LRI and MRI scenarios are slightly asymmetric. Estimated 2060 demands under the LRI scenario are 4.5 Mgd (20.6 percent) less than under the CT scenario. Under the MRI scenario, total demands are 5.6 Mgd (25.7 percent) higher than under the CT scenario. These differences and their asymmetry reflect different assumptions about the future values and their effect on demand of three explanatory variables: median household income, marginal price of water, and water conservation.

Table 2.14 Comparison of CT and LRI Scenarios

Source	2010 Normal (Mgd)	2060 CT (Mgd)	2060 LRI (Mgd)	2060 LRI -CT (Mgd)[1]	2060 LRI/CT-1 (%)[2]
Groundwater (locally sourced[3])	5.3	5.2	4.2	-1.0	-19.2
Surface Water (locally sourced)	12.4	16.6	13.1	-3.5	-21.1
Groundwater (imported[4])	0	0	0	0	0
Surface Water (imported)	0	0	0	0	0
REGIONAL TOTAL	**17.7**	**21.8**	**17.3**	**-4.5**	**-20.6**

[1]2060 LRI-CT (Mgd): Demand in 2060 (LRI) minus demand in 2060 (CT) (Mgd)
[2]2060 LRI/CT-1 (%): Demand in 2060 (LRI) divided by demand in 2060 (CT) minus 1, expressed as a percentage. This value indicates the difference between 2060 LRI and CT estimates relative to the 2060 CT value.
[3]Locally sourced: water that is withdrawn from its source within the county of the demand
[4]Imported: water that is withdrawn from its source outside of the county of the demand

Table 2.15 Comparison of CT and MRI Scenarios

Source	**2010 Normal (Mgd)**	**2060 CT (Mgd)**	**2060 MRI (Mgd)**	**2060 MRI -CT (Mgd)[1]**	**2060 MRI/CT-1 (%)[2]**
Groundwater (locally supplied[3])	5.3	5.2	6.3	1.1	21.2
Surface Water (locally supplied)	12.4	16.6	21.0	4.4	30.4
Groundwater (imported[4])	0	0	0	0	0
Surface Water (imported)	0	0	0	0	0
REGIONAL TOTAL	**17.7**	**21.8**	**27.4**	**5.6**	**25.7**

[1] 2060 MRI-CT (Mgd): Demand in 2060 (MRI) minus demand in 2060 (CT) (Mgd)

[2] 2060 MRI/CT-1 (%): Demand in 2060 (MRI) divided by demand in 2060 (CT) minus 1, expressed as a percentage. This value indicates the difference between 2060 MRI and CT estimates relative to the 2060 CT value.

[3] Locally supplied: water that is withdrawn from its source within the county of the demand

[4] Imported: water that is withdrawn from its source outside of the county of the demand

3 Demand for Self-Supplied Domestic Water

3.1 Background

Domestic water demand includes water for normal household purposes such as drinking, food preparation, bathing, washing clothes and dishes, flushing toilets, car washing, and watering lawns and gardens (Solley et al., 1998). In many areas, water for domestic purposes is provided by public water supply systems, but some is self-supplied. Nearly all of the self-supplied domestic water is obtained from groundwater sources. Domestic water demand that is satisfied by public water systems is accounted for in Chapter 2. Chapter 3 discusses domestic water demand by individuals who operate their own household water supply systems.

The USGS estimates county-level self-supplied domestic water demand by multiplying the estimated self-supplied county population by a per-capita water use coefficient. The self-supplied population is calculated as the difference between total county population and the estimated number of people served by public water systems, data that, for Illinois, are obtained from IEPA and other sources. The self-supplied domestic water use coefficient in Illinois has been changed several times since the USGS first began reporting self-supplied domestic water use in 1960. The coefficient used in the most recent USGS report on U.S. water usage, which covers 2010, is 80 gallons per person per day (Maupin et al., 2014).

3.1.1 Reported Domestic Withdrawals

County-level self-supplied domestic populations and demand have been reported by the USGS for every USGS data compilation year (Hutson et al., 2004, Kenny et al., 2009, Maupin et al., 2014, Solley et al., 1993, 1998).

Table 3.1 shows the USGS reported self-supplied domestic population for the years 1990, 1995, 2000, 2005, and 2010 for each county in the study region. Also included in Table 3.1 are estimates of the 2010 self-supplied domestic population that we derived from IWIP data. We computed these estimates as the difference between the 2010 county population and the sum of populations served by public water systems in the county, as reported to IWIP. The estimates of self-supplied population suggest a declining trend, although the USGS-reported 2010 estimate violates this trend. Across all three regions for which the ISWS is currently developing estimates of future water demand (Figure 1.1), the self-supplied population declined at a rate of 1.0 percent per year between 1990 and 2010. In the Kankakee subregion, the self-supplied population declined at a rate of 0.5 percent per year between 1995 and 2010.

Table 3.2 shows USGS estimates of water demand by the self-supplied domestic sector from 1990 to 2010. In 2010, self-supplied domestic demand in the Kankakee subregion totaled 3.10 Mgd. The greatest self-supplied domestic population in the region is in Kankakee County.

Table 3.1 Estimated Historical Self-Supplied Domestic Population, by County

County	USGS					This Study
	1990[1]	**1995**[2]	**2000**[3]	**2005**[4]	**2010**[5]	**2010**
Ford	2,740	4,900	3,820	2,980	3,530	2,413
Iroquois	10,950	7,650	7,500	9,540	9,490	7,786
Kankakee	30,050	31,030	24,280	20,770	26,680	22,345
REGIONAL TOTAL	**43,740**	**43,580**	**35,600**	**33,290**	**39,700**	**32,544**

[1] Solley et al. (1993)
[2] Solley et al. (1998)
[3] Hutson et al. (2004)
[4] Kenny et al. (2009)
[5] Maupin et al. (2014)

Table 3.2 Historical Self-Supplied Domestic Water Demand, by County (Mgd) (USGS)

County	1990[1]	1995[2]	2000[3]	2005[4]	2010[5]
Ford	0.20	0.44	0.34	0.27	0.28
Iroquois	0.79	0.69	0.67	0.86	0.76
Kankakee	2.17	2.79	2.19	1.87	2.06
REGIONAL TOTAL	**3.16**	**3.92**	**3.20**	**3.00**	**3.10**

[1] Solley et al. (1993)
[2] Solley et al. (1998)
[3] Hutson et al. (2004)
[4] Kenny et al. (2009)
[5] Maupin et al. (2014)

3.2 Future Demand

3.2.1 Water Demand Relationship

We were unable to develop a valid model to capture the relationship between per-capita water demand in the domestic sector and key explanatory variables. Therefore, the effects of future income and climatic conditions were estimated using an elasticity of +0.12183 for income and a conservation trend of -0.00412. These coefficients were taken from the estimated public supply model, which is discussed in Chapter 2 and Appendix A. The conservation trend was applied in the LRI scenario, reduced by half (to -0.00206) for the CT scenario, and assumed to be zero in the MRI scenario.

3.2.2 Projected Self-Supplied Population

We estimated the future self-supplied domestic population in each county of the study region using the self-supplied population in 2010 (using IWIP data [Table 3.1], the projected 2010-2060 change in total county population (Table 2.8, Appendix B), and estimates of the population served by public systems from 2015 to 2060 (Table 2.9, Table A.4). These estimated projections are shown for 2010, 2030, and 2060 in Table 3.3.

Since the majority of the self-supplied population is served by domestic wells, we employed 2010 counts of domestic wells in each county, determined from well completion reports on file at the ISWS, together with our estimates of self-supplied population, to compute the number of people supplied per domestic well (Table 3.4). We computed these values as a metric to validate our estimates of self-supplied domestic populations; on a county level, reasonable estimates of persons supplied per well range from one to four. The available data on population served by private domestic wells in Connecticut indicate that Connecticut contains 322,578 domestic wells supplying a population of 822,575, implying that each well supplies 2.55 individuals (Connecticut Department of Public Health, 2015). For the Kankakee subregion, these computations suggest that, overall, our estimates are reasonable, since the regional totals suggest that 2.7 persons are supplied by each domestic well, and county-level estimates range from 1.0 to 3.4 persons per well (Table 3.4).

For the study region, we estimated that the total self-supplied population will decrease between 2010 and 2060 from 32,544 to 10,577 people. This represents a decrease of 21,967 people (Table 3.3).

Table 3.3 Self-Supplied Population by County

County	2010	2030	2060	2010-2060 Change
Ford	2,413	1,783	1,783	-630
Iroquois	7,786	5,721	5,589	-2,197
Kankakee	22,345	14,519	3,205	-19,140
REGIONAL TOTAL	**32,544**	**22,023**	**10,577**	**-21,967**

Table 3.4 Estimated Counts of Domestic Wells, Self-Supplied Population, and Person Per Well (2010)

County	Domestic Well Count	Self-Supplied Population	Persons Per Well
Ford	2,512	2,413	1.0
Iroquois	2,827	7,786	2.8
Kankakee	6,512	22,345	3.4
REGIONAL TOTAL	**11,851**	**32,544**	**2.7**

3.2.3 Scenarios of Water Demand

3.2.3.1 Current Trends (Baseline) Scenario (CT)

This scenario characterizes conditions during the period from 2010 to 2060 as an extension of recent trends in the principal factors influencing water demand. The assumptions of the CT scenario are the following:

1. Self-supplied domestic population follows county total population growth.
2. Annual growth of median household income during the 2005-2050 period is 1.0 percent.

3. The future conservation rate is -0.00206, which is half the trend suggested by the historical data.

3.2.3.2 Less Resource Intensive Scenario (LRI)

The Less Resource Intensive scenario captures future conditions that would lead to less water withdrawals by the self-supplied domestic sector. The assumptions of the LRI scenario are the following:

1. Self-supplied domestic population follows county total population growth.
2. Annual growth of median household income during the 2010-2060 period is 0.7 percent.
3. The future conservation rate is the same as the estimated historical trend, or -0.00412.

3.2.3.3 More Resource Intensive Scenario (MRI)

The more resource intensive scenario represents future conditions that would lead to greater water demand by the self-supplied domestic sector. The assumptions of the MRI scenario are the following:

1. Self-supplied domestic population follows county total population growth.
2. Annual growth of median household income during the 2010-2060 period is 1.2 percent.
3. The estimated historical conservation trend will not continue after 2010.

3.2.4 Scenario Results

Estimated self-supplied domestic water demand under the three scenarios is shown in Table 3.5 and Appendix C. Note that the 2010 estimates shown in Table 3.5 and Appendix C are based on our model of self-supplied domestic water demand and are not USGS estimates, which are shown in Table 3.2. Under all three scenarios, estimated self-supplied domestic demand in the region decreases substantially. Under the CT scenario, self-supplied domestic demand is projected to decrease from 2.60 Mgd in 2010 to 0.81 Mgd in 2060, a decrease of 1.79 Mgd, or 68.9 percent. Under the LRI scenario, self-supplied domestic demand would decrease to a total of 0.72 Mgd in 2060, a decrease of 1.89 Mgd, or 72.4 percent, from the 2010 total. Self-supplied domestic demand under the MRI scenario decreases by 1.69 Mgd from 2010 to a total demand in 2060 of 0.91 Mgd; this represents a decrease of 65.0 percent.

Table 3.5 Self-Supplied Domestic Demand Scenarios

Year	**Self-Supplied Population**	**Demand**	
		gpcd	**Mgd**
Current Trends (Baseline) Scenario (CT)			
2010	32,544	80.0	2.60
2015	28,888	79.7	2.30
2020	25,882	79.3	2.05
2025	22,836	79.0	1.80
2030	22,023	78.7	1.73
2035	20,115	78.3	1.58
2040	18,208	78.0	1.42
2045	16,300	77.7	1.27
2050	14,393	77.3	1.11
2055	12,485	77.0	0.96
2060	10,577	76.7	0.81
2010-2060 Change	**-21,967**	**-3.3**	**-1.79**
2010-2060 Change (%)	**-67.5**	**-4.2**	**-68.9**
Less Resource Intensive Scenario (LRI)			
2010	32,544	80.0	2.60
2015	28,888	78.7	2.27
2020	25,882	77.4	2.00
2025	22,836	76.2	1.74
2030	22,023	74.9	1.65
2035	20,115	73.7	1.48
2040	18,208	72.5	1.32
2045	16,300	71.3	1.16
2050	14,393	70.2	1.01
2055	12,485	69.0	0.86
2060	10,577	67.9	0.72
2010-2060 Change	**-21,967**	**-12.1**	**-1.89**
2010-2060 Change (%)	**-67.5**	**-15.1**	**-72.4**
More Resource Intensive Scenario (MRI)			
2010	32,544	80.0	2.60
2015	28,888	80.6	2.33
2020	25,882	81.2	2.10
2025	22,836	81.8	1.87
2030	22,023	82.4	1.81
2035	20,115	83.0	1.67
2040	18,208	83.6	1.52
2045	16,300	84.2	1.37
2050	14,393	84.8	1.22
2055	12,485	85.4	1.07
2060	10,577	86.0	0.91
2010-2060 Change	**-21,967**	**6.0**	**-1.69**
2010-2060 Change (%)	**-67.5**	**7.5**	**-65.0**

4 Demand for Self-Supplied Water for Power Generation

4.1 Background

Water needs for power generation include both off-stream (surface water) and groundwater for cooling of thermoelectric facilities as well as in-stream (or diverted) surface water flows for hydroelectric power generation. Power plants also need water for other purposes, such as ash sluicing, though in much smaller volumes. In this study, water demand for power generation focuses specifically on water withdrawals at self-supplied facilities.

Since there are comparatively few of either type of facility in the Kankakee subregion, in this chapter we employ as our database the power-generating facilities in three separate, but adjacent, IDNR water supply planning regions for which the ISWS, in 2014 and 2015, is simultaneously estimating future water demand to 2060. In addition to the Kankakee subregion, these include the Middle Illinois and Rock River regions (Figure 1.1).

The demand analysis for power generation was based on 2010 water demand data, which was the most recently available data when the study was performed in 2014. We acknowledge that much has changed in the power generation sector since 2010. Appendix I provides a brief summary of possible future trends and recommendations for more in-depth analysis.

4.1.1 Water Demand for Thermoelectric Power Generation

Water for thermoelectric power generation is used almost entirely for cooling. Because of the high demand for cooling water, most plants are sited adjacent to large rivers or large surface water bodies. Cooling system design, as well as gross generation capacity, strongly influence water demand. Two categories of cooling processes are employed: 1) once-through, and 2) closed-loop cooling. Once-through cooling water is typically withdrawn from a large river and virtually all of the water is immediately returned to its supply source, usually a short distance downstream of the withdrawal location, albeit at a higher temperature. Closed-loop cooling involves water recirculation, in which water is cooled either through a large cooling pond, evaporative cooling towers, or heat exchangers at the power plant.

Water used by electric power plants for cooling purposes is classified by the USGS as thermoelectric generation water usage. It represents the water employed in the production of heat-generated electric power. Heat sources may include nuclear fission or fossil fuels, such as coal, petroleum, and natural gas. Three major types of thermoelectric plants include conventional steam, nuclear steam, and internal combustion turbine plants. In the latter, the prime mover is an internal combustion diesel or gas-fired engine. Since no steam or condensation cooling is involved, almost no water is used in internal combustion power generation.

In conventional steam and nuclear steam power plants, the prime mover is a steam turbine, and water is used primarily for cooling and condensing steam after it leaves the turbine. The “waste” heat removed in the condenser is transferred to the surrounding environment through a combination of evaporation and heating of water. Appendix D discusses the theoretical requirements for cooling water at thermoelectric power plants.

4.1.2 Water Demand for Hydroelectric Power Generation

Hydroelectric power plants use the gravitational force of falling or flowing water to generate electricity. The consequences of water use by hydroelectric power plants depend on the layout of the plant relative to the river channel and the balance between the streamflow diverted for power generation (if streamflow is diverted at all) and the streamflow remaining in the source channel. The impacts on streamflow will likely be minimal for run-of-the-river plants (plants constructed directly on the stream) with low head (i.e., height of fall of water) and small storage behind a dam. Other plants employ diversion channels to temporarily convey a proportion of streamflow away from the stream channel to the power plant and then return the flow to the stream channel. On stream reaches where a diversion channel has diverted a proportion of flow, there may be concerns about reduced flow in the source stream below the diversion channel intake and above its downstream confluence with the source stream. Impacts may be more serious where diversion channels are long and if a large proportion of streamflow is diverted.

In this report, we do not estimate future water demand for hydroelectric power generation because such demand represents an in-stream use of water, with no loss of water from the stream. We also acknowledge that diversion channels can have consequences for source streams. Moreover, although our convention is to use the word *demand* to represent the water employed for hydroelectric power generation, and suggest that plant operators rely on this flow being available, this is not necessarily the case. For the most part, hydroelectric plants can and do generate electricity with whatever flow is available in the stream and are not reliant on a minimum flow. Thus, to estimate future water demand for hydroelectric power generation is misleading and misrepresents operating practices at these facilities.

4.1.3 Reported Plant-Level Power Generation and Water Demand

According to the United States Energy Information Administration (EIA) (2015c), 50 generation facilities exist within 15 of the 21 counties of the three study areas (Appendix E). Total nameplate capacity of the 50 plants is 11,735 megawatts (MW).

4.1.3.1 Thermoelectric Power Plants

Power plants that use once-through cooling return used water at a higher temperature than the ambient temperature in the river, which results in additional (forced) evaporation from the river. Less than 3 percent of the water withdrawn at plants using once-through cooling is typically consumed, mainly through forced evaporation (Solley et al., 1998).

Most large, traditional power plants using closed-loop cooling have a large cooling lake through which water is recirculated (withdrawn and returned). The returned water is at a higher temperature, which causes evaporation from the lake, typically resulting in a loss of 2 to 3 percent of the total amount of circulated water. A separate source of make-up water is needed to replace that lost through evaporation. Also, some of the recirculated water is extracted from the system and discharged as effluent as a way to remove hardness and chemicals that build up during recirculation. This effluent, often called blow-down, is typically discharged downstream from the source of the make-up water. A more modern type of closed-loop cooling system, involving evaporative cooling towers, intakes less water but consumes most of the water used.

Water demand by plants using once-through cooling is typically greater per unit of generated electricity than by plants using closed-loop cooling. The proportion of the withdrawn water lost to evaporation or consumed is greater from plants using closed-loop systems, however. Closed-loop systems with cooling towers, for example, can lose from 30 percent in nuclear facilities to 70 percent in plants using fossil fuels (Dziegielewski and Bik, 2006).

The difference between the amount of water withdrawn and water returned to the source (or discharged) usually represents consumptive use. In once-through cooling systems in which water is returned to the source at a higher temperature, the consumptive use is also calculated to include the amount of additional (forced) evaporation above ambient conditions caused by the higher water temperature. The amount of water consumed by power plants can often be difficult to calculate. Torcellini et al. (2003) calculated the average consumptive loss (by evaporation) in Illinois to be 1.05 gallons per kilowatt-hour (gal/KWh) of generated energy. However, this estimate is noticeably greater than that for neighboring states. The six-state regional average consumptive loss (weighted by total production) for Illinois, Indiana, Iowa, Michigan, Missouri, and Wisconsin was calculated to be 0.6 gal/KWh. The amount varies considerably depending on the cooling process. The greater average consumptive rate calculated by Torcellini et al. (2003) for Illinois is assumed herein to be associated with the large number of high-capacity, once-through power plants located along Lake Michigan and the major rivers of Illinois (Illinois, Mississippi, Rock, Des Plaines, and Kankakee).

With a nameplate capacity of 270 MW, the sole listed power plant in the Kankakee Watershed is in Gibson City (Ford County). It is small in comparison with other power plants listed in Table 4.1, and uses natural gas combustion turbines and does not use cooling water. It does not report water use to IWIP but appears to obtain water from the Gibson City public water system.

Of the 50 plants in the three study regions, nine thermoelectric plants account for nearly 69 percent of total generation capacity. The generation capacities of these nine large thermoelecric power plants are listed in Table 4.1. Total generation capacity (measured as gross capacity) of the nine plants is 8,056 MW. The remaining thermoelectric generators in the study regions do not represent large users of water for power generation. In this report, their water demand is accounted for in the public-supply sector (Chapter 2) and self-supplied commercial-industrial sector (Chapter 5).

Table 4.1 Existing Moderate to Large Thermoelectric Power Plants in Three Water Supply Planning Regions

Power Plant	County	Nameplate Capacity (MW)[1]	Gross Generation (2010) (MWh)[2]	Water Demand (2010) (Mgd)	Unit Use Water Demand (2010) (Gal/kWh)[3]
Kankakee Subregion					
Gibson City (Natural Gas)	Ford	270	20,001	No data	Not determined
Middle Illinois Region					
Exelon – LaSalle Co Station (Nuclear)	LaSalle	2,340	20,089,000	70.90[4]	29.865
Ameren Cilco - Edwards Station (Coal)	Peoria	780	4,394,000	386.74	32.149
Dynegy Midwest Gen - Hennepin Power (Coal)	Putnam	306	2,440,000	197.26	29.531
Rock River Region					
Lee Energy (Natural Gas)	Lee	814	No data	No data	Not determined
Exelon - Byron Station (Nuclear)	Ogle	2,450	20,848,000	55.52	0.973
Cordova Energy (Natural Gas)	Rock Island	611	161,500	0.26	0.592
Exelon - Quad Cities Station (Nuclear)	Rock Island	2,019	14,565,000	1,103.87	27.682
NRG Rockford I & II (Natural Gas)	Winnebago	484	No data	No data	Not determined

[1] MW: megawatts
[2] MWh: megawatt-hours
[3] gal/kWh: gallons per kilowatt-hours
[4] When recycled cooling pond water is included, total water withdrawals are 1642 Mgd. Consumptive water demand (difference between the make-up water and the blow-down return water) was approximately 26 Mgd.

4.1.3.2 Hydroelectric Power Plants

Eight small-capacity hydroelectric power plants in the three study regions divert significant amounts of water from streams to generate electricity before returning the water to its source stream (Table 4.2). Although the existing hydroelectric plants in the study regions are small-capacity facilities, they require large flows of water through the turbines per kWh of electric energy generated.

Water demands shown in Table 4.2 are estimates of the flow of water through the electricity-generating turbines at the plants. These demands are included in this report because they represent the flows employed at typical hydroelectric power plants in the study regions. As discussed in Section 4.1.2, we do not estimate future water demand for hydroelectric power generation.

Table 4.3 illustrates diverted flows and power generation at the North American Hydro-Dayton hydroelectric power plant as an example of operating conditions at a hydroelectric plant in the region. From 1998 to 2012, the Dayton plant diverted an average of 17 percent of Fox River flow for power generation. In general, both the gross diversion and the diversion as a proportion of Fox River flow at the Dayton plant have increased during the period.

Table 4.2 Existing Hydroelectric Power Plants in Three Water Supply Planning Regions

Power Plant	**County**	**Nameplate Capacity (MW)**[1]	**Gross Generation (2010) (MWh)**[2]	**Water Demand (2010) (Mgd)**	**Unit Use Water Demand (2010) (Gal/kWh)**[3]
Kankakee Subregion					
Kankakee Hydro Facility	Kankakee	1.20	2,587	No data	Not determined
Middle Illinois Region					
Marseilles Hydro Power Station (closed)	LaSalle	No data	Not applicable	Not applicable	Not applicable
National Hydro Corp.	LaSalle	No data	No data	No data	Not determined
North American Hydro – Dayton	LaSalle	3.68	16,125	735.81	16,667
Peru Hydroelectric Power Station	LaSalle	7.60	30,569	No data	Not determined
Rock River Region					
Dixon Hydroelectric Dam	Lee	3.00	12,578	No data	Not determined
Mid American Energy Co - Moline Hydro Plant	Rock Island	3.60	6,966	723.33	37,926
Sears Hydroelectric Plant	Rock Island	1.40	2,590	No data	Not determined
Upper Sterling Hydro Power Plant	Whiteside	2.20	3,365	389.69	42,298
North American Hydro - Rockton	Winnebago	1.10	7,529	1,037.61	50,337

[1] MW: megawatts
[2] MWh: megawatt-hours
[3] gal/kWh: gallons per kilowatt-hours

Table 4.3 Diversion of Fox River for Hydroelectric Power Generation, North American Hydro - Dayton (LaSalle County) (1998-2012)

Year	Diversion (cfs)[1]	Fox River Flow (cfs)[1]	Diversion (% of Fox River Flow)	Power Generation (MWh)[2]	Normalized Diversion (Gal/kWh)[3]
1998	5	2,072	0%	10,806	120
1999	102	2,531	4%	20,142	1,193
2000	106	2,039	5%	21,055	1,193
2001	112	2,360	5%	22,107	1,193
2002	78	2,165	4%	15,438	1,193
2003	60	979	6%	11,908	1,193
2004	85	2,133	4%	16,716	1,193
2005	67	1,466	5%	13,178	1,193
2006	590	1,367	43%	21,323	6,528
2007	590	3,239	18%	Not available	Not available
2008	500	3,798	13%	15,727	7,500
2009	670	3,759	18%	19,000	8,324
2010	1,139	3,520	32%	16,125	16,667
2011	1,326	2,618	51%	24,128	12,966
2012	720	1,623	44%	13,086	12,987
AVERAGE	**410**	**2,378**	**17%**	**17,196**	**5,246**

[1] cfs: cubic feet per second
[2] MWh: megawatt-hours
[3] gal/kWh: gallons per kilowatt-hours

4.2 Water Demand Relationships for Thermoelectric Power Generation

We employed a straightforward unit-coefficient method to estimate future water demand for thermoelectric power generation. This method represents water demand at a thermoelectric facility as the product of gross generation at the plant and the rate of water demand per unit of generated electricity. The specific coefficients and relationship for the two main types of cooling systems are discussed below.

Previous studies of water usage in plants with once-through cooling systems show that total water demand at a thermoelectric power plant depends primarily on the level of generation, but it is also a function of operational efficiency (i.e., the percent of capacity utilization), thermal efficiency, the design temperature rise in the condenser at 100 percent capacity, fuel type, and other system design and operational conditions (Dziegielewski and Bik, 2006, Yang and Dziegielewski, 2007). However, the usefulness of the published water demand relationships is limited because the reported equations are estimated from data extracted from returns of the U.S. Energy Information Administration's Form EIA-767 (*Annual Steam-Electric Plant Operation and Design Report*) (U.S. Energy Information Administration, 2015d), which, discontinued in 2005, solicited only net (not gross) electricity generation. More precise estimation of cooling-water demand is possible using gross generation.

The data in Table 4.1 include water demand and gross generation in four thermoelectric plants in the study regions that use once-through cooling. Figure 4.1 is a plot of gross generation versus water demand in 2010 at the four plants. The slope of the regression line in Figure 4.1 suggests that average water demand at thermoelectric power plants using once-through cooling in the three study regions is approximately 29 gallons/kWh of gross generation.

For closed-loop plants with cooling towers, water demand (referred to as *makeup water*) is generally less than 1.0 gallon per kWh of gross generation (Dziegielewski and Bik, 2006, Dziegielewski et al., 2002a).

Our estimates of future water demand for thermoelectric power generation at hypothetical future power plants are based on the electric energy generation and water demands of existing large, self-supplied plants. However, new power plants are likely to have higher power generation efficiencies and possibly use different fuels than in the existing plants. As a result, the water demand rate per kWh will almost certainly be lower in the future than for the exisiting self-supplied facilities. In deriving estimates of future water demand at existing power plants, we employed the actual normalized water demand at each plant (last column of Table 4.1).

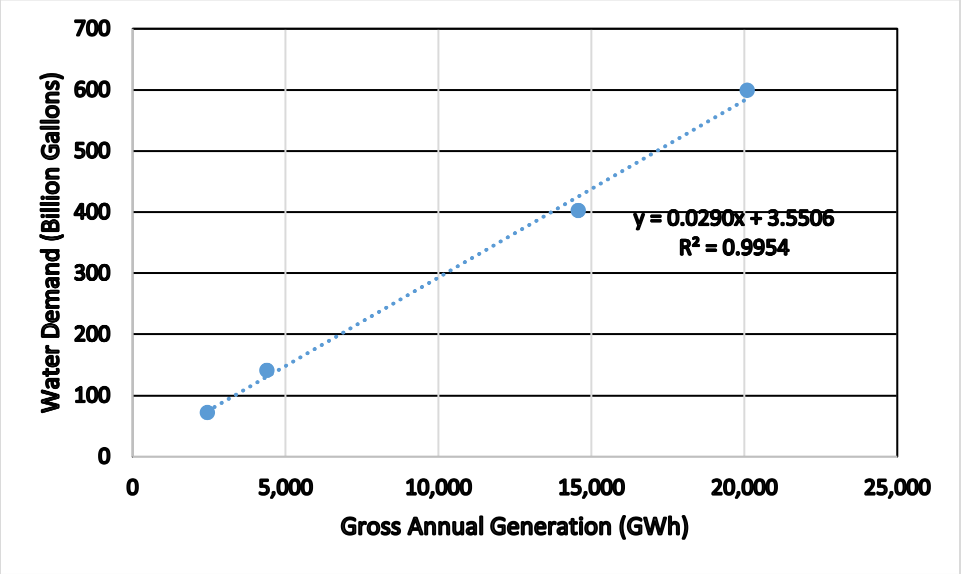

Figure 4.1 Gross electricity generation versus water demand for four thermoelectric power plants in the three study regions that use once-through cooling (2010)

4.3 Future Demand for Electricity

Future water demand by the power generation sector will depend on the level of future generation and also on the types of generators and cooling systems employed. Before characterizing future scenarios of water demand for thermoelectric power generation, we examined future trends in demand for electricity in the three study regions. With deregulation of the electric power industry, the demand for electricity in a geographical area cannot be linked directly to local generation. However, an understanding of future electricity demand is informative in characterizing future generation trends.

