FUTURE WATER DEMANDS AND COAL DEVELOPMENT POTENTIAL IN KASKASKIA RIVER BASIN IN ILLINOIS

Revised Final Technical Report DEV 08-1

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Ben Dziegielewski and Terri Thomas
Southern Illinois University Carbondale
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Project Title: **FUTURE WATER DEMANDS AND COAL DEVELOPMENT POTENTIAL IN KASKASKIA RIVER BASIN IN ILLINOIS**

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Principal Investigator: Ben Dziegielewski, Southern Illinois University Carbondale
Other Investigators: Terri Thomas, Southern Illinois University Carbondale
Project Manager: Dr. Debalina Dasgupta, ICCI

ABSTRACT

This study analyzed the existing water demands as well as future water-demand scenarios for all major user sectors in the 22-county regional planning area that includes the Kaskaskia River basin in Southwestern and Central Illinois. The objective was to determine future water demands during the period from 2010 until 2050 and compare the sectoral demands with the potential water needs for coal development and processing and thermoelectric generation within the study area. The total resident population in the 22 counties is expected to increase between 2000 and 2050 by 244,313 persons (or 23.5 percent, from 1,038,990 to 1,283,303 persons in 2050). Total population served by public water supply systems in the 22 counties that includes only parts of Macoupin, Madison, Saint Clair and Monroe counties was 557,837 persons in 2005 and is projected to increase to 665,768 persons in 2050. Total current water withdrawals in 2005 (excluding once-through cooling in power generation) were 159.6 million gallons per day (mgd) or 158.7 mgd when adjusted to normal weather conditions. By 2050 total water needs under normal weather conditions could range from 178.7 mgd under less resource intensive (LRI) regional development scenario, to 221.5 mgd under current trends (CT) baseline scenario, and up to 291.8 mgd under the more resource intensive (MRI) scenario. These scenario results indicate that additional water demands could increase by 20.0 mgd to 133.1 mgd (or by 13 to 84 percent) depending on the assumptions about the future paths of regional development.

EXECUTIVE SUMMARY
Future Water Demands and Coal Development Potential in Kaskaskia River Basin in Illinois

In Illinois, the Kaskaskia River basin is the most managed river system for water-supply use. With recent allocations administered by Illinois Department of Natural Resources' Office of Water Resources for use with electricity generation, coal mining and regional water supplies, the availability of water from the river and its two large federal reservoirs, Carlyle Lake and Lake Shelbyville became limited. The available water supply from the state storage in Carlyle Lake and Lake Shelbyville, totaling approximately 42 mgd, is now fully allocated. A detailed assessment of future water needs for public supply, electricity generation and coal mining and its utilization is needed in order to determine the future availability of water will be adequate to supply for these sectors and in consideration of development of additional supplies.

This study performed the analysis of the existing water demands as well as future water-demand scenarios for all major user sectors in the 22-county regional planning area of Kaskaskia River basin in Southwestern and Central Illinois (see Figure 1). The study area was defined by the Illinois Department of Natural Resources (IDNR) to include the entire Illinois counties of Christian, Shelby, Moultrie, Douglas, Coles, Cumberland, Montgomery, Bond, Fayette, Effingham, Jasper, Clinton, Marion, Clay, Richland, Washington, Wayne and Randolph and the parts of Macoupin, Madison, Saint Clair and Monroe counties which are located within the Kaskaskia River watershed. The water demand scenarios reach to the year 2050 and cover water withdrawals by six major user sectors: coal mining and processing, thermoelectric power generation, public supply sector, self-supplied domestic sector, self-supplied commercial and industrial sector, and irrigation and agriculture sector.

The study examined two main drivers of future water demand: future population and economic growth. The expected increase in total population for the 22-county study area between 2000 and 2050 is projected to be 244,313 persons (or 23.5 percent, from 1,038,990 to 1,283,303). Total population served by public water supply systems in the 22 counties that includes only parts of Macoupin, Madison, Saint Clair and Monroe counties was 557,837 persons in 2005 and is projected to increase to 665,768 persons in 2050 (an increase of 107,931 persons or 19.3 percent). By 2050, total water needs (excluding once-through cooling flows for power generation) within the study area could range from 181.3 mgd under less resource intensive scenario, to 227.6 mgd under current trends baseline scenario, and up to 298.0 mgd under the more resource intensive scenario scenario.

In the coal mining and processing sector, the future water withdrawals would increase by 7.3 mgd from 2.8 mgd in 2005 to 10.1 mgd in 2050 under the baseline case (CT) scenario. Under the LRI scenario, total withdrawals would decrease by 1.4 mgd (with no additional water withdrawals for coal conversion) and under the more resource intensive scenario, total water withdrawals could increase by 22.1 mgd (from 2.8 mgd in 2005 to 24.9 mgd in 2050, assuming that the five proposed mines will be in production by 2015, and two coal conversion plants will be added, one in Montgomery County by 2020 and one in Fayette County by 2015).

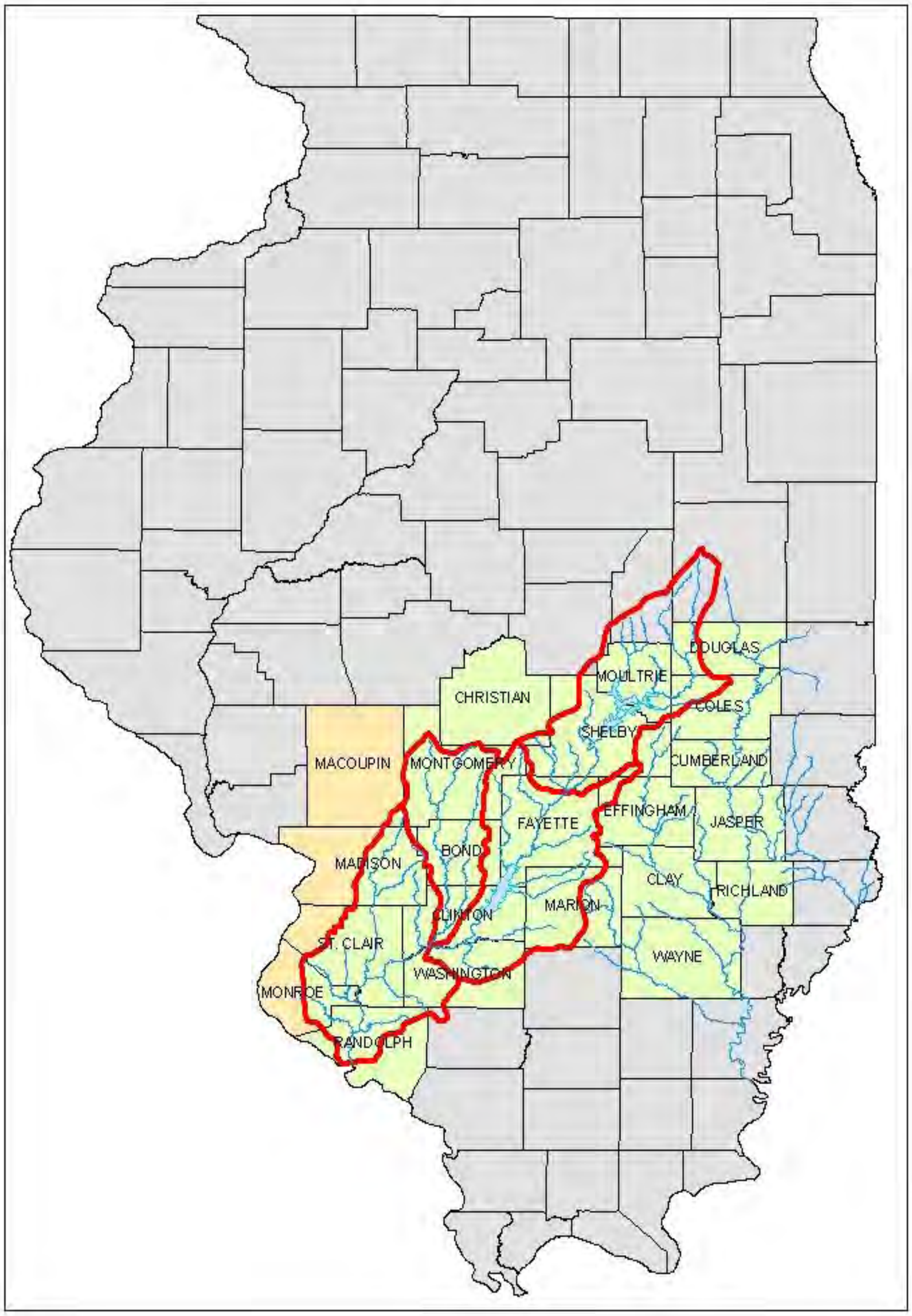

Figure 1. Southwestern and Central Illinois 22-County Study Area
and Kaskaskia River Basin

OBJECTIVES

The aim of this study is the analysis of the existing water demands as well as future water-demand scenarios for all major user sectors in the 22-county regional planning area of Kaskaskia River basin in Southwestern and Central Illinois with special emphasis on the coal mining and processing and energy generation sectors. The objective was to determine future water demands during the period from 2010 until 2050 (in 5-year intervals) and compare the sectoral demands with the potential water needs for coal development and processing and thermoelectric generation within the study area.

To address the study objectives, future water demand scenarios are assessed within the study area which was defined by the Illinois Department of Natural Resources (IDNR) to include the entire Illinois counties of Christian, Shelby, Moultrie, Douglas, Coles, Cumberland, Montgomery, Bond, Fayette, Effingham, Jasper, Clinton, Marion, Clay, Richland, Washington, Wayne and Randolph and the parts of Macoupin, Madison, Saint Clair and Monroe counties which are located within the Kaskaskia River watershed (see Figure 1). The water demand scenarios reach to the year 2050 and cover water withdrawals and deliveries by all major user sectors and geographical service areas within the region.

INTRODUCTION AND BACKGROUND

Sustainability of existing water supply systems is a concern in many regions that experience population and economic growth and where water availability is already constrained because of limits on water allocation, minimum flow requirements or local hydrological conditions. In addition, climate change is expected to alter meteorological and hydrological regimes and possibly result in lower water availability.

In Illinois, the Kaskaskia River basin is the most managed river system for water-supply use. With recent allocations administered by Illinois Department of Natural Resources' Office of Water Resources for use with electricity generation, coal mining and regional water supplies, the availability of water from the river and its two large federal reservoirs, Carlyle Lake and Lake Shelbyville became limited. The available water supply from the state storage in Carlyle Lake and Lake Shelbyville, totaling approximately 42 mgd, is now fully allocated. A detailed assessment of future water needs for public supply, electricity generation and coal mining (and its utilization) is needed in order to compare water needs for these sectors to the future availability of water and consideration of potential for development of additional supplies.

DATA AND PROCEDURES

The project team at Southern Illinois University Carbondale (SIUC), in collaboration with the Illinois State Water Survey (ISWS), and the Illinois District of the United States Geological Survey (USGS), prepared data sets on historical withdrawals and deliveries, which were subsequently used in developing water-demand relationships for future scenarios. The USGS data compilations are focused on water withdrawals from surface and groundwater sources. Data collected by ISWS also include water purchased by public water supply systems. Although some historical data presented throughout the report as withdrawals within county boundaries, data for public water supply sector represent withdrawals and deliveries of water to service areas which represent geographically-referenced water demand.

The principal source of data on historical water withdrawals is the Illinois Water Information Program (IWIP) of the ISWS, a voluntary water-withdrawal reporting program established in 1978. Additional data were obtained from the National Water Use Inventory Program (NWUIP) of the USGS. Information on major drivers of water demand including population and employment were obtained from the Illinois Department of Commerce and Economic Opportunity (DCEO) and Department of Employment Security. Other data were obtained from state and federal agencies, most often from routinely collected statistics available from libraries, or in electronic format on agency websites.

Any assessment of water demands necessarily depends on the measurement and estimation of water use. In practice it is impossible to know precisely all water uses – there are many different types of water users and specific purposes of use and only some uses are metered. For uses which are not metered, various estimation methods are usually employed to determine the quantity of water use. Because water use depends on many factors, the analysis of water demands requires data on those factors.

The historical county-level water withdrawal data for benchmark years 1985, 1990, 1995, 2000 and 2005 were obtained from the ISWS and the USGS compilations. The data allowed developing initial estimates of water withdrawals and deliveries for the following six major sectors and seven subsectors:

1. Coal mining and processing sector:
   a. coal mining and cleaning
   b. coal conversion
2. Thermoelectric power generation
3. Public supply sector
4. Self-supplied domestic sector
5. Self-supplied commercial and industrial sector;
   a. biofuel refining
6. Irrigation and agriculture sector:
   a. agricultural irrigation
   b. golf course irrigation
   c. livestock watering
   d. environmental withdrawals

The historical data on water withdrawals (and public-supply deliveries) in each sector were supplemented with the corresponding data on demand drivers and explanatory variables for each demand area and user sector. Standard 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. While the overall accuracy of the data used in this project is not ideal, the available data and their quality are considered to be adequate for the purpose of developing future scenarios of water demand.

The techniques for developing future water demand varied by sector and included unit-use methods, multiple regressions, and mass balance estimation of irrigation demands. These techniques provide future water demand numbers as a function of demand drivers (i.e., population, employment, coal production, power generation, irrigated acreage, depending on user sector) and variables which influence average rates of water demand (i.e., weather conditions, price of water, income, employment mix, and others). Table 1 lists the drivers and estimated elasticities of the explanatory variables for each demand sector. A detailed discussion of methodologies is included separately for each sector in Appendices A through G at the end of this report.

Table 1 Drivers of Water Demand and Elasticities of Explanatory Variables

Demand Sector	Demand Driver	Explanatory Variables	Elasticity/ Coefficient
Coal mining & conversion	Production	Unit-use coefficients	36-403
Power Generation	Gross electric generation	Unit-use coefficients	0.04-0.90[a] 25.2 -71.0[b]
Public Supply	Population served	Air temperature Precipitation Employment fraction Price of water Median household income Conservation trend	0.9775 -0.0584 0.3982 -0.0612 0.3008 -0.0054
Industrial & Commercial	Employment	Unit-use coefficients	15.0-195.7[c]
Agriculture & Irrigation	Irrigated acres Livestock counts	Rainfall deficit Unit-use coefficients	1.00 0.03-35.0[d]
Domestic Self-supplied	Population	Unit-use coefficient	90.0

[a] The values represent unit withdrawal coefficients in gallons per kilowatt-hour of gross generation in plants with closed-loop cooling systems. [b] The values represent unit withdrawal coefficients in plants with open-loop once through cooling systems. [d] The values represent unit use coefficient per animal type.

Future water withdrawals will respond to changes in the future values of the driver variables (i.e., population, employment, coal production, electric generation, or irrigated acreage). However, the change in water demand will not be strictly proportional to changes in demand drivers. The increases or decreases in future demand will also depend on the future values of explanatory variables such as price, income, or weather conditions. These variables will influence future unit rates of water usage (i.e., gallons per capita). The effects of changes in explanatory variables on unit-use rates are determined by the elasticities and coefficients which were derived through statistical analysis of the historical data and are shown in the last column of Table 1.

Estimates of future water demand were prepared for three different scenarios. The scenarios were defined by varying assumptions regarding the future values of demand drivers and explanatory variables. The purpose of the scenarios is to capture future water withdrawals under three different sets of future conditions. The scenarios do not represent forecast or predictions, nor set upper and lower bounds of future water use. Different assumptions or conditions could result in withdrawals that are within or outside of this range. A listing of assumptions for each of the three scenarios is given in Table 2.

Table 2 Assumptions for Factors Affecting Future Water Demands in the 22-County Study Area

Factor	Scenario 1- Current Trends (CT) or Baseline	Scenario 2- Less Resource Intensive (LRI)	Scenario 3 – More Resource Intensive (MRI)
Total population	Official projections	Official projections	Official projections
Mix of commercial/ industrial activities	Current trends	No increase in water-intensive industry	Increase in water-intensive industry
Median household income	Existing projections of 0.7 %/year growth	Existing projections of 0.5 %/year growth	Higher growth of 1.0 %/years
Coal mining and processing	Five new mines, one CCS and one CTL plant to be built	No new coal conversion plans, reduced mine production	New mines and coal conversion plants, maintained mine production
Power generation	Two new plants within study area	One new power plant existing generation declines	Five new power plants in study area
Water conservation	Continuation of historical trend	50% higher rate than historical trend	50% lower than historical trend
Future water prices	Future price increases (1.5%/year)	Higher future price increases (2.5%/year)	Recent increasing trend (0.9%/year) will continue
Irrigated land	Constant cropland increasing golf courses	Constant cropland + no increase in golf courses	Increasing 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 (1971-2000)	30-year normal (1971-2000)	30-year normal (1971-2000)

[d] Changes in normal weather conditions were considered under separate climate change scenarios.

The assumptions used in formulating the scenarios are not connected (i.e., causally linked). For example, the assumption of the higher growth rate of income is not related to the assumption of higher water prices. Additional discussion of sector-specific assumptions is included in the Appendices which describe water demand scenarios for each sector.

RESULTS AND DISCUSSION

The main drivers of future water demand are future population and economic growth which is represented in this study as future employment and location of new industrial plants and power plants. Table 3 shows the expected increase in total population in each of the 22 counties by 2050. For the 22-county study area, total resident population across all 22 counties is expected to increase between 2000 and 2050 from 1,038,990 to 1,239,023. This represents an increase of 244,013 persons (or 23.5 percent).

Table 3 Resident Population Projections 2000-2050
for 22-County Kaskaskia Study Area

County	2000	2005	2030	2050	2000-50 Change	Percent Change
Bond	17,664	17,583	20,064	21,510	3,846	21.8
Christian	35,431	36,254	40,601	41,325	5,894	16.6
Clay	14,592	14,684	15,927	16,998	2,406	16.5
Clinton	35,593	37,278	44,621	45,308	9,715	27.3
Coles	53,285	53,896	59,746	61,377	8,092	15.2
Cumberland	11,275	11,429	13,182	14,333	3,058	27.1
Douglas	19,955	20,713	24,607	27,729	7,774	39.0
Effingham	34,322	35,980	44,752	49,129	14,807	43.1
Fayette	21,837	21,807	22,570	22,962	1,125	5.2
Jasper	10,135	10,137	10,403	10,910	775	7.6
Marion	41,762	42,566	47,285	51,640	9,878	23.7
Montgomery	30,704	30,573	32,124	36,414	5,710	18.6
Moultrie	14,317	15,129	17,588	19,083	4,766	33.3
Randolph	33,951	34,129	37,004	40,136	6,185	18.2
Richland	16,181	16,220	17,867	19,268	3,087	19.1
Shelby	22,931	23,080	24,471	25,459	2,528	11.0
Washington	15,178	15,314	16,793	17,797	2,619	17.3
Wayne	17,184	16,815	16,690	17,459	275	1.6
Total 18 counties	*446,297*	*453,587*	*507,295*	*538,837*	*92,540*	*20.7*
Macoupin	49,103	49,622	59,442	64,912	15,809	32.2
Madison	259,391	261,758	296,342	315,120	55,729	21.5
Monroe	27,667	30,162	43,111	48,389	20,722	74.9
St. Clair*	256,532	254,993	297,211	316,045	59,513	23.2
Total 4 partial counties	*592,693*	*596,535*	*642,348*	*744,466*	*151,773*	*25.6*
Total 22-counties	1,038,990	1,050,122	1,149,643	1,283,303	244,313	23.5

Source: Illinois Department of Commerce and Economic Opportunity. The 2005 estimates shown for comparison. * St. Clair county projections are adjusted based on the 2010 U.S. Census numbers.

Table 4 provides a summary of the future water demand scenarios of average day water withdrawals for six categories of users within the major user sectors. For 2005, both the reported values and weather-adjusted values (where adjustments were possible) are shown. The future scenario withdrawals in 2050 are compared to 2005 values – both withdrawal numbers represent normal weather conditions. The last column of the table shows changes in 2050 withdrawals relative to the baseline CT scenario.