It is reasonable to expect that the future demand for electricity within the study regions will change because of population growth and the concomitant increase in economic activity. Current electricity demand within the study regions is challenging to determine precisely with available data, but per-capita electricity demand can be approximated by dividing the current aggregate sales of electricity by population served. Table 4.4 compares available estimates of per-capita electricity demand computed in this way for different geographical areas.

Of the estimates in Table 4.4, the estimate of 10.14 MWh/capita-year, reported by the Illinois Commerce Commission for the year 2006, is to us the most justifiable approximation of 2010 electricity demand in the 21 counties of the three study regions. The demand is only slightly lower than the 2005 statewide rate reported by the U.S. Energy Information Administration (10.77 MWh/capita-year) and the 2010 national average (12.97 MWh/capita-year). As such, the estimate can be considered conservative for future per-capita electricity demand in the three study regions.

At the national level, total electricity sales to all sectors (i.e., residential, commercial, and industrial) are expected to increase from 3927 billion kWh in 2007 to 5021 billion kWh in 2035 (AEO2010 reference case, U.S. Energy Information Administration (2018)). During the same time period, the projected U.S. population is expected to increase from 302.4 million (2007) to 390.7 million (2035). This implies that, at the national level, per-capita electricity demand will remain relatively constant, decreasing only slightly from 12.97 MWh/capita-year (2007) to 12.85 MWh/capita-year (2035).

We estimated future county and regional electricity demand as the product of projected future county population and estimated per-capita electricity demand of 10.14 MWh/capita-year (Table 4.4). For all three study regions, we employed county-level projections of population obtained from the Illinois Department of Public Health (IDPH) for the period 2015 to 2025, but, as discussed in Appendix B, these estimates do not extend to years beyond 2030. We therefore developed our own projections of county population for the period 2030 to 2060 for all three study regions using trends in historical and IDPH projections.

A comparison of the 2010 estimates of thermoelectric power generation (Table 4.1) with the estimates of 2010 electricity demand (Table 4.5) shows that total 2010 thermoelectric energy generation (62,497,871 MWh, but this is a minimum value since data are not available for a few facilities) greatly exceeds the estimated 2010 electricity demand within the three study regions of 13,945,349 MWh (1,594,038 MWh in the Kankakee subregion, 4,078,511 MWh in the Middle Illinois Region, and 8,272,800 MWh in the Rock River Region). This discrepancy attests to the fact that about 80 percent of the local thermoelectric generation in the study regions is exported.

Future electricity generation will follow demand, but the U.S. Energy Information Administration (2014) (AEO 2015 reference case) forecasts that new additions to generating capacity in the U.S. will mainly use natural gas and renewable sources of energy (Figure 4.2).

Table 4.4 Available Estimates of Per-Capita Electricity Demand

Source	Year	Electricity Demand (MWh/capita-year)	Geographic Area
Energy Information Administration (EIA)[1]	2005	10.77	Illinois
Illinois Commerce Commission (ICC)[2]	2006	10.14	Illinois
California Energy Commission[3]	2009	10.59	Illinois
Energy Information Administration (EIA)[1]	2010	12.97	United States
Illinois Commerce Commission (ICC)[2]	2013	10.36	Illinois

[1] U.S. Energy Information Administration (2015b)
[2] Illinois Commerce Commission (2015)
[3] California Energy Commission (2016)

Table 4.5 Population-Based Estimates of Future Electricity Demand in Three Study Regions

County	2010		2060	
	Population	**Electricity Demand, MWh**	**Population**	**Electricity Demand, MWh**
Kankakee Subregion (Annualized 2010-2060 Change in Electricity Demand = 0.20%)				
Ford County	14,078	142,751	13,448	136,363
Iroquois County	29,663	300,783	27,686	280,736
Kankakee County	113,462	1,150,505	132,903	1,347,640
REGIONAL TOTAL	**157,203**	**1,594,038**	**174,037**	**1,764,739**
Middle Illinois Region (Annualized 2010-2060 Change in Electricity Demand = 0.10%)				
LaSalle County	113,866	1,154,601	112,418	1,139,919
Livingston County	38,853	393,969	41,520	421,016
Marshall County	12,630	128,068	11,911	120,778
Peoria County	186,270	1,888,778	197,596	2,003,627
Putnam County	5,994	60,779	5,998	60,820
Stark County	5,967	60,505	5,585	56,632
Woodford County	38,640	391,810	48,165	488,390
REGIONAL TOTAL	**402,220**	**4,078,511**	**423,193**	**4,291,181**
Rock River Region (Annualized 2010-2060 Change in Electricity Demand = 0.13%)				
Boone County	54,144	549,020	76,814	778,894
Bureau County	34,905	353,937	33,681	341,525
Carroll County	15,364	155,791	14,169	143,674
Henry County	50,432	511,380	48,233	489,083
Jo Daviess County	22,660	229,772	22,137	224,469
Lee County	35,970	364,736	36,645	371,577
Ogle County	53,448	541,963	58,521	593,400
Rock Island County	147,632	1,496,988	158,035	1,602,472
Stephenson County	47,680	483,475	46,242	468,894
Whiteside County	58,472	592,906	55,267	560,407
Winnebago County	295,151	2,992,831	321,297	3,257,955
REGIONAL TOTAL	**815,858**	**8,272,800**	**871,040**	**8,832,349**

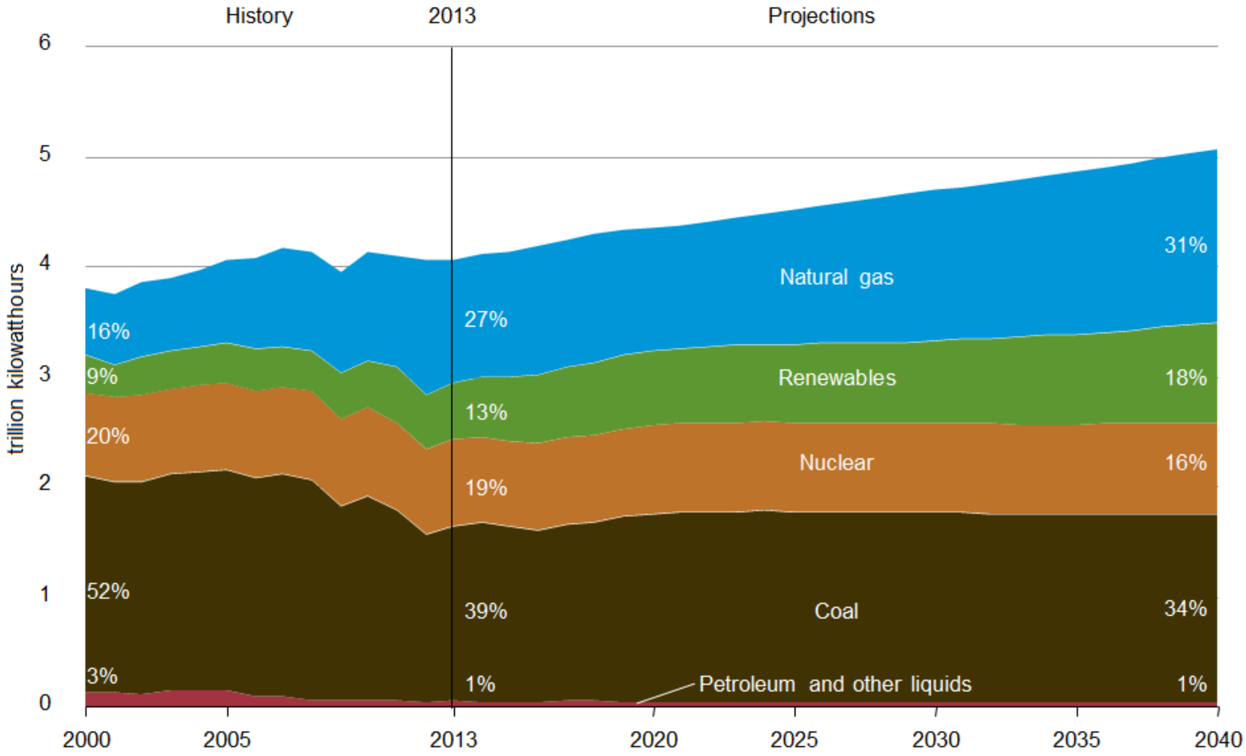

Figure 4.2 National projections of electricity generation by fuel type (U.S. Energy Information Administration, 2015a)

4.4 Scenarios of Water Demand

We have developed three scenarios of future water demand for thermoelectric power generation that reflect plausible conditions of electric power generation in the study regions. Because no large thermoelectric power generation facilities are presently located in the Kankakee subregion, the current trends and less resource intensive scenarios are precisely the same, assuming no addition of such facilities within the period ending 2060. We have assumed a nameplate capacity of 1200 MWh for the Gibson City (Ford County) facility with a closed-loop cooling system, which is typical of natural-gas-fired installations of this type.

4.4.1 Current Trends (Baseline) Scenario (CT)

Under this scenario, future generation of electricity in the study regions continues in the existing thermoelectric power plants at current levels of gross generation, and no new plants are built. The specific assumptions underlying this scenario are the following:

1. Future generation in the existing thermoelectric power plants will continue at 2010 levels of gross generation.
2. No new thermoelectric power plants (with steam turbines that require water-based cooling) will be added through the end of the study period in 2060.

4.4.2 Less Resource Intensive Scenario (LRI)

This scenario assumes future conditions that would lead to reduced water demand for thermoelectric power generation. Such an outcome would result if some of the existing thermoelectric plants would retire and not replace the older generating units. Because no large thermoelectric generation facilities are presently located in the Kankakee subregion, however, the LRI and CT scenarios, in the case of this region, are identical. The specific assumptions defining the less resource intensive (LRI) scenario include the following:

1. Future generation in the existing thermoelectric power plants will continue at 2010 levels of gross generation.
2. There are other fossil fuel generators that may be retired or replaced during the planning horizon of this study. However, because we have no specific information about this we assume that future generation in the thermoelectric power plants that remain continues at 2010 levels of gross generation.

4.4.3 More Resource Intensive Scenario (MRI)

This scenario assumes future conditions that would lead to greater water demand for thermoelectric power generation. Greater demand would result if additional thermoelectric power plants are built within the study regions. The MRI scenario is based on the following specific assumptions:

1. One new gas-fired combined-cycle thermoelectric plant with gross capacity of 1200 MW becomes operational in Kankakee County, near existing high-capacity transmission corridors, by 2020.
2. The new plant will employ a closed-loop cooling system, as required by the USEPA Phase I 316(b) rule, which will be supplied with surface water.

4.5 Scenario Results

Scenario results are shown in Table 4.6. Under the CT and LRI scenarios, demand for self-supplied water of power generation remains at the 2010 total of 0 Mgd through 2060. Under the MRI scenario, in which we assumed an additional large power plant that becomes operational in 2020, demand for self-supplied water of power generation increases to 10.96 Mgd. We can revise our MRI scenario definition to reflect the addition of power plants having different gross generation capacities, but we wish to consult with local authorities to obtain accurate information on proposed facilities before embarking on this course.

Table 4.6 Water Demand Scenarios for Power Generation

Year	Gross Electric Generation (MWh)	Total Demand (Mgd)
Current Trends (Baseline) Scenario (CT)		
2010	2,000	0
2015	2,000	0
2020	2,000	0
2025	2,000	0
2030	2,000	0
2035	2,000	0
2040	2,000	0
2045	2,000	0
2050	2,000	0
2055	2,000	0
2060	2,000	0
2010-2060 Change	**0**	**0**
2010-2060 Change (%)	**0**	**0**
Less Resource Intensive Scenario (LRI)		
2010	2,000	0
2015	2,000	0
2020	2,000	0
2025	2,000	0
2030	2,000	0
2035	2,000	0
2040	2,000	0
2045	2,000	0
2050	2,000	0
2055	2,000	0
2060	2,000	0
2010-2060 Change	**0**	**0**
2010-2060 Change (%)	**0**	**0**
More Resource Intensive Scenario (MRI)		
2010	2,000	0
2015	2,000	0
2020	8,000,000	10.96
2025	8,000,000	10.96
2030	8,000,000	10.96
2035	8,000,000	10.96
2040	8,000,000	10.96
2045	8,000,000	10.96
2050	8,000,000	10.96
2055	8,000,000	10.96
2060	8,000,000	10.96
2010-2060 Change	**7,998,000**	**10.96**
2010-2060 Change (%)	**399,900**	**10.96**

5 Demand for Self-Supplied Water for Industrial and Commercial Uses

5.1 Background

The industrial and commercial (IC) sector includes water used for a range of institutional and nonresidential purposes. The industrial subsector includes water used for “industrial purposes such as fabrication, processing, washing, and cooling, and includes such industries as steel, chemical and allied products, paper and allied products, mining, and petroleum refining,” and the commercial sub-sector includes water used for “motels, hotels, restaurants, office buildings, other commercial facilities, and institutions” (Avery, 1999). The industrial subsector encompasses water used for mining, including quarrying and extraction of naturally-occurring minerals, milling, and other operations at the mine site (Avery, 1999).

IC water demand is satisfied with self-supplied water or water purchased from public water systems, but this chapter is concerned principally with self-supplied IC water demand. IC demand for puchased water is summarized, but we included this component of IC demand in public system demand, which we discuss in Chapter 2.

5.1.1 Historical Self-Supplied IC Demand

County-level totals of self-supplied withdrawals have been estimated, compiled, and reported by the USGS since 1985 under the USGS National Water-Use Information Program (U.S. Geological Survey, 2014). Table 5.1 shows the 1990, 1995, 2000, 2005, and 2010 USGS estimates, with mining and non-mining IC demand separated for all data years except 2000, when mining IC demand was not estimated. Detailed explanations of the USGS methodologies for developing these estimates are available in summary reports (Hutson et al., 2004, Kenny et al., 2009, Maupin et al., 2014, Solley et al., 1993, 1998).

County totals in Table 5.1 display geographic variability in self-supplied IC demand across data years. For 2010, the USGS estimated zero self-supplied non-mining IC demand in Kankakee and Iroquois Counties; the Ford County total of 1.46 Mgd is the entire non-mining IC demand in the subregion (Figure 5.1). Similarly, 97 percent of the self-supplied mining demand in the region, which totaled 3.84 Mgd, occured in Kankakee County (Figure 5.1). The variability of the estimated demand is partially attributable to the methods by which the self-supplied withdrawals are inventoried.

The estimates of self-supplied IC non-mining and mining demand in Table 4.1 do not display strong temporal trends. Self-supplied non-mining demand averaged about 0.2 Mgd during the first four data years (1990-2005), but the regional total increased markedly between 2005 and 2010, when demand in Ford County increased from 0 to 1.46 Mgd with the 2009 opening of a corn-processing plant in Gibson City. Self-supplied mining demand, not estimated for 2000, totaled less than 1 Mgd in 1990 and 1995 but increased to 8.24 and 3.84 Mgd in 2005 and 2010, respectively.

Table 5.1 Historical Self-Supplied IC Water Demand (Mgd) (U.S. Geological Survey, 2014)

County	**Non-Mining**					**Mining**				
	1990	**1995**	**2000**	**2005**	**2010**	**1990**	**1995**	**2000**	**2005**	**2010**
Ford	0	0.10	0	0	1.46	0.03	0.70	NE[1]	3.09	0.06
Iroquois	0.07	0.08	0.07	0.07	0	0	0	NE	0.08	0.07
Kankakee	0.12	0.18	0.09	0.09	0	0.79	0	NE	5.07	3.71
REGIONAL TOTAL	**0.19**	**0.36**	**0.16**	**0.16**	**1.46**	**0.82**	**0.70**	**NE**	**8.24**	**3.84**

[1] NE: not estimated

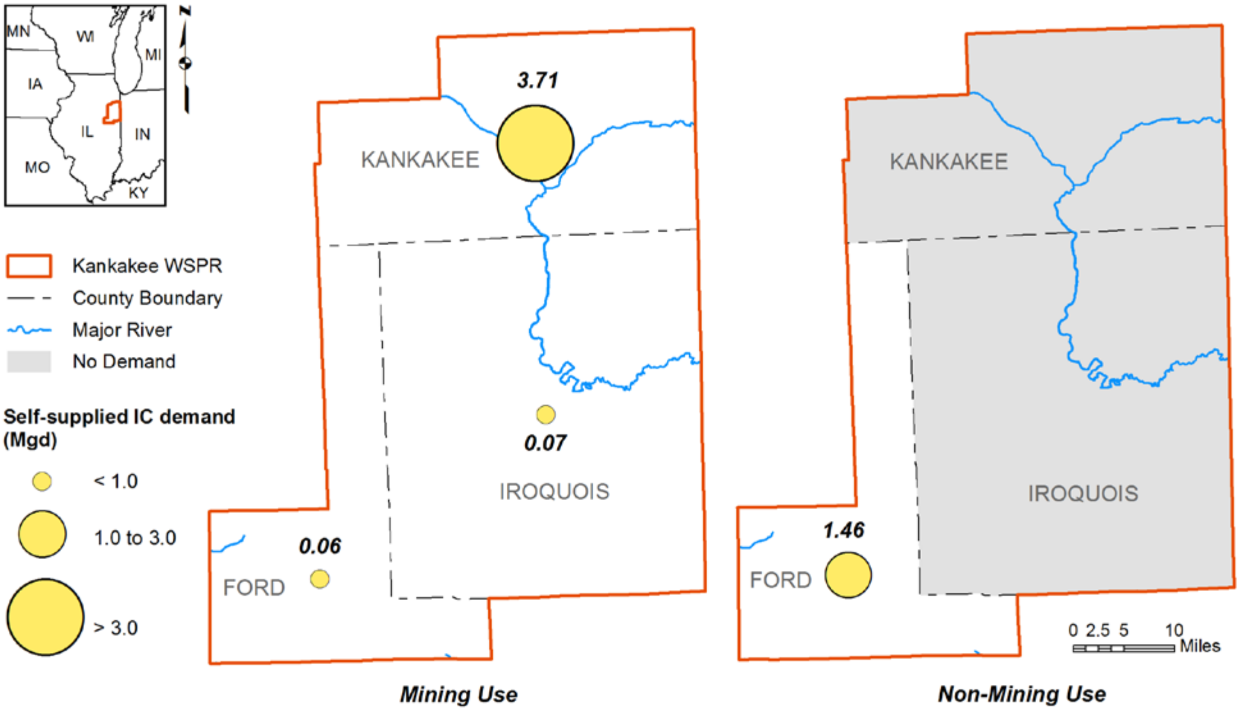

Figure 5.1 Self-supplied IC demand for mining and non-mining uses, 2010 (Mgd), by county (U.S. Geological Survey, 2014). There was no reported mining use in Kankakee or Iroquois Counties in 2010.

5.1.2 Historical Public Supply Deliveries to IC Users

In addition to using self-supplied water, IC facilities also use water purchased from public water systems. The demand for purchased IC water is included in the estimates of future public water system demand discussed in Chapter 2, but, for completeness, Table 5.2 shows estimated purchases of water from public water systems by IC customers in 2010. We computed the estimates in Table 5.2 from other values provided by the USGS. For 2005, we computed these values by subtracting the USGS estimate of public system deliveries for domestic use (DO-PSDel) from public system withdrawals (PS-Wtotl) (U.S. Geological Survey, 2014). We computed IC purchases for 2010 similarly, but the 1990 and 1995 values were computed by summing USGS estimates of public system deliveries to commercial and industrial customers. Public system deliveries to IC customers are not computable from USGS estimates for 2000.

Table 5.2 Deliveries from Public Water Systems to IC Facilities (Mgd) (U.S. Geological Survey, 2014)

County	1990	1995	2000	2005	2010
Ford	0.30	0.14	NE[1]	0.66	0.64
Iroquois	0.18	0.22	NE	0.29	0.54
Kankakee	6.74	8.68	NE	7.40	7.50
REGIONAL TOTAL	**7.22**	**9.04**	**NE**	**8.35**	**8.68**

[1] NE: Not estimated

5.2 Data and Estimation Methods

5.2.1 Demand Rates

The USGS estimates of county-level demand for self-supplied water by IC facilities that form the basis for our estimates of future self-supplied IC demand were supplemented with ISWS facility-level data on demand and employment to ascertain average rates of demand per employee at each facility. Although these data are not comprehensive in the sense that they do not include all self-supplied IC facilities in the region, they provide a sense of the wide range of per-employee demand that characterizes IC water demand.

Based on data reported to IWIP, facility-level demand totals in the subregion ranged from <0.1 to 4.8 Mgd, and employee-level demand ranged across five orders of magnitude, from 11.0 to 215,773.1 gallons per employee per day (gped). The large variation in employee-level demand reflects differences in water requirements among different types of commercial and industrial establishments. We examined self-supplied IC demand by Standard Industrial Classification (SIC) code, which are codes that identify and classify the activity or activities representing the primary line(s) of business of a firm (U.S. Department of Labor Occupational Safety and Health Administration, 2015) (Table 5.3). Analysis based on SIC codes show that, of the self-supplied IC establishments for which data are available, the greatest total and per-employee water demand in the Kankakee subregion is for production of crushed and broken limestone (SIC code 1422) and of construction sand and gravel (code 1442). In 2010, water demand for such activities totaled 3.5 and 4.8 Mgd, respectively, with per-employee demand approximately 160,000 gped.

The variability of self-supplied IC water demand per employee for different SIC codes tends to be high, making the development of a statistical model to estimate aggregate self-supplied IC water demand challenging.

Table 5.3 Self-Supplied IC Water Demand by SIC Code for Selected Facilities (2010)

SIC Code	SIC Code Definition	Demand (Mgd)	Number of Employees	Per Employee Demand (gped[1])
1422	Crushed and Broken Limestone	3.5	21	164,401.2
1442	Construction Sand and Gravel	4.8	30	159,039.0
2047	Dog and Cat Food	0.0	35	13.8
2869	Industrial Organic Chemicals, NEC[2]	1.5	55	26,507.9
5191	Farm Supplies	0.0	30	86.7

[1] gped: Gallons per employee per day

[2] NEC: Not elsewhere classified

5.2.2 Water Use Relationships

Water withdrawals and purchases for IC purposes are usually explained in economic terms, with water treated as a factor of production. For a study such as this, econometric models of water demand would ideally be developed based on a comparison of the outputs and the price of water and other inputs. Unfortunately, such data are rarely collected at the county level and are not publicly available because of their proprietary nature. An alternative and commonly used approach is to estimate water demand based on the size and type of products or services produced by the firm. This can be accomplished using unit-use coefficients. Because the size of businesses is frequently represented by the number of employees, and because demand varies considerably with the nature of the business enterprise, self-supplied IC water demand is frequently expressed as water demand per employee for a specified type of business.

To estimate future self-supplied IC water demand in the region, county-level employment data were obtained and compared to total county-level IC water demand, both self-supplied and purchased from public systems. The most detailed and relevant county-level employment data are the U.S. Census Bureau (2015b) County Business Patterns data series, which provide subnational economic data by industry, and the Illinois Department of Employment Security (2014) projections of future employment.

Table 5.4 shows aggregate and per employee IC water demand at the county level in 2010. It shows that per employee IC water demand, computed at the county level, is less variable, ranging from 94.0 to 525.3 gped, than per employee IC demand in the subset of self-supplied firms summarized by SIC code in Table 5.3. The reduced variability of the county-level estimates of IC water demand reflects the fact that computation of these estimates averages out differences in water demand between different types of IC establishments. Table 5.5 shows county totals of self-supplied and delivered water used by IC facilities in the region in 2010.

The county-level estimates of per-employee demand shown in Table 5.4 were applied in estimating future IC water demand in each county of the region. The percentage fractions from Table 5.5 were applied to estimate self-supplied withdrawals.

Table 5.4 Total Employment and Total IC Water Demand, By County (2010)

County	Total Employment[1]	Total IC Demand (Mgd)[2]	Per Employee IC Demand (gped[3])
Ford	4,112	2.16	525.3
Iroquois	6,491	0.61	94.0
Kankakee	35,226	11.21	318.2
REGIONAL TOTAL	**45,829**	**13.98**	**305.0**

[1] U.S. Census Bureau (2015b)
[2] U.S. Geological Survey (2014)
[3] gped: gallons per employee per day

Table 5.5 County IC Water Demand, Self-Supplied and Purchased (2010) (U.S. Geological Survey, 2014)

County	Self-Supplied (Mgd)	Purchased (Mgd)	Percent Self-Supplied
Ford	1.52	0.64	70.4
Iroquois	0.07	0.54	11.5
Kankakee	3.71	7.50	33.1
REGIONAL TOTAL	**5.30**	**8.68**	**37.9**

5.3 Future Water Demand

5.3.1 Future Employment and Productivity

The main driver of future IC water demand is assumed to be the future output of goods and services, which is a function of total employment and labor productivity.

Table 5.6 shows 2010 and projected future employment for the counties of the Kankakee subregion as estimated by the Illinois Department of Employment Security (2014). Between 2010 and 2020, total employment is projected to increase by 8255 employees, or 18 percent.

Employment projections are available from the Illinois Department of Employment Security (2014) only for the period 2012 to 2022. These employment growth projections are based on labor force development projections and may exceed the estimates of actual county-level employment. Also, these relatively high growth rates may not be sustained over a period of five decades. Therefore, for the period 2025-2060, we reduced the 2010-2020 annual growth rate by 30 percent and 50 percent for the periods 2021-2040 and 2041-2060, respectively.

Estimates of the long-term growth in labor productivity in the U.S. between 1973 and 2014 range from 1.2 to 2.6 percent per year; it is estimated at 1.4 percent for the period 2007 to 2014 (U.S. Department of Labor Bureau of Labor Statistics, 2015). Projections of future growth in labor productivity in Illinois are not available, however, so for this study we assumed long-term rates of labor productivity growth of 1.0 to 1.5 percent per year. These assumed growth rates make the estimates of future self-supplied IC demand based on them conservative. Higher future increases in productivity translate to greater physical output per employee and would yield higher estimates of self-supplied IC demand.

Table 5.6 Historical and Projected Employment in the Kankakee Subregion

County	2010 Employment[1]	2020 Employment[2]	Annual Rate of Change (2010-2020) (%)	2040 Employment[3]	2060 Employment[4]
Ford	4,112	4,484	0.87	5,089	5,694
Iroquois	6,491	7,078	0.87	7,078	7,078
Kankakee	35,226	42,521	1.90	45,369	48,232
REGIONAL TOTAL	**45,829**	**54,084**	**NA[5]**	**57,536**	**61,005**
ANNUAL REGIONAL RATE OF CHANGE (%)	**ND[6]**	**1.67**	**NA**	**0.31**	**0.29**

[1] U.S. Census Bureau (2015b)
[2] Illinois Department of Employment Security (2014)
[3] For 2021-2040, assumed annual rates of change are computed by reducing the 2010-2020 rate by 30 percent
[4] For 2041-2060, assumed annual rates of change are computed by reducing the 2010-2020 rate by 50 percent
[5] NA: Not applicable
[6] ND: Not determined

5.3.2 New Self-Supplied Industrial Plants

Self-supplied IC demand will exceed our estimates if new water-intensive IC facilities locate within the region and their per-employee demands exceed the county average values shown in Table 5.4. Although we have not at this time accounted for the addition of new water-intensive self-supplied IC facilities, such facilities and their associated demands can be added. Their addition, however, will require that we make assumptions about the location and water demand characteristics of the added facilities.

One plausible approach to account for the addition of such demands is to employ hypothetical ethanol and biodiesel production plants and/or hydraulic-fracturing ("fracking") sand mining and production facilities to represent new self-supplied water-intensive industrial facilities. Although their future is not certain, ethanol and biodiesel production plants are expected by many analysts to be constructed and to increase water demand in the region (Renewable Fuels Association, 2015). We would base water demand estimates for each added facility on an assumption about its production capacity, which is often provided in proposals and permit applications, and on available data pertaining to the water demand characteristics of the type of facility. For example, demand estimates for self-supplied ethanol production plants could be based on the results of a 2006 survey summarized by Wu (2007), which showed that ethanol plants use 2.65 to 6.10 gallons of fresh water to produce 1 gallon of ethanol. Wu (2007) further distinguished between dry- and wet-mill ethanol production facilities, which, as the survey shows, use an average of 3.45 and 3.92 gallons of water, respectively, per gallon of ethanol produced.

Biodiesel refining requires less water per unit of fuel produced than ethanol production. Pate et al. (2007) reported an approximate consumptive use of about 1 gallon of fresh water per gallon of biodiesel produced and an estimated overall water usage of up to 3 gallons of fresh water per gallon of biodiesel produced.

5.3.3 Water Demand by Source

Table 5.7 shows the percentages of self-supplied IC demand satisfied by self-supplied groundwater and surface water in 2010. We maintained the 2010 proportionalities shown in Table 5.7 to 2060, the end of the planning period covered by this study.