Table 4 Summary of Water Withdrawal Scenarios for 22 County Study Area, Illinois (in MGD)

Scenario/ Sector	2005 Reported With-drawals	2005[e] Normal With-drawals	2050 Normal With-drawals	2005-2050 Change MGD	2005-2050 Change (%)	Change From CT Scenario MGD
CT- Current Trends (Baseline)						
Public Supply	58.1	56.5	70.5	14.0	24.8	0.0
Self-supplied I&C	7.1	7.1	9.6	2.5	34.4	0.0
Self-supplied Domestic	19.0	19.0	23.2	4.3	22.6	0.0
Irrigation and Ag	25.2	25.9	31.9	6.0	23.2	0.0
Coal Mining	2.8	2.8	10.1	7.3	257.0	0.0
Power Plants [f]	512.7	512.7	541.5	28.8	5.6	0.0
Power Plant Makeup [f]	47.4	47.4	76.2	28.8	60.8	0.0
Total w/o Once-through	159.6	158.7	221.5	62.8	39.6	0.0
LRI – Less Resource Intensive						
Public Supply	58.1	56.5	66.0	9.5	16.8	-4.5
Self-supplied I&C	7.1	7.1	7.7	0.6	7.9	-1.9
Self-supplied Domestic	19.0	19.0	18.8	-0.1	-0.8	-4.4
Irrigation and Ag	25.2	25.9	28.4	2.5	9.6	-3.5
Coal Mining	2.8	2.8	1.5	-1.4	-47.9	-8.6
Power Plants [f]	512.7	512.7	384.9	-127.8	-24.9	-156.6
Power Plant Makeup [f]	47.4	47.4	56.3	8.9	18.8	-19.9
Total w/o Once-through	159.6	158.7	178.7	20.0	12.6	-42.8
MRI – More Resource Intensive						
Public Supply	58.1	56.5	75.4	18.9	33.5	4.9
Self-supplied I&C	7.1	7.1	20.8	13.7	192.3	11.2
Self-supplied Domestic	19.0	19.0	33.9	14.9	78.8	10.7
Irrigation and Ag	25.2	25.9	38.6	12.7	49.0	6.7
Coal Mining	2.8	2.8	24.9	22.1	776.4	14.8
Power Plants [f]	512.7	512.7	558.7	46.0	9.0	17.2
Power Plant Makeup [f]	47.4	47.4	98.2	50.8	107.2	22.0
Total w/o Once-through	159.6	158.7	291.8	133.1	83.9	70.3

[e] For comparison with future values, the 2005 withdrawals were adjusted by the model to represent normal weather conditions. Small decimal point discrepancies in different tables are due to independent rounding.

[f] Power plants withdrawals (both once-through and makeup) include only withdrawals from Kaskaskia basin.

The last two rows of each scenario panel in Table 4 show the sum of total withdrawals with and without once-through cooling water flows for power generation. The discussion which follows concentrates primarily on total withdrawals which exclude once-through withdrawals by power plants (but include makeup water withdrawals for closed-loop cooling).

The results in Tables 4 show that by 2050 total water withdrawals could range from 178.7 mgd under LRI scenario, to 221.5 mgd under CT scenario, and up to 291.8 mgd under the MRI scenario.

Under the the baseline (CT) scenario, total withdrawals (excluding once-through flows in power plants) would increase from the weather adjusted value of 159.6 (or reported (actual weather) value of 158.7 mg) in 2005 by 62.8 mgd (or 39.6 percent) in 2050. Most of this increase represents growth in withdrawals for power plant makeup water and public supply sectors.

Under the assumptions of the LRI scenario, total withdrawals (excluding once-through flows in power plants) would increase by 20.0 mgd, or 12.6 percent. Relative to the CT scenario for 2005, this represents a decrease of 42.8 mgd. Most of this decrease comes from lower demands in power makeup and public supply sectors.

Finally, under the MRI scenario, total withdrawals (excluding once-through cooling flows in power plants) would increase from the normal weather value of 158.7 mg in 2005 to 291.8 mgd in 2050. The total increase would be 133.1 mgd, or 83.9 percent. Relative to the CT scenario for 2005, this represents a 70.3 mgd increase in total withdrawals. The main reasons for the increase are the assumptions leading to a large increase in makeup water requirements as well as assumptions of lower price increases and lower conservation, combined with a higher rate of growth in median household income.

In the coal mining and processing sector, the future water withdrawals would increase by 7.3 mgd from 2.8 mgd in 2005 to 10.1 mgd in 2050 under the baseline case (CT) scenario. Under the LRI scenario, total withdrawals would decrease by 1.4 mgd (with no additional water withdrawals for coal conversion) and under the more resource intensive scenario (MRI), total water withdrawals could increase by 22.1 mgd from 2.8 mgd in 2005 to 24.9 mgd in 2050.

In the power generation sector, the future makeup water withdrawals for cooling would increase within the Kaskaskia Basin by 28.8 mgd (or 60.8 percent) from the current value of 47.4 mgd to 76.2 mgd in 2050 under the baseline case (CT) scenario. Most of the projected increase would represent the consumptive use that is associated with makeup water for cooling towers. Under the LRI scenario, the Kaskaskia Basin withdrawals would increase only by 8.9 mgd. Finally, under the MRI scenario, total makeup water withdrawals within the Kaskaskia Basin would increase by 50.8 mgd (or 107.2 percent) from the current value of 47.4 mgd to 98.2 mgd in 2050. Most of the projected increase would represent the consumptive use that is associated with makeup water for cooling towers.

In public supply sector, under the current trend (CT) scenario, the future total water withdrawals would increase from 58.1 mgd in 2005 (under actual 2005 weather conditions) to 70.5 mgd in 2050 (under normal weather conditions). Under the less resource intensive (LRI) scenario, the future total water withdrawals for public water supply would increase by 16.8 percent, from the normal weather demand of 56.5 mgd in 2005, to 66.0 mgd in 2050. Finally, under the more resource intensive (MRI) scenario, the future water withdrawals for public water supply would increase by 33.5 percent, from the normal weather demand of 56.5 mgd in 2005, to 75.4 mgd in 2050. A detailed discussion of results is included in sector-specific appendices at the end of this report.

Future water demands can also be affected by changes in the future climate. Specifically, the values of air temperature and precipitation, which are used as explanatory variables in the water-use model for public water supply, represent long-term averages based on the 30 year record from 1971 to 2000. Because the period of analysis for water demand scenarios extends until the year 2050, the average weather conditions may change in response to regional and global climate change.

Climate models indicate that by 2050, there may be a possible average annual temperature departure of up to +6 °F from the 1971-2000 long-term normal in Illinois. Climate models also indicate a possible departure from 1971-2000 normal annual precipitation in Illinois in a range from -5 inches to +5 inches per year. The expected changes in annual temperature and precipitation would result in changes during the growing season. The temperature increase of 6 °F will also apply to the summer growing season. The distribution of precipitation is expected to range from +2.5 inches to -3.5 inches during the growing season.

Future withdrawals may be affected by these temperature and precipitation scenarios. The effects of these changes will vary by user sector, depending on each sector's sensitivity of water withdrawals to air temperature and precipitation. Table 5 summarizes the effects of climate changes on water withdrawals in four sectors.

The last column of Table 5 shows the changes in withdrawals relative to the withdrawals under the CT scenario. The largest change (relative to the CT scenario) in total withdrawals of 11.29 mgd by 2050 would result from the combined effect of the temperature increase and decrease in summer precipitation. More than one half of this change would be in the public supply sector. A recurrence of a historic drought (with a 40% precipitation deficit would result in a 7.30 mgd (5.8 percent) increase in demand above the CT scenario.

Table 5 Effects of Possible Climate Change on Water Withdrawals
in 22 County Kaskaskia Basin, Illinois (MGD)

Weather Scenario/ Sector	2005[g] Water Withdrawals MGD	2050 Water Withdrawals MGD	2005-2050 Change	Change from CT in 2050
CT Scenario				
Public supply	56.46	70.45	13.99	0.00
Self-supplied domestic	18.95	23.23	4.28	0.00
Irrigation and agriculture	25.89	31.89	6.00	0.00
All three sectors	101.30	125.57	24.27	0.00
CT ΔT +6F +2.5"R				
Public supply	56.46	74.62	18.16	4.17
Self-supplied domestic	18.95	24.65	5.70	1.42
Irrigation and agriculture	25.89	30.84	4.95	-1.05
All three sectors	101.30	130.11	28.81	4.54
CT ΔT +6F –3.5"R				
Public supply	56.46	76.08	19.62	5.63
Self-supplied domestic	18.95	25.25	6.30	2.02
Irrigation and agriculture	25.89	35.23	9.34	3.34
All three sectors	101.30	136.56	35.26	10.99
Drought (40% R deficit)				
Public supply	56.46	72.59	16.13	2.14
Self-supplied domestic	18.95	23.93	4.98	0.70
Irrigation and agriculture	25.89	36.35	10.46	4.46
All three sectors	101.30	132.87	31.57	7.30

[g] 2005 water withdrawals are adjusted for normal weather conditions. *ΔT* = temperature increase. Small decimal value differences are due to independent rounding. R = summer precipitation.

Table 6 shows the distribution of water withdrawals by sources within and outside the Kaskaskia River basin. Current withdrawals within the 22-county study area include 25.8 mgd of groundwater and 83.2 mgd surface water within the basin. The balance of 49.6 mgd is from groundwater and surface water sources outside the basin.

The 2050 scenarios show surface water withdrawals within the Kaskaskia Basin ranging from 125.2 mgd under CT scenario and possibly as high as 168.8 mgd under LRI scenario. The withdrawals would be to 91.5 mgd under LRI scenario.

Table 6 Summary of Water Withdrawal Scenarios by Source of Supply (in MGD)

Scenario/ Sector	Kaskaskia Ground Water	Kaskaskia Surface Water	Non-Kaskaskia GW & SW	Total Withdrawals MGD
2005 (Normal)				
Public Supply	5.8	23.6	27.1	56.5
Self-supplied I&C	0.5	0	6.6	7.1
Self-supplied Domestic	14	0	4.9	18.9
Irrigation and Ag	5.5	9.4	11	25.9
Coal Mining	0	2.8	0	2.8
Power Plants (Makeup)	0	47.4	0	47.4
Total - All sectors	25.8	83.2	49.6	158.7
CT 2050				
Public Supply	7.7	29.1	33.7	70.5
Self-supplied I&C	0.6	0	9	9.6
Self-supplied Domestic	16.8	0	6.4	23.2
Irrigation and Ag	7.4	9.8	14.7	31.9
Coal Mining	0	10.1	0	10.1
Power Plants	0	76.2	0	76.2
Total - All sectors	32.5	125.2	63.8	221.5
LRI 2050				
Public Supply	7.2	27.2	31.6	66
Self-supplied I&C	0.5	0	7.2	7.7
Self-supplied Domestic	13.6	0	5.2	18.8
Irrigation and Ag	6.7	6.5	15.2	28.4
Coal Mining	0	0.9	0.6	1.5
Power Plants	0	56.3	0	56.3
Total - All sectors	28	91.5	59.8	178.7
MRI 2050				
Public Supply	8.2	31.1	36	75.4
Self-supplied I&C	9.3	0	11.5	20.8
Self-supplied Domestic	24.5	0	9.4	33.9
Irrigation and Ag	7.9	14.6	16.1	38.6
Coal Mining	0	24.9	0	24.9
Power Plants	0	98.2	0	98.2
Total - All sectors	49.9	168.8	73.0	291.8

CONCLUSIONS AND RECOMMENDATIONS

The results of the analysis of future water demand scenarios show that total water supply needs in the 22-county study area will continue to increase to meet the demands of growing population and the concomitant growth in the economy of the region. However, the growth in total water demand could be faster or slower depending on which assumptions and expectations about the future conditions will prevail.

Other findings of the study pertain to additional factors which could alter future water demands in the study area. The main factors are future climate and periodic droughts. Future demands in all sectors are likely to be higher if future annual average air temperature increases and/or annual precipitation decreases. Also, future demands will likely increase during future droughts given a re-occurrence of a worst historical drought, with a 40 percent deficit in precipitation during the summer growing season.

The results of this study lend support to several recommendations which are offered here for consideration by the resources agencies of the State of Illinois and the Kaskaskia Regional Water Resources Planning Committee (RWSPC).

1. The experience of preparing this project points to the importance of the availability of accurate data on water withdrawals and use. The State of Illinois is fortunate to have instituted a voluntary water inventory program at the Illinois State Water Survey. The IWIP database on withdrawal points and annual quantities of water withdrawn during the last three decades made this study possible. However, the program is voluntary, subject to intermittent funding, and not all withdrawals are reported during the yearly surveys. Improved data reporting would provide a basis for future studies of water demands. State resource agencies should consider actions that would improve the quality of water withdrawal data, as well as expand the scope of data collection to include data on return flows, which would permit estimation of consumptive use and preparation of water budgets within different hydrologic regions of Illinois.

2. Water conservation trend in the historical data captures only past conservation. However, it is a crude measure of the achieved gains in long-term efficiency of water usage. More detailed studies of the current water usage should be undertaken in order to measure the ongoing improvements in the efficiency of water use and, more importantly, determine the potential for future efficiency gains. With this knowledge, new conservation practices could be identified and implemented by water users in the various sectors in order to achieve the saving which are assumed in the LRI scenario.

3. Finally, an important component of water resources management is monitoring of water use over time. Therefore, it would be important to establish and maintain an inventory of water withdrawals and use for each of the 22 counties. The inventory should include both the data on withdrawal points and on water use in geographically-referenced water demand areas, such as areas served by public

water supply system or irrigated lands. The data collected in this study could serve as a starting point. The inventory should be updated through data collection and/or compilation of the ISWS statewide data on at least the annual basis. The most important function of a water use data inventory would be the ability to monitor future changes in water withdrawals and use. The inventory could be developed and maintained by the Southwestern Illinois Resource Conservation and Development.

In summary, the overall recommendation based on the results of this study is to encourage the Kaskaskia RWSPC to recognize the need to create and maintain an expanded knowledge base about both the regional and local water demands by all sectors and subsectors of water users. This knowledge base is needed to support a regional long-term water management program in the Kaskaskia region.

REFERENCES

A complete list of references used in the text of the sector-specific appendices is shown in Appendix I at the end of this report.

APPENDICES TO THE REPORT

Appendix A – Overview of the Study
Appendix B – Water for Coal Mining and Processing
Appendix C – Self-Supplied Water for Power Generation
Appendix D – Public Water Supply
Appendix E – Self-Supplied Domestic Use
Appendix F – Industrial and Commercial Water Demand
Appendix G – Irrigation, Environmental and Agricultural Water Demand
Appendix H – Sensitivity to Climate Change and Drought
Appendix I – References (for Appendices A-H)

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Appendix A

OVERVIEW OF THE STUDY

1.1 BACKGROUND

1.1.1 Planning Needs

Sustainability of existing water supply systems is a concern in many regions that experience population and economic growth and where water availability is already constrained because of limits on water allocation, minimum flow requirements or local hydrological conditions. In addition, climate change is expected to alter meteorological and hydrological regimes and possibly result in lower water availability.

The knowledge of the amount of water that will be required in the future and the availability of water in existing and potential sources of supply are important prerequisites for ensuring adequate water supply in the future. Credible long-term estimates of water demands can help water planners to achieve an efficient allocation of water supplies among competing uses.

In the past, water supply systems were usually developed locally with little regional coordination. However, the consideration of long-term water supply sustainability requires a shift of planning focus from the local level to the watershed level, or larger geographical regions. The regional scope of planning is appropriate where major sources of water supply such as groundwater aquifers, lakes, or rivers are shared by users in multiple localities. Also, availability of water supply depends on both local and more distant sources and can be assessed only at a geographical scale that encompasses river watersheds and/or groundwater aquifers.

With respect to water demand, the assessment conducted at a regional scale provides for a better alignment of hydrologic boundaries with administrative units for which water use measurements and socio-economic data are available. Also, the involvement of stakeholders in a regional approach to water supply planning should reduce conflicts between municipalities or groups of water users while providing a solid basis for management of common regional sources of water supply.

While Illinois is endowed with abundant water resources in comparison to other states, the availability of water supplies is a concern in several regions of the State. In an effort to avert potential future water resources problems, the Governor issued the Executive Order 2006-1 which has lead to two regional studies of water supply and demand in Northeastern and East-Central Illinois. This report is prepared as a component of the third regional study in Southwestern and Central Illinois – an area which encompasses the Kaskaskia River Basin.

The aim of this study is the analysis of the existing water demands as well as future water-demand scenarios for all major user sectors in the 22-county regional planning area of Kaskaskia River basin (including 18 complete counties and parts of 4 western counties) in Southwestern and Central Illinois with special emphasis on the coal mining and processing and energy generation sectors. The objective was to determine future water demands during the period from 2010 until 2050 and compare the sectoral demands with the potential water needs for coal development and processing and thermoelectric generation within the study area.

To address the study objectives, future water demand scenarios are assessed within the study area which was defined by the Illinois Department of Natural Resources (IDNR) to include the entire Illinois counties of Christian, Shelby, Moultrie, Douglas, Coles, Cumberland, Montgomery, Bond, Fayette, Effingham, Jasper, Clinton, Marion, Clay, Richland, Washington, Wayne and Randolph and the parts of Macoupin, Madison, Saint Clair and Monroe counties which are located within the Kaskaskia watershed. The water demand scenarios reach to the year 2050 and cover water withdrawals by all major user sectors and geographical service areas within the region.

1.1.2 Kaskaskia River Basin

The Kaskaskia River is the most managed river system in Illinois for water-supply use. With recent allocations administered by Illinois Department of Natural Resources' Office of Water Resources for use with electricity generation, coal mining and regional water supplies, the availability of water from the river and its two large federal reservoirs, Carlyle Lake and Lake Shelbyville became limited. The available water supply from the state storage in Carlyle Lake and Lake Shelbyville, totaling approximately 42 mgd, is now fully allocated. A detailed assessment of future water needs for public supply, electricity generation and coal mining and coal utilization is needed in order to assess the future availability of water for these sectors and planning for adequate water supplies.

Data on water withdrawals within the study area are collected under the Illinois State Water Survey Water Information Program and are periodically compiled by the USGS National Water Use Information Program. Table 1.1 shows the reported data on water withdrawals by major sector for both 22 counties and 18 complete counties plus the four partial western counties which straddle the boundary of the Kaskaskia watershed. The 2005 withdrawals within the 18 + 4 partial counties area include the amount of water obtained from surface and groundwater sources within the Kaskaskia River basin as well as water obtained by some counties from outside of the Kaskaskia drainage area.

The largest reported water withdrawals (in Table 1.1) are for thermoelectric power generation. The 2005 estimate of thermoelectric withdrawals was 1,254.70 million gallons per day (mgd). Total 2005 withdrawals without power generation were estimated to be 113.75 mgd. The largest category of withdrawals (other than thermoelectric power generation) is public water supply. The last column in the lower panel of Table 1.1 shows the values adjusted for the four partially included western counties and other adjustment made during this study.

Table 1.1 Historical Reported Total Withdrawals within the 22 and 18 Counties of the Study Area

Water Demand Sector	1985	1990	1995	2000	2005 Reported
*USGS Reported for 22 County Area**					
Public supply	114.68	119.02	117.97	145.26	123.69
Industrial/commercial	64.97	80.76	110.43	15.79	35.53
Domestic	23.86	16.49	32.73	32.81	18.93
Thermoelectric power	1,974.95	2,937.68	2,965.57	2,289.70	2,267.99
Mining	11.64	6.98	13.41	--	18.93
Livestock	10.84	10.71	11.43	9.08	9.92
Irrigation	1.14	3.75	3.62	1.28	11.28
Total 22 counties	2,202.08	3,175.39	3,255.16	2,493.92	2,486.27
Study Area: 18 counties + 4 partial counties					
Public supply	46.71	49.84	53.12	57.52	58.10
Industrial/commercial	--	--	--	--	6.92
Domestic	--	--	--	--	18.95
Thermoelectric power	--	--	--	--	1,254.70
Mining	--	--	--	--	4.34
Livestock	--	--	--	--	6.86
Irrigation	--	--	--	--	10.04
Total study area**	--	--	--	--	1,368.45

Source: USGS NWUIP;
* The 1985-2005 data for 22 counties are county-wide values reported by the USGS.
** The total derived for the 22-county Kaskaskia study area of 1,368.45 includes 8.32 mgd of water withdrawn for environmental purposes (not included in the USGS data).

1.2 SCOPE OF THE STUDY

The research team at Southern Illinois University Carbondale (SIUC), in collaboration with the Illinois State Water Survey (ISWS) and the State Coordinator of the National Water Use Information Program (NWUIP) in the USGS Illinois Water Science Center prepared data sets with historical water withdrawals.

The historical water withdrawals for public water supply were organized into 62 service areas and 22 county “remainder” areas in order to estimate sector-specific water demand relationships for the 22-county Kaskaskia study area. For other sectors, demands were assessed for individual large users or were aggregated by county. The historical data were used to estimate region-specific water use equations for the 22-county region. The estimated statistical water-use relationships and socioeconomic data projections for the

22 counties were applied to provide water use estimates in 5-year increments for the period 2010-2050.

The historical and projection data were used to define three (3) distinct future water demand scenarios extending to the year 2050. The three scenarios include:

Scenario 1 (CT): Current trends (or baseline scenario)
Scenario 2 (LRI): Low growth (or less resource intensive) scenario
Scenario 3 (MRI): High growth (or more resource intensive) scenario

All three scenarios rely on the official population and employment projections data (these projections are the same for all three scenarios); however, several assumptions that affect future demand rates vary across scenarios. Special emphasis is placed on assessing potential future water needs for coal mining, processing and utilization and energy production sectors.

1.2.1 Data and Demand Sectors

Any assessment of water demands necessarily depends on the measurement and estimation of water use. In practice it is impossible to know precisely all water uses – there are many different types of water users and specific purposes of use and only some uses are metered. For uses which are not metered, various estimation methods are usually employed to determine the quantity of water use. The data used in this study represent water withdrawals – the specific uses of water are not identified.

Because water use depends on many factors, the analysis of water demands requires data on those factors. The historical water withdrawal data for benchmark years 1985, 1990, 1995, 2000 and 2005 were obtained from the ISWS and the USGS compilations. The data included information on water withdrawals for the following sectors and subsectors:

1. Coal mining and processing sector:
    a. coal mining and cleaning
    b. coal processing
2. Thermoelectric power generation
3. Public supply sector
    a. residential demands
    b. nonresidential (commercial and industrial) demands
4. Self-supplied domestic sector
5. Self-supplied commercial and industrial sector;
    a. biofuel refining
6. Irrigation and agriculture sector:
    a. agricultural irrigation
    b. golf course irrigation
    c. livestock watering
    d. environmental withdrawals

The historical data on water withdrawals in each sector were supplemented with the corresponding data on demand drivers and explanatory variables for each demand area and user sector. The additional data on demand drivers included:

1. resident population and population served;
2. employment by place of work;
3. gross and net thermoelectric generation;
4. irrigated acres of cropland and golf courses;
5. livestock counts.

The explanatory variables which affect the unit rates of water use (e.g., per capita or per acre) in the public supply sector included:

1. median household income;
2. marginal price of water;
3. air temperature during growing season;
4. growing season precipitation;
5. employment/population ratio;
6. cooling degree-days.

The projections of future population and employment as well as data on future values of explanatory variables were used to generate the estimates of future water withdrawals for each of the six sectors and nine subsectors of water users within the study area.

The future scenarios of water withdrawals were prorated to the current points of water withdrawal (groundwater wells and surface water intakes) which correspond to specific service areas. The point withdrawals were prepared in the form of electronic spreadsheets and provided to the Illinois State Water Survey for direct input into groundwater and surface water models.

1.2.2 Withdrawals vs. Consumptive Use

From the hydrologic perspective, water use is a part of the water budget. At the most general level, water use can be defined as all water flows that are a result of human intervention within the hydrologic cycle. Accordingly, all water uses can be divided into in-stream and off-stream uses. In-stream use represents water that is used, but not withdrawn, from a natural water source for such purposes as hydroelectric power generation, navigation, water quality improvement, fish propagation, and recreation. Off-stream use represents water withdrawn or diverted from a groundwater or surface water source for public water supply, industry, irrigation, livestock, thermoelectric power generation, and other uses (Hudson et al., 2004). The term “water withdrawal” is used to designate 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 (also referred to as 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 part of amount withdrawn and returned back to the source is called "non-consumptive" use. The quantity of water "consumed" is utilized in calculating regional annual and monthly water budgets, and represents a measure of the volume of water that is not available for repeated use.

While a major portion of water withdrawn for such purposes as public water supply, power generation, and industrial use represents "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 source of groundwater. Similarly, water withdrawn from a river for public water supply must be continuously available at the intake and is not available for withdrawal for other uses upstream or immediately downstream from the intake.

A more restrictive definition of water use refers to water that is actually used at a specific site or for a specific purpose. Individual residential or commercial buildings, industrial facilities and other locations can obtain water from their own sources of supply or through connections to a public or private distribution system. Individual users of water within a defined geographical area can be classified into different categories and their combined use can be summed up into broader categories, or user sectors.

This study is focused on future water need as measured by water withdrawals, and did not include determinations of consumptive and non-consumptive uses for each sector and subsector. The primary purpose was to quantify water demand in terms of the volumes of water withdrawals from surface and groundwater sources in the 22-county study area. It does not quantify the water volumes being re-circulated or reused within industrial facilities, or discharges of treated wastewater to surface water bodies, or the infiltration of treated effluents into groundwater aquifers.

At the time of this study, the data on return flows which could be matched to withdrawals were not readily available and 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.

1.2.3 In-Stream Uses and Aquatic Ecosystem Needs

The broad definition of water use also includes environmental and in-stream uses of water. The 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 future water demand increases to provide for new population and economic growth, 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 last four decades there has been an increasing public interest and growing effort 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 (1975); however, they are not directly applicable to Illinois streams. The actual values must take into consideration a number of hydrological and ecological factors. The two dominant concerns in Central and Southwestern Illinois are: (1) safeguarding that shallow groundwater use and residential development do not reduce the natural low flows in streams, and (2) maintenance and improvement of water quality to improve aquatic habitat and recreation opportunities.

This study of water demand scenarios does not include water needs for aquatic ecosystems or other in-stream uses in the 22 county study area.

1.3 ANALYTICAL METHODS

1.3.1 Data Sources and Data Quality

Data on water withdrawals within the 22-county study area were collected through the Illinois Water Inventory Program (IWIP) of the Illinois State Water Survey (ISWS), a voluntary water-use reporting program established in 1978. Under this program, annual data on water withdrawal, water use, and some data on water returns are collected each year from water-using facilities which are inventoried in the database (all users are not included in the IWIP data base; e.g., questionnaires are not sent to agricultural irrigators). The data obtained through annual surveys include locations and annual amounts of water withdrawn from surface water and groundwater sources, and amounts of water purchased from local suppliers. The annual estimates are reported for five categories of use: public water supplies, self-supplied industries, agricultural irrigation, fish and wildlife, and conservation uses. Data can also be queried and summarized geographically and by water source categories.

Data used to specify explanatory variables and their future values came from several sources. Information on major drivers of water demand including population and employment were obtained from the state and federal agencies, most often from routinely collected statistics available from libraries or in electronic format on agency websites.

Standard 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.

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

Data on the current and historical water withdrawals obtained from the Illinois Water Inventory Program (IWIP) of the Illinois State Water Survey capture all significant groundwater and surface water withdrawals within the State of Illinois, although there is a small possibility that some significant withdrawals by self-supplied users are omitted because of the voluntary nature of the reporting program. However, this potential shortcoming was minimized by examining other sources of data on water use and data on known users of water (such as domestic wells), and correlates of water use (such as irrigated acreage). The examination of corroborating data is routinely employed by the United States Geological Survey (USGS) in preparing county level estimates of water withdrawals as a part of the National Water Use Information Program (NWUIP). The USGS county-level estimates for the years 1985, 1990, 1995, 2000, and 2005 were used to verify the estimates derived from the ISWS data. In case of data discrepancies, additional inquiries about the reported values were made in order to obtain the correct values.

Data on demand drivers such as population or employment as well as data on explanatory variables such as income or weather reflect the data quality of the governmental agencies involved in data collection and reporting. The main source of these data is the U.S. Census. Other agencies include Bureau of Economic Analysis, and the National Oceanic and Atmospheric Administration (NOAA).

1.3.2 Water Demand Models

Forecasts of water demand attempt to predict the future value of water use, Q_t, as a function of one or more explanatory variables and associated assumptions about the forecasting method and related parameters. The methods differ in terms of the number of explanatory variables and the form of the functional relationship. The forecasting methods also differ with respect to the structure of the forecast, especially in terms of separation of demands into more homogeneous categories of water use. This section describes a range of methods which can be found among the past forecasts of water demand.

In this study, the selection of analytical techniques for developing estimates of future water withdrawals (plus purchases) were dictated by the type of data on actual water quantities and the corresponding data on explanatory variables that were available for each sector of water users. 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, or acreage; and
q_{cit} = average rate of water requirement (or water usage) in gallons per capita-day, gallons per employee-day, etc.

The unit-use coefficient method assumes that future water demand will be proportional to the number of users N_{cit} while 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 the future changes in average rate of water usage, q_{cit} , in response to changing future conditions.

Water-demand relationships which quantify historical changes in q_{cit} can be expressed in the form of equations, where 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} represents per capita public supply water withdrawal within geographical area i during year t, X_j is a set of explanatory variables (e.g., air temperature, precipitation, price of water, median household income and others), which are expected to explain the variability in per capita use, and ε_{it} is 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 which served to fit the model to the data and also isolate observations which were likely to be outliers:

$$\ln PS_{it} = \alpha_o + \sum_j \beta_j \ln X_{jit} + \sum_k \gamma_k \ln R_{kit} + \sum_l \delta_l D_{lit} + \sum_m \rho_m S_{mit} + \varepsilon_{it} \tag{1.3}$$

where: PS_{it} represents per capita public supply water withdrawals (plus purchases) within geographical area i during year t (in gallons per capita per day), $X_j^{'s}$ are a set of explanatory variables, R_k are ratio (percentage) variables such as ratio of employment to population, D_l are indicator (or binary) variables designating specific water supply systems which assume the value of 1 for observations for the system and zero otherwise,

S_m are indicator spike variables designating individual observations in the data, ε_{it} is the random error, and $\alpha, \beta^{'s}, \gamma^{'s}, \delta^{'s}$ and $\rho^{'s}$ are the parameters to be estimated.

A large number of econometric studies of water demand have been conducted during the last 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. (2002) reviewed a number of studies of aggregated sectoral and regional demand.

1.3.3 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 were statistically significant and 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. (2002a). Additional information on the analytical methods, estimated model, and assumptions is included in the chapters which describe the analysis of water withdrawals and development of future water-demand scenarios for each major sector of use. A detailed description of the model development procedure is provided in Appendix A.

1.3.4 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 planning decisions on future water conservation and supply requirements. Generally, the uncertainty 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 which 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 uncertainty: Future values for one or more model variables cannot be known with certainty. Various assumptions must be introduced when projections are made for the water demand drivers (such as population, employment or irrigated acreage) as well as when projecting 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 for dealing with the last source of error – the scenario error. By defining three alternative scenarios a 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 in other to minimize the remaining three sources of error.

1.4 WATER DEMAND SCENARIOS

Estimates of future water withdrawals were prepared for three different scenarios. The scenarios include a less resource intensive (LRI) outcome, current trends (CT) or baseline case scenario, 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 withdrawals under three different sets of conditions. The three scenarios do not represent forecasts or predictions, nor do they 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 and employment/population ratios in the 22-county study area are assumed to remain unchanged during the forecast horizon. Additional general assumptions used in defining each of the three scenarios are described below.

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

The basic assumption of this scenario is that the recent trends (last 10 to 20 years) in population growth and economic development will continue. With respect to population growth the "current trends" are represented by the official forecasts of population and employment in the 22-county planning 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 use 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 the 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. The conservation trend in the historical data on water use is estimated as a part of the regression model.

1.4.2 Scenario 2 – Less Resources Intensive (LRI) Scenario

In this scenario, total population and employment growth in the study area at the same level as in Scenario 1. However, industrial withdrawals of water are assumed to decrease as some less water-intensive industrial activities continue to expand or locate in the study area. 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 lower income and higher water prices in the future.

1.4.3 Scenario 3 – More Resource Intensive (MRI) Scenario

In this scenario, the efficiency assumptions include less water conservation than indicated by the recent trends in Scenario 1. Industrial withdrawals of water would increase as some water-intensive manufacturing categories continue to expand or locate in the study area. 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 which describe estimates of water demand in each sector.

Table 1.2 Factors Affecting Future Water Demands in the 22-County Area

Factor	Scenario 1- Current Trends (CT) or Baseline	Scenario 2- Less Resource Intensive (LRI)	Scenario 3 – More Resource Intensive (MRI)
Total population	Official projections	Official projections	Official projections
Mix of commercial/ industrial activities	Current trends	No increase in water-intensive industry	Increase in water-intensive industry
Median household income	Existing projections of 0.7 %/year growth	Existing projections of 0.5 %/year growth	Higher growth of 1.0 %/years

Factor	Scenario 1- Current Trends (CT) or Baseline	Scenario 2- Less Resource Intensive (LRI)	Scenario 3 – More Resource Intensive (MRI)
Coal mining and processing	Five new mines, one CCS and one CTL plant to be built	No new coal conversion plants, reduced mine production	New mines and coal conversion plants, maintained mine production
Power generation	Two new plants within study area	One new power plant existing generation declines	Five new power plants in study area
Water conservation	Continuation of historical trend	50% higher rate than historical trend	50% lower than historical trend
Future water prices	Future price increases (1.5%/year)	Higher future price increases (2.5%/year)	Recent increasing trend (0.9%/year) will continue
Irrigated land	Constant cropland increasing golf courses	Constant cropland + no increase in golf courses	Increasing 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 (1971-2000)	30-year normal (1971-2000)	30-year normal (1971-2000)

1.5 ORGANIZATION OF SECTOR-SPECIFIC ANALYSES

The report is organized into main report and eight appendices. The main report is equivalent to an executive summary that combines the results for all sectors and briefly discusses some of the implications of this study for the further analysis of water withdrawals in the study areas.

Appendix A introduces the data and analytical models for estimating future water demands. The six major water use sectors are described in the six subsequent appendices (Appendices B, C, D, E, F, and G). Each of these appendices 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. Some appendices also include an Annex which contains detailed tables with primary data and/or auxiliary worksheets and other information used in the process of deriving future water withdrawals.

Appendix H describes the sensitivity analysis, which shows the impacts on water withdrawals under five climate change scenarios.

References for all the sector-specific appendices appear at the end of the report in Appendix I.

The final part of this project included an allocation of future withdrawals within each geographical area to the existing withdrawal points. The results of this work are not included in this report. Instead, the electronic tables of withdrawals allocated into individual points of water withdrawal were provided directly to the Illinois State Water Survey for their use as inputs into hydrologic groundwater (and surface water) models.

Appendix B

WATER FOR COAL MINING AND PROCESSING

2.1 BACKGROUND

2.1.1 Coal Mining in Kaskaskia Region

The coal mining activity in the Kaskaskia basin dates back to the middle of the 19th century. Figure 2.1 shows the number of opened and closed mines (mostly underground mines) per decade in the 22-county study area since the year 1840. In total, 1,662 coal mines have operated since 1842. The most intensive period of coal mining in terms of the number of active mines was between 1880 and 1940. Most coal mines existed in Macoupin, Madison, Randolph and St. Clair counties. Since the year 2000, 4 mines were closed or temporarily idled and in 2009 only three mines were operating.

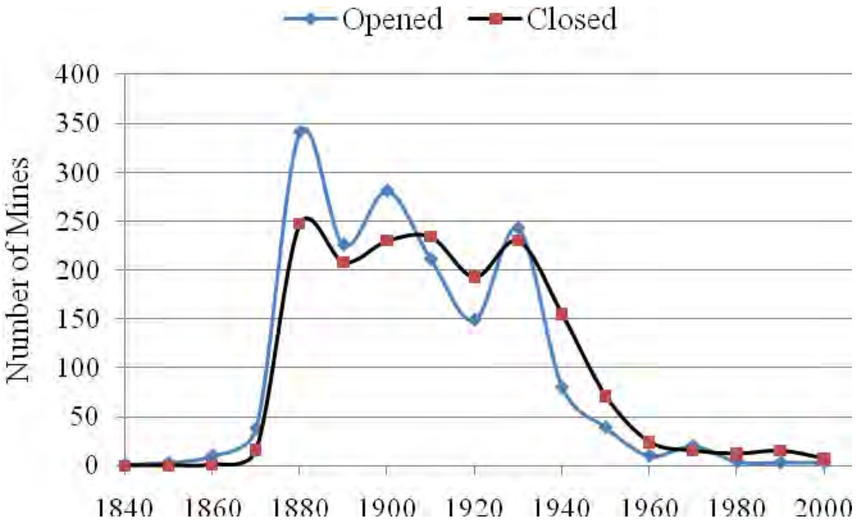

Figure 2.1 Number of Opened and Closed Coal Mines in the Kaskaskia Study Area

Historical data on coal production in the 22-county study area show a significant decline in total production after 1991 (Table 2.1). Continuous production during the 19 year period was reported only for the mines in Macoupin and Randolph counties. Coal production in the mines of Washington, Christian and Clinton counties stopped in 1999, 1994 and 1995, respectively. Coal production in Montgomery County resumed in 1999 and stopped in 2004. Some production between 1991 and 1993 was also reported in Douglas and St. Clair counties.

Combined production in the eight coal-producing counties of the study area has declined from 17.294 million tons in 1991 to 4.876 million tons in 2009 and increased to 5.536

million tons in 2010. During the same period, total Illinois coal production has declined by 42 percent -- from 60.036 million tons in 1991 to 34.651 million tons in 2009. Figure 2.2 compares the annual production in Illinois and in the study area.

Table 2.1 Recent Historical Coal Production in Illinois and in the Study Area: 1991-2010

Year	Illinois	Macou -pin	Randolph	Washing- ton	Christian	Clinton	Mont- gomery	Douglas /St. Clair	Total Study
1991	60,036	3,491	5,957	1,839	2,119	2,491	247	1,150	17,294
1992	60,332	4,242	6,300	1,630	1,605	3,076	0	16	16,869
1993	42,144	4,383	2,102	592	1,545	1,065	0	831	10,519
1994	54,026	4,809	3,434	2,225	1,457	3,007	0	0	14,932
1995	49,537	4,815	2,891	3,259	0	2,998	0	0	13,963
1996	47,311	5,454	2,103	3,676	0	2	0	0	11,235
1997	41,248	6,478	3,024	3,977	0	0	0	0	13,479
1998	39,639	5,775	2,390	4,065	0	0	0	0	12,230
1999	40,315	4,582	2,516	1,296	72	0	1,698	0	10,164
2000	33,541	4,264	2,504	0	0	0	2,074	0	8,842
2001	33,794	4,622	2,634	0	0	0	2,428	0	9,684
2002	33,446	4,872	2,549	0	0	0	2,019	0	9,440
2003	31,136	4,377	2,557	0	0	0	2,169	0	9,103
2004	32,279	4,420	1,461	0	0	0	1,895	0	7,776
2005	31,940	6,445	508	0	0	0	0	0	6,953
2006	32,962	5,682	2,439	0	0	0	0	0	8,121
2007	32,445	4,488	2,695	0	0	0	0	0	7,183
2008	32,918	1,408	3,198	0	0	0	0	0	4,606
2009	34,651	1,528	3,348	0	0	0	0	0	4,876
2010	33,400	2,338	3,198	0	0	0	0	0	5.536

Source: EIA, Annual Coal Reports

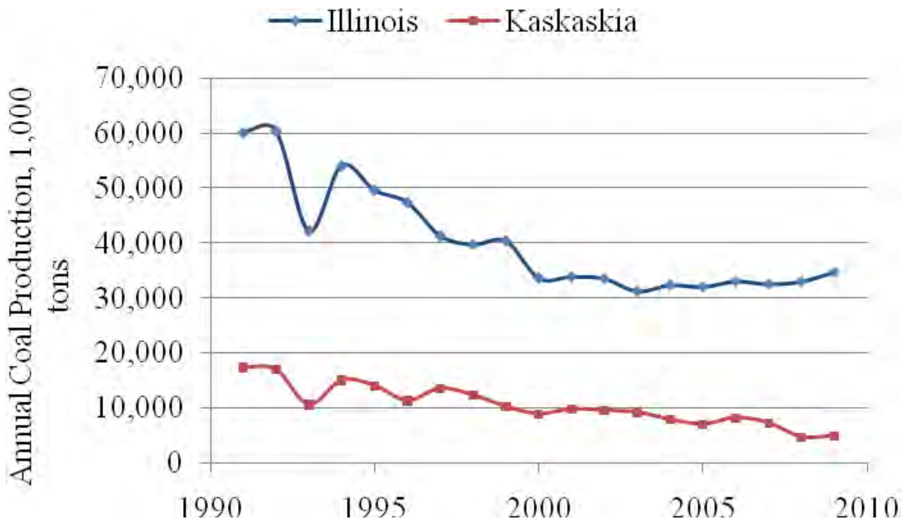

Figure 2.2 Annual Coal Production in Illinois and in the Study Area: 1991-2009

2.1.2 Existing and Proposed Coal Mines

In terms of the future potential for coal mining and processing, the available recent information suggests continuing presence and expansion of coal mining and coal related activities in the near term. In 2009, IDNR Office of Mines and minerals approved six new mine permits and three new mines awaited approval (DCEO, 2010). Also, there were eight mining permits under completeness review.