Table 5.7 Groundwater and Surface Water Demand by Self-Supplied IC Facilities, by County (2010) (U.S. Geological Survey, 2014)

County	Non-Mining (Mgd)			Mining (Mgd)			All Uses			
	Groundwater	Surface Water	Total	Groundwater	Surface Water	Total	Non-Mining (%)	Mining (%)	Groundwater (%)	Surface Water (%)
Ford	1.46	0.00	1.46	0.00	0.06	0.06	96	4	96	4
Iroquois	0.00	0.00	0.00	0.02	0.05	0.07	0	100	29	71
Kankakee	0.00	0.00	0.00	0.26	3.45	3.71	0	100	7	93
REGIONAL TOTAL	**1.46**	**0.00**	**1.46**	**0.28**	**3.56**	**3.84**	**28**	**72**	**33**	**67**

5.3.4 Scenarios of Water Demand

As for other water demand sectors, we have developed three scenarios of future self-supplied IC demand that reflect three different sets of plausible socioeconomic and weather conditions. For all three scenarios, we assumed that (1) total county employment will follow projections developed for this study based on growth rates determined from U.S. Census Bureau (2015b) and Illinois Department of Employment Security (2014) data; (2) the self-supplied portion of IC demand for each county will remain at the percentage computed from 2010 county totals reported by the USGS (2014), and (3) the proportions of groundwater and surface water in total self-supplied IC withdrawals will remain at percentages computed from 2010 county totals reported by the USGS (2014).

As described in Section 5.3.2, we can simulate added water-intensive self-supplied industrial facilities under the scenarios outlined here, but we have not done so as we would prefer to consult local authorities in advance regarding plausible county locations, water requirements, and operation start dates of the added facilities.

The specific assumptions used in each scenario are described below.

5.3.4.1 Current Trends (Baseline) Scenario (CT)

This scenario characterizes future conditions as extensions of recent trends in demand drivers and explanatory variables. The main demand driver is total county employment as projected for this study from data reported by the U.S. Census Bureau (2015b) and the Illinois Department of Employment Security (2014). Potentially, one or more additional water-intensive self-supplied industrial facilities could be added before 2060, with locations, water requirements, and operation start dates to be determined as described in Section 5.3.2. Additional assumptions are described below:

1. Future growth rate in labor productivity is 0.80 percent per year.
2. Adoption of water conservation measures achieves a demand reduction of 0.40 percent per year through 2060.

5.3.4.2 Less Resource Intensive Scenario (LRI)

Although this scenario assumes levels of county employment that are identical to those assumed under the CT scenario, the LRI scenario assumes additional conditions, described below, which would result in lower self-supplied IC water demand. No additional water-intensive self-supplied industrial facilities are envisioned under this scenario.

1. No new water-intensive industry (e.g., biodiesel or ethanol plants) locates within the region.
2. Future growth rate in labor productivity is 0.60 percent per year.
3. Adoption of water conservation measures achieves a demand reduction of 0.80 percent per year through 2060.

5.3.4.3 More Resource Intensive Scenario (MRI)

Like the LRI scenario, the MRI scenario assumes levels of county employment that are identical to those assumed under the CT scenario. Potentially, one or more additional water-intensive self-supplied industrial facilities could be added before 2060, with locations, water requirements, and operation start dates to be determined as described in Section 5.3.2. We also assumed the following conditions and developments that would result in higher self-supplied IC demand than either the CT or LRI scenarios:

1. Future growth rate in labor productivity is 1.00 percent per year.
2. No additional water conservation measures will affect self-supplied IC demand before 2060.

5.4 Scenario Results

Estimated future self-supplied IC water demand in the Kankakee Subregion is summarized in Table 5.8 and shown in detail in Appendix F. Under the CT scenario, self-supplied IC demand is projected to increase from 5.30 Mgd in 2010 to 8.87 Mgd in 2060. This represents an increase of 3.57 Mgd, or 67.3 percent. We estimated total self-supplied IC demand in 2060 at 6.57 Mgd under the LRI scenario and 11.94 Mgd under the MRI scenario. Note that these provisional scenarios do not simulate the effects on water demand of added self-supplied water-intensive industrial facilities as described in Section 5.3.2. This column is a place holder that could be populated based on comments, feedback, or additional information on industry and commercial water demand.

Table 5.8 Self-Supplied IC Water Demand Scenarios

Year	Demand (Mgd)		
	No added water-intensive IC demand	Added water-intensive IC demand	TOTAL
Current Trends (Baseline) Scenario (CT)			
2010 (Reported)[1]	5.30		5.30
2015	5.85	0	5.85
2020	6.47	0	6.47
2025	6.70	0	6.70
2030	7.01	0	7.01
2035	7.30	0	7.30
2040	7.59	0	7.59
2045	7.90	0	7.90
2050	8.21	0	8.21
2055	8.53	0	8.53
2060	8.87	0	8.87
2010 (Reported)-2060 Change	**3.57**		**3.57**
2010 (Reported)-2060 Change (%)	**67.3**		**67.3**
Less Resource Intensive Scenario (LRI)			
2010 (Reported)	5.30		5.30
2015	5.68	0	5.68
2020	6.09	0	6.09
2025	6.13	0	6.13
2030	6.22	0	6.22
2035	6.28	0	6.28
2040	6.34	0	6.34
2045	6.40	0	6.40
2050	6.46	0	6.46
2055	6.52	0	6.52
2060	6.57	0	6.57
2010 (Reported)-2060 Change	**1.27**		**1.27**
2010 (Reported)-2060 Change (%)	**24.0**		**24.0**
More Resource Intensive Scenario (MRI)			
2010 (Reported)	5.30		5.30
2015	6.03	0	6.03
2020	6.86	0	6.86
2025	7.33	0	7.33
2030	7.90	0	7.90
2035	8.47	0	8.47
2040	9.08	0	9.08
2045	9.73	0	9.73
2050	10.42	0	10.42

Year	**Demand (Mgd)**		
	No added water-intensive IC demand	**Added water-intensive IC demand**	**TOTAL**
2055	11.16	0	11.16
2060	11.94	0	11.94
2010 (Reported)-2060 Change	**6.64**		**6.64**
2010 (Reported)-2060 Change (%)	**125.3**		**125.3**

[1] U.S. Geological Survey (2014)

6 Demand for Self-Supplied Water for Irrigation, Livestock, and Environment

6.1 Background

The irrigation, livestock, and environmental (ILE) sector includes self-supplied water for irrigation of cropland and golf courses as well as water for livestock and environmental purposes.

In USGS inventories of water demand (U.S. Geological Survey, 2014), the designation *irrigation water withdrawals* includes “all water artificially applied to farm and horticultural crops as well as self-supplied water withdrawals to irrigate public and private golf courses” (Solley et al., 1998). In counties with significant proportions of land in irrigated agriculture, irrigation demand can represent a significant component of total water demand.

Livestock water demand encompasses water for individual animals, feedlots, dairies, fish farms, and other on-farm needs related to animal husbandry. The most common species supported by such water usage are cattle, sheep, goats, hogs, and poultry, but also included are horses, rabbits, bees, pets, fur-bearing animals in captivity, and fish in captivity (Avery, 1999). Livestock water demand as covered in this study includes five U.S Department of Agriculture (USDA) categories: cattle and cows, hogs and pigs, sheep and lambs, all goats, and horses.

A relatively small quantity of self-supplied water is employed for environmental purposes such as wetlands, forest and prairie preserves, park districts, game farms, and other uses that support environmental amenities.

We employed a range of data sources and computations to quantify present and future ILE water demand. The IWIP tracks irrigation withdrawals only for large agricultural irrigation systems and irrigated urban landscapes such as parks and golf courses. Therefore, our estimates of water demand for irrigation are based on an inventory of the total acreage of irrigated area (both cropland and golf courses) within each county of the study region. The IWIP collects very few data on agricultural livestock demand, so we based our estimates of agricultural livestock water demand on reported numbers of livestock, by type, within each county of the study region. We employed IWIP data as our basis for quanitifying environmental water demand. A review of the historical data on ILE water demand in the study region is presented in the following sections.

6.1.1 Water Demand for Irrigation

Table 6.1 shows the irrigated area in the Kankakee subregion, collected and reported through the USDA Census of Agriculture (U.S. Department of Agriculture, 2015), for the period 1987-2012. The totals in Table 6.1 include harvested cropland, pasture, and other irrigated land, but most is harvested cropland. Significant irrigated area in the subregion is present only in Kankakee County. Between 1992 and 2012, irrigated acreage remained fairly steady.

The USGS (2014) reports irrigation demand for both cropland and, since 1995, golf courses. Table 6.2 illustrates these estimates for the year 2010 for counties of the study region. Estimates of irrigation water demand are prepared by USGS researchers using a variety of methods that differ between, and sometimes within, individual states (Maupin et al., 2014), but all of these approaches require estimates of irrigated areas. Greater accuracy is afforded if the estimates of irrigated area are subdivided between cropland and golf courses, and, within the category of cropland, between differing crop types, because golf courses and crops of different types have differing water requirements. It is noteworthy and unfortunate that the estimates of irrigated area employed by the USGS differ from those reported by the USDA (U.S. Department of Agriculture, 2015), as the comparison of irrigated area in Table 6.1 and Table 6.2 shows; this is because the methodologies for acquisition and estimation of irrigated areas differ between these agencies. In Illinois, the USGS estimates of irrigation demand in most counties are based on the precipitation deficit during the irrigation season (Pat Mills, USGS, personal communication).

The USGS (2014) estimated that cropland irrigation withdrawals (equivalent to self-supplied cropland irrigation demand) in the Kankakee subregion totaled 8.14 Mgd in 2010, with the greatest demand in Kankakee County (Table 6.2). Golf course irrigation withdrawals (equivalent to self-supplied golf course irrigation demand) in 2010 totaled 0.50 Mgd.

Table 6.1 Irrigated Area in the Kankakee Subregion, by County (acres) (U.S. Department of Agriculture, 2015)

County	**1987**	**1992**	**1997**	**2002**	**2007**	**2012**
Ford	D*	1,515	688	693	55	771
Iroquois	1,221	1,175	4,424	2,627	4,072	3,133
Kankakee	7,822	17,297	13,695	14,056	15,950	14,573
REGIONAL TOTAL	**9,043**	**19,987**	**18,807**	**17,376**	**20,077**	**18,477**

*D = Data withheld due to disclosure limitations

Table 6.2 Irrigated Area and Irrigation Withdrawals, 2010 (U.S. Geological Survey, 2014)

County	**Irrigated Cropland**		**Irrigated Golf Courses**		**Annual Application Rate (inches)**
	Irrigated Area (acres)	**Irrigation Withdrawals (Mgd)**	**Irrigated Area (acres)**	**Irrigation Withdrawals (Mgd)**	
Ford	650	0.32	40	0.05	7.2
Iroquois	4,070	1.89	70	0.09	6.4
Kankakee	13,010	5.93	310	0.36	6.4
REGIONAL TOTAL	**17,730**	**8.14**	**420**	**0.50**	**6.4**

6.1.2 Water Demand for Livestock

Table 6.3 shows estimated head counts of five categories of livestock that were obtained from the USDA Census of Agriculture (U.S. Department of Agriculture, 2015) for the data year 2012. The estimates show that in 2012 in the Kankakee subregion there were 30,087 cattle and cows, 186,300 hogs and pigs, 1,735 sheep and lambs, 1,967 goats, and 1,169 horses. The largest inventories of animals were in Ford County, with the livestock numbers in that county strongly reflecting inventories of hogs and pigs. Iroquois County had the largest inventory of cattle and cows.

Table 6.4 shows historical water withdrawals for livestock (equivalent to self-supplied water demand for livestock) as estimated by the USGS (U.S. Geological Survey, 2014). Withdrawals totaled 1.29 Mgd in 2010 and have remained comparatively stable since 1990.

Table 6.3 Estimated Numbers of Livestock in the Kankakee Subregion, 2012 (U.S. Department of Agriculture, 2015)

County	Cattle and Cows	Hogs and Pigs	Sheep and Lambs	Goats	Horses
Ford	3,032	128,522	685	986	273
Iroquois	23,621	57,778	508	544	370
Kankakee	3,434	D*	542	437	526
REGIONAL TOTAL	**30,087**	**186,300**	**1,735**	**1,967**	**1,169**

*D = Data withheld due to disclosure limitations

Table 6.4 Estimated Water Demand for Livestock, 1990-2010 (U.S. Geological Survey, 2014)

County	Demand (Mgd)				
	1990	1995	2000	2005	2010
Ford	0.27	0.25	0.19	0.19	0.29
Iroquois	0.74	0.52	0.40	0.48	0.72
Kankakee	0.28	0.22	0.18	0.16	0.28
REGIONAL TOTAL	**1.29**	**0.99**	**0.77**	**0.83**	**1.29**

6.1.3 Water Demand for Environmental Uses

We identified self-supplied water demands for environmental purposes from the IWIP database. Table 6.5 shows total 2010 self-supplied demand for environmental purposes, by county, as documented in the IWIP database. Table 6.6 lists self-supplied environmental water demands by facility name. The total reported self-supplied demand in 2010 in the Kankakee subregion was <0.01 Mgd, all of which was withdrawn from groundwater sources for use in Kankakee River State Park. IWIP records also indicate that Kankakee State Park purchased <0.01 Mgd from Aqua Illinois-Kankakee Division (the public system supplying the City of

Kankakee), but this modest purchased amount is accounted for in our demand estimates for public systems (Chapter 2).

Trends in self-supplied environmental water demand are challenging to quantify owing to a scarcity of data. We have therefore aggregated 1990-2010 data from three separate, but adjacent, IDNR water supply planning regions for which the ISWS, in 2014 and 2015, simultaneously estimated future water demand to 2060 (Table 6.7). In addition to the Kankakee subregion, these include the Rock River and Middle Illinois regions (Figure 1.1). Although total demand is small relative to other sectors, the aggregated data, which represent demand at 34 facilities, suggest that self-supplied environmental water demand has increased markedly in recent decades at annual rates of about 6.1 percent from 1990 to 2010 and about 5 percent from 2000 to 2010. Conclusions about the magnitude and direction of trends in self-supplied environmental water demand must be tempered with the understanding that the same two facilities, both in Bureau County (in the Rock River region), account for 42 to 83 percent of annual water demand in the data years of 1990, 1995, 2000, 2005, and 2010.

Table 6.5 Reported Self-Supplied Environmental Water Demand

County	**Self-Supplied Demand (Mgd)**		
	Total	**Groundwater**	**Surface Water**
Ford	0	0	0
Iroquois	0	0	0
Kankakee	<0.01	<0.01	0
REGIONAL TOTAL	**<0.01**	**<0.01**	**0**

Table 6.6 Self-Supplied Demand for Environmental Purposes, By Facility (2010)

Facility Name	**Self-Supplied Demand (Mgd)**	**Demand by Source (Mgd)**	
		Groundwater	**Surface Water**
Iroquois County			
Iroquois County State Wildlife Area	0	0	0
Kankakee County			
Kankakee River State Park	0.002	0.002	0
REGIONAL TOTAL	**0.002**	**0.002**	**0**

Table 6.7 Self-Supplied Environmental Water Demand in Three Water Supply Planning Regions, 1990-2010 (Mgd)

Geography	1990	1995	2000	2005	2010
Kankakee Subregion					
Iroquois County	<0.01	0	0	0	0
Kankakee County	0.05	<0.01	0.01	<0.01	<0.01
REGIONAL TOTAL	**0.05**	**<0.01**	**0.01**	**<0.01**	**<0.01**
Middle Illinois Region					
LaSalle County	0.04	0.06	0.17	0.13	0.17
Marshall County	<0.01	<0.01	<0.01	<0.01	0
Peoria County	<0.01	<0.01	<0.01	<0.01	0
Putnam County	0.03	0.03	0.01	0.10	0.25
Woodford County	<0.01	<0.01	<0.01	0.43	0.60
REGIONAL TOTAL	**0.08**	**0.10**	**0.18**	**0.67**	**1.02**
Rock River Region					
Bureau County	0.80	2.23	2.81	3.28	2.46
Carroll County	0.34	0.11	0.06	0.51	0.69
Henry County	0.01	0.01	0.01	<0.01	<0.01
Jo Daviess County	0.01	0	0	0	0
Lee County	<0.01	<0.01	<0.01	<0.01	<0.01
Ogle County	0.01	0.06	0.07	0.07	0.09
Stephenson County	<0.01	<0.01	<0.01	<0.01	<0.01
Whiteside County	<0.01	<0.01	<0.01	<0.01	<0.01
Winnebago County	<0.01	<0.01	<0.01	<0.01	<0.01
REGIONAL TOTAL	**1.17**	**2.41**	**2.95**	**3.87**	**3.25**
TOTAL, ALL REGIONS	**1.30**	**2.52**	**3.14**	**4.54**	**4.27**

6.1.4 Sources of Water

We employed county-level estimates of irrigation and livestock demand by source (U.S. Geological Survey, 2014) and point-level data from IWIP on environmental demand to compute proportions of demand for each subsector satisfied by groundwater and surface water. Table 6.8 shows the percentage of water obtained from groundwater sources for each subsector.

Table 6.8 Percent of Self-Supplied ILE Demand Satisfied by Groundwater, By Subsector (2010)

County	**Irrigation**[1]		**Livestock**[1]	**Environmental**[2]
	Crops	**Golf Courses**		
Ford	100	100	100	0
Iroquois	100	56	100	0
Kankakee	87	75	100	100

[1] U.S. Geological Survey (2014)
[2] IWIP database

6.2 Water Demand Modeling

6.2.1 Water Demand for Irrigation

We estimated future water demand for both cropland and golf course irrigation using the following formula:

$$Q_t = \frac{325{,}851}{12 \cdot 365} A_t \cdot d_t \tag{6.1}$$

where:

Q_t = annual (seasonal) volume of irrigation water withdrawals in million gallons per day (Mgd) in year t;
A_t = irrigated land area in acres in year t;
d_t = depth of water application in inches in year t;
and the conversion factors represent: 325,851 gallons/acre-foot, 12 inches/foot, and 365 days/year.

The total seasonal application depth is estimated using the ISWS/USGS precipitation-deficit method, which quanitifies the irrigation rate required to compensate for weekly deficits in precipitation during the irrigation season in a study area. The method requires consultation of weekly precipitation records for the irrigation season, which we assumed would extend from May 1 to August 31. The irrigation season, which ends August 31, is shorter than the summer season used in estimating public system demand (Chapter 2), which ends September 30, because irrigation requirements in September are minimal (and can be omitted in the calculations of precipitation deficit).

Precipitation deficit is calculated by accumulating weekly deficits (or surpluses) over the 18 consecutive weeks of the irrigation season as follows:

1. If more than 1.25 inches of rain falls during the first week of the irrigation season, one-half the amount of rain exceeding 1.25 inches is added to the rain amount during the following week.
2. If less than 1.25 inches of rain falls during the first week, the difference between the actual precipitation and 1.25 inches is the precipitation deficit that is assumed to be the quantity of water, in inches, applied by irrigation that week.

3. For each subsequent week during the irrigation season, one-half of the cumulative precipitation during the previous week in excess of 1.25 inches is added to the precipitation amount for the week.
4. If the cumulative precipitation amount for a week is less than 1.25 inches, then the difference between the actual precipitation and 1.25 inches is the precipitation deficit that is assumed to be the quantity of water, in inches, applied by irrigation that week.
5. The precipitation deficits for each week are then added to determine the total irrigation water use during the irrigation season.

This procedure can be expressed as follows:

If the total precipitation in the first week r_1 is less than 1.25 inches, then

$$d_1 = r_1 - 1.25 \tag{6.2}$$

If the total precipitation in the first week r_1 is greater than 1.25 inches, then

$$\begin{aligned} d_1 &= 0 \\ r_2^e &= r_2 + (r_1 - 1.25)/2 \\ d_2 &= r_2^e - 1.25 \end{aligned} \tag{6.3}$$

where:

r_2^e = effective precipitation in week two.

In week two, again, the precipitation deficit will be zero if r_2^e is greater than 1.25 inches, and one-half of the precipitation surplus will carry to the next week.

The total seasonal precipitation deficit for the 18 weeks (i.e., 4 months) which make up the irrigation season is calculated as:

$$d_t = \sum_{i=1}^{18} d_i \tag{6.4}$$

6.2.1.1 Precipitation Deficits in the Study Region

Future water demand for irrigation will reflect precipitation deficits during the irrigation season, defined for purposes of this report as extending from May 1 to August 31. Our estimates of future irrigation demand are based on the “normal” 1981-2010 precipitation deficit, which we have computed from records of weekly precipitation at local weather stations (Table 6.9). Thus, we assumed that weather conditions for the period ending 2060 were comparable to those from 1981 to 2010. The precipitation deficit is an estimate of the total depth of water application, in inches, over the irrigated area of the region for which the precipitation deficit applies during the irrigation season. Comparison of the 1981-2010 precipitation deficits with those computed for

2010 (Table 6.9) suggest that irrigation water demand was significantly greater in the study region in 2010 than during a “normal” year.

Table 6.9 Irrigation-Season (May-August) Weather Statistics and Precipitation Deficits

County	**Station Used for Weather Characterization**		**Irrigation-Season (May-August) Statistics (1981-2010 “Normals”)**			**2010 Irrigation-Season (May-August) Precipitation Deficit (inches)[3]**
	Name	**ID[1]**	**Mean of Monthly Mean T (°F)[2]**	**Sum of Monthly Mean Precipitation (inches)[2]**	**Mean Precipitation Deficit (inches)[3]**	
Ford	Paxton	116663	68.90	16.00	-7.07	-9.72
Iroquois	Watseka 2 NW	119021	69.10	16.35	-7.07	-9.03
Kankakee	Kankakee Metro WWTP	114603	69.93	16.91	-7.73	-9.10
REGIONAL MEAN					**-7.29**	**-9.28**

[1] NWS COOP number (National Climatic Data Center, 2015)

[2] Monthly weather data for 1981-2010 were obtained from the Midwestern Regional Climate Center, Center for Atmospheric Science, ISWS

[3] Daily weather data employed for computation of precipitation deficits were obtained from (National Oceanic and Atmospheric Adminstration National Centers for Environmental Information, 2015)

6.2.2 Water Demand for Livestock

To estimate county-level livestock water demand in the study region, we multiplied unit water demand by animal type, derived from published values (Table 6.10 and Table 6.11), by estimated county populations of five major animal types. The animal types and the assumed water demand per head are cattle and cows (15 gal/d), hogs and pigs (7 gal/d), sheep and lambs (2 gal/d), all goats (3 gal/d), and horses (12 gal/d).

Table 6.10 Estimated Unit Water Demand for Livestock, by Animal Type (Avery, 1999)

Animal Type	**Estimated Water Demand (Gallons per day per animal)**
Dairy cows	35.0
Beef cattle	12.0
Horses and mules	12.0
Hogs	4.0
Goats	3.0
Sheep	2.0
Turkeys	0.12
Chickens	0.06
Rabbits	0.05
Mink	0.03

Table 6.11 Water Requirements of Farm Animals (Blocksome and Powell, 2006)

Livestock Type	Average Demand per Animal (Gal/day)	Average Demand per Animal (Gal/day)		
		40°F	60°F	80°F
Cows				
dry and bred	6-15	n.a.*	n.a.	n.a.
wintering pregnant	n.a.	6.0	7.4	n.a.
nursing	11-18	11.4	14.5	17.9
dairy	15-30	n.a.	n.a.	30-40
Feeders	4-15	n.a.	n.a.	n.a.
calves	4-5	n.a.	n.a.	9-10
growing cattle (600 lbs.)	n.a.	3-8	n.a.	8-13
growing cattle (800 lbs.)	n.a.	6.3	7.4	10.6
finishing cattle (800 lbs.)	n.a.	7.3	9.1	12.3
feedlot cattle (1,000 lbs.)	n.a.	8-13	n.a.	14-21
beef	8-12	n.a.	n.a.	20-25
Bulls	7-19	8.7	10.8	14.5
Sheep and Goats	2-3	n.a.	n.a.	n.a.
Llamas	5	n.a.	n.a.	n.a.
Horses	10-15	n.a.	n.a.	20-25
Swine	6-8	n.a.	n.a.	8-12

Note: * n.a = not available

6.3 Parameters Affecting Future ILE Water Demand

As discussed, we estimated future water demand for irrigation to be a function of irrigated area and summer precipitation deficit. We developed separate estimates of future irrigated areas for cropland and golf courses, as described below. Livestock water demand was estimated by multiplying the estimated unit water demand for five types of livestock by the estimated population of each animal type. Growth in environmental demand was based on recent historical trends.

6.3.1 Irrigated Area

6.3.1.1 Cropland

Based on the USDA Census of Agricuture (U.S. Department of Agriculture, 2015), irrigated agricultural acreage in 2012 (which includes irrigated cropland and a small proportion of irrigated pasture and other land) represents only 1.51 percent of total harvested cropland in the Kankakee subregion (Table 6.12). This small proportion suggests that irrigated cropland is not presently limited by the availability of cropland, an important consideration in projecting future irrigated cropland area. Between 1987 and 2012, irrigated cropland acreage in the region grew at an average annual rate of 1.3 percent. For comparison, the statewide rate of growth in irrigated acreage during the same 25-year period was 3.31 percent (Table 6.13).

Official estimates of future irrigated cropland acreage in the study region were not available. In their absence, we employed historical growth rates as a basis for projecting future irrigated acreage in the region.

Table 6.12 Irrigated Agricultural Land and Harvested Cropland (2012) (U.S. Department of Agriculture, 2015)

County	Irrigated Agricultural Land (acres)	Harvested Cropland (acres)	Percent Irrigated
Ford	771	290,265	0.27
Iroquois	3,133	616,671	0.51
Kankakee	14,573	320,367	4.55
REGIONAL TOTAL	**18,477**	**1,227,303**	**1.51**

Table 6.13 Long-Term Growth in Irrigated Agricultural Acreage in Illinois

Year	Irrigated Agricultural Land[1] (acres)	5-Year Average Growth Rate, Annualized (percent/year)	Long-Term Growth Rate Since Year in Left Column, Annualized (percent/year)[2]
1982	166,012		3.83
1987	208,105	4.62	3.31
1992	328,316	9.55	2.56
1997	351,676	1.38	2.82
2002	390,843	2.13	2.91
2007	474,454	3.95	1.95
2012	522,479	1.95	

[1] U.S. Department of Agriculture (2015)

[2] Annualized growth rates for periods ending in 2012 and starting with the year shown in the *Year* column. For example, the estimate of 3.83 percent/year in the top row of the table covers the period from 1982 to 2012, and the estimate of 3.31 percent/year, in the second row of the table, covers the period from 1987 to 2012.

6.3.1.2 Golf Courses

On the basis of drilling records on file at the ISWS and an electronic directory of U.S. golf courses (WorldGolf.com, 2015), we estimated that there are 15 golf courses in the Kankakee subregion. By contrast, there are 777 golf courses in Illinois (Golf Link, 2015). In general, golf course construction in the region occurred in two pulses separated by a period of reduced construction activity extending from the 1930s through the 1950s (Figure 6.1). From 1900 to 2002, when the first and last golf courses in the region were constructed, golf courses were constructed at an average rate of 1 course every 6.8 years (0.1 golf courses per year). The expansion of golf course numbers in the region from 1900-2002 reflects an annual growth rate of 2.7 percent, but the annual growth rate during the 1990-2009 period was only 1.6 percent. Four golf courses were constructed during the 1990-2009 period, or one new course built every five years (0.2 golf courses per year).

Recent national inventories of golf courses prepared by the National Golf Foundation (2015) showed that there has been negative net growth in U.S. golf facilities since 2006, as the number of golf facilities closed is greater than the number of new openings (Table 6.14). A golf facility contains at least one golf course.

Future water demand for golf course irrigation is a function of the estimates of future irrigated golf course area and summer precipitation deficit. The average irrigated area per 18-hole golf course is 40 acres (Black, 1983). The USGS water use inventories (U.S. Geological Survey, 2014) also use an average irrigated area of 40 acres per 18-hole golf course as a basis for computing irrigation totals. In addition, a study conducted by the Golf Course Superintendents Association of America (2015) and the USEPA (2015a) confirmed the average irrigated area per 18-hole golf course to be approximately 40 acres. Therefore, assuming an average irrigated area of 40 acres per 18-hole golf course and the rate of future golf course construction, future irrigated golf course areas can be estimated.

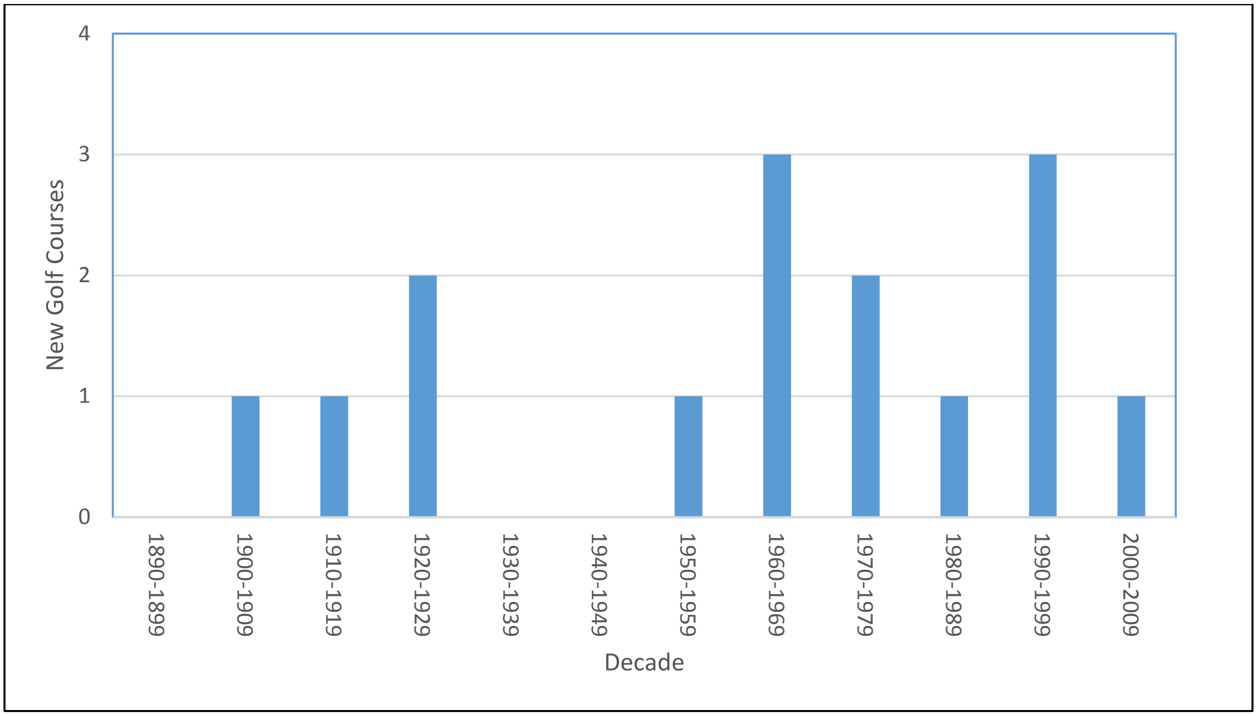

Figure 6.1 Golf course construction in the Kankakee subregion. None were constructed during the 1930-1939 and 1940-1949 periods.

Table 6.14 New Golf Course Opening and Construction in the U.S.

Year	Net Additions Since 1990	Year	Net Additions Since 1990
1990		2003	72
1991	158	2004	56
1992	206	2005	-5
1993	229	2006	-62
1994	244	2007	-9
1995	391	2008	-34
1996	267	2009	-90
1997	261	2010	-61
1998	298	2011	-138
1999	295	2012	-141
2000	292	2013	-133
2001	202	2014	-144
2002	138		

6.3.2 Livestock Head Counts

To develop estimates of future livestock water demand, we employed estimates of future U.S. livestock head counts developed in February 2014 by the USDA (U.S. Department of Agriculture Economic Research Service, 2014). These estimates are prepared annually. Table 6.15 shows projected head counts in the U.S. between 2012 and 2023. Annual rates of growth in head counts for this period range from -0.05 percent for dairy cows to 1.25 percent for hogs. As discussed in Section 6.4, we employed these growth rates, with an adjustment, as a basis for estimating future livestock head counts in the study region.

Table 6.15 Estimated Livestock Head Counts, 2012-2023 (U.S. Department of Agriculture Economic Research Service, 2014)

Animal Type	Head Count, 2012 (1000s)	Head Count, 2023 (1000s)	Change, 2012-2023 (1000s)	Annual Rate of Growth, percent
Cattle	90,538	96,088	5,550	0.54
Beef cows	30,158	33,668	3,510	1.01
Dairy cows	9,233	9,185	-48	-0.05
Total cows	39,387	42,681	3,294	0.73
Cattle and cows	129,925	138,769	8,844	0.60
Hogs	66,361	76,094	9,733	1.25

6.4 Scenarios of Water Demand

Future ILE water demand will respond to changes in demand drivers (e.g., irrigated acres) as well as gains in water use efficiency.

6.4.1 Current Trends (Baseline) Scenario (CT)

This scenario characterizes conditions during the period from 2010 to 2060 as an extension of recent trends in the principal factors influencing water demand. The specific assumptions of the CT scenario are the following:

1. For the period 2010-2025, we assumed the lowest historical rate of growth in total irrigated cropland acreage in the study region during the period 1987-2012. For the period 2030-2060, we assumed growth in irrigated cropland acreage at 50 percent of the growth rate during the period 2002-2012.
2. We assumed that irrigated golf course area expands at a rate of 0.6 new 18-hole golf courses per decade. Compared to historical growth rates of golf course area, this assumed rate of increase represents only a slight expansion of irrigated golf course area.
3. For the period 2010-2030, we assumed the 2012-2023 rates of growth in livestock head counts developed by the U.S. Department of Agriculture Economic Research Service (2014). For the period 2030-2060, we assumed growth in livestock head counts at 50 percent of the 2012-2023 growth rates specified by the U.S. Department of Agriculture Economic Research Service (2014). Our assumptions are identical for the MRI scenario (Section 6.4.3).
4. We assumed that environmental demand increases at the rate of 1.0 percent per year.

6.4.2 Less Resource Intensive Scenario (LRI)

1. For the entire forecast period ending 2060, we assumed the maximum irrigated cropland acreage reported for the historical period 1987-2012. In other words, we assumed there would be no increase in irrigated acreage.
2. We assumed no expansion of irrigated golf course area.
3. Growth in livestock head counts was based on the average head counts during 1997-2012 as the 2060 estimate (or constant 2010 estimates if the 1997-2012 estimate is lower than the 2010 value).
4. We assumed that environmental demand remained constant at the current (2010) level.

6.4.3 More Resource Intensive Scenario (MRI)

1. For the entire forecast period ending 2060, we assumed a 2.0 percent annual rate of growth in irrigated cropland acreage, which is among the higher annual rates implied by data for the historical period 1987-2012.
2. We assumed that new 18-hole golf courses are added at an annual rate of 1.0 percent per year, approximately the rate of growth prevailing during the period 1990-2009.
3. For the period 2010-2030, we assumed the 2012-2023 rates of growth in livestock head counts developed by the U.S. Department of Agriculture Economic Research Service (2014). For the period 2030-2060, we assumed growth in livestock head counts at 50

percent of the 2012-2023 growth rates specified by the U.S. Department of Agriculture Economic Research Service (2014). Our assumptions are identical for the CT scenario (Section 6.4.1).

4. Environmental demand was assumed to increase at a rate of 2.5 percent per year.

6.5 Scenario Results

Estimated demand under the three scenarios is shown in Appendix G and summarized in Table 6.16. Under the CT scenario, total demand increases by 56.1 percent during the period 2010 to 2060, from 15.63 Mgd in 2010 (adjusted to normal 1981-2010 weather conditions) to 24.39 Mgd in 2060, an increase of 8.76 Mgd. Under the LRI scenario, total demand increases by 2.56 Mgd (16.4 percent) from 2010 to 2060, and under the MRI scenario, total demand increases by 10.36 Mgd, or 66.3 percent, between 2010 and 2060.

Table 6.17 shows estimates of the sources of water for ILE demand assuming the 2010 proportionality of sources is maintained to 2060. Under the CT scenario, groundwater demand increases by 56.5 percent, from 13.75 to 21.52 Mgd, from 2010 to 2060. Surface water demand is far less, increasing from 1.88 to 2.88 Mgd (52.8 percent) during the period. Under the LRI scenario, surface water demand increases by 7.3 percent during the period 2010 to 2060, from 1.88 to 2.02 Mgd, while groundwater demand increases by 2.42 Mgd (17.6 percent), from 13.75 to 16.17 Mgd. Under the MRI scenario, groundwater demand increases by 66.4 percent, from 13.75 to 22.89 Mgd, from 2010 to 2060. Surface water demand under the MRI scenario increases by 65.0 percent, but magnitudes remain low in comparison to groundwater demand, with the total surface water demand increasing only to 1.22 Mgd in 2060.

Table 6.16 ILE Water Demand Scenarios

Year	Irrigation		Livestock (Mgd)	Environmental (Mgd)	Total ILE (Mgd)
	Cropland (Mgd)	Golf Course (Mgd)			
Current Trends (Baseline) Scenario (CT)					
2010 (Reported)[1]	10.90	0.23	2.08	0.002	13.21
2010 (Normal)[2]	13.26	0.28	2.08	0.002	15.63
2015	14.17	0.29	2.20	0.002	16.66
2020	15.13	0.30	2.33	0.002	17.76
2025	16.16	0.31	2.46	0.002	18.93
2030	16.71	0.32	2.60	0.002	19.63
2035	17.27	0.33	2.74	0.002	20.35
2040	17.85	0.34	2.90	0.002	21.10
2045	18.45	0.35	3.07	0.002	21.87
2050	19.07	0.36	3.24	0.002	22.68
2055	19.72	0.37	3.43	0.003	23.52
2060	20.38	0.38	3.63	0.003	24.39
2010 (Normal)-2060 Change[3]	**7.12**	**0.10**	**1.54**	**0.001**	**8.76**
2010 (Normal)-2060 Change (%)	**53.7**	**34.9**	**74.0**	**28.3**	**56.1**
Less Resource Intensive Scenario (LRI)					
2010 (Reported)[1]	10.90	0.23	2.08	0.002	13.21
2010 (Normal)[2]	13.26	0.28	2.08	0.002	15.63
2015	13.36	0.28	2.20	0.002	15.85
2020	13.46	0.28	2.33	0.002	16.08
2025	13.57	0.28	2.46	0.002	16.31
2030	13.67	0.28	2.60	0.002	16.55
2035	13.77	0.28	2.74	0.002	16.80
2040	13.87	0.28	2.90	0.002	17.06
2045	13.97	0.28	3.07	0.002	17.33
2050	14.08	0.28	3.24	0.002	17.60
2055	14.18	0.28	3.43	0.002	17.89
2060	14.28	0.28	3.63	0.002	18.19
2010 (Normal)-2060 Change[3]	**1.02**	**0.00**	**1.54**	**0.000**	**2.56**
2010 (Normal)-2060 Change (%)	**7.7**	**0.0**	**74.0**	**0.0**	**16.4**
More Resource Intensive Scenario (MRI)					
2010 (Reported)[1]	10.90	0.23	2.08	0.002	13.21
2010 (Normal)[2]	13.26	0.28	2.08	0.002	15.63
2015	14.32	0.30	2.20	0.002	16.82
2020	15.47	0.31	2.33	0.002	18.11
2025	16.70	0.33	2.46	0.003	19.49
2030	17.36	0.35	2.60	0.003	20.31
2035	18.05	0.36	2.74	0.003	21.16
2040	18.76	0.38	2.90	0.003	22.04
2045	19.49	0.40	3.07	0.003	22.97
2050	20.26	0.42	3.24	0.004	23.93

Year	**Irrigation**		**Livestock (Mgd)**	**Environmental (Mgd)**	**Total ILE (Mgd)**
	Cropland (Mgd)	**Golf Course (Mgd)**			
2055	21.06	0.44	3.43	0.004	24.94
2060	21.89	0.47	3.63	0.004	25.99
2010 (Normal)-2060 Change[3]	**8.63**	**0.18**	**1.54**	**0.002**	**10.36**
2010 (Normal)-2060 Change (%)	**65.1**	**64.5**	**74.0**	**110.5**	**66.3**

[1] 2010 (Reported): reported irrigation and livestock demand in 2010 (U.S. Geological Survey, 2014); environmental demand computed by the authors from IWIP data

[2] 2010 (Normal): weather-normalized irrigation demand in 2010 (obtained by substituting normal weather conditions in the estimation model); reported and weather-normalized livestock and environmental demand are equal

[3] Changes are computed relative to 2010 (Normal) values

Table 6.17 ILE Demand by Source

Year	Demand (Mgd)		
	Groundwater	Surface Water	Total
Current Trends (Baseline) Scenario (CT)			
2010 (Reported)[1]	11.67	1.54	13.21
2010 (Normal)[2]	13.75	1.88	15.63
2015	14.65	2.01	16.66
2020	15.62	2.14	17.76
2025	16.65	2.28	18.93
2030	17.27	2.36	19.63
2035	17.91	2.44	20.35
2040	18.58	2.52	21.10
2045	19.27	2.60	21.87
2050	19.99	2.69	22.68
2055	20.74	2.78	23.52
2060	21.52	2.88	24.40
2010 (Normal)-2060 Change[3]	**7.77**	**0.99**	**8.76**
2010 (Normal)-2060 Change (%)	**56.5**	**52.8**	**56.1**
Less Resource Intensive Scenario (LRI)			
2010 (Reported)[1]	11.67	1.54	13.21
2010 (Normal)[2]	13.75	1.88	15.63
2015	13.95	1.90	15.85
2020	14.17	1.91	16.08
2025	14.39	1.92	16.31
2030	14.61	1.94	16.55
2035	14.85	1.95	16.80
2040	15.09	1.96	17.06
2045	15.35	1.98	17.33
2050	15.61	1.99	17.60
2055	15.89	2.01	17.89
2060	16.17	2.02	18.19
2010 (Normal)-2060 Change[3]	**2.42**	**0.14**	**2.56**
2010 (Normal)-2060 Change (%)	**17.6**	**7.3**	**16.4**
More Resource Intensive Scenario (MRI)			
2010 (Reported)[1]	11.67	1.54	13.21
2010 (Normal)[2]	13.75	1.88	15.63
2015	14.79	2.03	16.82
2020	15.92	2.19	18.11
2025	17.13	2.36	19.49
2030	17.85	2.46	20.31
2035	18.60	2.55	21.16
2040	19.39	2.66	22.04
2045	20.21	2.76	22.97
2050	21.06	2.87	23.93
2055	21.95	2.99	24.94

Year	**Demand (Mgd)**		
	Groundwater	**Surface Water**	**Total**
2060	22.89	3.11	25.99
2010 (Normal)-2060 Change[3]	**9.14**	**1.22**	**10.36**
2010 (Normal)-2060 Change (%)	**66.4**	**65.0**	**66.3**

[1] 2010 (Reported): reported irrigation and livestock demand in 2010 (U.S. Geological Survey, 2014); environmental demand computed by the authors from IWIP data

[2] 2010 (Normal): weather-normalized irrigation demand in 2010 (obtained by substituting normal weather conditions in the estimation model); reported and weather-normalized livestock and environmental demand are equal

[3] Changes are computed relative to 2010 (Normal) values

7 Sensitivity of Demand to Climate Change and Drought

7.1 Possible Changes and Effects

This chapter discusses plausible effects of regional and global climate change on water demand in the region during the timeframe of our analysis, which ends in 2060. We also discuss likely effects of periodic drought on water demand.

The estimates of future water demand discussed in the previous chapters assume normal weather conditions based on historical data. Specifically, the values of air temperature and precipitation used as explanatory variables in the water-demand model for public water supply represent long-term averages based on the 30-year record from 1981 to 2010. We used historical precipitation data to compute precipitation deficits for estimates of future irrigation demand. These “climate normals” are expected to change (or shift) under climate change scenarios.

7.1.1 Range of Climate Change Predictions

7.1.1.1 Characterization of Climate Changes by Dziegielewski and Chowdhury (2008)

Climate models discussed by Dziegielewski and Chowdhury (2008) show that, by 2050, average annual temperatures in Illinois may depart by up to +6 °F from the 1971-2000 long-term normal. These climate models also indicate that normal annual precipitation in Illinois could depart from 1971-2000 normals by -5 inches to +5 inches per year by 2050. Figure 7.1 and Figure 7.2 illustrate the predictions of the multiple global climate models discussed by Dziegielewski and Chowdhury (2008) with the results grouped into three families (A1, A2, and B1) based on the scenario.

In Figure 7.1 and Figure 7.2, scenario A1 assumes very rapid economic growth, a global population peak in mid-century, and rapid introduction of new and more efficient technologies. Scenario A2 describes a very heterogeneous world with high population growth, slow economic development, and slow technological change. Scenario B1 describes a convergent world, with the same global population as A1, but with more rapid changes in economic structure toward a service and information economy. The 5 percent and 95 percent confidence limits shown in Figure 7.1 and Figure 7.2 bracket 90 percent of model results, excluding the lower and upper 5 percent of results (Intergovernmental Panel on Climate Change, 2007).

Dziegielewski and Chowdhury (2008) assumed, for purposes of water demand estimation in northeastern Illinois, that the changes in annual temperature and precipitation indicated by Figure 7.1 and Figure 7.2 implied similar changes during the growing season. In modeling water demand to 2050, they therefore assumed for the summer growing season a temperature increase of 6 °F and precipitation changes ranging from +2.5 inches to -3.5 inches.

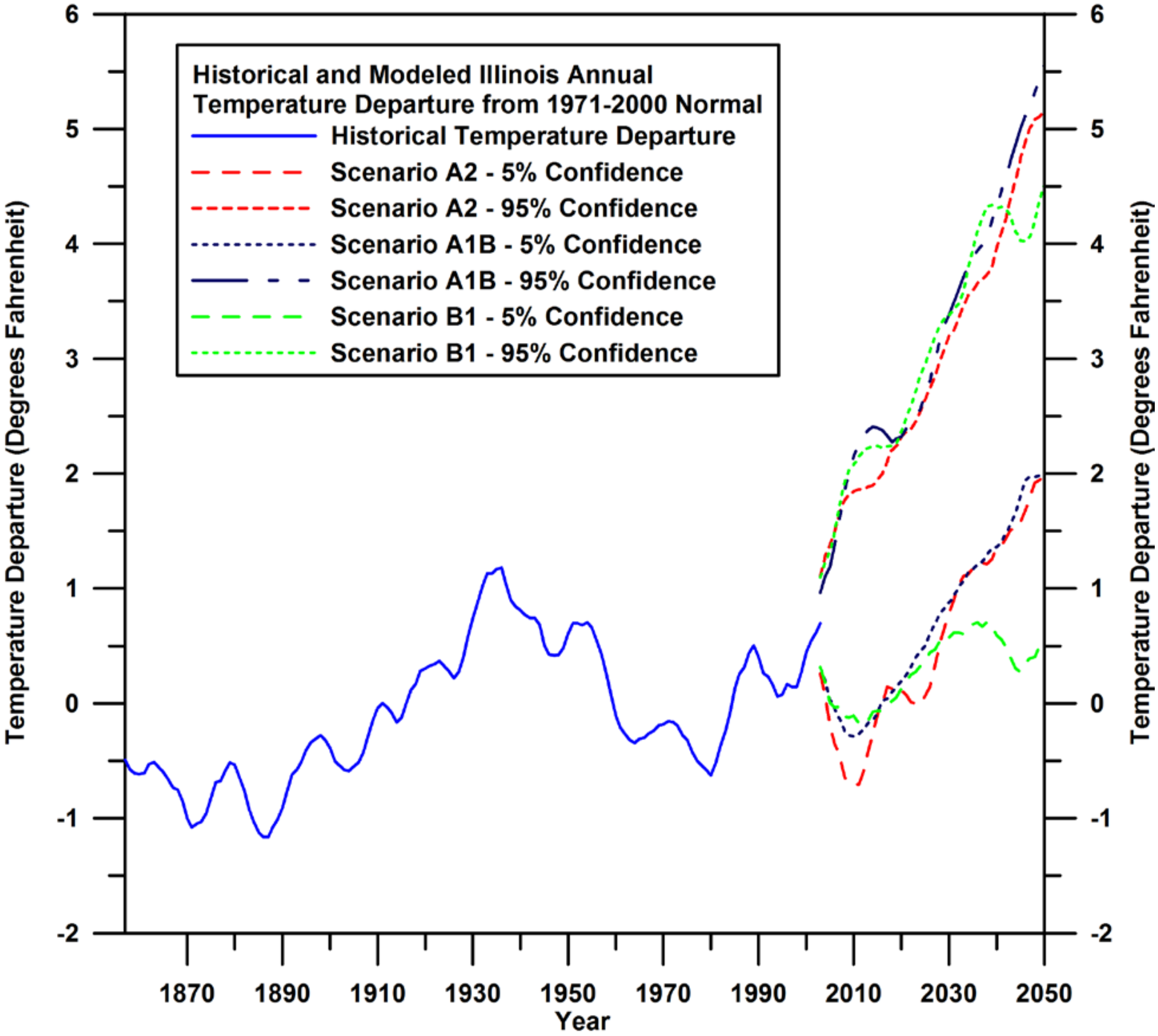

Figure 7.1 Departures from Illinois 1971-2000 annual temperature normal discussed by Dziegielewski and Chowdhury (2008).

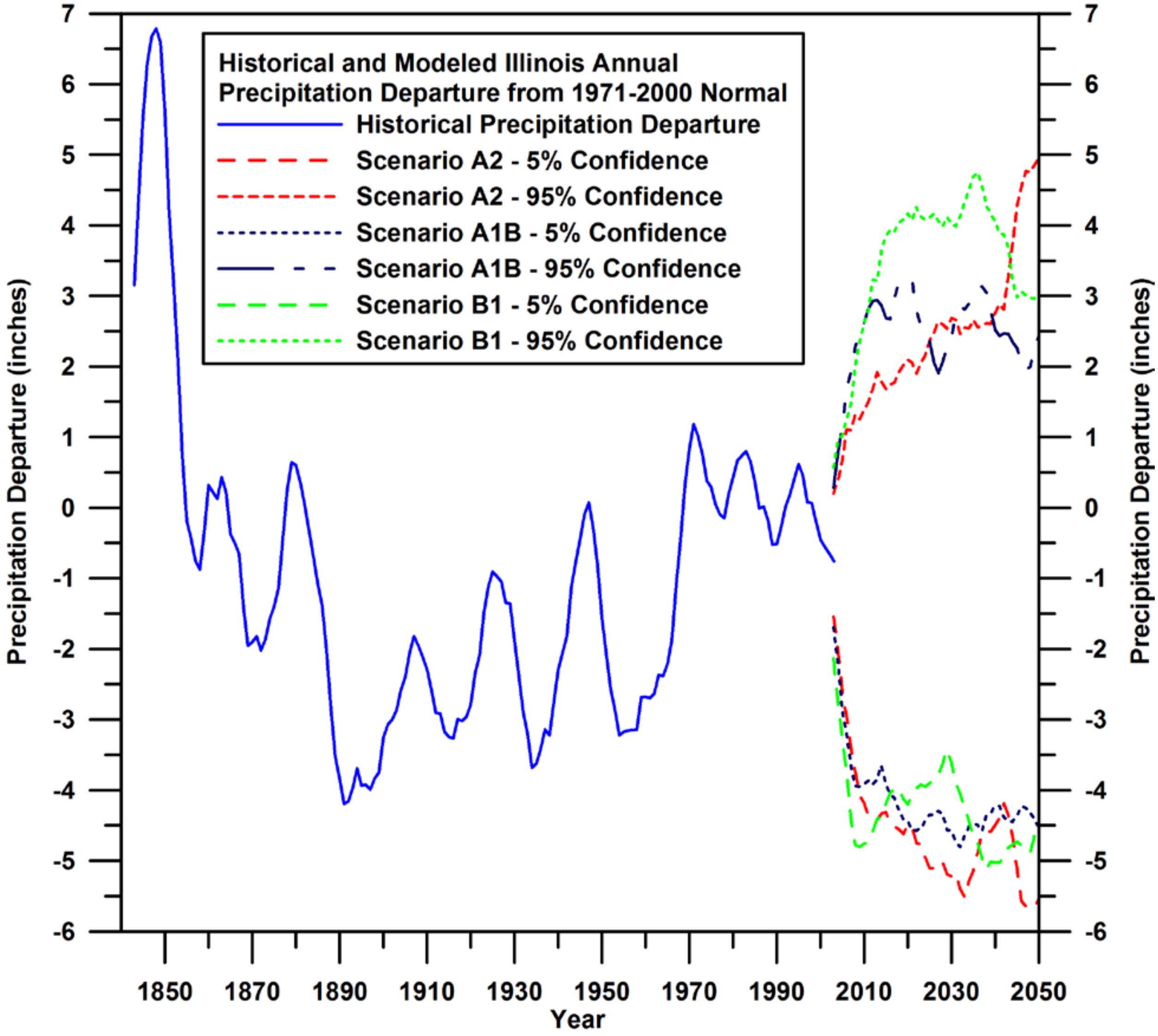

Figure 7.2 Departures from Illinois 1971-2000 annual precipitation normal discussed by Dziegielewski and Chowdhury (2008).

7.1.1.2 Most Recent Climate Model Predictions

More recent modeling of climate change provides greater spatial resolution than the statewide models referenced by Dziegielewski and Chowdhury (2008). Climate change data are currently provided by USEPA (2015b) for model grid cells having an area of ½ degree of longitude by ½ degree of latitude. For the contiguous United States, these grid cells have dimensions of approximately 32 by 32 miles.

Table 7.1 shows model results from USEPA (2015b) for three scenarios of climate change, for model grid cells representative of study area counties based on the degree of intersection between the grid cells and counties. The data characterize climate change as positive or negative departures from 1971-2000 climate normals. Modeled changes in temperature and precipitation are averaged over two 30-year time periods, which we identified using the midpoint of each period, i.e., a *2035 period*, which extends from 2021-2050, and a *2060 period*, which extends from 2046-2075. The three scenarios represent a range of model results for each 32 by 32 mile grid cell. We designated these as (1) the *Hot/Dry* scenario, which represents a hotter and drier future climate; (2) the *Warm/Wet* scenario, which represents a future climate with less warming but increased precipitation relative to other model results; and (3) the *Central* scenario, which falls in the middle of the distribution of model results.

Table 7.2 and Table 7.3 show normals of maximum daily temperature and total precipitation, respectively, for all calendar months, as well as seasonal averages, at weather stations located in the individual counties of the Kankakee subregion. Normals based on both 1971-2000 and 1981-2010 accounting periods are included in these tables.

For our analysis of the impacts of climate change on water demand, we had to assume monthly changes in temperature and precipitation on the basis of the annual data available from the USEPA (2015b). The implied USEPA scenario predictions (i.e., new climate normals) for 2035 and 2060 were compared with the normals for 1981-2010 when estimating the potential impacts on water demands in 2035 and 2060.

Although future changes in climate during different seasons of the year are challenging to ascertain, we briefly examined the historical changes in climate normals between the 1971-2000 and 1981-2010 periods. Shifts in climate normals for an average monthly maximum daily temperature and average monthly precipitation show that recent climate change effects, as represented by the normals, are not evenly distributed across the calendar months. Temperature increases were greater from October to April than during the growing season (May to September). The average percentage increase (across the weather stations) in maximum temperature was -0.46 percent during the five months from May to September but +0.79 percent during the remaining seven months. Precipitation is affected oppositely; the increase in precipitation was greater during the growing season than during the remaining months. The average effect across the stations suggests that a 0.8 percent increase in precipitation occurred during the five months of growing season, and the 0.6 percent increase occurred during the remaining seven months.

These effects were not extrapolated to the long-term (i.e., 2035 and 2060) climate change scenarios; uniform shifts in normal values were assumed for all months of the year.

Table 7.1 Change in Annual Average Temperature and Annual Precipitation Relative to 1971-2000 Climate Normals for Three Climate Scenarios (U.S. Environmental Protection Agency, 2015b)

County[1]	**Averaging period**[2]	**Change in Annual Temperature (°F)**			**Change in Annual Precipitation (%)**		
		Hot/Dry	**Central**	**Warm/Wet**	**Hot/Dry**	**Central**	**Warm/Wet**
Ford	2035 Period	3.19	2.70	2.39	-0.51	3.03	5.79
	2060 Period	6.21	5.27	4.66	-1.00	5.29	11.30
Iroquois	2035 Period	3.17	2.59	2.27	-0.43	3.51	5.92
	2060 Period	6.19	5.06	4.41	-0.83	6.85	11.54
Kankakee	2035 Period	3.20	2.70	2.39	-0.10	3.25	5.94
	2060 Period	6.25	5.27	4.68	-0.19	6.35	11.58
KANKAKEE SUBREGION	**2035 Period**	**3.19**	**2.66**	**2.35**	**-0.35**	**3.26**	**5.88**
	2060 Period	**6.22**	**5.20**	**4.58**	**-0.67**	**6.16**	**11.47**

[1] Temperature and precipitation data are approximatations for county locations that are based on model output data gridded to ½- by ½-degree cells.

[2] The 2035 Period includes the years 2021-2050, and the 2060 Period includes the years 2046-2075.