Table 2.2 lists three existing (active) and five new coal mines in the study area and four coal preparation plants. Among the active mines the Gateway and Crown III are within the Kaskaskia Basin. Shay #1 Mine located near Carlinville is in the Sangamon River Basin. The five new mines and four preparation plants are located within the Kaskaskia Basin.

Table 2.2 Existing and New Coal Mines in Kaskaskia Study Area

Mine Name	Operating Company	County	Annual Production (1,000 tons)
Operating coal mines[a]:			*2009/2010*
1. Gateway	Peabody Midwest Mining Co.	Randolph	3,348/3,198
2. Crown III	Tri County Coal LLC/ Springfield Coal Co.	Macoupin/ Montgomery	1,360/1,311
3. Shay #1	MaRyan Mining LLC	Macoupin	168/1,027
Proposed coal mines:			*Estimated*
1. Deer Run Mine – P#399	Hillsboro Energy LLC	Montgomery	8,000-10,000
2. Taylorville Mine – P#402	Taylorville Mining LLC	Christian	<3,000
3. Lively Grove Mine – P#373	Prairie State Gen. Co.	Washington	6,500

4. Hawkeye Mine – P#411	Knight Hawk Coal	Randolph	--
5. Marys River Mine	Peabody Midwest Mining	Randolph	1,000
Preparation plants:			
1. Gateway (active)	Black Beauty Coal Co.	Randolph	
2. Knight Hawk (active)	Knight Hawk Coal Co.	Perry/Randolph	
3. Randolph Preparation (inactive)	Peabody Coal Co.	Washington	
4. Deer Run Preparation (new)	Hillsboro Energy LLC	Montgomery	

P# = IDNR Permit Application number. [a] There are also five nonproducing or temporarily idled mines (RLP Pawnee Properties in Christian Co., ExonMobil Coal in Clinton Co., Murdock Mine in Douglas Co., Deer Run in Montgomery Co. and Crown II Mine in Macoupin Co.).

Among the three active mines, the Macoupin Energy LLC received the permit from the IDNR Office of Mines and Minerals (OMM) to continue underground coal mining at Monterey #1 Mine (previously operated by ExxonMobil) south of Carlinville in Macoupin County. This mine is now operated as Shay #1 Mine by the MaRyan Mining company.

In terms of new mines, in 2009, Natural Resource Partners has signed an agreement to acquire approximately 200 million tons of coal reserves related to the existing 804 acre site of Deer Run Mine located east of Hillsboro in Montgomery and Bond Counties. The new longwall mine is expected to start production in 2011.

Another recent development is the 200 acre site to include an underground mine of bituminous coal and a small surface mine of lignite coal just north of Taylorville (Christian County Coal Mine) that may sell coal to the proposed generation plant of the Taylorville Energy Center (TEC) – currently under construction. The TEC facility, if built, is expected to use 2.5 million tons of coal annually. As of mid-2011 the construction of this facility is on hold.

Another proposed mine, Lively Grove, will serve the Prairie State Energy Campus with net electricity generation capacity of 800 MW in each of two generator units. Unit 1 of the power plant is scheduled to go on line in August 2011, with the Unit 2 scheduled for May 2012. Over 200 million tons of recoverable coal located adjacent to the Campus will provide fuel for the plant. This amount is adequate to supply the campus for 30 years at approximately 6.5 million tons per year. The Prairie State facility is expected to use 18 mgd and up to 24 mgd of water from the Kaskaskia River.

The Hawkeye Mine will be a small surface mine to begin operations in the summer of 2010. The coal produced by this mine will likely be transported to the Perry Eagle preparation plant and no significant water supplies will be required for the mine operations.

Finally, the Mary's River mine to be operated by Peabody Midwest Mining LLC and located near Sparta in northeast Randolph County would produce about 1 million tons a year and was scheduled to begin operations around 2011. However, as of mid-2011, this mine is not expected to open in 2011.

Some mining operations also include coal preparation plants. These plants are usually located at or near coal mines and in some cases one preparation plant can serve multiple coal mines. The available information shows one existing coal preparation plant in Randolph County and one existing plant located on the Randolph/Perry county line operated by Knight Hawk Coal Company. The proposed Jordan Grove Mine will not have a preparation plant.

The new Deer Run mine coal preparation plant will utilize water from the sedimentation basins on site and from Shoal Creek if such water is available or will purchase water from Hillsboro and Litchfield to meet the coal processing needs.

2.1.3 Proposed Coal Conversion Plants

New coal conversion plants will require significant quantities of water for coal processing and cooling. Several coal conversion plants have been proposed for locations within the 22-county study area (Table 2.3). Some of these proposals have been abandoned or became inactive while others may still be under consideration. These proposals are briefly described below because some of the may be reactivated in the future.

Recently, one coal conversion plant was approved and another remained under consideration. The Taylorville Energy Center plant was to be built in Christian County and the FutureGen coal gasification plant was planned for a site near Mattoon in Coles County. The proposed FutureGen plant and CO_2 sequestration site consists of 444 acres and is located approximately 1 mile northwest from Mattoon. Both plants would use municipal effluent as a source of cooling and process water.

Taylorville plant would obtain treated effluent from the Sanitation District of Decatur. Also, a similar secure water source is potentially available for FutureGen from two wastewater treatment facilities (Mattoon and Charleston wastewater plants), which when combined with the construction and operation of an onsite reservoir, would ensure an adequate water supply to the plant. Total water supply needs of the FutureGen plant would be 4.3 mgd.

Table 2.3 Proposed and Abandoned Coal Conversion Plants in Kaskaskia Study Area

Mine/Plant Name	Operating Company	County	Production Capacity
Previously proposed:			
1. FutureGen IGCC plant	FutureGen Alliance	Coles	275 MW
2. Taylorville Energy Center	Tenaska and MDL Holding Co.	Christian	730 MW
Abandoned or inactive:			
1. Fayette IGCC/GTL plant	Clean Coal Power Resources	Fayette	100,000 bbd
2. Drummond CTL Plant	Drummond Coal Company	Montgomery	48,000 bbd
3. Illinois Clean Fuels	America Clean Coal Fuels	Coles	4,300,000 tons
4. FuturGen - Tuscola	FutureGen Alliance	Douglas	275 MW

Among the group of abandoned or inactive proposals is the IGCC/GTL coal conversion plant that was proposed for Fayette County by Clean Coal Power Resources Inc. The proposal included a coal gasification plant and 2400-kilowatt power generating facility fueled by its own on-site underground coal mine. The company secured a 99-year coal mining lease from Fayette County Board that gave it mining rights to some 159,000 acres of coal reserves and a total of 1.6 billion in-place tons of coal. The entire facility would have consumed some 17 million tons of coal per year.

Two other proposed conversion plants included the Drummond's 48,000 barrels per day coal-to-liquid plant in Montgomery County and Illinois Clean Fuels plant in Coles County. Drummond Coal Company has proposed a coal-to-liquids plant that would be capable of producing 48,000 barrels of fuels per day. No information on the source of water supply for this plant was available. The Illinois Clean Fuels project proposed for Oakland, in Coles County would use coal and biomass to produce diesel and jet fuels and also use carbon capture and storage technologies. The plant aimed to convert an estimated 4.3 million tons of coal and biomass per year into approximately 400 million gallons per year of synthetic diesel fuel and jet fuel.

The proposed Tuscola Site was the alternative FutureGen facility location. It consists of approximately 345 acres located 1.5 miles west of the City of Tuscola within Douglas County. The supply of process water for the plant would be obtained from an existing 80-acre 150 million-gallon water holding pond at the Lyondell-Equistar Chemical Company located near the proposed site. This pond contains raw water pumped from the adjacent Kaskaskia River and during low-flow conditions the pond is supplemented by groundwater from the Mahomet aquifer through wells located near Bondville, Illinois. The FutureGen Tuscola Plant would draw about 4.3 mgd.

2.2 WATER REQUIREMENTS

2.2.1 Water Withdrawal Rates

Coal mines usually require access to a source of water for such mining processes as dust suppression during the cutting process of the continuous miner in underground mines. Water is also used for coal washing, dust suppression, sanitary use by employees and other uses at the mine site. Estimates of water requirements range from 10 gallons to more than 150 gallons per ton of coal produced (NETL, 2006). A study from Australia reported average water use of 53 gallons per ton of coal produced (Evans et al., 2003).

The actual amounts of water used vary because of differences in operating practices and site-specific circumstances. For example, water requirements for coal washing are reported in the range of 20 to 40 gallons per ton of coal washed (Gleick 1994; Lancet 1993). Probstein and Gold (1978) reported that in coal preparation most water is used in dust control at transfer points such as surge bins and storage sites. The amount of water used for this purpose in the U.S. mines was estimated at 10 to 15 lb per 1000 lb of coal. This is equivalent to 1.2 to 1.8 gallons per ton of coal.

In addition to coal preparation at the coal mining sites, further coal processing may include coal gasification, liquefaction and other coal conversion processes. According to Bechtel (1998) coal liquefaction plants for indirect liquefaction of eastern coal require approximately 7.3 gallons of water per gallon of Fischer-Tropsch (F-T) liquid. This is equivalent to 307 gallons per barrel.

Water requirements for integrated gasification combined cycle (IGCC) power plants are reported to range from 678 to 830 gallons per megawatt-hour (Parsons, 2005). Table 2.4 shows the estimates of water requirements for different types of coal gasification plants which were developed in a study by NETL (2006). The estimates of total plant requirements for fresh makeup water range from 497 gallons per MWh to 1,169 gallons/MWh of gross generation.

Table 2.4 Estimated Total Water Requirements in Coal Gasification Plants

Plant Type	Gal/MWh
ConocoPhillips E-Gas™ IGCC	678
GE Energy Radiant-Convective IGCC plant	744
GE Energy Quench IGCC	750
Shell IGCC Plant	823
Natural Gas Combined Cycle Plant	497
Subcritical Pulverized Coal (PC) Boiler	1,169
Supercritical Pulverized Coal (PC) Boiler	1,042

Source: NETL (2006)

Coal-to-liquids (CTL) plants require less water per million Btu of product than electricity generating plants. Cartwright (2007) found estimates of water usage rates ranging from 1-1.5 barrels of water per barrel of product at a zero-discharge, air cooled plants to 5-7 barrels of water per barrel of liquids at a plant with water cooling and less use of waste heat (assuming 2 bbl of liquid per ton of 9000 Btu/lb sub-bituminous coal). These estimates are equivalent to 42-63 gallons/bbl to 210-294 gallons/bbl. However, a design profile of a CTL plant developed by Headwaters Incorporated estimated the requirement of 36,000 acre-feet per year of make-up water for a facility that produces 40,000 barrels per day. This estimate is equivalent to the usage rate of 804 gallons per barrel.

2.2.2 USGS Reported Mining Water Withdrawals in the Study Area

Water withdrawals that are associated with coal mining are reported together with mining of other minerals, solids and gases. According to the USGS classification, mining water use includes water for the extraction of naturally occurring minerals, solids (such as coal and ores), liquids (such as crude petroleum), and gases (such as natural gas). Water use estimates for this sector also include uses "associated with quarrying, well operations, milling (crushing, screening, washing, floatation, and so forth) and other preparations customarily done at the mine site or as part of a mining activity" (Solley et al., 1998).

All of the reported water use in this sector is self-supplied, and some of the water comes from saline water sources.

Information on total mining water withdrawals in Illinois is collected by Illinois State Water Survey (ISWS) using questionnaires that are sent to mining companies in the State. County total mining water withdrawals are estimated by aggregation of the water use data of the mining companies located in that county (Avery, 1999). USGS compiles mining withdrawals based on the state data and other sources. Table 2.5 shows water withdrawals for the mining sector which were reported by the USGS for the years of 1985, 1990, 1995 and 2005.

Table 2.5 USGS Reported Combined Mining Withdrawals by County.

County	Freshwater Withdrawals - MGD				Saline Water Withdrawals, MGD			
	1985	1990	1995	2005	1985	1990	1995	2005
Bond	0.26	0.00	0.00	0.57	0.00	0.00	0.00	0.00
Christian	1.41	0.23	0.00	0.00	0.47	0.46	0.46	0.46
Clay	0.18	0.00	0.00	0.00	0.96	0.72	0.72	0.72
Clinton	1.44	1.76	2.07	0.59	0.35	0.31	0.31	0.31
Coles	0.15	0.01	0.00	0.15	0.03	0.12	0.12	0.12
Cumberland	0.07	0.09	0.00	0.18	0.15	0.11	0.11	0.11
Douglas	1.79	0.24	0.24	0.24	0.00	0.00	0.00	0.00
Effingham	0.06	0.00	0.00	0.00	0.19	0.22	0.22	0.22
Fayette	0.08	0.00	0.00	0.08	6.52	1.28	1.28	1.28
Jasper	0.02	0.00	0.00	0.00	0.59	1.10	1.10	1.10
Marion	1.94	0.00	0.00	0.00	10.20	0.65	0.65	0.65
Montgomery	0.05	0.14	0.19	0.74	0.00	0.00	0.00	0.00
Moultrie	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Randolph	0.02	0.67	0.27	3.15	0.02	0.00	0.00	0.00
Richland	0.03	0.00	0.00	0.00	0.92	0.91	0.91	0.91
Shelby	0.00	0.00	0.00	0.08	0.03	0.04	0.04	0.04
Washington	0.06	0.00	0.00	0.00	0.36	0.35	0.35	0.35
Wayne	0.31	0.00	0.00	0.00	1.55	1.71	1.71	1.71
Macoupin	1.81	1.65	2.57	2.97	0.00	0.00	0.00	0.00
Madison	0.01	0.00	0.00	1.06	0.10	0.09	0.09	0.09
Monroe	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.00
Saint Clair	1.95	2.19	0.00	0.90	0.00	0.00	0.00	0.00
Total 22 counties	11.64	6.98	5.34	10.85	22.44	8.07	8.07	8.07

The amount of reported freshwater withdrawals decreased by about 50 percent between 1985 and 1995 and then increased to 10.85 mgd in 2005. Total withdrawals of saline water were reported to be 8.07 mgd for the last three compilation years.

2.2.3 Reported Coal Mining Withdrawals by IWIP

The Illinois Water Use Information Program (IWIP) obtains data from individual mine sites. Table 2.6 compares the available reported withdrawals and the level of coal production from existing and recently closed mines in the 22-county study area.

Table 2.6 Historical Coal Production and Available Reported Water Withdrawals by Coal Mines in Kaskaskia River Basin

Company/Mine Name, County Name	Coal Production (tons)	Annual Water Withdrawals, MGD				
		1990	1993	2005	2006	2007
Consolidation Coal Hillsboro-6, Montgomery	1,895,000	0.238	0.450			
Freeman United Coal Crown #3, Macoupin	1,871,490	0.048	0.184			
Freeman United Crown #2, Macoupin	1,565,265		2.119			
Gateway Underground Mine, Randolph	507,738			3.153	1.764	1.778
Monterey Coal Co - Mine # 2, Clinton	3,007,815	1.716	1.619	0.588	0.525	0.538
Monterey Coal Co Mine # 1, Macoupin	2,900,000	1.699	2.119	2.967	2.921	2.364
Peabody Coal - Freeburg Complex, St Clair						
Peabody Coal – Marissa Mine, Washington		0.004	0.027			

Notes: Gateway Mine was closed in 2003 and reopened in 2005. The production for 2006 was 2,467,600 tons and for 2007 it was 2,694,914 tons. Coal production for other mines represent the 2005 or earlier data.

The data in Table 2.6 indicate that average water withdrawals were in the range of 147 gallons per ton of coal produced. The unit withdrawals ranged from 36 gallons/ton Crown #3 mine to as 403 gallons/ton in the Monterey #1 mine.

The available estimates of the current water withdrawals by the three operating coal mines (see Table 2.1 above) indicate total withdrawals of 4.336 mgd (Monterey/Shay #1 – 2.364 mgd; Gateway – 1.778 mgd; and Crown III – 0.184 mgd).

2.2.4 Estimation of Future Water Use

A straightforward unit-coefficient method was used in this study to derive future quantities of water withdrawals for coal mines and coal conversion plants. This method represents water demand as a product of total annual amount of coal production (and preparation) at the mine and the unit rate of water required in gallons per ton. For coal conversion plants only estimates for coal-to-liquids conversion plants are included in this sector. The IGCC plants that generate electrical energy are included in the electric power generation sector (Appendix C).

The assumed unit-use coefficients for coal mines, coal preparation and conversion plants are shown in Table 2.7. For the existing coal mines

Table 2.7 Existing and New Coal Mines in Kaskaskia Study Area

Description	Units	Unit-Use Coefficient
Operating coal mines:		
1. Gateway	Gallons/ton	194.0
2. Crown III	Gallons/ton	36.0
3. Shay #1	Gallons/ton	403.0
Operating preparation plants:		
1. Gateway (active)	Gallons/ton	96.0
2. Knight Hawk (active)	Gallons/ton	96.0
New coal mines	Gallons/ton	147.0
New preparation plants	Gallons/ton	96.0
New conversion plants	Gallons/bbl	63.0

The usage rates for Gateway and Shay #1 mines used in the estimation of future water use were reduced by subtracting the rate of water use for coal preparation plants. The assumed average rate of 147 gallons/ton for new mines does not include water required for coal preparation.

2.3 FUTURE COAL DEVELOPMENT

Future water withdrawals that are associated with coal mining and conversion will depend on the level of coal production and the development of coal preparation and conversion facilities. Figure 2.3 shows historical changes in coal production in the state of Illinois relative to coal production east of Mississippi River and the U.S. total. It shows gradual declines in the production of the Eastern and Illinois coal after 1992 despite a continuing growth of total U.S. production since 1971.