Table 7.2 Normal (30-Year Average) Values of Maximum Daily Air Temperature (°F)

County (Station)	Time period*	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	ANNUAL	May-Sep	Oct-Apr
Ford (Paxton)	1971-2000	29.9	35.3	47.5	60.7	72.3	81.9	84.6	82.8	77.2	65.0	49.0	35.3	60.1	79.8	46.1
	1981-2010	31.1	35.9	47.9	61.4	72.0	80.9	83.6	82.4	77.4	64.3	49.3	35.0	60.2	79.3	46.4
Iroquois (Watseka 2 NW)	1971-2000	30.1	35.6	47.8	60.2	72.0	81.7	84.4	82.5	76.8	64.4	48.7	35.5	60.0	79.5	46.0
	1981-2010	31.5	36.3	48.3	61.4	72.3	81.6	84.2	82.8	77.5	64.7	50.0	35.5	60.6	79.7	46.8
Kankakee (Kankakee Metro WWTP)	1971-2000	31.1	36.8	48.3	60.7	72.8	82.6	85.7	83.5	77.6	65.1	49.5	36.4	60.8	80.4	46.8
	1981-2010	32.0	36.5	48.0	61.0	71.8	81.6	84.6	82.9	77.2	64.4	49.9	35.7	60.6	79.6	46.8
Difference between 1971-2000 and 1981-2010 periods		1.17	0.33	0.20	0.73	-0.33	-0.70	-0.77	-0.23	0.17	-0.37	0.67	-0.33	0.17	-0.37	0.37

Table 7.3 Normal (30-Year Average) Values of Total Precipitation (inches)

County (Station)	Time period*	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	ANNUAL	May-Sep	Oct-Apr
Ford (Paxton)	1971-2000	1.66	1.40	3.17	3.41	4.38	3.47	3.75	3.26	3.20	3.30	3.02	3.04	37.06	18.06	19.00
	1981-2010	1.88	1.80	2.68	3.57	4.25	3.99	4.28	3.48	2.90	3.32	3.41	2.62	38.18	18.90	19.28
Iroquois (Watseka 2 NW)	1971-2000	1.61	1.73	3.36	3.77	4.04	4.62	4.22	3.65	3.41	2.91	3.33	2.57	39.22	19.94	19.28
	1981-2010	1.67	1.80	2.90	3.57	4.27	4.14	4.49	3.45	3.08	3.41	3.20	2.38	38.36	19.43	18.93
Kankakee (Kankakee Metro WWTP)	1971-2000	1.77	1.62	2.78	3.80	4.54	4.44	4.38	3.11	3.47	2.70	3.36	2.61	38.58	19.94	18.64
	1981-2010	1.99	1.86	2.54	3.48	4.81	4.14	4.65	3.31	3.19	3.11	3.48	2.60	39.16	20.10	19.06
Difference between averages for 1971-2000 and 1981-2010 periods		0.17	0.24	-0.40	-0.12	0.12	-0.09	0.36	0.07	-0.30	0.31	0.13	-0.21	0.28	0.16	0.12

7.1.2 Quantifying Climatic Impacts on Water Demand

The estimated effects of climate change on water demand vary by sector and reflect the sensitivity of water demand by the sector to air temperature and precipitation. This section discusses specific assumptions about the changes in weather variables assumed in our analysis of climate change effects on water demand by each sector.

7.1.2.1 Demand by Public Water Systems

The sensitivity of public water system demand to weather conditions is captured by two variables: (1) average maximum-daily temperatures during the five-month growing season from May to September, and (2) total precipitation during the growing season. The estimated constant elasticity of the temperature variable is +1.13185, meaning that per-capita water demand is expected to increase by 1.13185 percent in response to a 1.0 percent increase in the average maximum daily temperature during the growing season. The estimated constant elasticity of growing-season precipitation is -0.05946, indicating that average annual per-capita water demand is expected to decrease by 0.05946 percent in response to a 1.0 percent increase in total precipitation.

7.1.2.2 Demand for Self-Supplied Domestic Water

The sensitivity of self-supplied domestic withdrawals to weather conditions is captured by two variables: (1) average of maximum-daily temperatures during the five-month growing season from May to September, and (2) total precipitation during the growing season. We assumed that the constant elasticity of the temperature and precipitation variables is the same as estimated for the public water systems.

7.1.2.3 Demand for Self-Supplied Water for Power Generation

Higher air temperatures will impact water demand for cooling of thermoelectric power plants. For plants having once-through cooling systems, warmer intake water may lead to increased demand in order to meet the limitations on thermal pollution. For plants with closed-loop cooling systems, higher air temperatures will affect the performance of cooling towers and cooling lakes. However, the actual impacts on water demand are challenging to quantify and are not included in our sensitivity analysis.

7.1.2.4 Demand for Self-Supplied Water for Industrial and Commercial Uses

The sensitivity of industrial and commercial (IC) water demand to weather conditions is affected by total cooling degree-days, and to some degree, total precipitation during the five month summer season from May to September. We have not estimated these effects, however, because no statistical models with quantified weather effects (such as elasticity of cooling degree-days) were developed for the IC sector.The scenario demands were calculated using unit use coefficients which remained unchanged during the forecast horizon.

7.1.2.5 Demand for Self-Supplied Water for Irrigation, Livestock, and Environmental Uses

For the purpose of sensitivity analysis with respect to climate change, water demand for irrigation is affected by decreased or increased irrigation-season precipitation and by increased temperature, which increases evapotranspiration. Changes in precipitation rates will result in changes in the precipitation deficit, which we employed to estimate demand for irrigation. We estimated the effects of future climate scenarios only on cropland irrigation. The relative (percentage) effects of climate on golf course irrigation would be the same. No climate effects on water demand for livestock and environmental uses were estimated because of the lack of information on the sensitivity of water demand to climatic conditions in these sectors.

7.2 Estimated Effects of Climate Change

7.2.1 Water Demand by Public Water Systems

We assumed that summer growing season temperatures will increase by the same magnitudes as the annual average temperatures for the 2035 and 2060 Periods (Table 7.1), but we allocated annual changes in normal precipitation uniformly among the calendar months of the year. We employed regional averages of model grid cell output, obtained from USEPA (2015b), as the basis for computing climate change effects on public water system demand. These regional averages are shown in Table 7.4.

The effects on CT scenario public system demand of the temperature and precipitation changes shown in Table 7.4 are shown in Table 7.5. Note that Table 7.5 compares 2035 and 2060 demands under the CT scenario—results computed for 1981-2010 normal climate for a single year—with, respectively, 2035 Period and 2060 Period results under the condition of climate change. For clarity, the results shown for 1981-2010 normal climate are identified with the designators 2035N and 2060N. The 2035 Period and 2060 Period estimates for conditions of climate change are based on CT scenario assumptions except for the assumptions of temperature and precipitation. Note that temperature and precipitation during the 2035 Period and 2060 Period are 30-year averages based on modeled temperature and precipitation for the periods 2021 to 2050 and 2046 to 2075, respectively. Thus, the percentage difference shown between the 2035N and 2035 Period results, and between the 2060N and 2060 Period results, should be regarded as an average difference that applies, in each case, to a 30-year period. The results shown in Table 7.5, then, show that the Hot/Dry scenario of climate change would increase public system demand to the greatest degree, followed by the Central scenario, and, finally, the Warm/Wet scenario. We estimated public-system demand under the Hot/Dry climate scenario during the 2060 Period to be 2.2 Mgd greater than in 2060 under normal weather conditions, a 10.0 percent increase. On the other hand, under the Warm/Wet scenario of climate change, public-system demand during the 2060 Period is 1.5 Mgd greater than in 2060 under normal weather conditions, a 6.9 percent increase.

Table 7.4 Regional Changes[1] in 1971-2000 Normal Values of Annual Average Temperature and Annual Precipitation, 2035 and 2060 Averaging Periods

Climate Parameter	2035 Period[2]			2060 Period[2]		
	Hot/Dry	Central	Warm/Wet	Hot/Dry	Central	Warm/Wet
Change in Annual Average Temperature (°F)[3]	3.19	2.66	2.35	6.22	5.20	4.58
Change in Annual Precipitation (%)[3]	-0.35	3.26	5.88	-0.67	6.16	11.47

[1]Changes are averages, for an area approximating the Kankakee subregion, of model output gridded to ½- by ½-degree cells.
[2]The 2035 Period includes the years 2021-2050, and the 2060 Period includes the years 2046-2075.
[3]Although the shifts in °F and % changes are in relation to the 1971-2000 climate normals, the estimated effects on water use are obtained by comparing the calculated future (2035 and 2060) normal values with the 1981-2010 normal values used in the scenario forecasts.

Table 7.5 Estimated Public System Demand under Climate Change Scenarios Discussed in Text (Mgd)

County	2010N*	2035N* (CT)	2035 Period (2021-2050)			2060N* (CT)	2060 Period (2046-2075)		
			Hot/ Dry	Central	Warm / Wet		Hot/ Dry	Central	Warm/ Wet
Ford	1.49	1.49	1.57	1.55	1.54	1.46	1.61	1.58	1.56
Iroquois	2.19	2.16	2.25	2.23	2.22	2.05	2.22	2.18	2.16
Kankakee	14.01	16.51	17.46	17.30	17.21	18.30	20.15	19.81	19.59
REGIONAL TOTAL	**17.69**	**20.16**	**21.28**	**21.09**	**20.97**	**21.81**	**23.98**	**23.57**	**23.31**
DIFFERENCE FROM 2035N (REGION) (%)			**5.6**	**4.6**	**4.0**				
DIFFERENCE FROM 2060N (REGION) (%)							**10.0**	**8.1**	**6.9**

*N: demand under normal weather conditions based on the 1981-2010 climate normal

7.2.2 Demand for Self-Supplied Domestic Water

We have adjusted future estimates of CT-scenario self-supplied domestic demand using the estimates of temperature and precipitation changes detailed in Table 7.4. Adjustments are based on the estimated constant elasticities of public water system demand with respect to maximum air temperature (i.e., +1.13185) and total precipitation (i.e., -0.05946) during the five-month (May to September) landscape irrigation season.

The effect of changes in temperature and precipitation on self-supplied domestic demand is shown in Table 7.6. As discussed in reference to public-system demand estimates under scenarios of climate change, Table 7.6 compares 2035N and 2060N demands under the CT scenario—results computed for 1981-2010 normal climate for a single year—with, respectively, 2035 Period and 2060 Period results under the condition of climate change. The 2035 Period and 2060 Period estimates for conditions of climate change are based on CT scenario assumptions except for the assumptions of temperature and precipitation. Assumed temperature and precipitation during the 2035 Period and 2060 Period are 30-year averages based on modeled temperature and precipitation for the periods 2021 to 2050 and 2046 to 2075, respectively. Thus, the percentage difference shown between the 2035N and 2035 Period results and between the 2060N and 2060 Period results should be regarded as an average difference that applies in each case to a 30-year period. Under the Hot/Dry climate scenario, CT scenario self-supplied domestic demand during the 2060 Period is 0.08 Mgd (9.2 percent) greater than 2060 CT demand under 1981-2010 normal weather conditions (Table 7.6). Under the Warm/Wet climate scenario, the 2060 Period demand is 0.05 Mgd (6.2 percent) greater than the 2060 CT demand under 1981-2010 normal weather conditions.

Table 7.6 Estimated Self-Supplied Domestic Demand under Climate Change Scenarios Discussed in Text (Mgd)

County	**2010N***	**2035N* (CT)**	**2035 Period (2021-2050)**			**2060N* (CT)**	**2060 Period (2046-2075)**		
			Hot/ Dry	**Central**	**Warm /Wet**		**Hot/ Dry**	**Central**	**Warm/ Wet**
Ford	0.19	0.14	0.15	0.15	0.15	0.19	0.14	0.15	0.15
Iroquois	0.62	0.45	0.46	0.46	0.46	0.62	0.45	0.46	0.46
Kankakee	1.79	0.99	1.05	1.04	1.03	1.79	0.99	1.05	1.04
REGIONAL TOTAL	**2.60**	**1.58**	**1.66**	**1.64**	**1.63**	**2.60**	**1.58**	**1.66**	**1.64**
DIFFERENCE FROM 2035N (REGION) (%)			**5.3**	**4.3**	**3.7**			**5.3**	**4.3**
DIFFERENCE FROM 2060N (REGION) (%)									

*N: demand under normal weather conditions based on the 1981-2010 climate normal

7.2.3 Demand for Self-Supplied Water for Irrigation of Cropland

We estimated cropland irrigation demand based on the estimated precipitation deficit during the irrigation season, which is in turn computed from daily and weekly weather data. We also accounted for the effects of increasing air temperature under future climate scenarios. Table 7.7 shows the normal values of average temperature and total precipitation during the four-month irrigation season for counties in the study area; these are shown for both the 1971-2000 and 1981-2010 30-year periods used to compute climate normals. Table 7.7 also shows precipitation deficits computed for the 1981-2010 period using the 1981-2010 precipitation normals.

Because the climate models that are the basis for our estimates of future temperature and precipitation change cannot reliably forecast daily weather conditions, in order for us to estimate irrigation demand under conditions of climate change, it was first necessary to indirectly estimate the precipitation deficit under climate change scenarios using the methodology described in the following two paragraphs.

The 1981-2010 preciptation deficits and 1981-2010 precipitation normals from Table 7.7, together with analogous data for the two other study regions for which the ISWS is presently estimating future water demand (Table 7.8, Figure 1.1), are plotted (Figure 7.3, Figure 7.4), and a line is interpolated through the plotted data. The plots of these data differ in that Figure 7.3 displays all of the data points detailed in Table 7.7 and Table 7.8, and Figure 7.4 omits data points representing two outliers (Boone and Putnam Counties). The lines interpolated through these data represent a relationship useful for estimating the precipitation deficit during the four-month irrigation season on the basis of the four-month total precipitation.

Of the alternative linear relationships shown in Figure 7.3 and Figure 7.4, we used the one shown in Figure 7.4 on the basis that this relationship is more representative of conditions in Illinois since it omits the Boone and Putnam County outliers. The equation is:

$$d_t = 17.954 - 0.52 \cdot P_n \tag{7.1}$$

where:

d_t = precipitation deficit during four-month irrigation season; and
P_n = normal precipitation during the irrigation season, increased or decreased according to the climate scenarios.

In order to estimate future water demand for irrigation in addition to developing and employing a methodology for assuming future precipitation deficits under a changed climate, we had to correct for the departure of future temperature normals from the 1981-2010 normals. The effect of air temperature on historical water demands in 2010 was omitted in Chapter 6 because they were assumed to be small and were not accounted for by the check-book method. For changes in the future normal values of temperature, our correction was based on the analysis of potential evapotranspiration and monthly temperature by Dr. Ken Kunkel and his staff at ISWS. Dr. Kunkel is presently affiliated with the Cooperative Institute for Climate and Satellites, Asheville, North Carolina. Kunkel approximated the correct total irrigation application depth using an adjustment of 0.1 inches/°F such that:

$$d_t^c = d_t + 0.1 \cdot (T_a - T_n) \tag{7.2}$$

where:

d_t^c = the corrected total application depth during the four-month irrigation season;
T_a = average monthly air temperature during the May through August growing season; and
T_n = average of normal monthly temperatures during the May through August growing season.

To develop this relationship, Kunkel analyzed soil moisture model data to examine year-to-year variability in the ratio of actual to potential evapotranspiration (ET/PET) for each month of the growing season. *Potential evapotranspiration* is the amount of evapotranspiration that would occur if a sufficient water source were available. *Actual evapotranspiration* is the amount of water that is actually removed from a surface through evapotranspiration. In July and August, there are years when the model-estimated ratio was 1.0, indicating that the use of PET as actual ET is appropriate. In June, the highest ET/PET values are in the range of 0.90 to 0.95, and in May, the highest ET/PET values are near or slightly above 0.70. The average value ET/PET in

May is 0.50. Assuming that a period of dry weather in May would concern a farmer enough to irrigate, irrigation would ideally be conducted to achieve a maximum ET/PET of 0.70.

Because using a weighted coefficient for ET/PET ratio would require monthly data, and seasonally aggregated data are used in this study, no downward adjustment of actual ET is introduced. Thus we assumed an ET/PET value of 1.0 for all months of the irrigation season. This assumption contributes to a slight overestimation of the effects of increased temperature on irrigation water demand.

Our estimates of the effects of climate change on water demand for cropland irrigation of the temperature and precipitation changes shown in Table 7.4 are shown in Table 7.9. Table 7.9 compares 2035N and 2060N demands under the CT scenario—results computed for 1981-2010 normal climate for a single year—with, respectively, 2035 Period and 2060 Period results under the condition of climate change. The 2035 Period and 2060 Period estimates for conditions of climate change are based on CT scenario assumptions, except for the assumptions of temperature and precipitation. Note that the assumed temperature and precipitation during the 2035 Period and 2060 Period are 30-year averages based on modeled temperature and precipitation for the periods 2021 to 2050 and 2046 to 2075, respectively. Thus, the percentage difference shown between the 2035N and 2035 Period results, and between the 2060N and 2060 Period results, should be regarded as an average difference that applies, in each case, to a 30-year period. During the 2060 Period, under the Hot/Dry climate scenario, an average temperature increase of 6.22°F and a decrease in precipitation of 0.67 percent, would together result in a 2.19 Mgd increase in irrigation demand (a 10.7 percent increase) relative to 2060 demand under the CT scenario under normal 1981-2010 climate. Under the Warm/Wet climate scenario, the estimated 2060 Period irrigation demand is 0.51 Mgd less than the 2060 CT demand under 1981-2010 normal climate, a 2.5 percent decrease. Under the Central climate scenario, an estimated 2060 Period irrigation demand is 0.65 Mgd less than 2060 CT demand under 1981-2010 normal climate, a 3.2 percent decrease.

Table 7.7 Estimated May-August Normal Average Temperature, Total Precipitation, and Precipitation Deficit for Weather Stations Used in This Study

County	**Mean Monthly Temperature (May-August) (°F)**		**Total Precipitation (May-August) (inches)**		**Precipitation Deficit (inches)**
	1971-2000	**1981-2010**	**1971-2000**	**1981-2010**	**1981-2010**
Ford	69.18	68.9	14.86	16	-9.72
Iroquois	69.28	69.1	16.53	16.35	-9.03
Kankakee	69.5	69.93	16.47	16.91	-9.1
REGIONAL AVERAGE	**69.32**	**69.31**	**15.95**	**16.42**	**-9.28**

Table 7.8 Estimated May-August Normal Average Temperature, Total Precipitation, and Precipitation Deficit for Weather Stations Used in the Study (Other Study Regions as Shown in Figure 1.1)

County	**Mean Monthly Temperature (May-August) (°F)**		**Total Precipitation (May-August) (inches)**		**Precipitation Deficit (inches)**
	1971-2000	**1981-2010**	**1971-2000**	**1981-2010**	**1981-2010**
		Middle Illinois Region			
LaSalle	69.65	69.73	15.55	15.83	-9.91
Livingston	69.70	69.73	15.57	15.32	-10.05
Marshall	71.20	71.70	15.55	15.55	-9.88
Peoria	68.35	69.70	16.13	16.79	-9.48
Putnam	70.15	69.93	15.92	16.00	-8.39
Stark	68.35	69.70	16.13	16.79	-9.48
		Rock River Region			
Boone	70.78	69.73	17.40	17.44	-7.84
Bureau	70.30	69.73	16.55	17.72	-8.39
Carroll	67.90	71.70	17.48	18.42	-8.25
Henry	70.60	69.70	16.63	16.72	-9.19
Jo Daviess	66.80	69.93	16.57	17.10	-8.78
Lee	66.70	69.70	15.99	17.15	-9.22
Ogle	67.45	69.85	15.47	15.76	-9.68
Rock Island	70.55	69.73	17.32	17.62	-8.67
Stephenson	66.80	69.73	16.10	16.83	-9.17
Whiteside	69.23	71.70	17.38	17.67	-9.07
Winnebago	68.90	69.70	17.14	17.21	-9.39

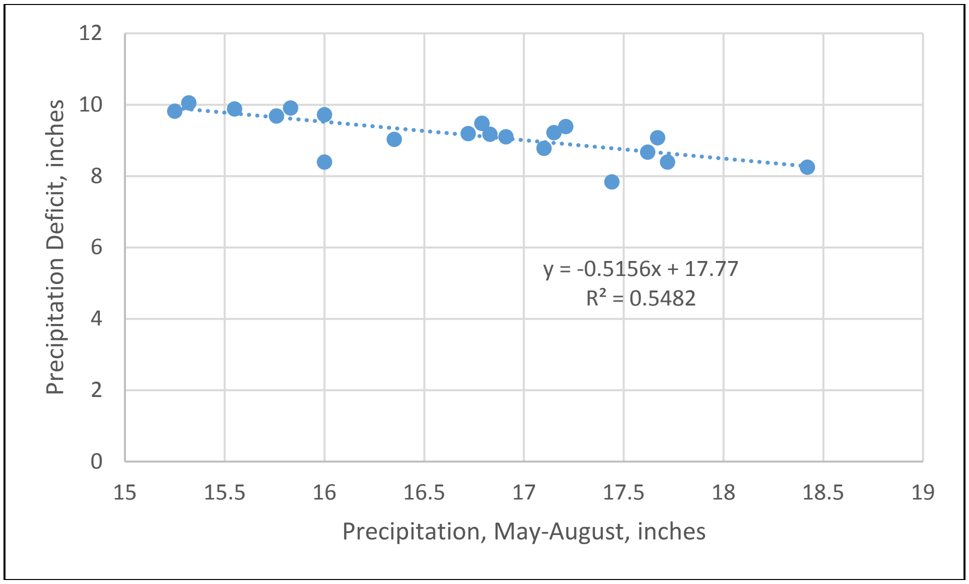

Figure 7.3 Precipitation deficit versus normal May-August precipitation for three study regions shown in Figure 1.1. The plot includes one data point for each county in the three regions.

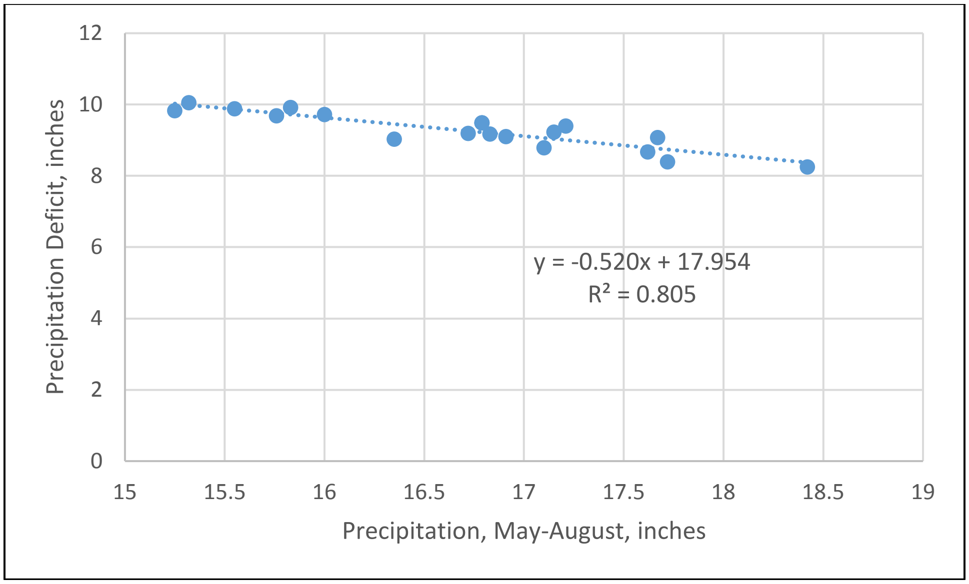

Figure 7.4 Precipitation deficit versus normal May-August precipitation for three study regions shown in Figure 1.1. The plot includes one data point for each county in the three regions, excluding outliers (Boone and Putnam Counties).

Table 7.9 Estimated Self-Supplied Irrigation Demand under Climate Change Scenarios Discussed in Text (Mgd)

County	**2010N***	**2035N* (CT)**	**2035 Period (2021-2050)**			**2060N* (CT)**	**2060 Period (2046-2075)**		
			Hot/ Dry	**Central**	**Warm /Wet**		**Hot/ Dry**	**Central**	**Warm/ Wet**
Ford	0.51	0.66	0.76	0.74	0.72	0.51	0.66	0.76	0.74
Iroquois	2.42	3.15	3.40	3.27	3.18	2.42	3.15	3.40	3.27
Kankakee	10.33	13.46	14.34	13.80	13.42	10.33	13.46	14.34	13.80
REGIONAL TOTAL	**13.26**	**17.27**	**18.50**	**17.81**	**17.33**	**13.26**	**17.27**	**18.50**	**17.81**
DIFFERENCE FROM 2035N (REGION) (%)			**7.1**	**3.1**	**0.3**			**7.1**	**3.1**
DIFFERENCE FROM 2060N (REGION) (%)									

*N: demand under normal weather conditions based on 1981-2010 climate normal

7.3 Estimated Effects of Drought

In addition to the long-term, hypothetical phenomenon of climate change, water demand will, with certainty, be affected by periodic droughts. Although the severity and duration of future droughts is not known, their impact on water demand can be estimated from historical climate records. The most severe historical droughts in Illinois took place in the 1930s and 1950s. These were multiyear droughts associated with growing season precipitation deficits during the driest year of approximately 40 percent below normal. For this analysis, we assumed that during future droughts, the 1981-2010 growing-season precipitation would be reduced by 40 percent to be consistent with a worst-case historical drought.

7.3.1 Water Demand by Public Water Systems

Table 7.10 shows the effect of severe drought on average-day public system water demand. These results were computed using the same assumptions as for the CT scenario, but precipitation has been reduced to reflect a summer-season precipitation deficit that is 40 percent of 1981-2010 normal precipitation; this reduction is consistent with summer season precipitation deficits during most severe recorded droughts in Illinois. The results in Table 7.10 indicate that during a drought year consistent with a worst-case historical drought, public system demand increases by 8.8 percent in 2035 and 13.3 percent in 2060 relative to the CT scenario under constant 1981-2010 average climate for those years. This percentage increase is equivalent to an additional 1.8 Mgd in 2035 and an additional 2.9 Mgd in 2060.

Table 7.10 Estimated Public System Demand under Drought Scenario (Mgd)

County	2010N*	2035N* (CT)	2035 Drought	2060N* (CT)	2060 Drought
Ford	1.49	1.49	1.62	1.46	1.66
Iroquois	2.19	2.16	2.32	2.05	2.29
Kankakee	14.01	16.51	18.00	18.30	20.77
REGIONAL TOTAL	**17.69**	**20.16**	**21.93**	**21.81**	**24.71**
DIFFERENCE FROM 2035N (REGION) (%)			**8.8**		
DIFFERENCE FROM 2060N (REGION) (%)					**13.2**

*N: demand under normal weather conditions based on 1981-2010 climate normal

7.3.2 Demand for Self-Supplied Domestic Water

Water demand for self-supplied domestic uses is also affected by periodic droughts. For this analysis, we assumed that total summer-season precipitation during future droughts will be reduced by 40 percent from the 1981-2010 normal. This reduction is consistent with a worst-case historical drought in Illinois.

Based on our analysis, under drought conditions, self-supplied domestic demand in each county increases by a percentage that is comparable to the increase in public-system demand under drought conditions (Table 7.11). Regionally, self-supplied domestic demand in 2035 is about 8.5 percent greater under drought conditions than in 2035 under CT-scenario assumptions with normal 1981-2010 conditions. Self-supplied domestic demand in 2060 is 12.5 percent greater in 2060 than in 2060 under CT-scenario assumptions with normal 1981-2010 conditions. This percentage increase is equivalent to an additional 0.13 Mgd in 2035 and an additional 0.10 Mgd in 2060.

Table 7.11 Estimated Self-Supplied Domestic Demand under Drought Scenario (Mgd)

County	2010N*	2035N* (CT)	2035 Drought	2060N* (CT)	2060 Drought
Ford	0.19	0.14	0.15	0.14	0.16
Iroquois	0.62	0.45	0.48	0.43	0.48
Kankakee	1.79	0.99	1.08	0.25	0.28
REGIONAL TOTAL	**2.60**	**1.58**	**1.71**	**0.81**	**0.91**
DIFFERENCE FROM 2035N (REGION) (%)			**8.5**		
DIFFERENCE FROM 2060N (REGION) (%)					**12.5**

*N: demand under normal weather conditions based on 1981-2010 climate normal

7.3.3 Demand for Self-Supplied Water for Irrigation of Cropland

Irrigation demands are very sensitive to drought. Our analysis assumed a future drought comparable to a worst-case historical drought in which growing-season precipitation is reduced by 40 percent. Such conditions would substantially increase the amount of water applied for crop and turf irrigation. Table 7.12 shows the consequences for average-day water demand for cropland irrigation during such a drought. Self-supplied cropland irrigation demand increases by approximately 44.3 percent in 2035 above the 2035 demand estimated for CT-scenario conditions, which include 1981-2010 normal precipitation. Demand in 2060 under drought conditions is about 47.7 percent greater than in 2060 under CT-scenario assumptions. These percentage increases are equivalent to an additional 7.7 Mgd in 2035 and an additional 9.7 Mgd in 2060.

Table 7.12 Estimated Irrigation Demand under Drought Scenario (Mgd)

County	**2010N***	**2035N* (CT)**	**2035 Drought**	**2060N* (CT)**	**2060 Drought**
Ford	0.51	0.66	0.99	0.78	1.19
Iroquois	2.42	3.15	4.58	3.72	5.54
Kankakee	10.33	13.46	19.36	15.88	23.37
REGIONAL TOTAL	**13.26**	**17.27**	**24.93**	**20.38**	**30.10**
DIFFERENCE FROM 2035N (REGION) (%)			**44.3**		
DIFFERENCE FROM 2060N (REGION) (%)					**47.7**
DIFFERENCE FROM 2060N (REGION) (%)					**36.6**

*N: demand under normal weather conditions based on 1981-2010 climate normal

8 Summary

In this section we briefly summarize the demand estimates in four tables. Table 8.1, Table 8.2, and Table 8.3 show estimates by sector for each county, and for the Kankakee subregion, for the CT, LRI, and MRI scenarios. Table 8.4 shows total demand, by county and region, for each scenario.