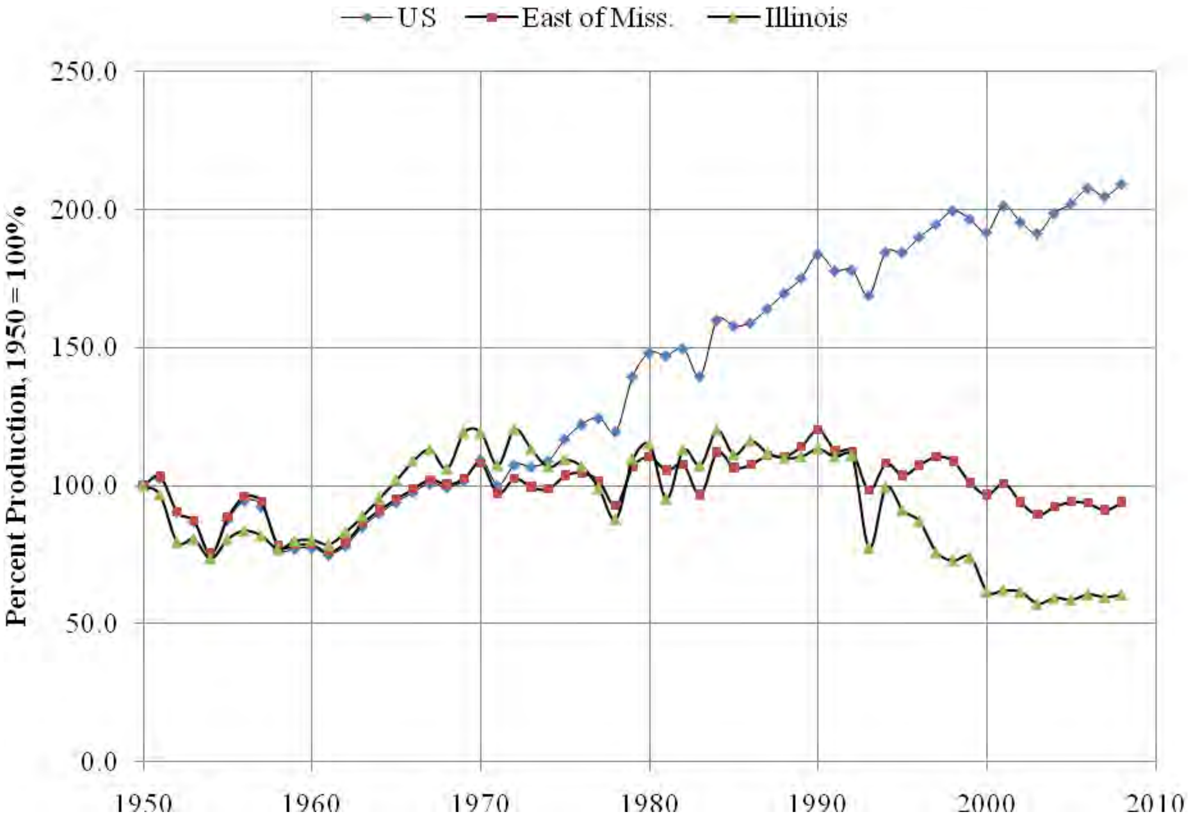

Figure 2.3 Historical Changes in Coal Production in the U.S., East of Mississippi and Illinois

The Energy Information Administration (EIA) reported in the 2009 Annual Energy Outlook report that from 1980 to 2007 the average annual growth in the U.S. coal production was 0.9 percent per year. For the period from 2007 to 2030, the EIA reference case forecast used the growth rate of 0.6 percent per year. The EIA also predicted that the production of higher sulphur coal in the Interior region (primarily in Illinois, Indiana and Kentucky) will rebound with the adoption of flue gas desulphurization (FGD) by the existing coal-fired power plants and the addition of new coal-fired capacity in the Southeast (EIA, 2009).

According to the most recent EIA forecast (AEO2010), additional demand for coal is expected to supply new coal-to-liquids (CTL) conversion plants. According to the AEO2010 reference case, coal use at CTL plants would grow from 32 million short tons in 2020 to 68 million short tons in 2035. In the near term, the EIA suggested a goal is 300,000 barrels of liquid transportation fuels per day by 2015 using the CTL technology (EIA, 2010).

In terms of the outlook for future production of Illinois coal, it is reasonable to assume that the production will rebound in the near term once the mines that are under construction as well as the permitted mines start production. In the long term, the production of Illinois coal should continue to grow because of two factors: (1) the high coal reserves (see Table 2.8) in Illinois and (2) new demands for coal by coal conversion plants.

Table 2.8 Reported Coal Reserves in the United States

State	2007 Reserves (million tons)	Percent
Montana	67,949	28.4
Wyoming	36,418	15.2
Illinois	34,453	14.4
West Virginia	16,161	6.8
Kentucky	13,413	5.6
Pennsylvania	10,602	4.4
Ohio	10,402	4.3
Colorado	8,824	3.7
Texas	8,609	3.6
New Mexico	6,319	2.6
North Dakota	6,239	2.6
Remaining 18 states*	19,910	8.3
U.S. Total	239,297	100.0

The remaining 18 states by rank are: Indiana, Missouri, Alaska, Alabama, Utah, Iowa, Oklahoma, Virginia, Washington, Kansas, Tennessee, Maryland, South Dakota, Arkansas, Michigan, Oregon, North Carolina and Georgia.
Source: Mikael Höök, and Kjell Aleklett. 2009

In the 22-county Kaskaskia River region, the 2009 production was approximately 4.9 million tons per year. In 2010, the production increased to 5.7 million tons and would increase to approximately 7 million tons if the Shay #1 mine operates at full capacity. The production would be increased by 18.5 to 20.5 million tons per year once the Deer Run, Taylorville, Lively Grove and Marys River mines reach their planned production capacity. This indicates that by 2015 total coal production in the study area could reach 27.5 million tons per year. The assumed volumes of 2015 coal production under forecast scenarios range from 17.808 to 25.308 million tons.

2.4 FUTURE WATER DEMAND SCENARIOS

The three future scenarios are designed to capture future conditions of water demand for coal mining and conversion (excluding thermoelectric generation of electricity) which would provide the future water withdrawals for this sector under three different sets of conditions. The scenarios include less resources intensive outcome, current trends (or baseline case), and more resource intensive outcome.

The key assumptions for the scenarios include the level of production for individual coal mines, preparation plants and coal conversion plants as well as the length of time each mine will operate before its closure. The length of operation in years was estimated by dividing the reported recoverable coal reserves by annual production. The assumptions used in the formulation of each scenario are described below.

2.4.1 Scenario 1 – Current Trends (Baseline Case)

Under this baseline scenario, future coal production in the 22-county study area would continue in the three existing coal mines until their planned closure. The level of production would be maintained at the planned capacity of each mine. The closure times were assumed to take place before 2020 for Gateway Mine (with 20.5 million tons of reserves), by 2035 for Crown III Mine (with 71 million tons of reserves) and by 2025 for Shay #1 Mine (with 40 million tons of reserves).

In addition, the mines that are currently under construction are assumed to begin operation before 2015 and continue production until their coal reserves are exhausted.

The specific assumptions for the current trends (CT) scenario are:

1. Future production in the three existing coal mines will continue at the current level of production capacity until their assumed closure (Gateway in 2020, Crown III in 2035 and Shay #1 in 2025).
2. The five new mines (those currently under construction) will reach their production capacity by 2015.
3. Upon the future retirement of the existing and new mines, the future production capacity will be maintained by opening new replacement mines (within the same counties).
4. The proposed FutureGen plant will be built in Coles County by 2020 (the plant's water use is included in electric power generation).
5. One coal-to-liquids plant will be built in Montgomery County by 2020.

2.4.2 Scenario 2 – Less Resource Intensive Case

The intent of this scenario is to define future conditions which would lead to less water withdrawals by the coal mining and coal conversion sector.

The specific assumptions for the less resource intensive (LRI) scenario are:

1. Future demand for Illinois coal mined within the study area counties will continue to grow to absorb the planned production of the existing and new mines.

Operation of the three existing coal mines will continue at the current level of production capacity until their assumed closure (Gateway in 2020, Crown III in 2035 and Shay #1 in 2025).

2. No new mines will be opened beyond those currently under construction. The new mines (those currently under construction) will gradually reduce production and retire after 2030.

3. New mines and new coal preparation plants will not require new withdrawals of freshwater from the Kaskaskia basin; they will rely on water stored in ponds on mine properties and treated municipal wastewater (where available).

4. No new coal conversion plants will be built within the 22-county study area.

2.4.3 Scenario 3 –More Resource Intensive Case

The intent of this scenario is to define future conditions which would lead to higher water withdrawals by the coal mining and processing sector. Higher water withdrawals would result if additional coal mines and coal conversion plants are permitted and built.

For the purpose of this scenario, an assumption is made that all five proposed coal mines will be constructed and will begin operation by 2015.

The specific assumptions for the more resource intensive (MRI) scenario are:

1. Future demand for Illinois coal mined within the study area counties will continue to grow to meet the demands of new coal conversion and power plants both within and outside of the 22-county study area.

2. The five proposed mines will be in production by 2015. The level of production in these new mines will be maintained by constructing replacement new coal mines (within the same counties) once their coal reserves are exhausted.

3. The Taylorville Energy Center IGCC plant in Christian County will be completed by 2015 and would absorb the production of Taylorville Mine (the plant's water use is included in electric power generation).

4. Two coal conversion plants will be added -- one in Montgomery County by 2020 and one in Fayette County by 2015.

5. Additional coal preparation plants will be added to provide coal cleaning for 85 percent of total coal production.

6. New mines and new coal conversion plants will obtain freshwater withdrawals from the Kaskaskia River basin.

2.5 SCENARIO RESULTS

The results of the assumptions for each of the three scenarios on water withdrawals are summarized in Table 2.9 below.

Under the baseline case (CT) scenario, the future water withdrawals for coal mining and processing would increase by 7.30 mgd from 2.84 mgd in 2005 to 10.14 mgd in 2050.

Under the LRI scenario, total withdrawals would decrease by 2.19 mgd from 2.84 mgd in 2005 to 1.48 mgd in 2050. This scenario assumes no additional water withdrawals for coal conversion.

Under the MRI scenario, total water withdrawals for coal mining would increase by 19.45 mgd from 2.84 mgd in 2005 to 22.29 mgd in 2050.

Table 2.9 Coal Mining and Processing Water Demand Scenarios in Kaskaskia Study Area

Year	Coal Production	Mining Withdrawals	Coal Preparation	Coal Conversion	Total Withdrawals
	1000 ton/year	MGD	MGD	MGD	MGD
CT					
Current	4,876	1.96	0.88	0.00	2.84
2010	15,808	2.19	3.01	0.00	5.20
2015	23,308	5.21	3.01	0.00	8.22
2020	21,960	4.59	2.66	3.02	10.27
2025	18,960	4.59	2.66	3.02	10.27
2030	18,960	4.59	2.66	3.02	10.27
2035	17,600	4.46	2.66	3.02	10.14
2040	17,600	4.46	2.66	3.02	10.14
2045	17,600	4.46	2.66	3.02	10.14
2050	17,600	4.46	2.66	3.02	10.14
2005-50 Change	12,724	2.50	1.78	3.02	7.30
2005-50, %	261.0	127.3	201.7	--	256.8
LRI					
2005	4,876	1.96	0.88	0.00	2.84
2010	15,808	2.19	3.01	0.00	5.20
2015	23,308	5.21	3.01	0.00	8.22
2020	21,960	4.59	2.66	0.00	7.25
2025	18,960	4.59	2.66	0.00	7.25
2030	18,960	4.59	2.66	0.00	7.25
2035	15,600	4.18	2.13	0.00	6.31
2040	11,600	3.09	1.60	0.00	4.70
2045	7,600	2.01	1.08	0.00	3.09
2050	3,600	0.92	0.55	0.00	1.48
2005-50 Change	-1,276	-1.04	-0.33	0.00	-1.36
2005-50, %	-26.2	-52.9	-37.3	--	-48.1
MRI					
2005	4,876	1.96	0.88	0.00	2.84
2010	17,808	2.99	4.18	0.00	7.18
2015	25,308	6.01	5.56	6.30	17.88
2020	28,308	6.69	6.27	9.32	22.29
2025	28,308	6.69	6.27	9.32	22.29
2030	28,308	6.69	6.27	9.32	22.29
2035	28,308	6.69	6.27	9.32	22.29
2040	28,308	6.69	6.27	9.32	22.29
2045	28,308	6.69	6.27	9.32	22.29
2050	28,308	6.69	6.27	9.32	22.29
2005-50 Change	23,432	4.73	5.39	9.32	19.45
2005-50, %	480.6	241.6	612.4	--	684.8

APPENDIX B ANNEX

Table A2.1 Assumed Production Levels in Future Coal Mining and Processing; CT Scenario

Facility Type	Current	2010	2015	2020	2025	2030	2035	2040	2045	2050
Mines (1000 tons)										
1. Gateway	3,348	3,348	3,348	0	0	0	0	0	0	0
2. Crown III	1,360	1,360	1,360	1,360	1,360	1,360	0	0	0	0
3. Shay #1	168	3,000	3,000	3,000	0	0	0	0	0	0
N1. Deer Run	0	8,000	8,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
N2. Taylorville	0	0	0	0	0	0	0	0	0	0
N3. Lively Grove	0	0	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500
N4. Hawkeye	0	100	100	100	100	100	100	100	100	100
N5. Marys River	0	0	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Prep Plants (1000 tons)										
1. Gateway	3,348	3,348	3,348	0	0	0	0	0	0	0
2. Knight Hawk	0	100	100	100	100	100	100	100	100	100
N1. Deer Run	0	8,000	8,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
N2. Jordan Grove	0	0	0	0	0	0	0	0	0	0
N3. New Prep Plant #3	0	0	0	0	0	0	0	0	0	0
N4. New Prep Plant #4	0	0	0	0	0	0	0	0	0	0
Conversion (1000 bbd)										
C1. CTL Plant #1	0	0	0	0	0	0	0	0	0	0
C2. CTL Plant #2	0	0	0	48	48	48	48	48	48	48
C3. CTL Plant #3	0	0	0	0	0	0	0	0	0	0

N= new, C= new conversion plant

Table A2.2 Assumed Production Levels in Future Coal Mining and Processing: LRI Scenario

Facility Type	Current	2010	2015	2020	2025	2030	2035	2040	2045	2050
Mines (1000 tons)										
1. Gateway	3,348	3,348	3,348	0	0	0	0	0	0	0
2. Crown III	1,360	1,360	1,360	1,360	1,360	1,360	0	0	0	0
3. Shay #1	168	3,000	3,000	3,000	0	0	0	0	0	0
N1. Deer Run	0	8,000	8,000	10,000	10,000	10,000	8,000	6,000	4,000	2,000
N2. Taylorville	0	0	0	0	0	0	0	0	0	0
N3. Lively Grove	0	0	6,500	6,500	6,500	6,500	6,500	4,500	2,500	500
N4. Hawkeye	0	100	100	100	100	100	100	100	100	100
N5. Marys River	0	0	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Prep Plants (1000 tons)										
1. Gateway	3,348	3,348	3,348	0	0	0	0	0	0	0
2. Knight Hawk	0	100	100	100	100	100	100	100	100	100
N1. Deer Run	0	8,000	8,000	10,000	10,000	10,000	8,000	6,000	4,000	2,000
N2. Jordan Grove	0	0	0	0	0	0	0	0	0	0
N3. New Prep Plant #3	0	0	0	0	0	0	0	0	0	0
N4. New Prep Plant #4	0	0	0	0	0	0	0	0	0	0
Conversion (1000 bbd)										
C1. CTL Plant #1	0	0	0	0	0	0	0	0	0	0
C2. CTL Plant #2	0	0	0	0	0	0	0	0	0	0
C3. CTL Plant #3	0	0	0	0	0	0	0	0	0	0

N= new, C= new conversion plant

Table A2.3 Assumed Production Levels in Future Coal Mining and Processing: MRI Scenario

Facility Type	Current	2010	2015	2020	2025	2030	2035	2040	2045	2050
Mines (1000 tons)										
1. Gateway	3,348	3,348	3,348	3,348	3,348	3,348	3,348	3,348	3,348	3,348
2. Crown III	1,360	1,360	1,360	1,360	1,360	1,360	1,360	1,360	1,360	1,360
3. Shay #1	168	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000
N1. Deer Run	0	8,000	8,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
N2. Taylorville	0	2,000	2,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000
N3. Lively Grove	0	0	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500
N4. Hawkeye	0	100	100	100	100	100	100	100	100	100
N5. Marys River	0	0	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Prep Plants (1000 tons)										
1. Gateway	3,348	3,348	3,348	3,348	3,348	3,348	3,348	3,348	3,348	3,348
2. Knight Hawk	0	100	100	100	100	100	100	100	100	100
N1. Deer Run	0	8,000	8,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
N2. Jordan Grove	0	0	0	0	0	0	0	0	0	0
N3. New Prep Plant #3	0	3,752	9,002	9,702	9,702	9,702	9,702	9,702	9,702	9,702
N4. New Prep Plant #4	0	0	0	0	0	0	0	0	0	0
Conversion (1000 bbd)										
C1. CTL Plant #1	0	0	100	100	100	100	100	100	100	100
C2. CTL Plant #2	0	0	0	48	48	48	48	48	48	48
C3. CTL Plant #3	0	0	0	0	0	0	0	0	0	0

N= new, C= new conversion plant

Appendix C

SELF-SUPPLIED WATER FOR POWER GENERATION

3.1 BACKGROUND

3.1.1 Thermoelectric Water Withdrawals

Water withdrawn by electric power plants is classified by the USGS as thermoelectric generation water use. It represents the water applied in the production of heat-generated electric power. The heat sources may include fossil fuels such as coal, petroleum, natural gas, or nuclear fission. The main use of water at power plants is for cooling.

The three major types of thermoelectric plants include: conventional steam, nuclear steam, and internal combustion plants. In internal combustion plants, 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 by 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 sensible heating of water. The wet cooling systems fall into two broad categories: once-through cooling systems and closed-loop (or recirculating) systems.

Coal conversion power plants require water both for coal processing (i.e., gasification) and steam cooling. Process water is needed in the IGCC plants because water is added to the gasification reactions and to promote shift within the gasifier to hydrogen and carbon dioxide.

3.1.2 Electric Generation in the Study Area

According to the inventory of electric generators maintained by the Energy Information Agency (EIA), there are 34 generation facilities in the 22 counties (although some generators are located outside of the study area in the four western counties). Total nameplate capacity of the 34 plants is approximately 8,000 MW (see Table A3.1 in Chapter 3 Annex). Of the total number of plants, there are eight large plants which account for nearly 92 percent of total generation capacity. The generation capacities of the seven large power plants and one smaller peaking plant are listed in Table 3.1. Also included are the names and generation capacities of three proposed generation plants and one proposal that have been abandoned.

Total generation capacity (measured as gross capacity) of these 8 plants is 7,329 MW. The proposed three plants would increase total generation capacity by between 1,800 MW and 2,330 MW. The remaining small generators in the study area do not represent large users of water for power generation and their water demand is included in the self-supplied commercial-industrial sector or public-supply sector. The estimates of future water needs for electric power generation are based on the amount of electric energy generation and cooling water needs of the large plants which are self-supplied.

Table 3.1 Existing and Proposed Large Power Plants in the 22-County Area

Company/Plant Name	County	Owner	Water Source	Nameplate Capacity (MW)
Existing Plants:				
1. Coffeen Station	Montgomery	Ameren EGC	Coffeen Lake on McDavid Branch (Shoal Creek)	1,005
2. Newton Station	Jasper	Ameren EGC	Laws Creek (Ohio R. drainage)	1,235
3. Kincaid Station	Christian/ Clinton	Dominion ES	Sanchris Lake (Sangamon R.)	1,319
4. Baldwin Energy	Randolph	Dynegy Midwest G.	Baldwin Lake/Kaskaskia	1,892
5. Holland Energy Facility	Shelby	Tenaska Frontier/ Hoosier Energy	Kaskaskia River	665
6. Venice Station	Madison	Ameren UE	Mississippi River	492
7. Wood River Station	Madison	Dynegy Midwest Gen	Mississippi River	650
8. Freedom Power	Fayette	Southwestern Electric Coop Inc	Fayette Co. Water (Kaskaskia B.)	47
Proposed Plants:				
1. Prairie State Energy	Washington	Prairie Power Inc.	Kaskaskia River	810/ 1600
2. Taylorville Energy Center	Christian	Christian County Generation, L.L.C	Effluent -Sanitation District of Decatur	730
Inactive/Abandoned:				
1. FutureGen	Mattoon	FutureGen Industrial Alliance Inc	Municipal effluent + pond	275
2. Baldwin Energy Complex	Randolph	Dynegy Midwest Generation	Kaskaskia River	1,300 MW

Freedom Power is a gas turbine peaking plant with operating capacity of 45 MW. Holland Energy is a 630-megawatt natural gas combined cycle facility. Prairie State Energy Campus consists of two supercritical units with a nominal net output capacity of 800 MW each. Unit 1 of the power plant is scheduled to go on line in August 2011, with the Unit 2 scheduled for May 2012.

3.1.3 Theoretical Cooling Water Requirements

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:

$$L = \frac{6823(1-e)}{Te} \tag{3.1}$$

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 decimal fraction.

For example, in a coal-fired plant with thermal efficiency of 40 percent and the condenser temperature rise of 20 °F, the water flow rate obtained from Equation 3.1 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:

$$W = E \cdot \frac{1}{1-\frac{c}{c_o}} \tag{3.2}$$

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:

$$E = (1.91145 \cdot 10^{-6}) \cdot aQ \tag{3.3}$$

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:

$$Q = 3414426 \cdot P \cdot \frac{1-e}{e} \tag{3.4}$$

where:
P = the rated capacity of the plant in MW; and
e is thermodynamic efficiency of 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.

While 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 (Harte and El-Gasseir, 1978; Gleick, 1993; Baum et al., 2003).

3.1.4 USGS Reported County-Level Withdrawals for Power Generation

The USGS National Water Use Information Program reported thermoelectric withdrawals in six of the 22 counties which are included in the study area. Table 3.2 shows the USGS-reported withdrawals for these six counties during the past five data compilation years: 1985, 1990, 1995, 2000, and 2005.

Table 3.2 USGS Reported Thermoelectric Water Withdrawals (in MGD) in Six Counties in the 22-County Study Area (1985 – 2005)

County	1985	1990	1995	2000	2005	Adjusted 2006 Base year
Christian	859.45	793.43	770.85	749.10	830.84	784.1
Jasper	387.67	419.18	529.68	526.70	605.41	525.3
Montgomery	328.86	420.00	328.49	439.60	505.36	438.3
Randolph	30.70	1,047.75	1,173.97	32.30	32.32	32.3
Madison	368.27	257.32	162.58	542.00	293.08	292.1
Total for 6 counties	1,974.95	2,937.68	2,965.57	2,289.70	2,267.01	2,072.1
Total corrected for Randolph Co.	1,974.95	1,921.93	1,823.60	2,289.70	2,267.01	2,072.1

Source: USGS water use reports, various years. Values represent average annual withdrawals in million gallons per day (mgd). The USGS data do not include the Holland Energy plant in Shelby County. The withdrawals include intakes in Mississippi River by Venice and Wood River plants in Madison County. The adjusted 2006 estimates of withdrawals were used as the base year values.

The USGS reported data in Table 3.2 show total 2005 withdrawals in the 22 counties of 2,267 million gallons per day (mgd). The shift in withdrawals in Randolph County is the result of change in the definition of withdrawals by the Baldwin plant. The reported withdrawals in the range of 30 to 32 mgd represent water pumpage from Kaskaskia River to supplement losses in the elevated cooling pond. The withdrawals in the range of 1,100 mgd represent pumpage from the cooling pond to the condensers through a once through system through which water is circulated back to the pond. The last row of Table 3.2 shows total withdrawals which exclude the recirculated pumpage from the cooling pond at the Baldwin plant. The historical data on reported withdrawals show an increase between 1995 and 2000. The six-county total reported withdrawals have increased from

1,823.6 mgd in 1995 to 2,289.7 mgd in 2000 – an increase of 466.1 mgd or 25.6 percent. The higher withdrawals in 2000 were reported for Montgomery County (Coffeen Station) and Madison County (Venice Station).

Actual withdrawals within the Kaskaskia basin are lower than the totals in Table 3.2 because some power plants withdraw water from the Mississippi and Ohio basins (see Table 3.1). Data on power generation and withdrawals in the plants that use Kaskaskia water are described in the following section.

3.1.5 Reported Plant-Level Withdrawals

Table 3.3 contains plant-level information obtained for the purpose of this study. Of the seven existing large power generation plants within the 22 counties only three rely on Kaskaskia Basin water (Coffeen, Baldwin and Holland). Two plants (Venice and Wood River Stations) draw water from Mississippi River and one plant (Newton Station) operates on Laws Creek within the Ohio River drainage. Finally, the Kincaid plant uses Sanchris Lake built by damming Clear Creek, a tributary of the South Fork of the Sangamon River.

The two proposed plants include Prairie State and Taylorville Generation. The Prairie State plant plans to obtain water from Kaskaskia River basin (up to 24 mgd). There is a secure water source for Taylorville Generation from wastewater treatment facility of the Decatur Sanitation District.

Table 3.3. Gross Generation and Water Withdrawals
by Power Plants in Kaskaskia River Basin

Company/Plant Name	Nameplate Capacity	2006 Gross Generation	2005 With-drawals MGD	2006 With-drawals MGD	2007 With-drawals MGD	2006 Gallons/ kWh
3. Coffeen Station	1,005	6,233,516	438.3	438.3	474.8	25.7
4. Baldwin Energy	1,892	13,379,542	26.4	25.1	31.7	0.9
5. Holland Energy	665	645,085	5.5	5.5	5.5	3.1
Totals	3,562	20,258,143	470.2	468.9	512.0	23.1

Coffeen Station reported the quantity of water that is pumped directly to the condensers and then returned back to the lake. The other two are closed-loop makeup water plants that withdraw water to replace losses and blowdown in cooling towers (Holland Energy), or water losses and discharges from a perched cooling lake (Baldwin Energy). Table 3.3 shows 2006 water withdrawals by the three plants to be 821.9 mgd. Almost all of these withdrawals represent non-consumptive use at Coffeen Station because the water withdrawn is returned to the sources after passing through the condensers. The consumptive losses of water in Coffeen Lake used by Coffees Station should be in the range of 1.0 gallon/kWh or approximately 9.0 mgd.

3.2 WATER-DEMAND RELATIONSHIPS

A straightforward unit-coefficient method was used in this study to derive future quantities of water withdrawals for thermoelectric power plants. This method represents water demand as a product of total gross generation at the plant and the unit rate of water required in gallons per kilowatt-hour. The specific coefficients and relationship for the two main types of cooling systems are discussed below.

Previous studies of water use in plants with once-through cooling systems show that total water withdrawals depend primarily on the level of generation in kWh per year and also vary depending on the operational efficiency (i.e., the percent of capacity utilization), thermal efficiency of the plant, 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-use relationships is somewhat limited because the reported equations are estimated from the data derived from the EIA-767 Steam Electric Plant Operation and Design Report which includes only net electric generation. More precise estimation methods for cooling water withdrawals can be derived using gross generation.

Figure 3.1 below shows a plot of the reported water withdrawals versus gross generation for the six plants from Table 3.1 that reported once-through cooling flows (i.e., Coffeen, Newton, Kincaid, Baldwin, Venice and Wood River).

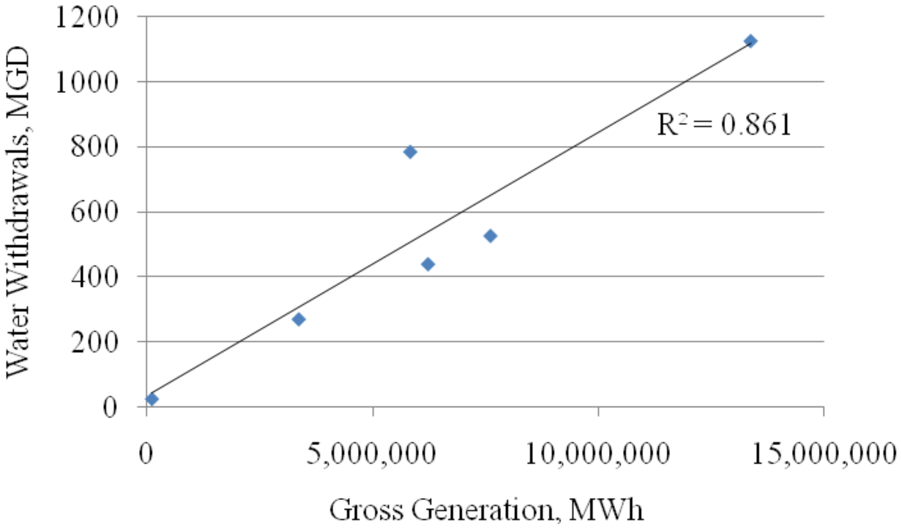

Figure 3.1 Relationship Between Total Water Withdrawals and Gross Generation for Six Power Plants in the 22-County Area

The regression line which is fitted to the data points shows a correlation R^2 of 0.861. The R^2 coefficient indicates that 86.1 percent of variance in total withdrawals among the seven plants is explained by the values of gross generation. The relationship between the amount of generation and water withdrawals is also confirmed by previous studies of water withdrawals for power generation (Dziegielewski et al., 2002; Dziegielewski and Bik, 2006).

The slope of the regression line on Figure 3.1 is 29.6 gallons/kWh. This value represents the average incremental unit withdrawal per 1 kWh of gross generation. In deriving future estimates of water withdrawal for the existing power plants, the actual unit withdrawals at each plant were used (see the last column of Table 3.3). The estimate of 29.6 gallons/MWh was applied for new once-through cooling power plants.

3.3 FUTURE DEMAND FOR ELECTRICITY

Future water withdrawals of the power generation sector will depend on the level of future generation and also on the type of generators and cooling systems. Before constructing the future scenarios for the thermoelectric sector, it is helpful to examine the future trends in demand for electricity. Because of the deregulation of electric power industry, the demand for electricity in any geographical area cannot be directly linked with local generation. However, the knowledge of the future demand for electricity could help in determining the future trends in generation.

It is reasonable to expect that the future demand for electricity within the 22-county study area will change because of population growth and the concomitant increase in economic activity. Although the current use of electricity within the study area is difficult to determine precisely -- an approximate level of electricity usage per capita can be derived by comparing the current aggregate sales of electricity (state and national) with population served. Table 3.4 compares the available estimates of per capita energy consumption for different geographical areas.

Using the data in Table 3.4, the estimate of 10.14 MWh per capita per year reported by the Illinois Commerce Commission appears to be the best approximation of electricity use in the 22-county study area. It is only slightly lower than the statewide rate reported by the Energy Information Agency (10.77 MWh/capita/year) and national average (12.97 MWh/capita/year) it can be considered a conservative estimate of future per capita use of electricity in the study area.

Table 3.4 Available Estimates of Per Capita Consumption of Electricity

Source and Data Year	Electricity Use MWh/capita/year	Comments
Illinois Commerce Commission (ICC), 2006	10.14	State-wide electricity sales and number of customers
Energy Information Agency (EIA), 2005	10.77	Illinois average
Energy Information Agency (EIA), 2010	12.97	U.S. average

According to the EIA, at the national level, total electricity sales to all sectors (i.e., residential, commercial, and industrial) are expected to increase from 3,927 billion kWh in 2007 to 5,021 billion kWh in 2035 (AEO2010 reference case, EIA, 2010. During the same time period the projected U.S. population is expected to increase from 302.41 million in 2007 to 390.70 million in 2035. This implies that at the national level, per capita use of electricity is expected to remain relatively constant changing from the 2007 level of 12.97 MWh/capita/year to 12.85 MWh/capita/year in 2035.

In the 22-county area, that total electric energy generation (37,202,116 MWh/year in 2005) greatly exceeds the estimated electricity usage within the study area (estimated at 4,599,372 MWh/year in 2005). Thus, nearly 90 percent of the local electric generation is exported. This result indicates that local demand for electricity will have little influence on the future level of generation. The future generation is determined through the use of assumptions about the proposed new power plants and likely curtailment of generation in the oldest existing plants.

3.4 WATER DEMAND SCENARIOS

The three future scenarios are designed to capture future conditions of water demand for electric power generation which would provide the future water withdrawals for this sector under three different sets of conditions. The scenarios include less resources intensive outcome, current trends (or baseline case), and more resource intensive outcome. The assumptions used in the formulation of each scenario are described below.

3.4.1 Scenario 1 – Current Trends (Baseline Case)

Under this baseline scenario, future generation of electricity in the 22-county study area would continue in the existing power plants and two plants would be completed.

The specific assumptions for the current trends (CT) scenario are:

1. Future generation in the existing power plants will continue at the 2005 level of gross generation.

2. One new power generation plant (Prairie State) will be added at operating at capacity by 2015.

3. A new “clean-coal” power plant similar to FutureGen will be constructed by 2025 and will use Kaskaskia Basin water.

3.4.2 Scenario 2 – Less Resource Intensive Case

The intent of this scenario is to define future conditions which would lead to less water withdrawals by the power generation sector. Such an outcome would result if some of the existing plants would retire and not replace older generating units.

The specific assumptions for the less resource intensive (LRI) scenario are:

1. Future generation in the existing power plants will gradually decline from the 2005 levels of gross generation to reach a level of 50 percent of the capacity at Baldwin and Coffeen plants.

2. One new power generation plant (Prairie State) will be added by 2015.

3.4.3 Scenario 3 –More Resource Intensive Case

The intent of this scenario is to define future conditions which would lead to higher water withdrawals by the power generation sector. Higher water withdrawals would result if additional power plants are built within the study area. Also, it is reasonable to assume that if any new conventional power plants are built anywhere in the country they would be required to use closed-loop cooling systems in accordance with the USEPA Phase I 316(b) rule.

For the purpose of this scenario, an assumption is made that both FutureGen-like plant and two additional clean coal power plants with gross capacity of 650 MW each would be constructed within the 22-county study area. The FutureGen plant would be built by 2020 and the two additional plants would be built later during the planning horizon. For the purpose of constructing this scenario, it is assumed that one plant would be built in Randolph County by 2025 and another in Fayette County by 2035. If the two plants are built, it was assumed that both plants would use Kaskaskia basin water as makeup water for closed-loop cooling system with cooling towers.

The specific assumptions for the more resource intensive (MRI) scenario are:

1. Future generation in the existing power plants will continue at the 2005 level of gross generation.

2. A new "clean-coal" power plant similar to FutureGen will be constructed by 2020 and will use Kaskaskia Basin water.

3. The two proposed coal conversion plants with a power generation component (i.e., Prairie State and Taylorville Energy) would be completed (Prairie State by 2015 and Taylorville Energy by 2020). However, Taylorville energy will rely on treated wastewater from Decatur for any makeup cooling water needs.

4. Two additional new clean coal plants will be constructed within the 22-county study area (one in Randolph and one in Fayette County) during the later part of the study period: one by 2025, and one by 2035. Both will use Kaskaskia Basin water for cooling makeup.

5. The new plants, if built, would be located near high-capacity transmission corridors, would use closed-loop cooling systems.

3.5 SCENARIO RESULTS

The results of the above assumptions for each of the three scenarios on water withdrawals are summarized in Table 3.5 below.

Under the baseline case (CT) scenario, the future total Kaskaskia Basin water withdrawals for power generation would increase from the current volume of 512.7 mgd in 2005 to 541.5 mgd in 2050. This represents an increase of 28.7 mgd or 5.6 percent of the current withdrawals. In terms of makeup water (mostly consumptive use that is associated with makeup water for cooling ponds or towers), water use would increase by 28.7 mgd (or 60.6 percent) from the current value of 47.4 mgd to 76.2 mgd in 2050.

Under the LRI scenario, total Kaskaskia Basin withdrawals would decline by 127.8 mgd, or 24.9 percent, because of the assumption that the existing plants will operate at a lower percentage of their capacity after 2020. The use of makeup water would change only slightly from 47.4 mgd in 2005 to 56.3 mgd in 2050.

Under the MRI scenario, total Kaskaskia Basin water withdrawals would increase by 46.0 mgd or 9.0 percent from the current value of 512.7 mgd to 558.7 mgd by 2050. The makeup water withdrawals would increase by 50.8 mgd (or 107 percent) from the current value of 47.4 mgd to 98.2 mgd in 2050. Most of the projected increase would represent the consumptive use that is associated with makeup water for cooling ponds or towers.

Table 3.5 Thermoelectric Power Generation and Water Demand Scenarios in 22-County Kaskaskia Study Area

Year	Gross Generation within Study Area	Total Kaskaskia Basin Water Withdrawals	Total Kaskaskia Basin Makeup Water Withdrawals
	MWh/year	MGD	MGD
CT			
2005	20,258,143	512.7	47.4
2010	20,258,143	512.7	47.4
2015	31,470,943	536.7	71.4
2020	31,470,943	536.7	71.4
2025	33,398,143	541.5	76.2
2030	33,398,143	541.5	76.2
2035	33,398,143	541.5	76.2
2040	33,398,143	541.5	76.2
2045	33,398,143	541.5	76.2
2050	33,398,143	541.5	76.2
2005-50 Change	13,140,000	28.7	28.7
2005-50, %	64.9	5.6	60.6
LRI			
2005	20,258,143	512.7	47.4
2010	31,470,943	536.7	71.4
2015	31,470,943	536.7	71.4
2020	30,743,431	535.0	69.7
2025	29,710,650	509.9	67.4
2030	28,677,869	484.9	65.2
2035	27,645,088	459.9	63.0
2040	26,612,307	434.9	60.8
2045	25,579,526	409.9	58.5
2050	24,546,745	384.9	56.3
2005-50 Change	4,288,602	-127.8	8.9
2005-50, %	21.2	-24.9	18.8
MRI			
2005	20,258,143	512.7	47.4
2010	20,258,143	512.7	47.4
2015	36,586,783	536.7	71.4
2020	38,513,983	536.7	76.2
2025	43,069,183	547.7	87.2
2030	43,069,183	547.7	87.2
2035	47,624,383	558.7	98.2
2040	47,624,383	558.7	98.2
2045	47,624,383	558.7	98.2
2050	47,624,383	558.7	98.2
2005-50 Change	27,366,240	46.0	50.8
2005-50, %	135.1	9.0	107.0

APPENDIX C ANNEX

Table A3.1 Electric Power Generators in the 22-County Kaskaskia Study Area

Plant name	Owner	County	Water Source	Nameplate Capacity, KW	2005 KWh Generation
Archer Daniels Midland Taylorville	Archer Daniels	Christian	Municipal	4,600	
Kincaid Generation LLC	Dominion Energy Services Co	Christian	Sangchris Lake	1,319,000	6,544,527
Five Oaks Gas Recovery	Central Illinois Pub Serv Co	Christian	n/a	3,200	
Flora Generating Station	City of Flora	Clay	n/a	587	
Flora Site A	City of Flora	Clay	Municipality	5,400	
Flora Site B	City of Flora	Clay	Municipality	3,600	
IMEA Flora	Illinois Municipal Electric Agency	Clay	Municipality	9,000	
Raccoon Creek Energy Center	Union Electric Co.	Clay	--	320,000	42,748
Breese	City of Breese	Clinton	Municipality	11,900	
Altamont	City of Altamont	Effingham	Municipal Water System	7,200	
Freedom Power Project	Southwestern Electric Coop Inc	Fayette	Kaskaskia River	47,000	
Stallings	Dynegy Midwest Generation Inc.	Madison	Municipality	95,200	3,477
Wood River	Dynegy Midwest Generation Inc.	Madison	Mississippi River	650,000	3,168,697
Highland	City of Highland	Madison	Municipality	17,600	
Roxana Resource Recovery	Illinois Electrical Gen Partn	Madison	--	4,400	
IMEA Highland	City of Highland	Madison	Municipality	3,600	
Venice	Ameren/Union Electric Co	Madison	Mississippi River	623,500	
Kinmundy	Ameren CIPS Co	Marion	--	270,000	
IMEA Waterloo	Illinois Municipal Electric Agency	Monroe	Municipality	5,400	
Waterloo	City of Waterloo	Monroe	Municipality	17,800	
Coffeen	Ameren Energy	Montgomery	Mcdavid Branch	1,005,400	4,779,268
Sullivan	City of Sullivan	Moultrie	--	18,500	13,353,176
Baldwin Energy Complex	Dynegy Midwest Gen. Inc.	Randolph	Baldwin Lake	1,892,100	
Red Bud	Red Bud City of	Randolph	Municipality	16,500	
Holland Energy Facility	Holland Energy LLC	Shelby	Kaskaskia River	665,000	857,194
Energy Shelby County	GenOn Energy Inc.	Shelby	City of Neoga, Lake Mattoon	360,000	84,917
Freeburg	Village of Freeburg	St Clair	Municipal -Village of Freeburg	10,300	
Mascoutah	City of Mascoutah	St Clair	Municipality	6,700	
Milam Gas Recovery	Bio-Energy Partners	St Clair	--	2,400	20,824
MEP Investments LLC	MEP Investments LLC	Washington	Wells	456	
Prairie State Generating Station	Prairie Power Inc	Washington	Kaskaskia River (Cooling)	1,600,000	
Fairfield	City of Fairfield	Wayne	Municipality	7,500	
Total				7,985,946	28,854,828

Source: U.S. Department of Energy, The Energy Information Administration (EIA) 2005 EIA-906/920 Monthly Time Series File and EIA-860

Table A3.2 Total Water Withdrawals for Thermoelectric Generation by County for Three Scenarios (in MGD)