Note that we include both reported and normalized 2010 demand in Table 8.1, Table 8.2, and Table 8.3. Climate-normalized totals are estimated only for the public supply and self-supplied ILE sectors; however, for all other demand sectors, the reported and normalized totals for 2010 are equivalent. The scenario totals in Table 8.4 reflect the same mix of reported and climate-normalized sector totals included in Table 8.1, Table 8.2, and Table 8.3.

As discussed in Section 4.5 and Section 5.3.2, the sector totals for the self-supplied thermoelectric power generation and self-supplied IC sectors are subject to revision. Namely, we provided for the simulation of new power plants and water-intensive industrial facilities and retirement of existing facilities at the discretion of reviewers of this report.

Table 8.1 Summary of Demand Estimates, CT Scenario (Mgd)

Geography and Sector	**2010 (Reported)[1]**	**2010 (Normal)[2]**	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**	**2055**	**2060**
Ford County												
Public Supply	1.46	1.49	1.50	1.50	1.49	1.49	1.48	1.48	1.48	1.47	1.47	1.46
Self-Supplied Domestic	0.19	0.19	0.16	0.14	0.13	0.14	0.14	0.14	0.14	0.14	0.14	0.14
Thermoelectric Power Generation	0	0	0	0	0	0	0	0	0	0	0	0
Self-Supplied Industrial and Commercial	1.52	1.52	1.62	1.73	1.79	1.92	2.02	2.12	2.23	2.34	2.45	2.57
Self-Supplied Irrigation, Livestock, and Environmental	1.19	1.49	1.58	1.68	1.79	1.88	1.98	2.09	2.19	2.31	2.43	2.56
Ford County Total	*4.36*	*4.70*	*4.86*	*5.05*	*5.20*	*5.43*	*5.62*	*5.83*	*6.04*	*6.26*	*6.49*	*6.73*
Iroquois County												
Public Supply	2.23	2.19	2.26	2.23	2.21	2.19	2.16	2.14	2.11	2.09	2.07	2.05
Self-Supplied Domestic	0.62	0.62	0.53	0.46	0.39	0.45	0.45	0.44	0.44	0.44	0.43	0.43
Thermoelectric Power Generation	0	0	0	0	0	0	0	0	0	0	0	0
Self-Supplied Industrial and Commercial	0.07	0.07	0.07	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.09	0.09
Self-Supplied Irrigation, Livestock, and Environmental	2.70	3.23	3.44	3.65	3.88	4.03	4.18	4.33	4.49	4.66	4.84	5.02
Iroquois County Total	*5.62*	*6.12*	*6.30*	*6.42*	*6.56*	*6.75*	*6.87*	*7.00*	*7.13*	*7.28*	*7.43*	*7.59*
Kankakee County												
Public Supply	14.32	14.01	15.04	15.30	15.72	16.12	16.51	16.89	17.26	17.62	17.96	18.30
Self-Supplied Domestic	1.79	1.79	1.61	1.45	1.29	1.14	0.99	0.84	0.69	0.54	0.39	0.25
Thermoelectric Power Generation	0	0	0	0	0	0	0	0	0	0	0	0
Self-Supplied Industrial and Commercial	3.71	3.71	4.16	4.66	4.83	5.01	5.20	5.39	5.58	5.78	5.99	6.20
Self-Supplied Irrigation, Livestock, and Environmental	9.32	10.91	11.64	12.42	13.26	13.72	14.19	14.68	15.18	15.71	16.25	16.81
Kankakee County Total	*29.14*	*30.41*	*32.45*	*33.83*	*35.10*	*35.99*	*36.89*	*37.80*	*38.71*	*39.65*	*40.59*	*41.56*

Geography and Sector	2010 (Reported)[1]	2010 (Normal)[2]	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060
Kankakee Subregion												
Public Supply	18.01	17.69	18.80	19.03	19.42	19.80	20.15	20.51	20.85	21.18	21.50	21.81
Self-Supplied Domestic	2.60	2.60	2.30	2.05	1.80	1.73	1.58	1.42	1.27	1.11	0.96	0.81
Thermoelectric Power Generation	0	0	0	0	0	0	0	0	0	0	0	0
Self-Supplied Industrial and Commercial	5.30	5.30	5.85	6.47	6.70	7.01	7.30	7.60	7.90	8.21	8.53	8.86
Self-Supplied Irrigation, Livestock, and Environmental	13.21	15.63	16.66	17.75	18.93	19.63	20.35	21.10	21.86	22.68	23.52	24.39
REGIONAL TOTAL	**39.12**	**41.23**	**43.61**	**45.30**	**46.85**	**48.17**	**49.38**	**50.63**	**51.88**	**53.18**	**54.51**	**55.87**

[1] 2010 (Reported): reported demand in 2010

[2] 2010 (Normal): incudes weather normalized demand for public supply and self-supplied irrigation, livestock, and environmental (ILE) sectors in 2010

Table 8.2 Summary of Demand Estimates, LRI Scenario (Mgd)

Geography and Sector	2010 (Reported)[1]	2010 (Normal)[2]	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060
Ford County												
Public Supply	1.46	1.49	1.47	1.45	1.43	1.41	1.39	1.37	1.35	1.33	1.31	1.30
Self-Supplied Domestic	0.19	0.19	0.16	0.14	0.12	0.13	0.13	0.13	0.13	0.13	0.12	0.12
Thermoelectric Power Generation	0	0	0	0	0	0	0	0	0	0	0	0
Self-Supplied Industrial and Commercial	1.52	1.52	1.57	1.63	1.64	1.7	1.74	1.77	1.81	1.84	1.87	1.91
Self-Supplied Irrigation, Livestock, and Environmental	1.19	1.49	1.55	1.61	1.68	1.75	1.82	1.9	1.99	2.08	2.18	2.28
Ford County Total	*4.36*	*4.70*	*4.75*	*4.83*	*4.87*	*4.99*	*5.08*	*5.17*	*5.28*	*5.38*	*5.48*	*5.61*
Iroquois County												
Public Supply	2.23	2.19	2.13	2.06	2.00	1.94	1.88	1.82	1.77	1.71	1.66	1.61
Self-Supplied Domestic	0.62	0.62	0.53	0.45	0.37	0.43	0.42	0.41	0.40	0.40	0.39	0.38
Thermoelectric Power Generation	0	0	0	0	0	0	0	0	0	0	0	0
Self-Supplied Industrial and Commercial	0.07	0.07	0.07	0.08	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
Self-Supplied Irrigation, Livestock, and Environmental	2.70	3.23	3.32	3.42	3.51	3.61	3.71	3.82	3.92	4.03	4.14	4.26
Iroquois County Total	*5.62*	*6.12*	*6.05*	*6.01*	*5.95*	*6.05*	*6.08*	*6.12*	*6.16*	*6.21*	*6.26*	*6.32*
Kankakee County												
Public Supply	14.32	14.01	14.16	14.11	14.21	14.29	14.34	14.39	14.41	14.42	14.41	14.39
Self-Supplied Domestic	1.79	1.79	1.59	1.42	1.25	1.09	0.93	0.78	0.63	0.49	0.35	0.22
Thermoelectric Power Generation	0	0	0	0	0	0	0	0	0	0	0	0
Self-Supplied Industrial and Commercial	3.71	3.71	4.04	4.39	4.42	4.45	4.47	4.50	4.53	4.55	4.57	4.60
Self-Supplied Irrigation, Livestock, and Environmental	9.32	10.91	10.98	11.05	11.12	11.19	11.26	11.34	11.41	11.49	11.57	11.66
Kankakee County Total	*29.14*	*30.41*	*30.77*	*30.97*	*31.00*	*31.02*	*31.00*	*31.01*	*30.98*	*30.95*	*30.90*	*30.87*
Kankakee Subregion												
Public Supply	18.01	17.69	17.76	17.62	17.64	17.64	17.61	17.58	17.53	17.46	17.38	17.30

Geography and Sector	2010 (Reported)[1]	2010 (Normal)[2]	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060
Self-Supplied Domestic	0	2.60	2.27	2.00	1.74	1.65	1.48	1.32	1.16	1.01	0.86	0.72
Thermoelectric Power Generation	00	0	0	0	0	0	0	0	0	0	0	0
Self-Supplied Industrial and Commercial	5.300	5.30	5.68	6.10	6.13	6.22	6.28	6.34	6.41	6.46	6.51	6.58
Self-Supplied Irrigation, Livestock, and Environmental	13.21	15.63	15.85	16.08	16.31	16.55	16.79	17.06	17.32	17.60	17.89	18.20
REGIONAL TOTAL	**39.12**	**41.23**	**41.56**	**41.80**	**41.82**	**42.06**	**42.16**	**42.30**	**42.42**	**42.53**	**42.64**	**42.80**

[1] 2010 (Reported): reported demand in 2010

[2] 2010 (Normal): incudes weather normalized demand for public supply and self-supplied irrigation, livestock, and environmental (ILE) sectors in 2010

Table 8.3 Summary of Demand Estimates, MRI Scenario (Mgd)

Geography and Sector	**2010 (Reported)[1]**	**2010 (Normal)[2]**	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**	**2055**	**2060**
Ford County												
Public Supply	1.46	1.49	1.54	1.55	1.56	1.57	1.58	1.59	1.61	1.62	1.63	1.64
Self-Supplied Domestic	0.19	0.19	0.17	0.15	0.13	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Thermoelectric Power Generation	0	0	0	0	0	0	0	0	0	0	0	0
Self-Supplied Industrial and Commercial	1.52	1.52	1.67	1.83	1.96	2.16	2.34	2.54	2.75	2.97	3.21	3.46
Self-Supplied Irrigation, Livestock, and Environmental	1.19	1.49	1.59	1.7	1.81	1.91	2.01	2.12	2.24	2.36	2.49	2.63
Ford County Total	*4.36*	*4.70*	*4.97*	*5.23*	*5.46*	*5.79*	*6.08*	*6.40*	*6.75*	*7.10*	*7.48*	*7.88*
Iroquois County												
Public Supply	2.23	2.19	2.40	2.42	2.44	2.46	2.48	2.50	2.52	2.54	2.57	2.59
Self-Supplied Domestic	0.62	0.62	0.54	0.47	0.40	0.47	0.47	0.47	0.48	0.48	0.48	0.48
Thermoelectric Power Generation	0	0	0	0	0	0	0	0	0	0	0	0
Self-Supplied Industrial and Commercial	0.07	0.07	0.08	0.08	0.09	0.09	0.10	0.10	0.11	0.11	0.12	0.13
Self-Supplied Irrigation, Livestock, and Environmental	2.70	3.23	3.47	3.72	3.99	4.15	4.32	4.50	4.69	4.89	5.10	5.31
Iroquois County Total	*5.62*	*6.12*	*6.49*	*6.69*	*6.92*	*7.17*	*7.37*	*7.57*	*7.80*	*8.02*	*8.27*	*8.51*
Kankakee County												
Public Supply	14.32	14.01	15.97	16.58	17.36	18.15	18.96	19.77	20.60	21.44	22.29	23.15
Self-Supplied Domestic	1.79	1.79	1.62	1.49	1.34	1.20	1.05	0.90	0.75	0.59	0.44	0.28
Thermoelectric Power Generation	0	0	0	10.96	10.96	10.96	10.96	10.96	10.96	10.96	10.96	10.96
Self-Supplied Industrial and Commercial	3.71	3.71	4.28	4.95	5.28	5.65	6.03	6.44	6.88	7.34	7.83	8.35
Self-Supplied Irrigation, Livestock, and Environmental	9.32	10.91	11.77	12.69	13.69	14.25	14.82	15.41	16.04	16.68	17.35	18.05
Kankakee County Total	*29.14*	*30.41*	*33.64*	*46.67*	*48.63*	*50.21*	*51.82*	*53.48*	*55.23*	*57.01*	*58.87*	*60.79*
Kankakee Subregion												
Public Supply	18.01	17.69	19.91	20.55	21.36	22.18	23.02	23.86	24.73	25.60	26.49	27.38

Geography and Sector	2010 (Reported)[1]	2010 (Normal)[2]	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060
Self-Supplied Domestic	2.60	2.60	2.33	2.10	1.87	1.81	1.67	1.52	1.37	1.22	1.07	0.91
Thermoelectric Power Generation	0	0	0	10.96	10.96	10.96	10.96	10.96	10.96	10.96	10.96	10.96
Self-Supplied Industrial and Commercial	5.30	5.30	6.03	6.86	7.33	7.90	8.47	9.08	9.74	10.42	11.16	11.94
Self-Supplied Irrigation, Livestock, and Environmental	13.21	15.63	16.83	18.11	19.49	20.31	21.15	22.03	22.97	23.93	24.94	25.99
REGIONAL TOTAL	**39.12**	**41.23**	**45.10**	**58.58**	**61.01**	**63.17**	**65.27**	**67.45**	**69.77**	**72.13**	**74.62**	**77.18**

[1] 2010 (Reported): reported demand in 2010

[2] 2010 (Normal): incudes weather normalized demand for public supply and self-supplied irrigation, livestock, and environmental (ILE) sectors in 2010

Table 8.4 Summary of Estimated Demand Totals, All Scenarios (Mgd)

Geography and Sector	2010 (Reported)[1]	2010 (Normal)[2]	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060
Ford County												
LRI	4.36	4.70	4.75	4.83	4.87	4.99	5.08	5.17	5.28	5.38	5.48	5.61
CT	4.36	4.70	4.86	5.05	5.20	5.43	5.62	5.83	6.04	6.26	6.49	6.73
MRI	4.36	4.70	4.97	5.23	5.46	5.79	6.08	6.40	6.75	7.10	7.48	7.88
Iroquois County												
LRI	5.62	6.12	6.05	6.01	5.95	6.05	6.08	6.12	6.16	6.21	6.26	6.32
CT	5.62	6.12	6.30	6.42	6.56	6.75	6.87	7.00	7.13	7.28	7.43	7.59
MRI	5.62	6.12	6.49	6.69	6.92	7.17	7.37	7.57	7.80	8.02	8.27	8.51
Kankakee County												
LRI	29.14	30.41	30.77	30.97	31.00	31.02	31.00	31.01	30.98	30.95	30.90	30.87
CT	29.14	30.41	32.45	33.83	35.10	35.99	36.89	37.80	38.71	39.65	40.59	41.56
MRI	29.14	30.41	33.64	46.67	48.63	50.21	51.82	53.48	55.23	57.01	58.87	60.79
Kankakee Subregion												
LRI	39.12	41.23	41.56	41.80	41.82	42.06	42.16	42.30	42.42	42.53	42.64	42.80
CT	39.12	41.23	43.61	45.30	46.85	48.17	49.38	50.63	51.88	53.18	54.51	55.87
MRI	39.12	41.23	45.10	58.58	61.01	63.17	65.27	67.45	69.77	72.13	74.62	77.18

[1] 2010 (Reported): reported demand in 2010

[2] 2010 (Normal): incudes weather normalized demand for public supply and self-supplied irrigation, livestock, and environmental (ILE) sectors in 2010

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Appendix A. Public System Demand-Estimation Methodology and Supplemental Tables

A.1 Public System Demand-Estimation Methodology

A regression equation was fitted to historical data on per-capita public system demand and the corresponding six explanatory variables (average of maximum daily temperatures during the five-month summer season from May to September, total precipitation during the May-September summer season, ratio of local employment to resident population, median household income in 2010 dollars, marginal price of water in 2010 dollars, and an annual time [conservation] trend variable).

The data include 470 observations (5 data years times 94 water service areas) from three Illinois Department of Natural Resources (IDNR)-defined water supply planning regions for which the ISWS simultaneously estimated water demand, the 7-county Middle Illinois region (Meyer et al., In press-a), the 11-county Rock River region (Meyer et al., In press-b), and the 3-county Kankakee subregion (this report). However, data on the marginal price of water could be obtained for only 296 data points, and thus this smaller subset of observations was used in estimating the parameters of the regression model.

The estimation methodology initially employed a procedure known as *robust regression* (Yohai and Zamar, 1997), which allows for the reduction of the undue influence of specific "problematic" observations on estimated model parameters. Potentially problematic observations include outliers, whose values lie at the extremes, as well as leverage points, which have a strong influence on the overall fit and estimated parameters of a model. Note that an observation can be designated as a leverage point, but not a "bad" leverage point; it can confirm the underlying relationship, as opposed to changing it.

The robust regression procedures identified 18 problematic observations (out of 296), of which 4 were designated as potential outliers and 14 as potential leverage points (with one observation–the 2005 Putnam County residual–being both an outlier and a leverage point).

The final regression model of per-capita water use was estimated after excluding four outlier points (LaSalle 2000, 2005, 2010, and Putnam Co. residual 2005) and six "undue/unjustifiable" leverage points (Colona East 2000, Peru 2010, Toluca 2010, Wyoming 2010, Stockton 2010, and East Moline 2010).

The regression equation was estimated as a log-linear model in which the dependent variable (per-capita water use) and four independent variables were converted to their natural logarithms. The ratio of employment to population and the time trend variable were left in their linear form. The resultant ordinary least squares (OLS) regression model is shown in Table A.1.

The regression equation explains about 35 percent of the variance in log-transformed per-capita water use. Two variables, employment-to-population ratio and marginal price, have highly significant regression coefficients ($p<0.0001$). The significance of the remaining four independent variables is marginal, but all four have t-statistics greater than 1. Despite the low statistical significance of the two weather variables (as well as the income and time trend variables), the sizes and signs of the estimated regression coefficients are near their expected values (in comparison to the literature and the coefficients obtained in three other regional water demand studies in Illinois).

Table A.1 Estimated Log-Linear Equation of Per-Capita Water Demand – Regression Output

Description	**Parameter**
R Square	0.348869
R Square Adj.	0.334866
Root Mean Square Error	0.251919
Mean of Response	4.781111
Observations (or Sum Weights)	286

	DF	**Sum of Squares**	**Mean Square**	**F Ratio**	**Prob. > F**
Model	6	9.48679	1.58113	24.9142	<0.0001
Error	279	17.706218	0.06346		
C. Total	285	27.193008		0.03173	

Term	**Estimate**	**Std Error**	**t Ratio**	**Prob. >|t|**
Intercept	-0.42031	4.22315	-0.10	0.9208
Ln (Max. Summer Temperature)	1.13185	0.93504	1.21	0.2271
Ln (Total Summer Precipitation)	-0.05946	0.05681	-1.05	0.2961
Employment/Population Ratio	0.50331	0.06283	8.01	<0.0001
Ln (Median Household Income)	0.12183	0.09050	1.35	0.1793
Ln (Marginal Price of Water)	-0.19770	0.03438	-5.75	<0.0001
Time Trend	-0.00412	0.00293	-1.40	0.1616

Table A.2 Active Public Water Systems in the Kankakee Watershed Region

Ford County

Cabery
Elliott
Gibson City
Kempton
Melvin
Paxton
Piper City
Roberts
Sibley
Stelle Community Assn

Iroquois County

Ashkum
Bayles Lake Lot Owners Assn
Beaver Creek Village MHP
Beaverville
Belmont Acres Mutual Water Co
Buckley
Chebanse
Cissna Park
Clifton
Crescent City
Danforth
Donovan
Gilman
Iroquois Mobile Estates MHP
Lake Iroquois Association
Loda
Martinton
Merkle - Kniprath Nursing Home
Milford
Onarga
Prairieview Lutheran Home
Sheldon
Sugar Creek Manufactured Home Comm, LLC
Thawville
Watch E Kee MHP
Watseka
Wellington
Woodland

Kankakee County

Aqua Illinois - Highland Estates
Aqua Illinois - Kankakee Division
Aqua Illinois - Skyline
Aqua Illinois - Sun River Terrace
Barberry Acres MHP
Bills MHP
Buckingham
Countryside Mobile Estates MHP
Good Shepherd Manor
Herscher
Hopkins Park
Lake Shannon Inc
Manteno MHP
Momence
Pembroke Water System
Reddick
Rivercrest MHP
Skyview Estates
St Anne
Sunny Acres MHP
Windmill Estates MHP

Table A.3 Historical Values of Dependent and Independent Variables for Dominant Systems

Public Water System	Year	Demand (Mgd)	Demand (gpcd)	Max. Summer T (°F)[1]	Summer Precip. (inches)[2]	Employment-to-Population Ratio	Marginal Price (2010$)	Median Household Income (2010$)
Ford County								
Gibson City	1990	0.60	162.6	77.0	15.4	0.370		42,177
Gibson City	1995	0.77	211.2	78.6	15.8	0.406		45,168
Gibson City	2000	0.86	248.1	79.4	15.6	0.543	1.91	47,977
Gibson City	2005	0.77	219.5	81.6	18.4	0.550	1.63	42,129
Gibson City	2010	0.70	195.3	81.4	21.4	0.612	1.81	38,637
Paxton	1990	0.49	109.6	77.0	15.4	0.387		39,617
Paxton	1995	0.61	135.4	78.6	15.8	0.354		43,965
Paxton	2000	0.70	148.5	79.4	15.6	0.358		49,759
Paxton	2005	0.56	116.6	81.6	18.4	0.379		44,549
Paxton	2010	0.51	108.0	81.4	21.4	0.318	3.10	48,917
Piper City	1990	0.11	119.9	77.0	15.4	0.367		
Piper City	1995	0.12	151.6	78.6	15.8	0.380		
Piper City	2000	0.08	84.7	79.4	15.6	0.248		50,711
Piper City	2005	0.14	139.3	81.6	18.4	0.253	1.12	37,766
Piper City	2010	0.07	72.6	81.4	21.4	0.179	2.50	28,783
Iroquois County								
Clifton	1990	0.17	122.3	78.1	19.6	0.270		
Clifton	1995	0.20	142.0	80.9	18.8	0.273		
Clifton	2000	0.15	105.1	79.7	19.3	0.248		62,148
Clifton	2005	0.12	89.0	81.9	16.6	0.225		60,350
Clifton	2010	0.15	105.3	81.5	21.5	0.193	2.40	60,345
Gilman	1990	0.20	100.8	78.1	19.6	0.430	2.50	
Gilman	1995	0.24	120.8	80.9	18.8	0.433	2.56	
Gilman	2000	0.29	162.3	79.7	19.3	0.541	2.63	47,977
Gilman	2005	0.24	132.5	81.9	16.6	0.524	2.81	43,332
Gilman	2010	0.24	131.0	81.5	21.5	0.466	3.00	40,781
Milford	1990	0.28	163.1	78.1	19.6	0.335		
Milford	1995	0.17	109.9	80.9	18.8	0.306		
Milford	2000	0.18	117.1	79.7	19.3	0.297		39,631
Milford	2005	0.23	169.5	81.9	16.6	0.162		36,920
Milford	2010	0.16	119.1	81.5	21.5	0.211	2.60	35,694
Onarga	1990	0.13	98.5	78.1	19.6	0.207		
Onarga	1995	0.15	112.2	80.9	18.8	0.205		
Onarga	2000	0.16	113.7	79.7	19.3	0.224		47,190
Onarga	2005	0.17	118.6	81.9	16.6	0.191		45,230
Onarga	2010	0.16	99.7	81.5	21.5	0.256	4.15	44,762
Watseka	1990	0.60	105.2	78.1	19.6	0.810	2.50	36,133
Watseka	1995	0.72	126.3	80.9	18.8	0.792	2.19	38,120
Watseka	2000	0.66	116.4	79.7	19.3	0.620	1.97	40,067
Watseka	2005	0.58	105.8	81.9	16.6	0.438	2.47	35,796
Watseka	2010	0.64	117.2	81.5	21.5	0.590	3.16	34,690

Public Water System	Year	Demand (Mgd)	Demand (gpcd)	Max. Summer T (°F)[1]	Summer Precip. (inches)[2]	Employment-to-Population Ratio	Marginal Price (2010$)	Median Household Income (2010$)
Kankakee County								
Aqua IL - Kankakee Div	1990	9.34	155.6	78.8	22.5	0.540	2.72	33,880
Aqua IL - Kankakee Div	1995	10.99	199.9	81.1	18.0	0.540	3.10	37,297
Aqua IL - Kankakee Div	2000	12.02	185.0	80.4	20.8	0.508	3.16	40,365
Aqua IL - Kankakee Div	2005	12.89	192.4	82.2	14.4	0.500	3.07	45,257
Aqua IL - Kankakee Div	2010	12.68	158.5	81.8	23.3	0.430	3.62	49,994
Herscher	1990	0.11	79.9	78.8	22.5	0.343		
Herscher	1995	0.13	86.7	81.1	18.0	0.313		
Herscher	2000	0.16	91.2	80.4	20.8	0.295		63,509
Herscher	2005	0.15	88.2	82.2	14.4	0.245		63,775
Herscher	2010	0.13	78.8	81.8	23.3	0.226	5.45	65,417
Momence	1990	0.80	237.9	78.8	22.5	0.680	0.73	42,395
Momence	1995	0.67	198.0	81.1	18.0	0.559	0.88	46,323
Momence	2000	0.85	246.4	80.4	20.8	0.668	1.18	49,883
Momence	2005	0.77	211.1	82.2	14.4	0.720	1.23	46,271
Momence	2010	0.76	223.5	81.8	23.3	0.689	1.17	44,570
St Anne	1990	0.17	107.6	78.8	22.5	0.256		
St Anne	1995	0.16	117.0	81.1	18.0	0.248		
St Anne	2000	0.14	119.1	80.4	20.8	0.366		51,736
St Anne	2005	0.19	162.2	82.2	14.4	0.370		45,432
St Anne	2010	0.21	172.7	81.8	23.3	0.327	1.00	41,667

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[1] Average of monthly maximum summer (May-September) T (°F)

[2] Total summer (May-September) precipitation (inches)

Table A.4 Allocation of Future Population Served to Water Supply Systems (CT, LRI, and MRI Scenarios)

Public Water System	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**	**2055**	**2060**
Ford County											
Gibson City	3,572	3,572	3,572	3,572	3,572	3,572	3,572	3,572	3,572	3,572	3,572
Paxton	4,725	4,725	4,725	4,725	4,725	4,725	4,725	4,725	4,725	4,725	4,725
Piper City	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Ford County Residual	2,368	2,368	2,368	2,368	2,368	2,368	2,368	2,368	2,368	2,368	2,368
Ford County Total	*11,665*	*11,665*	*11,665*	*11,665*	*11,665*	*11,665*	*11,665*	*11,665*	*11,665*	*11,665*	*11,665*
Iroquois County											
Clifton	1,400	1,422	1,444	1,466	1,488	1,510	1,532	1,554	1,576	1,598	1,620
Gilman	1,813	1,813	1,813	1,813	1,813	1,813	1,813	1,813	1,813	1,813	1,813
Milford	1,380	1,380	1,380	1,380	1,380	1,380	1,380	1,380	1,380	1,380	1,380
Onarga	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600
Watseka	5,500	5,500	5,500	5,500	5,500	5,500	5,500	5,500	5,500	5,500	5,500
Iroquois County Residual	10,184	10,184	10,184	10,184	10,184	10,184	10,184	10,184	10,184	10,184	10,184
Iroquois County Total	*21,877*	*21,899*	*21,921*	*21,943*	*21,965*	*21,987*	*22,009*	*22,031*	*22,053*	*22,075*	*22,097*
Kankakee County											
Aqua IL – Kankakee Division	80,000	83,606	87,212	90,818	94,424	98,031	101,637	105,243	108,849	112,455	116,061
Herscher	1,680	1,736	1,792	1,849	1,905	1,961	2,017	2,073	2,130	2,186	2,242
Momence	3,420	3,600	3,779	3,959	4,138	4,318	4,497	4,677	4,856	5,036	5,215
St Anne	1,212	1,228	1,245	1,261	1,277	1,294	1,310	1,326	1,342	1,359	1,375
Kankakee County Residual	4,805	4,805	4,805	4,805	4,805	4,805	4,805	4,805	4,805	4,805	4,805
Kankakee County Total	*91,117*	*94,975*	*98,833*	*102,691*	*106,549*	*110,408*	*114,266*	*118,124*	*121,982*	*125,840*	*129,698*
REGIONAL TOTAL	**124,659**	**128,539**	**132,419**	**136,299**	**140,179**	**144,060**	**147,940**	**151,820**	**155,700**	**159,580**	**163,460**

Table A.5 Total Public System Demand by Study Area and County, Current Trends (CT) Scenario (Mgd)

Public Water System	**2010 Reported[1]**	**2010 Normal[2]**	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**	**2055**	**2060**
Ford County												
Gibson City	0.698	0.682	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.67	0.67	0.67
Paxton	0.510	0.552	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.54
Piper City	0.073	0.079	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Ford County Residual	0.180	0.181	0.19	0.18	0.18	0.18	0.18	0.18	0.17	0.17	0.17	0.17
Ford County Total	*1.460*	*1.494*	*1.50*	*1.50*	*1.49*	*1.49*	*1.48*	*1.48*	*1.48*	*1.47*	*1.47*	*1.46*
Iroquois County												
Clifton	0.147	0.149	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
Gilman	0.238	0.233	0.24	0.24	0.23	0.23	0.23	0.23	0.22	0.22	0.22	0.22
Milford	0.164	0.161	0.17	0.16	0.16	0.16	0.16	0.16	0.15	0.15	0.15	0.15
Onarga	0.160	0.157	0.16	0.16	0.16	0.16	0.15	0.15	0.15	0.15	0.15	0.14
Watseka	0.645	0.632	0.65	0.64	0.64	0.63	0.62	0.61	0.61	0.60	0.59	0.58
Iroquois County Residual	0.876	0.860	0.89	0.87	0.86	0.85	0.84	0.83	0.82	0.81	0.80	0.79
Iroquois County Total	*2.230*	*2.192*	*2.26*	*2.23*	*2.21*	*2.19*	*2.16*	*2.14*	*2.11*	*2.09*	*2.07*	*2.05*
Kankakee County												
Aqua IL–Kankakee Division	12.683	12.405	13.35	13.75	14.15	14.54	14.91	15.27	15.62	15.96	16.29	16.61
Herscher	0.132	0.130	0.14	0.14	0.14	0.15	0.15	0.15	0.15	0.16	0.16	0.16
Momence	0.765	0.748	0.82	0.67	0.69	0.71	0.73	0.75	0.78	0.80	0.81	0.83
St Anne	0.209	0.205	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21
Kankakee County Residual	0.530	0.519	0.53	0.53	0.52	0.51	0.51	0.50	0.50	0.49	0.48	0.48
Kankakee County Total	*14.319*	*14.006*	*15.04*	*15.30*	*15.72*	*16.12*	*16.51*	*16.89*	*17.26*	*17.62*	*17.96*	*18.30*
REGIONAL TOTAL	**18.009**	**17.692**	**18.81**	**19.04**	**19.42**	**19.80**	**20.16**	**20.51**	**20.85**	**21.18**	**21.50**	**21.81**

[1] 2010 (Reported): computed from reported total demand in 2010

[2] 2010 (Normal): computed from weather-normalized total demand in 2010 (obtained by substituting normal weather conditions into the regression model)

Table A.6 Total Public System Demand by Study Area and County, Less Resource Intensive (LRI) Scenario (Mgd)

Public Water System	**2010 Reported[1]**	**2010 Normal[2]**	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**	**2055**	**2060**
Ford County												
Gibson City	0.698	0.682	0.67	0.67	0.66	0.65	0.64	0.63	0.63	0.62	0.61	0.61
Paxton	0.510	0.552	0.55	0.54	0.53	0.53	0.52	0.51	0.51	0.50	0.50	0.49
Piper City	0.073	0.079	0.08	0.08	0.08	0.07	0.07	0.07	0.07	0.07	0.07	0.07
Ford County Residual	0.180	0.181	0.18	0.17	0.16	0.16	0.15	0.15	0.14	0.14	0.14	0.13
Ford County Total	*1.460*	*1.494*	*1.47*	*1.45*	*1.43*	*1.41*	*1.39*	*1.37*	*1.35*	*1.33*	*1.31*	*1.30*
Iroquois County												
Clifton	0.147	0.149	0.15	0.14	0.14	0.14	0.14	0.13	0.13	0.13	0.13	0.13
Gilman	0.238	0.233	0.23	0.22	0.21	0.21	0.20	0.19	0.19	0.18	0.17	0.17
Milford	0.164	0.161	0.16	0.15	0.15	0.14	0.14	0.13	0.13	0.12	0.12	0.12
Onarga	0.160	0.157	0.15	0.15	0.14	0.14	0.13	0.13	0.13	0.12	0.12	0.11
Watseka	0.645	0.632	0.61	0.59	0.57	0.56	0.54	0.52	0.51	0.49	0.47	0.46
Iroquois County Residual	0.876	0.860	0.83	0.81	0.78	0.76	0.73	0.71	0.69	0.67	0.64	0.62
Iroquois County Total	*2.230*	*2.192*	*2.13*	*2.06*	*2.00*	*1.94*	*1.88*	*1.82*	*1.77*	*1.71*	*1.66*	*1.61*
Kankakee County												
Aqua IL–Kankakee Division	12.683	12.405	12.56	12.68	12.79	12.88	12.95	13.00	13.04	13.06	13.07	13.06
Herscher	0.132	0.130	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Momence	0.765	0.748	0.77	0.61	0.62	0.63	0.64	0.64	0.65	0.65	0.65	0.66
St Anne	0.209	0.205	0.20	0.20	0.19	0.19	0.19	0.18	0.18	0.18	0.17	0.17
Kankakee County Residual	0.530	0.519	0.50	0.49	0.47	0.46	0.44	0.43	0.41	0.40	0.39	0.38
Kankakee County Total	*14.319*	*14.006*	*14.16*	*14.11*	*14.21*	*14.29*	*14.34*	*14.39*	*14.41*	*14.42*	*14.41*	*14.39*
REGIONAL TOTAL	**18.009**	**17.692**	**17.76**	**17.62**	**17.64**	**17.63**	**17.61**	**17.58**	**17.53**	**17.46**	**17.38**	**17.29**

[1] 2010 (Reported): computed from reported total demand in 2010

[2] 2010 (Normal): computed from weather-normalized total demand in 2010 (obtained by substituting normal weather conditions into the regression model)

Table A.7 Total Public System Demand by Study Area and County, More Resource Intensive (MRI) Scenario (Mgd)

Public Water System	**2010 Reported[1]**	**2010 Normal[2]**	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**	**2055**	**2060**
Ford County												
Gibson City	0.70	0.682	0.70	0.70	0.71	0.71	0.72	0.72	0.73	0.73	0.74	0.74
Paxton	0.51	0.552	0.56	0.57	0.57	0.58	0.58	0.58	0.59	0.59	0.60	0.60
Piper City	0.07	0.079	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.09
Ford County Residual	0.18	0.181	0.20	0.20	0.20	0.20	0.20	0.21	0.21	0.21	0.21	0.21
Ford County Total	*1.460*	*1.494*	*1.54*	*1.55*	*1.56*	*1.57*	*1.58*	*1.59*	*1.61*	*1.62*	*1.63*	*1.64*
Iroquois County												
Clifton	0.15	0.149	0.17	0.17	0.17	0.18	0.18	0.19	0.19	0.19	0.20	0.20
Gilman	0.24	0.233	0.25	0.26	0.26	0.26	0.26	0.26	0.27	0.27	0.27	0.27
Milford	0.16	0.161	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.19	0.19	0.19
Onarga	0.16	0.157	0.17	0.17	0.17	0.18	0.18	0.18	0.18	0.18	0.18	0.18
Watseka	0.64	0.632	0.69	0.70	0.70	0.71	0.71	0.72	0.72	0.73	0.73	0.74
Iroquois County Residual	0.88	0.860	0.94	0.95	0.95	0.96	0.97	0.98	0.98	0.99	1.00	1.00
Iroquois County Total	*2.230*	*2.192*	*2.40*	*2.42*	*2.44*	*2.46*	*2.48*	*2.50*	*2.52*	*2.54*	*2.57*	*2.59*
Kankakee County												
Aqua IL–Kankakee Division	12.68	12.405	14.18	14.90	15.63	16.37	17.12	17.88	18.64	19.42	20.21	21.01
Herscher	0.13	0.130	0.15	0.15	0.16	0.16	0.17	0.18	0.18	0.19	0.20	0.20
Momence	0.76	0.748	0.86	0.72	0.76	0.80	0.84	0.88	0.93	0.97	1.01	1.05
St Anne	0.21	0.205	0.22	0.23	0.24	0.24	0.25	0.25	0.26	0.26	0.27	0.27
Kankakee County Residual	0.53	0.519	0.57	0.57	0.58	0.58	0.58	0.59	0.59	0.60	0.60	0.61
Kankakee County Total	*14.319*	*14.006*	*15.97*	*16.58*	*17.36*	*18.15*	*18.96*	*19.77*	*20.60*	*21.44*	*22.29*	*23.15*
REGIONAL TOTAL	**18.009**	**17.692**	**19.91**	**20.54**	**21.36**	**22.19**	**23.02**	**23.87**	**24.73**	**25.60**	**26.48**	**27.38**

[1] 2010 (Reported): computed from reported total demand in 2010

[2] 2010 (Normal): computed from weather-normalized total demand in 2010 (obtained by substituting normal weather conditions into the regression model)

Table A.8 Per-Capita Public System Demand by Study Area and County, Current Trends (CT) Scenario (gpcd)

Public Water System	**2010 Reported[1]**	**2010 Normal[2]**	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**	**2055**	**2060**
Ford County												
Gibson City	195.3	190.9	191.7	191.2	190.8	190.4	190.0	189.7	189.3	188.9	188.5	188.2
Paxton	108.0	116.9	117.3	117.1	116.8	116.6	116.3	116.1	115.9	115.6	115.4	115.2
Piper City	72.6	78.6	78.9	78.7	78.6	78.4	78.2	78.1	77.9	77.8	77.6	77.5
Ford County Residual	75.8	76.5	78.8	77.8	76.9	76.0	75.1	74.2	73.3	72.4	71.5	70.6
Ford County Total	*125.2*	*128.1*	*129.0*	*128.5*	*128.1*	*127.7*	*127.3*	*126.9*	*126.5*	*126.0*	*125.7*	*125.3*
Iroquois County												
Clifton	105.3	106.7	109.8	108.5	107.2	105.9	104.6	103.4	102.1	100.9	99.7	98.5
Gilman	131.0	128.5	132.3	130.7	129.2	127.6	126.1	124.6	123.1	121.6	120.1	118.7
Milford	119.1	116.8	120.3	118.8	117.4	116.0	114.6	113.2	111.9	110.5	109.2	107.9
Onarga	99.7	97.9	100.7	99.5	98.3	97.1	96.0	94.8	93.7	92.5	91.4	90.3
Watseka	117.2	115.0	118.4	117.0	115.6	114.2	112.8	111.4	110.1	108.8	107.5	106.2
Iroquois County Residual	86.1	84.4	86.9	85.9	84.8	83.8	82.8	81.8	80.8	79.8	78.9	77.9
Iroquois County Total	*101.9*	*100.2*	*103.2*	*101.9*	*100.7*	*99.5*	*98.3*	*97.1*	*96.0*	*94.8*	*93.7*	*92.6*
Kankakee County												
Aqua IL–Kankakee Division	158.5	155.1	159.6	157.7	155.8	153.9	152.1	150.2	148.4	146.7	144.9	143.1
Herscher	78.8	77.1	79.4	78.4	77.5	76.5	75.6	74.7	73.8	72.9	72.0	71.2
Momence	223.5	218.7	226.9	176.2	174.0	172.0	169.9	167.8	165.8	163.8	161.8	159.9
St Anne	172.7	169.0	170.0	171.9	169.8	167.8	165.7	163.7	161.8	159.8	157.9	156.0
Kankakee County Residual	110.3	107.9	111.1	109.8	108.5	107.1	105.9	104.6	103.3	102.1	100.8	99.6
Kankakee County Total	*157.2*	*153.7*	*158.4*	*154.8*	*153.1*	*151.3*	*149.6*	*147.8*	*146.1*	*144.4*	*142.8*	*141.1*
REGIONAL TOTAL	**144.5**	**141.9**	**146.3**	**143.8**	**142.5**	**141.2**	**139.9**	**138.6**	**137.3**	**136.0**	**134.7**	**133.4**

[1] 2010 (Reported): computed from reported total demand in 2010

[2] 2010 (Normal): computed from weather-normalized total demand in 2010 (obtained by substituting normal weather conditions into the regression model)

Table A.9 Per-Capita Public System Demand by Study Area and County, Less Resource Intensive (LRI) Scenario (gpcd)

Public Water System	2010 Reported[1]	2010 Normal[2]	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060
Ford County												
Gibson City	195.3	190.9	188.6	186.3	184.1	181.9	179.7	177.6	175.5	173.4	171.4	169.4
Paxton	108.0	116.9	115.4	114.0	112.7	111.3	110.0	108.7	107.4	106.2	104.9	103.7
Piper City	72.6	78.6	77.6	76.7	75.8	74.9	74.0	73.1	72.2	71.4	70.6	69.7
Ford County Residual	75.8	76.5	74.1	71.8	69.5	67.3	65.2	63.1	61.2	59.2	57.4	55.6
Ford County Total	*125.2*	*128.1*	*126.2*	*124.4*	*122.6*	*120.9*	*119.2*	*117.5*	*115.9*	*114.3*	*112.7*	*111.1*
Iroquois County												
Clifton	105.3	106.7	103.3	100.0	96.9	93.8	90.9	88.0	85.2	82.5	79.9	77.4
Gilman	131.0	128.5	124.5	120.6	116.8	113.1	109.5	106.1	102.7	99.5	96.3	93.3
Milford	119.1	116.8	113.2	109.6	106.1	102.8	99.5	96.4	93.4	90.4	87.6	84.8
Onarga	99.7	97.9	94.8	91.8	88.9	86.1	83.4	80.7	78.2	75.7	73.3	71.0
Watseka	117.2	115.0	111.4	107.9	104.5	101.2	98.0	94.9	91.9	89.0	86.2	83.5
Iroquois County Residual	86.1	84.4	81.8	79.2	76.7	74.3	71.9	69.7	67.5	65.3	63.3	61.3
Iroquois County Total	*101.9*	*100.2*	*97.1*	*94.0*	*91.1*	*88.2*	*85.4*	*82.7*	*80.1*	*77.6*	*75.2*	*72.8*
Kankakee County												
Aqua IL–Kankakee Division	158.5	155.1	150.2	145.4	140.9	136.4	132.1	127.9	123.9	120.0	116.2	112.6
Herscher	78.8	77.1	74.7	72.3	70.0	67.8	65.7	63.6	61.6	59.7	57.8	56.0
Momence	223.5	218.7	215.1	162.5	157.3	152.4	147.6	142.9	138.4	134.1	129.8	125.7
St Anne	172.7	169.0	161.2	158.5	153.5	148.7	144.0	139.4	135.0	130.8	126.7	122.7
Kankakee County Residual	110.3	107.9	104.5	101.2	98.0	94.9	92.0	89.1	86.2	83.5	80.9	78.3
Kankakee County Total	*157.2*	*153.7*	*149.1*	*142.8*	*138.4*	*134.1*	*129.9*	*125.9*	*122.0*	*118.2*	*114.5*	*110.9*
REGIONAL TOTAL	**144.5**	**141.9**	**138.1**	**133.1**	**129.4**	**125.8**	**122.3**	**118.8**	**115.4**	**112.1**	**108.9**	**105.8**

[1] 2010 (Reported): computed from reported total demand in 2010

[2] 2010 (Normal): computed from weather-normalized total demand in 2010 (obtained by substituting normal weather conditions into the regression model)

Table A.10 Per-Capita Public System Demand by Study Area and County, More Resource Intensive (MRI) Scenario (gpcd)

Public Water System	**2010 Reported[1]**	**2010 Normal[2]**	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**	**2055**	**2060**
Ford County												
Gibson City	195.3	190.9	194.7	196.1	197.6	199.0	200.4	201.9	203.4	204.9	206.4	207.9
Paxton	108.0	116.9	119.2	120.1	120.9	121.8	122.7	123.6	124.5	125.4	126.3	127.3
Piper City	72.6	78.6	80.1	80.7	81.3	81.9	82.5	83.1	83.7	84.3	84.9	85.6
Ford County Residual	75.8	76.5	83.7	84.3	84.9	85.5	86.2	86.8	87.4	88.1	88.7	89.4
Ford County Total	*125.2*	*128.1*	*131.8*	*132.7*	*133.7*	*134.7*	*135.7*	*136.6*	*137.6*	*138.6*	*139.7*	*140.7*
Iroquois County												
Clifton	105.3	106.7	116.7	117.5	118.4	119.2	120.1	121.0	121.9	122.8	123.6	124.5
Gilman	131.0	128.5	140.6	141.6	142.7	143.7	144.7	145.8	146.9	147.9	149.0	150.1
Milford	119.1	116.8	127.8	128.7	129.7	130.6	131.6	132.5	133.5	134.5	135.4	136.4
Onarga	99.7	97.9	107.0	107.8	108.6	109.4	110.2	111.0	111.8	112.6	113.4	114.3
Watseka	117.2	115.0	125.8	126.7	127.6	128.6	129.5	130.4	131.4	132.3	133.3	134.3
Iroquois County Residual	86.1	84.4	92.3	93.0	93.7	94.4	95.1	95.8	96.5	97.2	97.9	98.6
Iroquois County Total	*101.9*	*100.2*	*109.6*	*110.4*	*111.2*	*112.1*	*112.9*	*113.7*	*114.6*	*115.4*	*116.2*	*117.1*
Kankakee County												
Aqua IL–Kankakee Division	158.5	155.1	169.6	170.8	172.1	173.3	174.6	175.9	177.2	178.5	179.8	181.1
Herscher	78.8	77.1	84.3	84.9	85.6	86.2	86.8	87.4	88.1	88.7	89.4	90.0
Momence	223.5	218.7	239.2	190.8	192.2	193.6	195.0	196.5	197.9	199.3	200.8	202.3
St Anne	172.7	169.0	179.2	186.2	187.5	188.9	190.3	191.7	193.1	194.5	195.9	197.3
Kankakee County Residual	110.3	107.9	118.1	118.9	119.8	120.7	121.5	122.4	123.3	124.2	125.1	126.0
Kankakee County Total	*157.2*	*153.7*	*168.2*	*167.7*	*169.0*	*170.4*	*171.7*	*173.1*	*174.4*	*175.8*	*177.1*	*178.5*
REGIONAL TOTAL	**144.5**	**141.9**	**154.9**	**155.1**	**156.7**	**158.3**	**159.8**	**161.4**	**162.9**	**164.4**	**166.0**	**167.5**

[1] 2010 (Reported): computed from reported total demand in 2010

[2] 2010 (Normal): computed from weather-normalized total demand in 2010 (obtained by substituting normal weather conditions into the regression model)

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Appendix B. Estimation of Future Population

B.1 Methodology

In the absence of existing estimates, we have estimated the resident population from 2030 to 2060 for each county in the study region (Figure B.1) and specific counties (Figure B.2 to Figure B.4, Table B.1). To develop these estimates, we used historical county-level population counts (1920-2000) and estimates of the 2010-2014 population on July 1 of each year (Table B.2), as well as available projections of future county population.

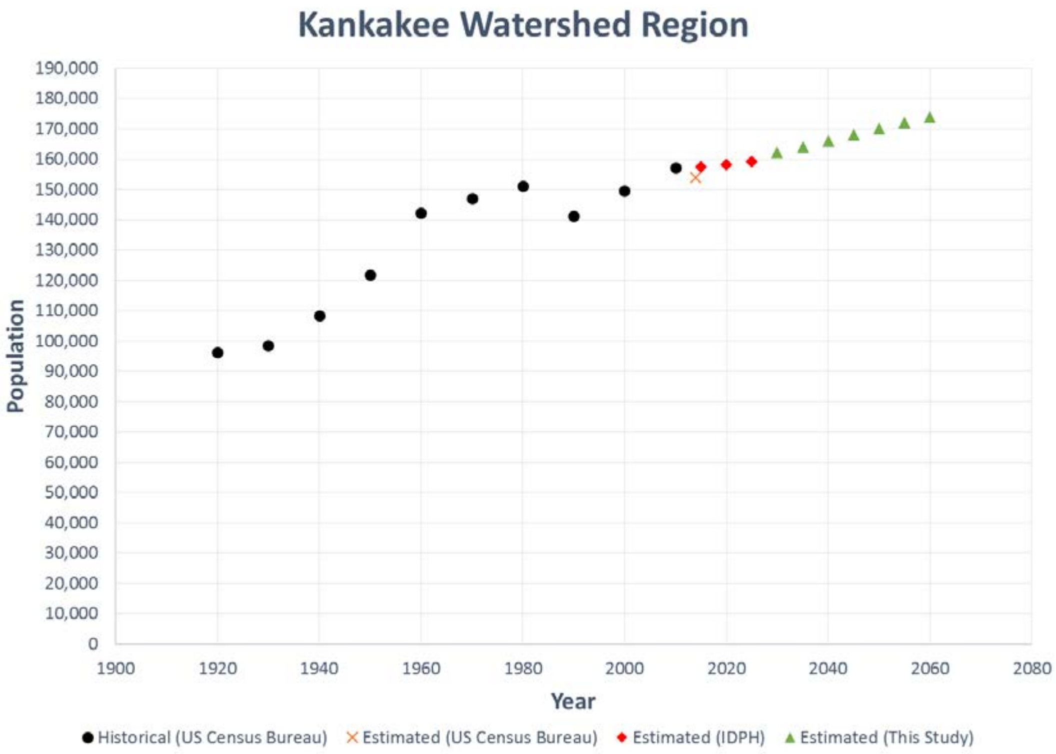
Historical population counts for the years 1920 to 1990 were obtained from the United States Census Bureau (1995), as was the count for 2000 (United States Census Bureau, 2004). Estimates of 2010-2014 population were obtained using the Advanced Search feature provided in the United States Census Bureau's *American FactFinder* (United States Census Bureau, 2015). Projections of county-level population–covering the years 2015, 2020, and 2025–were developed by the Illinois Department of Public Health (IDPH) and were obtained from the State of Illinois Data Portal (Data.Illinois.gov State of Illinois Data Portal, 2015). For this study, the IDPH projections were extended for an additional 35 years (2030-2060) using straightforward trend extension techniques that were fitted to historical population data and IDPH projections.

We employed estimates of the 2010 population on July 1, rather than census counts on April 1 (United States Census Bureau, 2014), because, as will be discussed, we frequently used the 2010 data in conjunction with the 2014 estimates, also estimated for July 1, and with the IDPH estimates, which are based on the July 1, 2010 Census Bureau estimates (Data.Illinois.gov State of Illinois Data Portal, 2015). The April 1 counts and July 1 estimates differ by 0.01 percent for Kankakee County, 0.02 percent for Ford County, and 0.19 percent for Iroquois County.

For each of the study region counties, we plotted census population counts for the years 1920 to 2000, estimates for 2010 and 2014, and the IDPH population projections from 2015 to 2025. We used the resulting plots to explore the population data for long-term trends, employing the Census Bureau's 2014 population estimate to validate the IDPH 2015 projection.

Among the three counties of the study region, the IDPH projections for Ford and Iroquois show a decreasing population during the 2015-2025 period. IDPH projects an increase in county population during this period only for Kankakee County. When comparing the IDPH projections and historical trends (including the Census Bureau's 2014 estimate), we decided to use the following methods and assumptions to extend the IDPH population projections to the 2030-2060 period:

1. For Ford (Figure B.2) and Iroquois Counties (Figure B.3), IDPH projections suggest declining populations from 2015 to 2025, a trend that is plausible based on historical data. In projecting population in these counties from 2030 to 2060, however, we assumed that the population will stabilize at the IDPH estimate for 2020.
2. Since the IDPH 2015-2025 population estimates for Kankakee County (Figure B.4) reflected a long-term upward trend prevailing since 1960, we used these values to estimate the 2030-2060 population. We estimated the 2030-2060 values using the *Fill/Series …* utility of Microsoft Excel 2013 (Microsoft Corporation, 2013), accessed via Excel's *Home* ribbon, selecting the *Linear* option under the *Type* menu and checking the *Trend* box. We employed the 2030-2060 values computed through this computation as our population estimates and use the IDPH estimates for the years 2015, 2020, and 2025.



3.

Figure B.1 Historical and projected population, Kankakee watershed region

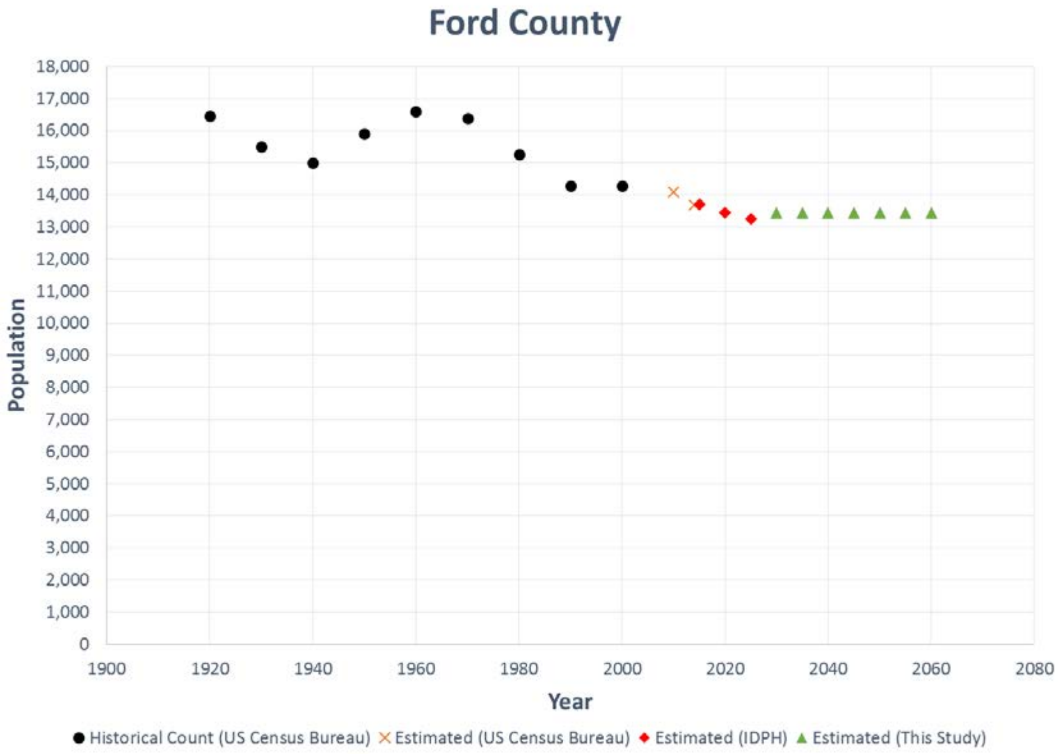


Figure B.2 Historical and projected population, Ford County

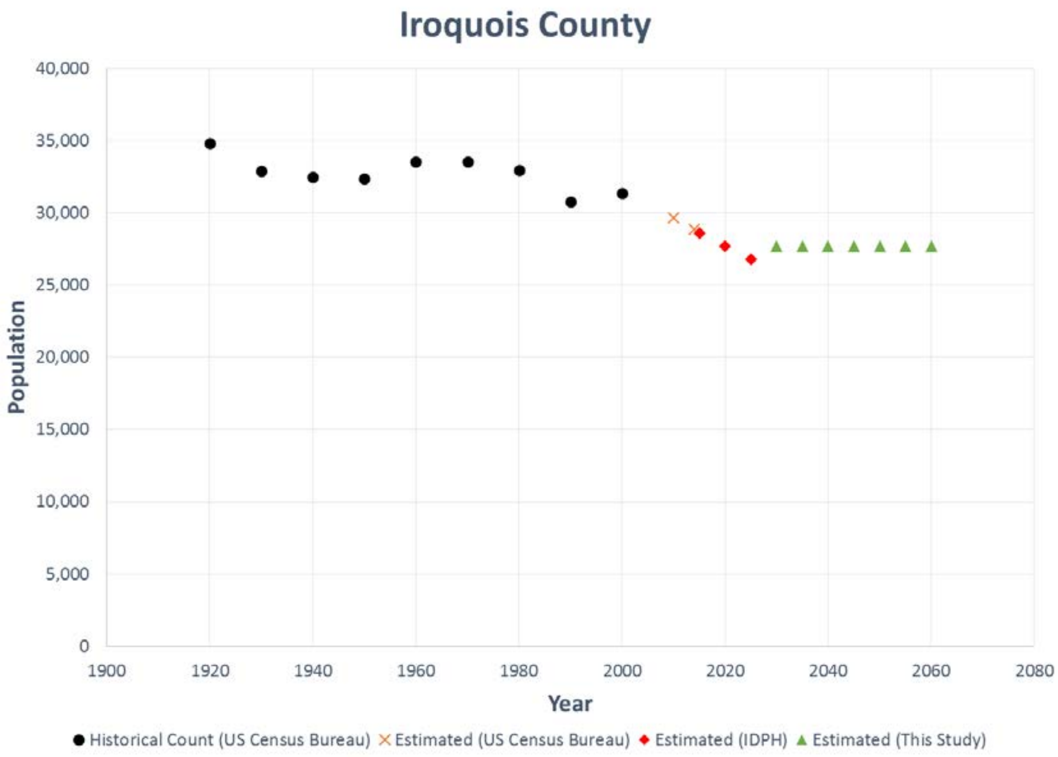


Figure B.3 Historical and projected population, Iroquois County

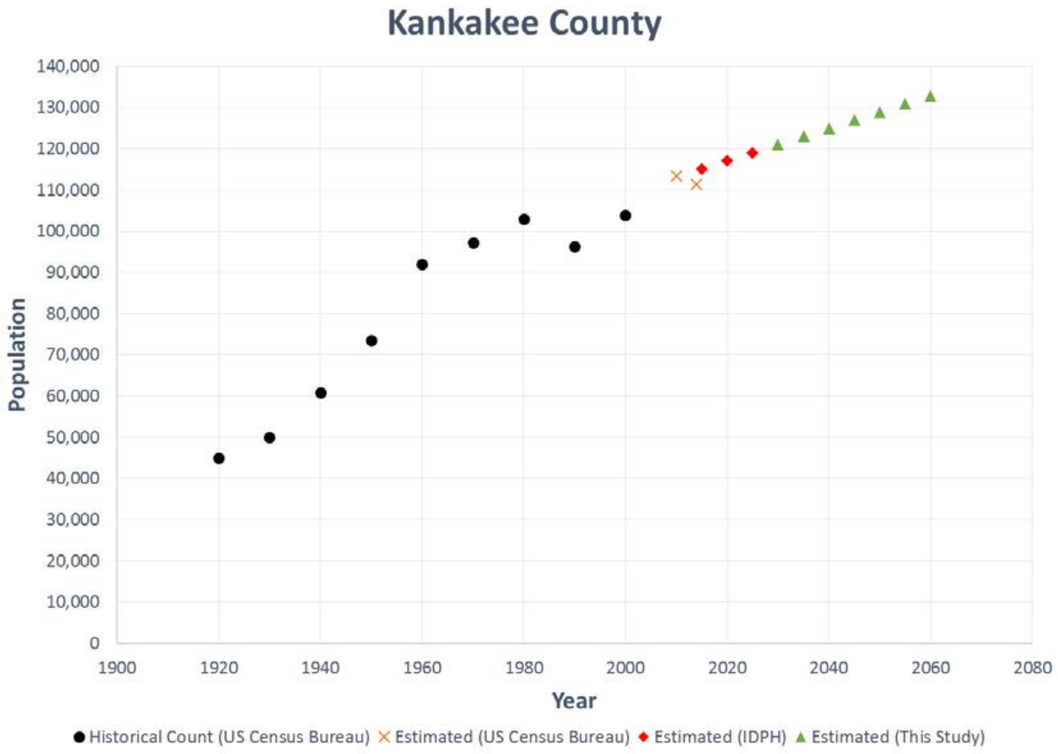


Figure B.4 Historical and projected population, Kankakee County

Table B.1 Projected County and Regional Population, 2015-2060

County	2015[1]	2020[1]	2025[1]	2030[2]	2035[2]	2040[2]	2045[2]	2050[2]	2055[2]	2060[2]
Ford	13,709	13,448	13,245	13,448	13,448	13,448	13,448	13,448	13,448	13,448
Iroquois	28,589	27,686	26,816	27,686	27,686	27,686	27,686	27,686	27,686	27,686
Kankakee	115,129	117,167	119,074	121,068	123,041	125,013	126,986	128,958	130,931	132,903
TOTAL	*157,427*	*158,301*	*159,135*	*162,202*	*164,175*	*166,147*	*168,120*	*170,092*	*172,065*	*174,037*