County	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
CT	*Current Trends (Baseline Case) Scenario*									
Christian	784.1	784.1	784.1	784.1	784.1	784.1	784.1	784.1	784.1	784.1
Coles	0.00	0.00	0.00	0.00	4.75	4.75	4.75	4.75	4.75	4.75
Jasper	525.3	525.3	525.3	525.3	525.3	525.3	525.3	525.3	525.3	525.3
Montgomery	474.8	474.8	474.8	474.8	474.8	474.8	474.8	474.8	474.8	474.8
Randolph	32.3	32.3	32.3	32.3	32.3	32.3	32.3	32.3	32.3	32.3
Shelby	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6
Washington	0.0	0.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0
Madison	292.1	292.1	292.1	292.1	292.1	292.1	292.1	292.1	292.1	292.1
Total	2,114.2	2,114.2	2,138.2	2,138.2	2,143.0	2,143.0	2,143.0	2,143.0	2,143.0	2,143.0
Total Kaskaskia	512.7	512.7	536.7	536.7	536.7	536.7	536.7	536.7	536.7	536.7
LRI	*Less Resource Intensive Scenario*									
Christian	784.1	784.1	784.1	738.6	693.1	647.5	602.0	556.5	511.0	465.4
Coles	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jasper	525.3	525.3	525.3	525.3	525.3	525.3	525.3	525.3	525.3	525.3
Montgomery	474.8	474.8	474.8	474.8	451.5	428.3	405.0	381.8	358.5	335.3
Randolph	32.3	32.3	32.3	30.6	28.8	27.0	25.3	23.5	21.8	20.0
Shelby	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6
Washington	0.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0
Madison	292.1	292.1	292.1	292.1	292.1	292.1	292.1	292.1	292.1	292.1
Total	2,114.2	2,138.2	2,138.2	2,090.9	2,020.4	1,949.9	1,879.3	1,808.8	1,738.3	1,667.7
Total Kaskaskia	512.7	536.7	536.7	535.0	509.9	484.9	459.9	434.9	409.9	384.9
MRI	*More Resource Intensive Scenario*									
Christian	784.1	784.1	784.1	738.6	693.1	647.5	602.0	556.5	511.0	465.4
Coles	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jasper	525.3	525.3	525.3	525.3	525.3	525.3	525.3	525.3	525.3	525.3
Montgomery	474.8	474.8	474.8	474.8	451.5	428.3	405.0	381.8	358.5	335.3
Randolph	32.3	32.3	32.3	30.6	28.8	27.0	25.3	23.5	21.8	20.0
Shelby	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6
Washington	0.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0
Madison	292.1	292.1	292.1	292.1	292.1	292.1	292.1	292.1	292.1	292.1
Total	2,114.2	2,138.2	2,138.2	2,090.9	2,020.4	1,949.9	1,879.3	1,808.8	1,738.3	1,667.7
Total Kaskaskia	512.7	536.7	536.7	535.0	509.9	484.9	459.9	434.9	409.9	384.9

Table A3.3 Makeup Water Withdrawals for Thermoelectric Generation by County for Three Scenarios (in MGD)

County	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
CT	*Current Trends (Baseline Case) Scenario*									
Bond	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Christian	15.7	15.7	15.7	15.7	15.7	15.7	15.7	15.7	15.7	15.7
Clay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Clinton	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Coles	0.0	0.0	0.0	0.0	4.8	4.8	4.8	4.8	4.8	4.8
Cumberland	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Douglas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Effingham	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fayette	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Jasper	10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5
Marion	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Montgomery	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5
Moultrie	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Randolph	32.3	32.3	32.3	32.3	32.3	32.3	32.3	32.3	32.3	32.3
Richland	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shelby	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6
Washington	0.0	0.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0
Wayne	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Macoupin	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Madison	28.6	28.6	28.6	28.6	28.6	28.6	28.6	28.6	28.6	28.6
Monroe	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Saint Clair	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total 22-co. area	102.2	102.2	126.2	126.2	130.9	130.9	130.9	130.9	130.9	130.9
Total Kaskaskia	47.4	47.4	71.4	71.4	76.2	76.2	76.2	76.2	76.2	76.2
LRI	*Less Resource Intensive Scenario*									
Bond	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Christian	15.7	15.7	15.7	14.8	13.9	13.0	12.0	11.1	10.2	9.3
Clay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Clinton	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Coles	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cumberland	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Douglas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Effingham	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fayette	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Jasper	10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5
Marion	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Montgomery	9.5	9.5	9.5	9.5	9.0	8.6	8.1	7.6	7.2	6.7

Moultrie	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Randolph	32.3	32.3	32.3	30.6	28.8	27.0	25.3	23.5	21.8	20.0
Richland	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shelby	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6
Washington	0.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0
Wayne	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Macoupin	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Madison	28.6	28.6	28.6	28.6	28.6	28.6	28.6	28.6	28.6	28.6
Monroe	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Saint Clair	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total 22-co. area	102.2	126.2	126.2	123.5	120.4	117.2	114.1	111.0	107.8	104.7
Total Kaskaskia	47.4	71.4	71.4	69.7	67.4	65.2	63.0	60.8	58.5	56.3
MRI	*More Resource Intensive Scenario*									
Bond	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Christian	15.7	15.7	16.2	16.2	16.2	16.2	16.2	16.2	16.2	16.2
Clay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Clinton	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Coles	0.0	0.0	0.0	4.8	4.8	4.8	4.8	4.8	4.8	4.8
Cumberland	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Douglas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Effingham	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fayette	0.0	0.0	0.0	0.0	0.0	0.0	11.0	11.0	11.0	11.0
Jasper	10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5
Marion	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Montgomery	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5
Moultrie	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Randolph	32.3	32.3	32.3	32.3	43.3	43.3	43.3	43.3	43.3	43.3
Richland	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shelby	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6
Washington	0.0	0.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0
Wayne	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Macoupin	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Madison	28.6	28.6	28.6	28.6	28.6	28.6	28.6	28.6	28.6	28.6
Monroe	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Saint Clair	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total 22-co. area	102.2	102.2	126.7	131.5	142.5	142.5	153.5	153.5	153.5	153.5
Total Kaskaskia	47.4	47.4	71.4	76.2	87.2	87.2	98.2	98.2	98.2	98.2

Appendix D

PUBLIC WATER SUPPLY

4.1 BACKGROUND

Public water supply refers to 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. EPA defines a “public” water system as a publicly-owned or privately-owned system that serves at least 25 people or 15 service connections for at least 60 days per year (USEPA, 2004a).

Not all users of water within a given geographical area rely on water delivered by public systems; some users have their own sources of supply and are considered to be self-supplied. The self-supplied users include industrial and commercial establishments that rely on their own wells or surface water intakes, as well as residential users who rely on private wells. The latter group of users is called the self-supplied domestic sector, and is included in Appendix E of this report.

4.1.1 Definition of Study Areas

According to the EPA data, there are 290 public water supply systems in the 22 counties of Central and Southwestern Illinois (Table 4.1). In 2005, these systems served the estimated population of 1,055,928 persons, as well as local businesses and institutions. The comparison of total resident population in each county with population served by public systems implies that in 2005 an additional 120,341 people (or about 10 percent of total population in the 22-county area) were served by domestic wells and other sources in the self-supplied domestic sector.

In order to develop future public water-use scenarios for the 22-county area, a sample of 62 large “dominant” public water supply systems (with some systems including multiple subsystems) was selected for detailed study of historical water use (see Figure 4.1). Each dominant system was defined as a water supply system in a geographical area consisting of one or more geographical parts with contiguous piped water services. Typically, the dominant system would consist of a water source (surface water, groundwater or purchased water), and related infrastructure, through which water is delivered to a part, or, in some cases, to the entire geographical area. If only a part of an area is served by the dominant system, the “system” definition, and its related statistical information, also includes all of the population, water demand, and related data for the entire partially-served entity, including water from sources other than the dominant system.

In addition to the 62 large systems, the remaining smaller systems within each county were combined into county remainder (or residual) study sub-areas. This allowed us to include all public-water supply systems when developing water demand scenarios. The complete listing of dominant systems and systems included in county residual areas is given in Table A4-1 in the Annex to this chapter.

Figure 4.1 Location of Cities Selected as Study Sites in the 22-county Study Area

Table 4.1 Public Water Supply Systems in the 22-County Study Area by County

County	2005 Resident County Population [a]	All Public Systems [b]		Systems used in Modeling	
		Number of Water Systems	Est. 2005 Population Served	Number of Water Systems	Est. 2005 Population Served
Bond	18,027	9	16,180	2	7,964
Christian	35,176	14	29,178	3	22,6 82
Clay	14,122	7	8,172	3	6,766
Clinton	36,095	21	33,044	5	14,045
Coles	51,065	13	75,503	3	38,071
Cumberland	10,973	4	4,786	2	3,054
Douglas	19,950	11	22,860	3	9,634
Effingham	34,581	13	33,227	3	25,011
Fayette	21,713	10	15,416	3	9,431
Jasper	10,020	5	16,545	2	3,329
Macoupin*	49,111 (17,657)	4	7,746	1	2,160
Madison*	264,309 (63,284)	14	36,565	2	19,749
Marion	40,144	16	48,134	5	25,048
Monroe*	31,040 (18,189)	3	9,429	1	484
Montgomery	30,396	18	17,416	2	7,613
Moultrie	14,510	7	12,981	4	9,636
Randolph	33,122	15	29,846	5	11,985
Richland	15,798	9	11,952	2	9,342
Shelby	22,322	11	15,401	3	9,966
St Clair*	260,067 (146,786)	18	91,389	3	37,698
Washington	14,922	12	15,467	3	4,753
Wayne	16,796	10	12,258	2	5,761
Totals*	1,044,259 (685,648)	244	563.495	62	284,182

[a] Source: Population Division, U.S. Census Bureau, Release Date: March 16, 2006

[b] Number of systems and population served obtained from Illinois EPA http://www.epa.state.il.us/water/drinking-water-watch/ . For 1995, the USGS estimated total resident population of the Kaskaskia basin of 429,210 persons (with 302,750 served by public systems).

* For these four western counties, the entire area of the county is reflected in the total population. However, the study area encompasses only those portions of these counties that are within the Kaskaskia watershed. The estimated resident population in partial counties is shown in parentheses.

4.1.2 Historical Water Withdrawal and Use Data

The data on public-supply water withdrawals were obtained from Mr. Timothy Bryant, Coordinator of the Illinois Water Inventory Program administered by the Illinois State Water Survey (ISWS). Under this program, a questionnaire is sent to all of the nearly 1,800 community water systems in the state. The questionnaire includes questions about water sources, withdrawals, and water deliveries to domestic, commercial, and industrial users (ISWS, 2007). If systems do not complete a survey for the USGS target years, water withdrawal is estimated based on extrapolation from data submitted in previous years. The withdrawal and population served data from each reporting system were aggregated to create the data on water use for the 62 dominant public water supply systems and 22 combined county remainder (or residual) sub-areas.

The IWIP data base contains data on annual withdrawals and purchases of water by public water supply systems. Only a subset of systems withdraws water directly from surface or groundwater sources. Other systems rely entirely on water purchased from a neighboring system or combine their own (self-supplied) withdrawals with purchases. For the purpose of this study, the reported data on self-supplied withdrawals and purchases for the 62 dominant systems were adjusted to include only water used in their respective retail service areas. Similarly, water use the "county remainder" areas represents only water delivered to retail service areas of the remaining systems in each county. This conversion of water withdrawals into water use in demand areas was necessary in order to develop forecasts of future water demand because the socioeconomic data correspond to water demand areas.

Table 4.2 shows the historical (1985-2005) data on estimated retail population served obtained from the IWIP database in the 62 public supply systems and 22 county residual sub-areas that were included in this study. According to the estimates in Table 4.2, retail service areas of the 62 systems served the population of 284,182 persons in 2005. Retail areas of all systems in county residual areas (within the study area) served 274,313 persons. Therefore, the total estimated population served in the 22-county study area was 558,495. These numbers closely correspond with the independently derived EPA estimates for all public systems shown in Table 4.1.

Table 4.2 Estimated Population Served by Public Water Systems

City/System/ Study Area	County	1985	1990	1995	2000	2005	2005 IWIP*
Greenville	Bond	5,271	6,656	6,200	7,264	7,264	7,264
Mulberry Grove	Bond	707	650	700	700	700	700
Bond County Residual	Bond	2,396	2,342	2,562	2,603	8,216	7,124
Kincaid	Christian	1,591	1,353	1,337	1,647	1,400	1,400
Pana	Christian	6,040	5,997	5,961	5,300	5,800	2,400
Taylorville	Christian	10,940	12,753	10,483	10,047	15,482	11,500
Christian County Resid.	Christian	7,471	6,983	6,515	6,424	6,496	4,023
Clay City	Clay	953	988	787	929	1,000	1,000
Flora	Clay	5,473	6,130	5,706	5,276	4,766	5,200
Louisville	Clay	1,120	1,200	1,200	1,242	1,000	1,000
Clay County Residual	Clay	1,031	659	764	593	1,406	786
Breese	Clinton	3,600	3,600	3,630	4,100	4,500	4,500
Carlyle	Clinton	3,500	3,500	3,500	3,406	3,425	3,425
Gateway Regional WC	Clinton	0	0	0	0	0	0
New Baden	Clinton	2,437	2,500	3,050	3,350	3,490	3,100

City/System/ Study Area	County	1985	1990	1995	2000	2005	2005 IWIP*
Trenton	Clinton	2,490	2,525	2,560	2,512	2,630	2,600
Clinton County Residual	Clinton	11,443	12,134	14,343	16,457	18,999	12,990
Charleston	Coles	19,354	19,950	20,400	20,000	21,500	21,500
Mattoon	Coles	18,750	21,602	22,100	21,326	15,481	18,000
Oakland	Coles	1,100	1,065	1,077	1,101	1,090	996
Coles County Residual	Coles	16,653	18,605	18,315	20,325	37,432	37,432
Neoga	Cumberland	1,658	1,700	1,790	1,775	1,854	1,854
Toledo	Cumberland	1,187	1,189	1,189	1,189	1,200	1,200
Cumberland County Res.	Cumberland	2,002	1,815	1,916	1,862	1,732	1,732
Arcola	Douglas	2,714	2,678	2,678	2,652	2,652	2,652
Tuscola	Douglas	4,070	4,500	4,339	4,324	4,448	4,448
Villa Grove	Douglas	2,600	2,700	2,700	2,734	2,534	2,534
Douglas County Residual	Douglas	2,546	3,250	10,369	12,173	13,226	5,050
Altamont	Effingham	1,394	1,034	1,076	2,595	2,501	2,283
Effingham	Effingham	7,050	4,425	4,513	12,000	20,510	12,000
Teutopolis	Effingham	1,680	1,700	2,000	2,000	2,000	1,600
Effingham County Resid.	Effingham	5,056	5,839	5,489	5,856	8,216	4,166
Ramsey	Fayette	1,058	1,100	976	1,000	1,000	1,000
St Elmo	Fayette	1,611	1,500	1,400	1,400	1,456	1,456
Vandalia	Fayette	6,110	6,022	6,000	6,975	6,975	6,975
Fayette County Residual	Fayette	2,980	2,759	3,067	5,583	5,985	5,410
Newton	Jasper	3,230	3,538	3,379	3,069	3,069	3,069
Saint Marie	Jasper	312	335	332	262	260	260
Jasper County Residual	Jasper	292	256	1,840	9,342	13,216	230
Mount Olive	Macoupin	2,463	2,200	2,100	2,150	2,160	2,160
Macoupin County Resid.	Macoupin	5,104	5,112	5,191	5,525	5,586	25,064
Highland	Madison	4,170	5,756	9,138	8,224	9,799	9,443
Troy	Madison	5,230	6,046	7,329	8,000	9,950	9,950
Madison County Residual	Madison	5,804	6,865	6,954	13,295	16,816	213,831
Centralia	Marion	14,222	15,000	31,293	16,000	14,200	1,4200
Kinmundy	Marion	945	900	1,000	900	892	892
Patoka	Marion	1,187	550	650	639	633	633
Salem	Marion	7,740	7,813	7,530	7,730	7,945	7,945
Wamac	Marion	1,650	1,617	1,500	1,500	1,378	1,378
Marion County Residual	Marion	9,233	11,417	11,489	11,249	18,086	18,466
Hecker	Monroe	531	543	500	475	484	280
Monroe County Residual	Monroe	5,036	5,138	7,089	7,614	8,945	19,809
Hillsboro	Montgomery	2,109	2,656	5,915	2,500	3,887	6,000
Litchfield	Montgomery	6,730	6,832	8,393	5,248	3,726	7,000
Montgomery County Res.	Montgomery	9,308	9,410	9,107	10,752	9,803	3,687
Arthur	Moultrie	1,332	1,000	2,100	2,100	2,300	2,300
Bethany	Moultrie	1,550	1,368	1,368	1,300	1,268	1,268
Lovington	Moultrie	1,313	1,300	1,300	1,222	1,222	1,222
Sullivan	Moultrie	4,400	4,367	4,354	4,350	4,846	4,846
Moultrie County Residual	Moultrie	3,434	3,460	3,407	5,933	3,345	845
Coulterville	Randolph	1,118	1,100	1,100	1,230	1,230	1,230
Evansville	Randolph	863	863	850	800	750	750

City/System/ Study Area	County	1985	1990	1995	2000	2005	2005 IWIP*
Red Bud	Randolph	2,920	2,850	3,100	3,400	3,442	3,442
Sparta	Randolph	4,830	5,000	4,600	4,431	4,486	4,486
Steeleville	Randolph	2,240	2,040	2,042	2,077	2,077	2,077
Randolph County Resid.	Randolph	15,204	15,289	14,994	16,342	17,861	21,634
Noble	Richland	832	832	750	400	342	342
Olney	Richland	9,090	8,700	10,100	9,100	9,000	9,000
Richland County Residual	Richland	1,113	1,073	1,709	1,452	2,610	1,106
Moweaqua	Shelby	1,922	1,931	1,800	1,800	2,000	2,000
Shelbyville	Shelby	4,950	5,000	5,000	5,000	6,841	--
Windsor	Shelby	1,228	1,225	1,200	1,243	1,125	1,125
Shelby County Residual	Shelby	3,815	4,030	3,855	4,058	5,435	4,190
Freeburg	St Clair	2,989	3,318	2,800	4,136	4,398	4,398
Kaskaskia Water District	St Clair	10,897	11,519	18,455	15,125	14,462	10,404
S L M Water Commission	St Clair	13,809	14,865	22,037	16,948	18,838	--
Shiloh	St Clair	0	0	3,300	0	0	--
St. Clair County Residual	St Clair	40,150	43,314	58,904	64,018	53,691	261,470
Ashley	Washington	658	650	650	311	308	289
Nashville	Washington	2,183	2,418	2,417	2,417	3,090	3,147
Okawville	Washington	1,976	1,274	1,274	1,300	1,355	1,355
Washington County Res.	Washington	7,140	7,476	15,107	10,017	10,714	2,752
Fairfield	Wayne	2,998	4,906	6,849	5,338	4,661	5,421
Wayne City	Wayne	1,132	900	1,100	1,300	1,100	1,100
Wayne County Residual	Wayne	2,204	2,107	3,915	4,826	6,497	2,305
Totals for 62 dominant systems		240,207	250,229	294,957	268,869	284,182	246,601
Total for county residuals		159,415	169,333	206,901	236,299	274,313	--
Total study area**		399,622	419,562	501,858	505,168	558,495	--

*2005 IWIP column shows the “unadjusted” estimates of population served in the IWIP data base for 2005 (designated as “pop_in” column).

**The total study area includes 18 entire counties and 4 partial county areas of Macoupin, Madison, Monroe and St. Clair counties.

The last two columns in Table 4.2 compare the originally reported population served (as pop_in) in the IWIP data base with adjusted numbers used in this study. In most cases the numbers are identical. The differences appear primarily in the estimates of population served in county residual areas and in 17 out of 62 systems. For example, for Pana (Christian County) population was reported to be 2,400 (plus 525 as “pop_out”). The adjusted value is 5,800 (based on reported values in other years).