[1] Estimated by Illinois Department of Public Health and available from Data.Illinois.gov State of Illinois Data Portal (2015) unless noted with asterisk, which are projections estimated for this study as described in the text.
[2] This study

Table B.2 Historical County and Regional Population, 1920-2014

County	1920[1]	1930[1]	1940[1]	1950[1]	1960[1]	1970[1]	1980[1]	1990[1]	2000[2]	2010[3]	2014[3]
Ford	16,466	15,489	15,007	15,901	16,606	16,382	15,265	14,275	14,272	14,078	13,688
Iroquois	34,841	32,913	32,496	32,348	33,562	33,532	32,976	30,787	31,386	29,663	28,879
Kankakee	44,940	50,095	60,877	73,524	92,063	97,250	102,926	96,255	104,010	113,462	111,375
TOTAL	*96,247*	*98,497*	*108,380*	*121,773*	*142,231*	*147,164*	*151,167*	*141,317*	*149,668*	*157,203*	*153,942*

[1] United States Census Bureau (1995)
[2] United States Census Bureau (2004)
[3] Estimated by United States Census Bureau, available from United States Census Bureau *American FactFinder* Advanced Search (United States Census Bureau, 2015)

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Appendix C. Self-Supplied Domestic Demand – Supplemental Tables

Table C.1 Total Self-Supplied Domestic Demand by County, Current Trends (CT) Scenario (Mgd)

County	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**	**2055**	**2060**
Ford	0.193	0.163	0.141	0.125	0.140	0.140	0.139	0.138	0.138	0.137	0.137
Iroquois	0.623	0.533	0.457	0.385	0.450	0.446	0.443	0.439	0.436	0.432	0.429
Kankakee	1.788	1.605	1.454	1.294	1.142	0.989	0.838	0.688	0.539	0.392	0.246
REGIONAL TOTAL	**2.604**	**2.301**	**2.053**	**1.804**	**1.732**	**1.575**	**1.420**	**1.266**	**1.113**	**0.961**	**0.811**

Table C.2 Total Self-Supplied Domestic Demand by County, Less Resource Intensive (LRI) Scenario (Mgd)

County	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**	**2055**	**2060**
Ford	0.193	0.161	0.138	0.120	0.134	0.131	0.129	0.127	0.125	0.123	0.121
Iroquois	0.623	0.526	0.446	0.371	0.429	0.420	0.412	0.403	0.395	0.387	0.380
Kankakee	1.788	1.586	1.419	1.248	1.088	0.931	0.779	0.632	0.490	0.351	0.218
REGIONAL TOTAL	2.604	2.273	2.004	1.739	1.650	1.483	1.320	1.163	1.010	0.862	0.718

Table C.3 Total Self-Supplied Domestic Demand by County, More Resource Intensive (MRI) Scenario (Mgd)

County	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**	**2055**	**2060**
Ford	0.193	0.165	0.145	0.129	0.147	0.148	0.149	0.150	0.151	0.152	0.153
Iroquois	0.623	0.539	0.468	0.398	0.471	0.473	0.474	0.476	0.478	0.479	0.481
Kankakee	1.788	1.624	1.488	1.340	1.196	1.048	0.898	0.746	0.592	0.435	0.276
REGIONAL TOTAL	2.604	2.328	2.101	1.867	1.814	1.669	1.522	1.372	1.220	1.066	0.910

Appendix D. Theoretical Cooling Water Requirements for Thermoelectric Power Generation

In once-through cooling systems, theoretical water requirements are a function of the amount of "waste" heat that has to be removed in the process of condensing steam. According to Backus and Brown (1975), the amount of water for one megawatt (MW) of electric generation capacity can be calculated as:

$$L = \frac{6823(1-e)}{Te} \tag{D.1}$$

where:

L = amount of water flow in gallons per minute per MW of generating capacity;
T = temperature rise of the cooling water in °F; and
e = thermodynamic efficiency of the power plant, expressed as a decimal fraction.

For example, in a coal-fired plant with a thermal efficiency of 40 percent and the condenser temperature rise of 20°F, the water flow rate obtained from Equation D.1 would be 512 gallons per minute (gpm) per MW. For a typical 650 MW plant, operating at 90 percent of capacity, the theoretical flow rate would be nearly 300,000 gpm, or 431.3 million gallons per day. The daily volume of cooling water is equivalent to approximately 31 gallons per 1 kWh of generation.

According to Croley et al. (1975), in recirculating systems with cooling towers, theoretical make-up water requirements are determined using the following relationship:

$$W = E \cdot \frac{1}{\frac{c}{c_o} - 1} \tag{D.2}$$

where:

c/c_0 is the concentration ratio; and
E = evaporative water loss, which for a typical mean water temperature of 80°F can be calculated as:

$$E = (1.91145 \cdot 10^{-6}) \cdot aQ \tag{D.3}$$

where:

a = the fraction of heat dissipated as latent heat of evaporation (for evaporative towers a = 75% to 85%); and
Q = rate of heat rejection by the plant in Btu/hr, which can be calculated as:

$$Q = 3414426 \cdot P \cdot \frac{1-e}{e} \tag{D.4}$$

where:

P = the rated capacity of the plant in MW; and
e is the thermodynamic efficiency of the plant expressed as a fraction.

Again, for a typical 650 MW coal-fired plant with 40 percent efficiency, the heat rejection would be 3,329 million Btu/hour and the evaporative water loss would be 5,091 gpm. At the concentration ratio c/c_o of 0.25, the make-up water flow would be 6,788 gpm or 0.63 gallons per 1 kWh of generation.

Although the theoretical (or minimum) water requirements for energy generation are similar for plants of the same type, the actual unit amounts of water withdrawn per kilowatt-hour of gross generation vary from plant to plant, even when the same type of cooling is used and at the same level of thermal efficiency of the plant. Significant differences in unit water use per kilowatt-hour of electricity generation among different types of cooling systems were reported in previous studies (Baum et al., 2003, Gleick, 1993, Harte and El-Gasseir, 1978).

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Appendix E. Power Generation Facilities in the Kankakee Watershed, Middle Illinois, and Northwestern Illinois Study Regions (U.S. Department of Energy, Energy Information Administration [EIA] 2010 EIA-906/920 Monthly Time Series File and EIA-860)

Plant Name	Prime Mover[1]	Energy Source[2]	Number of Units	Nameplate Capacity (MW[3])	Source of Water
KANKAKEE WATERSHED REGION					
Ford County					
Gibson City	GT	NG	2	270.0	
Kankakee County					
Bunge Oil	GT	NG	1	3.5	
CSL Behring LLC	GT	NG	1	4.2	Municipality
Kankakee Gas Recovery	IC	LFG	2	1.6	
Kankakee Hydro Facility	HY	WAT	3	1.2	Kankakee R
MIDDLE ILLINOIS REGION					
LaSalle County					
Blackstone Wind Farm II LLC	WT	WND	1	200.0	na[4]
Blackstone Wind Farm LLC	WT	WND	1	102.0	na
North American Hydro - Dayton	HY	WAT	3	3.6	Fox R
Grand Ridge Wind Energy Center	WT	WND	4	261.0	
LaSalle Generating Station	ST	NUC	2	2,340.0	Illinois R./Cooling L.
Oglesby	GT	NG	4	70.0	
Peru	GT	JF	1	10.0	Illinois R
Peru Hydroelectric Power Station	HY	WAT	4	7.6	Illinois R
Peru	IC	DFO	8	19.5	Illinois R
Streator Energy Partners LLC	IC	LFG	1	1.1	
Livingston County					
Biodyne Pontiac	GT	LFG	3	15.0	
Streator Cayuga Ridge South	WT	WND	1	150.0	
Peoria County					
Archer Daniels Midland Peoria	GT	NG	3	49.0	Illinois R
Archer Daniels Midland Peoria	ST	BIT	5	15.0	Illinois R
Biodyne Peoria	IC	LFG	5	4.0	
E D Edwards	ST	SUB	3	780.3	Illinois R
Putnam County					
Hennepin Power Station	ST	SUB	2	306.3	Illinois R
Stark County					
Camp Grove Wind Farm	WT	WND	1	150.0	na

Plant Name	Prime Mover[1]	Energy Source[2]	Number of Units	Nameplate Capacity (MW[3])	Source of Water
ROCK RIVER REGION					
Bureau County					
Agriwind LLC	WT	WND	1	8.4	
Crescent Ridge	WT	WND	1	53.0	
Princeton	IC	NG	8	37.9	Municipality
Providence Heights Wind LLC	WT	WND	1	72.0	
Henry County					
Geneseo	IC	DFO	1	4.8	Municipality
Geneseo		NG	7	24.6	Municipality
Geneseo	WT	WND	2	3.0	Municipality
Lee County					
Dixon Hydroelectric Dam	HY	WAT	5	3.0	Rock R
Dixon/Lee Energy Partners LLC	IC	LFG	4	4.4	
GSG LLC	WT	WND	1	80.0	na
Lee Energy Facility	GT	NG	8	814.4	Wells
Mendota Hills, LLC	WT	WND	1	50.4	na
Ogle County					
1515 S Caron Road	GT	NG	1	4.2	Municipality
Byron Generating Station	ST	NUC	2	2,449.8	Rock R/Cool. T
North Ninth Street	IC	DFO	3	2.9	Municipality
North Ninth Street		NG	5	14.8	Municipality
South Main Street	IC	NG	2	5.0	Municipality
Rock Island County					
Cordova Energy	CA	NG	1	191.2	Wells
Cordova Energy	CT	NG	2	420.0	Wells
John Deere Harvester Works	ST	BIT	4	10.0	Mississippi R
Moline	GT	NG	4	72.0	Mississippi R
MidAmerican Energy Co - Moline Hydro Plant	HY	WAT	4	3.6	Mississippi R
Quad Cities Generating Station	ST	NUC	2	2,018.6	Mississippi R
Sears Hydroelectric Plant	HY	WAT	4	1.4	Rock R
Upper Rock Energy Partners LLC	IC	LFG	4	4.4	
Stephenson County					
EcoGrove Wind LLC	WT	WND	1	100.5	na
Whiteside County					
Avenue A Generator Sets	GT	DFO	2	3.6	
Industrial Park	GT	DFO	5	9.0	
Upper Sterling Hydro Power Plant	HY	WAT	2	2.2	Municipal Wells

Plant Name	Prime Mover[1]	Energy Source[2]	Number of Units	Nameplate Capacity (MW[3])	Source of Water
Winnebago County					
Cadbury Adams - Rockford	GT	NG	1	4.7	Municipality
Ingersoll Milling Machine	GT	NG	7	4.6	Municipality
NRG Rockford I	GT	NG	2	316.0	
NRG Rockford II Energy Center	GT	NG	1	168.0	
North American Hydro - Rockton	HY	WAT	2	1.1	Rock R
Winnebago Energy Center LLC	IC	LFG	4	6.4	
ALL REGIONS					
TOTAL			166	11,734.8	

[1] Prime Mover: GT=gas turbine, HY=hydropower, IC=internal combustion, ST=steam turbine, WT=wind turbine
[2] Energy Source: BIT=bituminous coal, DFO=distillate fuel oil, JF=jet fuel, LFG=landfill gas, NG=natural gas, NUC=nuclear, SUB=subbituminous coal, WAT=water, WND=wind
[3] MW: megawatts
[4] na: not applicable

Appendix F. Self-Supplied Industrial and Commercial Demand – Supplemental Tables

Table F.1 Total Self-Supplied IC Demand by County, Current Trends (CT) Scenario (Mgd)

County	2010 Reported[1]	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060
Ford	1.52	1.62	1.73	1.79	1.92	2.02	2.12	2.23	2.34	2.45	2.57
Iroquois	0.07	0.07	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.09	0.09
Kankakee	3.71	4.16	4.66	4.83	5.01	5.20	5.39	5.58	5.78	5.99	6.20
REGIONAL TOTAL	**5.30**	**5.85**	**6.47**	**6.70**	**7.01**	**7.30**	**7.59**	**7.90**	**8.21**	**8.53**	**8.87**

[1] United States Geological Survey (2014)

Table F.2 Total Self-Supplied IC Demand by County, Less Resource Intensive (LRI) Scenario (Mgd)

County	2010 Reported[1]	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060
Ford	1.52	1.57	1.63	1.64	1.70	1.74	1.77	1.81	1.84	1.87	1.91
Iroquois	0.07	0.07	0.08	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
Kankakee	3.71	4.04	4.39	4.42	4.45	4.47	4.50	4.53	4.55	4.57	4.60
REGIONAL TOTAL	**5.30**	**5.68**	**6.09**	**6.13**	**6.22**	**6.28**	**6.34**	**6.40**	**6.46**	**6.52**	**6.57**

[1] United States Geological Survey (2014)

Table F.3 Total Self-Supplied IC Demand by County, More Resource Intensive (MRI) Scenario (Mgd)

County	2010 Reported[1]	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060
Ford	1.52	1.67	1.83	1.96	2.16	2.34	2.54	2.75	2.97	3.21	3.46
Iroquois	0.07	0.08	0.08	0.09	0.09	0.10	0.10	0.11	0.11	0.12	0.13
Kankakee	3.71	4.28	4.95	5.28	5.65	6.03	6.44	6.88	7.34	7.83	8.35
REGIONAL TOTAL	**5.30**	**6.03**	**6.86**	**7.33**	**7.90**	**8.47**	**9.08**	**9.73**	**10.42**	**11.16**	**11.94**

[1] United States Geological Survey (2014)

Reference

United States Geological Survey. 2014. Water Use in the United States: Water-Use Data Available from USGS. http://water.usgs.gov/watuse/data/ (accessed January 12, 2015).

Appendix G. Self-Supplied Irrigation, Livestock, and Environmental Demand – Supplemental Tables

Table G.1 ILE Demand by County, Current Trends (CT) Scenario (Mgd)

County	**2010 Reported[1]**	**2010 Normal[2]**	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**	**2055**	**2060**
Ford County												
Irrigation	0.24	0.54	0.57	0.61	0.65	0.67	0.69	0.72	0.74	0.77	0.79	0.82
Livestock	0.95	0.95	1.01	1.07	1.14	1.21	1.29	1.37	1.45	1.54	1.64	1.74
Environmental	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ford County Total	*1.19*	*1.49*	*1.58*	*1.68*	*1.79*	*1.88*	*1.98*	*2.09*	*2.19*	*2.31*	*2.43*	*2.56*
Iroquois County												
Irrigation	1.93	2.47	2.63	2.81	3.00	3.10	3.21	3.31	3.43	3.54	3.66	3.78
Livestock	0.77	0.77	0.80	0.84	0.88	0.92	0.97	1.02	1.07	1.12	1.18	1.24
Environmental	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Iroquois County Total	*2.70*	*3.23*	*3.44*	*3.65*	*3.88*	*4.03*	*4.18*	*4.33*	*4.49*	*4.66*	*4.84*	*5.02*
Kankakee County												
Irrigation	8.95	10.54	11.25	12.01	12.82	13.25	13.70	14.16	14.64	15.13	15.64	16.16
Livestock	0.37	0.37	0.39	0.41	0.43	0.46	0.49	0.51	0.54	0.58	0.61	0.65
Environmental	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Kankakee County Total	*9.32*	*10.91*	*11.64*	*12.42*	*13.26*	*13.72*	*14.19*	*14.68*	*15.18*	*15.71*	*16.25*	*16.81*
REGIONAL TOTAL	**13.21**	**15.63**	**16.66**	**17.76**	**18.93**	**19.63**	**20.35**	**21.10**	**21.87**	**22.68**	**23.52**	**24.40**

[1] Reported values of irrigation and livestock demand are from the United States Geological Survey (2014). Reported values of environmental demand are county-level sums of values reported by facilities to the IWIP.

[2] Irrigation demand computed for 1981-2010 normal weather conditions.

Table G.2 ILE Demand by County, Less Resource Intensive (LRI) Scenario (Mgd)

County	**2010 Reported[1]**	**2010 Normal[2]**	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**	**2055**	**2060**
Ford County												
Irrigation	0.24	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54
Livestock	0.95	0.95	1.01	1.07	1.14	1.21	1.29	1.37	1.45	1.54	1.64	1.74
Environmental	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ford County Total	*1.19*	*1.49*	*1.55*	*1.61*	*1.68*	*1.75*	*1.82*	*1.90*	*1.99*	*2.08*	*2.18*	*2.28*
Iroquois County												
Irrigation	1.93	2.47	2.52	2.58	2.63	2.69	2.74	2.80	2.85	2.91	2.96	3.02
Livestock	0.77	0.77	0.80	0.84	0.88	0.92	0.97	1.02	1.07	1.12	1.18	1.24
Environmental	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Iroquois County Total	*2.70*	*3.23*	*3.32*	*3.42*	*3.51*	*3.61*	*3.71*	*3.82*	*3.92*	*4.03*	*4.14*	*4.26*
Kankakee County												
Irrigation	8.95	10.54	10.59	10.64	10.68	10.73	10.77	10.82	10.87	10.91	10.96	11.01
Livestock	0.37	0.37	0.39	0.41	0.43	0.46	0.49	0.51	0.54	0.58	0.61	0.65
Environmental	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Kankakee County Total	*9.32*	*10.91*	*10.98*	*11.05*	*11.12*	*11.19*	*11.26*	*11.34*	*11.41*	*11.49*	*11.57*	*11.66*
REGIONAL TOTAL	**13.21**	**15.63**	**15.85**	**16.08**	**16.31**	**16.55**	**16.80**	**17.06**	**17.33**	**17.60**	**17.89**	**18.19**

[1] Reported values of irrigation and livestock demand are from the United States Geological Survey (2014). Reported values of environmental demand are county-level sums of values reported by facilities to the IWIP.

[2] Irrigation demand computed for 1981-2010 normal weather conditions.

Table G.3 ILE Demand by County, More Resource Intensive (MRI) Scenario (Mgd)

County	**2010 Reported**[1]	**2010 Normal**[2]	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**	**2055**	**2060**
Ford County												
Irrigation	0.24	0.54	0.58	0.62	0.67	0.70	0.73	0.76	0.79	0.82	0.85	0.88
Livestock	0.95	0.95	1.01	1.07	1.14	1.21	1.29	1.37	1.45	1.54	1.64	1.74
Environmental	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ford County Total	*1.19*	*1.49*	*1.59*	*1.70*	*1.81*	*1.91*	*2.01*	*2.12*	*2.24*	*2.36*	*2.49*	*2.63*
Iroquois County												
Irrigation	1.93	2.47	2.66	2.87	3.10	3.23	3.35	3.49	3.62	3.77	3.92	4.07
Livestock	0.77	0.77	0.80	0.84	0.88	0.92	0.97	1.02	1.07	1.12	1.18	1.24
Environmental	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Iroquois County Total	*2.70*	*3.23*	*3.47*	*3.72*	*3.99*	*4.15*	*4.32*	*4.50*	*4.69*	*4.89*	*5.10*	*5.31*
Kankakee County												
Irrigation	8.95	10.54	11.38	12.28	13.26	13.78	14.33	14.90	15.49	16.10	16.74	17.40
Livestock	0.37	0.37	0.39	0.41	0.43	0.46	0.49	0.51	0.54	0.58	0.61	0.65
Environmental	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01
Kankakee County Total	*9.32*	*10.91*	*11.77*	*12.69*	*13.69*	*14.25*	*14.82*	*15.41*	*16.04*	*16.68*	*17.35*	*18.05*
REGIONAL TOTAL	**13.21**	**15.63**	**16.82**	**18.11**	**19.49**	**20.31**	**21.16**	**22.04**	**22.97**	**23.93**	**24.94**	**25.99**

[1] Reported values of irrigation and livestock demand are from the United States Geological Survey (2014). Reported values of environmental demand are county-level sums of values reported by facilities to the IWIP.

[2] Irrigation demand computed for 1981-2010 normal weather conditions

Appendix H. Updated Tables

The initial draft of the "Water Demand in the Kankakee Water Supply Planning Subregion, 2010-2060" was completed in 2015. We now have more recent data that can be used to help with estimates of future demand in the region. In this document, we updated select tables from the public water systems, self-supplied power generation, and self-supplied water for industrial and commercial uses. We have not modified any of the demand projections.

Updated Table 2.4 Historical Public Supply Water Demand (Mgd)

Study Area	1990	1995	2000	2005	2010	2010
Ford County						
Gibson City	0.602	0.773	0.860	0.773	0.698	0.631
Paxton	0.490	0.614	0.701	0.559	0.510	0.501
Piper City	0.108	0.121	0.085	0.139	0.073	0.064
Ford County Residual	0.311[1]	0.224[1]	0.218[1]	0.224[1]	0.183[1]	0.192
Iroquois County						
Clifton	0.170	0.205	0.153	0.125	0.147	0.169
Gilman	0.202	0.242	0.294	0.240	0.238	0.264
Milford	0.282	0.170	0.177	0.232	0.169[1]	0.136
Onarga	0.128	0.153	0.162	0.169	0.160	0.204
Watseka	0.600	0.720	0.660	0.582	0.633[1]	0.594
Iroquois County Residual	0.892[1]	0.935[1]	1.010[1]	0.972[1]	0.891[1]	0.939
Kankakee County						
Aqua IL – Kankakee Division	9.336	10.992	12.023	12.888	12.683	11.681
Herscher	0.112	0.132	0.160	0.148	0.132	0.139
Momence	0.797	0.673	0.850	0.771	0.765	0.832
St Anne	0.167	0.158	0.143	0.195	0.209	0.113
Kankakee County Residual	1.640[1]	1.947[1]	2.302[1]	2.184[1]	1.660[1]	1.172
REGIONAL TOTAL	**15.837**	**18.059**	**19.798**	**20.201**	**18.349**	**17.631**

[1] Revised based on new reporting

Updated Table 5.5 Historical Self-Supplied IC Water Demand (Mgd) (USGS, 2014)

County	Non-Mining						Mining					
	1990	1995	2000	2005	2010	2013	1990	1995	2000	2005	2010	2013[4]
Ford	0	0.10	0	0	1.46	1.46[2]	0.03	0.70	NE[1]	3.09	0.06	0
Iroquois	0.07	0.08	0.07	0.07	0	0	0	0	NE	0.08	0.07	0
Kankakee	0.12	0.18	0.09	0.09	0.05[3]	0.05	0.79	0	NE	5.07	8.22[3]	4.20
REGIONAL TOTAL	**0.19**	**0.36**	**0.16**	**0.16**	**1.51**	**1.51**	**0.82**	**0.70**	**NE**	**8.24**	**8.35**	**4.20**

[1] NE: not estimated
[2] Same as last reported value in 2010
[3] Revised based on new reporting
[4] 2013 mining values are based on IWIP reported values

Updated Table 5.6 Self-Supplied IC Water Demand by SIC Code for Selected Facilities (2010)

SIC Code	SIC Code Definition	2010 Demand (Mgd)	2013 Demand (Mgd)
1422	Crushed and Broken Limestone	3.5	2.1
1442	Construction Sand and Gravel	4.8	3.1
2047	Dog and Cat Food	<0.1	<0.1
2869	Industrial Organic Chemicals, NEC[1]	1.5	1.5[2]
5191	Farm Supplies	<0.1	<0.1

[1] NEC: Not elsewhere classified
[2] Last reported in 2010

Appendix I. Updates and Recommendations for Studies of Water Demand Projections for Thermoelectric Power Generation

The current study used power generation data in 2010 as the baseline condition, and thus the data are not current. Limitations in our approach include the following:

- The analysis was based on total power-plant-level water use data and did not distinguish generating-unit-level and cooling-system-level data separately.
- The analysis needs to consider power plant lifespans for scenario development.
- Power generation technology and cooling technology advancements in the next 50 years need to be considered.
- The Energy Information Administration (EIA) databases, especially the EIA-923 and EIA-860 datasets, were not fully utilized for the study since they did not include water use beyond that used by generating units or cooling systems.
- The three water demand scenarios are oversimplified and similar because they do not consider many socioeconomic and technological factors.
- The regional water supply planning committee had no members from the power generation industry when this report was prepared; thus the concerns of the power generation industry in the region were not fully addressed.
- Thermoelectric power generation accounts for a high percentage of water demand. Recent changes in the power generation portfolio in Illinois have NOT been accounted for in the original report. Recent trends (since 2016) will significantly alter the future demand projections listed in this report.
- Regional climate models have improved significantly, especially since 2016. These models should be incorporated into future demand projections.

Since this study was done, we have become aware of trends and changes anticipated for the power generation industry that may affect water demands in the power generation sector. These include:

- Natural gas is the fuel source that is expected to grow the most on an absolute basis.
- Non-hydroelectric renewable energy is expected to grow the most on a percentage basis.
- Generators will be more efficient.
- Cooling technology efficiency is expected to increase and some power plants may reach the goal of zero liquid discharge (ZLD).
- On the other hand, carbon capture, utilization, and storage applications to power plants may increase water demands for the power generation sector.
- The Future Energy Jobs Act (FEJA) legislation was enacted in the state of Illinois in 2016. This legislation has targets for the deployment of “renewable energy resources” throughout the state (approximately 28 GW of new solar development and 13 GW of new wind development by 2025). Since solar and wind farms require almost no

water, the projected requirements for deployment of these technologies will significantly reduce water needs for thermoelectric power generation.

- Much of the nuclear fleet will reach a 50-year lifetime in the early 2020s. This has been the typical lifetime for nuclear plants within the U.S. Decisions will need to be made as to whether to deploy new plants or replace these nuclear plants (that require large volumes of water) with renewable sources that require less water.
- Many of the coal-fired power plant fleets in Illinois faced a similar challenge as was listed above for the nuclear fleet. There are some newer plants (circa 2010) that will have a longer lifetime and are approaching zero liquid discharge (ZLD).

Recommendations for future work:

- To better understand cooling and other water demands for power generation, generating-unit-level data are needed.
- Generating unit lifespans determine when units will be retired or replaced and thus should be considered for long-range projections.
- Long-term trends of power generation, cooling, and environmental abatement technologies, as well as fuel prices, federal and state regulations, etc., are critical for projecting future power generation. It is thus also critical to consider these trends for water demand projections for power generations.
- The EIA databases, such as EIA-923 and EIA-860, and EIA annual energy outlooks should be used and cross-checked with locally available data such as IWIP data.
- Input and feedback from the power generation industry to the regional water supply planning committee is critical, and thus efforts should be made to increase the engagement and participation of the industry to water supply planning.
- Use climate models to understand future variations in climate might impact the power generation portfolio, especially the deployment of renewables. Climate models could assist in maximizing the performance of renewables, which are expected to become more critical in Illinois' future power generation portfolio.
- FEJA targets should be included in future energy and related water demand projections for the state of Illinois.
- The U.S. Department of Energy has a number of projects to explore how to reuse waste water within power plants. These efforts would significantly decrease water usage at the power plants. The potential deployment of these technologies within Illinois should be explored.
- The deployment of carbon capture, utilization, and storage (CCUS) needs to be considered in the thermoelectric demand projections. Various tax credits at the federal level (e.g., 45Q) could lead to deployment of CCUS within the state of Illinois. In addition, carbon tax/carbon trading would stimulate CCUS and hence impact future water demands for thermoelectric generation in Illinois.
- Specifically, Zero Liquid Discharge (ZLD) and its impact on future water demands for the thermoelectric power generation application should be included.

- Outline how efforts within Federal R&D programs (e.g., U.S. DOE, USDA, DoD, etc.) could be deployed in Illinois, as well as their expected impact on future water demands for energy generation.