Table 4.3 shows the adjusted historical water use data for the 62 dominant public supply systems and 22 county residual areas. The data indicate the total 2005 system use of 42.35 million gallons per day (mgd). An additional 15.73 mgd were used by the systems in county residual sub-areas. The combined public-supply use in 2005 was 58.08 mgd and when divided by total population served of 558,495 persons, this total use was equivalent to the usage rate of approximately 104 gallons per capita per day (gpcd). Between 1985 and 2005, total public supply use has increased by 11.33 mgd or 24.2 percent. This implies average annual compounded growth rate of 1.0 percent. During the same period total population served has increased by 40 percent. The last column of Table 4.3 shows reported self-supplied withdrawals by systems included in the study.

Table 4.3 Historical Public-Supply Retail Water Use within Study Area (in MGD)

County	City/System /Study Area	1985	1990	1995	2000	2005	2005 IWIP*
Bond	Greenville	0.543	0.706	1.034	1.067	1.288	1.399
	Mulberry Grove	0.041	0.037	0.039	0.034	0.045	--
	Bond County Residual	0.220	0.213	0.187	0.200	0.535	--
Christian	Kincaid	0.222	0.223	0.255	0.140	0.127	--
	Pana	1.161	1.412	1.039	0.800	0.602	0.602
	Taylorville	2.422	2.674	1.737	2.374	2.175	2.361
	Christian County Residual	0.541	0.568	0.686	0.688	0.687	--
Clay	Clay City	0.086	0.086	0.091	0.089	0.076	0.076
	Flora	0.729	0.651	0.624	0.641	0.587	0.659
	Louisville	0.073	0.084	0.103	0.120	0.121	--
	Clay County Residual	0.052	0.053	0.055	0.044	0.080	--
Clinton	Breese	0.342	0.392	0.381	0.469	0.548	0.704
	Carlyle	0.416	0.508	0.452	0.597	0.733	1.342
	Gateway Regional WC	0.000	0.000	0.000	0.000	0.000	--
	New Baden	0.196	0.212	0.252	0.334	0.384	--
	Trenton	0.164	0.115	0.197	0.180	0.191	--
	Clinton County Residual	0.798	0.865	1.015	1.321	1.563	--
Coles	Charleston	1.307	1.211	1.811	1.473	1.310	1.557
	Mattoon	2.877	3.209	2.811	2.760	1.736	2.595
	Oakland	0.115	0.113	0.140	0.129	0.076	--
	Coles County Residual	0.816	0.901	1.046	0.962	1.056	--
Cumberland	Neoga	0.141	0.134	0.142	0.142	0.158	0.158
	Toledo	0.101	0.100	0.110	0.107	0.097	0.108
	Cumberland County Residual	0.172	0.171	0.205	0.200	0.198	--
Douglas	Arcola	0.240	0.215	0.333	0.316	0.316	--
	Douglas County Residual	0.281	0.294	1.120	1.136	1.232	--
	Tuscola	0.575	0.652	0.416	0.420	0.452	--
	Villa Grove	0.270	0.287	0.308	0.276	0.292	0.292
Effingham	Altamont	0.219	0.203	0.214	0.203	0.222	0.267
	Effingham	1.303	1.207	1.954	2.123	1.368	2.086
	Teutopolis	0.159	0.145	0.159	0.173	0.166	0.076
	Effingham County Residual	0.404	0.426	0.508	0.457	0.554	--
Fayette	Ramsey	0.093	0.085	0.093	0.094	0.086	0.086
	St Elmo	0.127	0.149	0.171	0.104	0.144	--
	Vandalia	0.424	0.639	0.752	0.655	0.836	0.991
	Fayette County Residual	0.354	0.456	0.398	0.568	0.586	--
Jasper	Newton	0.347	0.372	0.364	0.343	0.311	0.311
	Saint Marie	0.034	0.025	0.027	0.030	0.030	0.030
	Jasper County Residual	0.031	0.025	0.055	0.674	0.895	--
Macoupin	Mount Olive	0.248	0.220	0.185	0.214	0.205	0.234

County	City/System /Study Area	1985	1990	1995	2000	2005	2005 IWIP*
	Macoupin County Residual	0.441	0.525	0.588	0.592	0.471	--
Madison	Highland	0.764	1.116	0.060	1.087	1.007	1.309
	Troy	0.778	0.901	1.042	1.337	1.552	1.552
	Madison County Residual	0.529	0.690	0.763	0.836	0.984	--
Marion	Centralia	2.619	2.381	2.548	2.880	2.608	3.863
	Kinmundy	0.118	0.081	0.136	0.107	0.083	0.083
	Patoka	0.046	0.062	0.040	0.063	0.053	0.053
	Salem	0.682	0.728	0.834	0.920	0.926	1.260
	Wamac	0.094	0.095	0.091	0.089	0.087	--
	Marion County Residual	0.736	0.760	0.804	1.007	1.037	--
Monroe	Hecker	0.032	0.032	0.032	0.031	0.042	--
	Monroe County Residual	0.442	0.502	0.687	0.753	0.759	--
Montgomery	Hillsboro	0.942	0.878	0.908	1.004	1.132	1.359
	Litchfield	1.136	1.106	1.412	1.219	0.678	0.968
	Montgomery County Residual	0.751	0.832	0.776	0.879	1.006	--
Moultrie	Arthur	0.236	0.264	0.241	0.273	0.255	0.255
	Bethany	0.110	0.118	0.116	0.109	0.117	0.117
	Lovington	0.116	0.147	0.105	0.087	0.102	0.102
	Sullivan	0.497	0.607	0.494	0.657	0.621	0.847
	Moultrie County Residual	0.223	0.220	0.316	0.169	0.260	--
Randolph	Coulterville	0.186	0.182	0.179	0.143	0.143	0.143
	Evansville	0.076	0.073	0.078	0.068	0.072	0.072
	Red Bud	0.400	0.317	0.324	0.324	0.399	0.399
	Sparta	0.595	0.610	0.562	0.515	0.989	1.382
	Steeleville	0.196	0.256	0.268	0.281	0.273	0.273
	Randolph County Residual	2.286	1.953	1.935	2.089	1.768	--
Richland	Noble	0.049	0.048	0.060	0.064	0.064	--
	Olney	1.123	1.371	1.519	1.316	1.303	1.430
	Richland County Residual	0.087	0.078	0.096	0.091	0.184	--
Shelby	Moweaqua	0.137	0.164	0.178	0.192	0.171	0.171
	Shelbyville	0.639	0.540	0.757	0.818	0.697	0.750
	Windsor	0.091	0.085	0.103	0.092	0.090	0.090
	Shelby County Residual	0.326	0.337	0.345	0.349	0.400	--
St Clair	Freeburg	0.314	0.283	0.323	0.358	0.365	--
	Kaskaskia Water District	0.664	0.937	1.107	1.073	1.157	1.157
	SLM Water Commission	1.580	1.736	2.052	2.316	2.706	2.706
	Shiloh	0.000	0.239	0.294	0.290	0.000	--
	St. Clair County Residual	5.168	5.606	6.385	7.050	7.904	--
Washington	Ashley	0.060	0.059	0.068	0.041	0.039	--
	Nashville	0.690	0.622	0.636	0.505	0.948	0.542
	Okawville	0.109	0.108	0.105	0.112	0.135	--
	Washington County Residual	0.688	0.714	0.858	0.999	1.106	--
Wayne	Fairfield	1.002	0.926	0.904	0.859	0.812	0.923
	Wayne City	0.166	0.303	0.335	0.615	0.140	0.308
	Wayne County Residual	0.188	0.190	0.188	0.203	0.369	--
Totals for dominant systems		36.389	39.052	40.490	43.307	42.352	38.048
Total for county residuals		10.366	10.773	12.631	14.217	15.730	--

County	City/System /Study Area	1985	1990	1995	2000	2005	2005 IWIP*
Total study area**		46.755	49.825	53.121	57.524	58.082	61.128

* 2005 IWIP column shows the reported self-supplied withdrawals by systems in the study ("--" indicates all water is purchased except for county residuals where withdrawals were not estimated).
** Total study area withdrawals exclude withdrawals by Chester and Illinois American in East St. Louis, Alton and Granite City

In addition to public supply withdrawals, some withdrawals were made by self-supplied domestic users. Table 4.4 compares populations served by public-systems and self-supplied population by county.

Table 4.4 Self-Supplied Population and Domestic Withdrawals by County in 2005

County	2005 Resident County Population [a]	Self-Supplied Population		Population Served by Public Systems [b]		
		2005 USGS Reported Population	Calculated Un-served Population	Dominant Systems	County Remainder Areas	Total
Bond	18,027	4,907	1,847	7,964	8,216	16,180
Christian	35,176	9,996	5,998	22,682	6,496	29,178
Clay	14,122	5,992	5,950	6,766	1,406	8,172
Clinton	36,095	7,165	3,051	14,045	18,999	33,044
Coles*	51,065	1,965	-24,438	38,071	37,432	75,503
Cumberland	10,973	6,093	6,187	3,054	1,732	4,786
Douglas*	19,950	6,170	-2,910	9,634	13,266	22,860
Effingham	34,581	14,501	1,354	25,001	8,216	33,227
Fayette	21,713	7,953	6,297	9,431	5,985	15,416
Jasper*	10,020	2,930	-6,525	3,329	13,216	16,545
Macoupin**	49,111 (17,657)	9,911	41,365	2,160	5,586	7,746
Madison**	264,309 (63,284)	26,719	227,744	19,749	16,816	36,565
Marion*	40,144	1,754	-2,990	25,048	18,086	43,134
Monroe**	31,040 (18,189)	8,760	21,611	484	8,945	9,429
Montgomery	30,396	8,766	12,980	7,613	9,803	17,416
Moultrie	14,510	3,370	1,529	9,636	3,345	12,981
Randolph	33,122	7,032	3,276	11,985	17,861	29,846
Richland	15,798	2,378	3,846	9,342	2,610	11,952
Shelby	22,322	6,242	6,921	9,966	5,435	15,401
St Clair**	260,067 (146,786)	55,397	168,678	37,698	53,691	91,389
Washington*	14,922	7,272	-545	4,753	10,714	15,467
Wayne	16,796	5,236	4,538	5,761	6,497	12,258
Totals	1,044,259 (685,648)	210,509	485,764	284,182	274,313	558,495

[a] Source: Population Division, U.S. Census Bureau, Release Date: March 16, 2006
[b] Ppopulation served obtained from Illinois EPA http://www.epa.state.il.us/ water/drinking-water-watch/ .

*Negative values of un-served population indicate that dominant systems serve population in the neighboring counties.
** The entire area of the county is reflected in the total resident population. The calculated un-served population for these four counties includes both un-served population and population served by systems outside of the Kaskaskia basin study area.

4.2 WATER-DEMAND RELATIONSHIPS

4.2.1 Data on Explanatory Variables

A substantial data collection and processing effort was required in order to prepare appropriate explanatory variables for development of water-demand relationships. The dependent variable for the public-supply sector was defined as gross water demand per capita (including residential deliveries as well as deliveries to commercial, industrial, and institutional establishments located within areas served by public systems). Five independent variables were used to explain the variability of per capita water usage across study sites and at different time periods. They included: summer season air temperature, summer season precipitation, ratio of local employment-to-population, marginal price of water, and median household income. The data on the weather variables were obtained from the Center for Atmospheric Science of the Illinois State Water Survey. The data included observations on monthly temperature and precipitation for 22 stations in the study area, listed in Table 4.5. The weather data for each system and county remainder area were obtained from the closest station.

Table 4.5 Locations of Weather Stations in the Study Area

Station No.	Location	County
118781	Vandalia	Bond
115841	Morrisonville	Christian
113109	Flora 5 NW	Clay
111290	Carlyle Reservoir*	Clinton
111436	Charleston	Coles
112687	Effingham	Cumberland
118684	Tuscola^	Douglas
112687	Effingham	Effingham
118781	Vandalia	Fayette
112687	Effingham	Jasper
114108	Hillsboro	Macoupin
110137	Alton Melvin Price L&D	Madison
117636	Salem	Marion
118147	Sparta 1 W	Monroe
114108	Hillsboro	Montgomery
119354	Windsor	Moultrie
118147	Sparta 1 W	Randolph
116446	Olney 2S	Richland
119354	Windsor	Shelby
110510	Belleville SIU Rsch	St. Clair

116011	Nashville	Washington
112931	Fairfield Radio WFIW	Wayne

* Station No. 110510; Location Belleville SIU RSCH used for temperature and precipitation for year 1990.
^ Station No. 118740; Location Urbana used for temperature for year 2000.

Data on employment and median household income were obtained from the U.S. Census (http://quickfacts.census.gov/qfd/states) and from the 2005 American Community Survey. Data on historical prices of water were developed using data from a survey of state water prices conducted in 2003 (Dziegielewski, Kiefer and Bik, 2004). The 2005 and more recent prices were obtained from other available sources and through a direct telephonic contact with water utilities.

One additional variable was included to account for unspecified changes in usage rates that are likely to be influencing water withdrawals over time, and that represents general trends in water conservation behavior. Such influences include the increase in water-use awareness programs, implementation of Federal laws mandating adoption of conservation technologies, and a new emphasis on adoption of full-cost pricing of water. The "conservation trend" variable was specified as zero for 1985, 5 for 1990, 10 for 1995, 15 for 2000, and 20 for the year 2005.

4.2.2 Per Capita Water Withdrawals Equation

A log-linear model (specified as Equation 3 in Chapter 1) was applied to capture the relationship between per capita water withdrawals (and purchases) and the explanatory variables.

The statistical model explained per capita water withdrawal as a function of the maximum daily air temperatures during growing season (May to September), total precipitation during growing season, the ratio of employment to resident population, the marginal price of water, median household income, and the conservation trend variable.

The estimated structural part of the regression model is shown in Table 4.6. The complete model with estimates of the coefficients of binary variables is included as Table A4.14 in the Annex to this chapter. The Annex also includes a detailed description of the analytical steps of model development.

Table 4.6 Estimated Log-Linear Model of Per Capita Water Demand (GPCD) in Public-Supply Sector (Structural Variables Only)

Variables*	Estimated Coefficient	t Ratio	Probability >|t|
Structural model			
Intercept	-0.6474	-0.22	0.8289
Max. summer temperature (ln)	0.9775	1.47	0.1429
Summer precipitation (ln)	-0.0584	-1.32	0.1887

Variables*	Estimated Coefficient	t Ratio	Probability >|t|
Employment-population ratio	0.3982	8.77	<.0001
Marginal price of water (ln)	-0.0612	-2.54	0.0114
Median household income (ln)	0.3008	4.50	<.0001
Conservation trend	-0.0054	-2.69	0.0074

*Other model parameters and diagnostics are included in the Annex.

The estimated elasticities of the explanatory variables in the structural model have the expected signs and magnitudes. The constant elasticity of summer season temperature indicates that, on average, a 1 percent increase in temperature increases per capita water usage by 0.9775 percent. The negative constant elasticity of summer rainfall variable indicates that on average a 1 percent increase in summer precipitation decreases per capita water usage by 0.0584 percent. Similarly, a 1 percent increase in marginal price of water is associated with a 0.0.0612 percent decrease in per capita water deliveries, and a 1 percent increase in median household income results in a 0.3008 percent increase in per capita water usage.

The coefficient of employment-to-population ratio of 0.3982 indicates that in study areas with higher commercial/industrial employment relative to resident population, per capita water usage tends to be higher.

Another variable is the conservation trend, with the estimated coefficient of -0.0054. It indicates that in the historical data there was a significant declining trend in per capita water withdrawals of approximately 0.54 percent per year (the value of the coefficient multiplied by 100%).

The estimated regression equation also includes binary variables with statistically significant regression coefficients. These variables provide for a tighter fit of the model predictions to historical data, and their coefficients represent adjustments to the model intercept for individual study sites. The complete regression model explained 75 percent of time-series and cross-sectional variance in log-transformed per capita water use. 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 model is 15.4 percent.

4.2.3 Model Estimated and Reported Water Use in 2005

The estimated water-demand equations were used to generate estimates of both the historical and future water demand in each of the 84 study areas. Table 4.5 compares the reported and model-estimated values of per capita water-use rates for each system, and within county residual areas for 2005. In most cases, the differences between the predicted and reported values were relatively small. In cases where the differences for the 2005 data year were significant, additional calibrations of model intercepts were performed. The calibrated 2005 intercepts (shown in the last column of Table 4.3) were retained in preparing estimates of future water use. In 16 study areas, adjustments were made to the original data on water use and/or population served when preparing the final forecasts and the calibrated per capita rates significantly differ from the values that were initially used. These systems are identified with the asterisk in Table 4.3.

Table 4.7 Comparison of Reported, Model-Estimated and Calibrated Per Capita Water Use Rates in 2005

County	System Name/Area	Reported GPCD	Model-estimated GPCD	Calibrated Model GPCD
Bond	Bond County Residual	70.2	87.9	65.2
Bond	Greenville	177.6	147.2	177.3
Bond	Mulberry Grove	67.3	63.7	70.2
Christian	Christian County Residual*	95.9	95.9	105.7
Christian	Kincaid	87.2	137.0	91.5
Christian	Pana	103.8	150.0	103.8
Christian	Taylorville*	176.9	207.6	140.5
Clay	Clay City	79.7	90.2	75.9
Clay	Clay County Residual	56.9	64.0	57.2
Clay	Flora	121.8	133.2	123.2
Clay	Louisville*	96.9	93.2	122.4
Clinton	Breese	129.3	125.4	121.8
Clinton	Carlyle	217.2	167.2	214.1
Clinton	Clinton County Residual	82.3	78.4	82.2
Clinton	New Baden	109.9	100.7	111.0
Clinton	Trenton	71.9	109.4	73.1
Coles	Charleston	62.2	82.9	60.9
Coles	Coles County Residual*	51.4	51.5	119.7
Coles	Mattoon	119.9	142.3	119.7
Coles	Oakland*	80.2	92.0	69.3
Cumberland	Cumberland County Residual	116.5	107.7	114.6
Cumberland	Neoga	90.0	104.3	85.2
Cumberland	Toledo	85.6	98.9	80.7
Douglas	Arcola	112.3	103.8	119.1
Douglas	Douglas County Residual	93.1	116.2	93.1
Douglas	Tuscola	99.6	105.2	101.8
Douglas	Villa Grove	118.1	106.8	117.6
Effingham	Altamont*	98.6	109.7	88.7
Effingham	Effingham*	110.3	140.4	66.7
Effingham	Effingham County Residual	67.4	93.6	67.4
Effingham	Teutopolis*	101.7	110.3	83.2
Fayette	Fayette County Residual	98.0	132.3	97.8
Fayette	Ramsey	81.6	88.5	88.3
Fayette	St Elmo	101.3	93.5	98.0
Fayette	Vandalia	130.4	106.7	119.9

County	System Name/Area	Reported GPCD	Model-estimated GPCD	Calibrated Model GPCD
Jasper	Jasper County Residual	67.7	109.8	67.8
Jasper	Newton	104.7	103.8	101.4
Jasper	Saint Marie*	119.7	125.4	138.2
Macoupin	Macoupin County Residual	88.4	94.7	84.6
Macoupin	Mount Olive	94.8	99.0	94.0
Madison	Highland	109.2	121.4	102.4
Madison	Madison County Residual*	140.0	107.7	58.5
Madison	Troy	164.6	109.2	156.0
Marion	Centralia	183.6	166.8	183.8
Marion	Kinmundy	96.0	112.3	91.7
Marion	Marion County Residual	57.3	95.8	57.4
Marion	Patoka	86.3	92.5	84.3
Marion	Salem	123.7	118.1	116.6
Marion	Wamac	67.6	70.5	63.6
Monroe	Hecker	86.7	68.6	86.1
Monroe	Monroe County Residual	84.9	97.1	84.9
Montgomery	Hillsboro*	182.1	100.8	291.5
Montgomery	Litchfield*	101.0	110.7	181.9
Montgomery	Montgomery County Residual	109.4	95.3	105.0
Moultrie	Arthur	118.4	159.1	110.8
Moultrie	Bethany	93.5	89.6	92.2
Moultrie	Lovington	86.3	94.7	83.8
Moultrie	Moultrie County Residual	77.8	64.1	78.0
Moultrie	Sullivan	144.5	113.8	128.1
Randolph	Coulterville	120.7	152.1	115.7
Randolph	Evansville	103.3	95.6	105.3
Randolph	Randolph County Residual	99.0	132.6	98.9
Randolph	Red Bud	113.1	118.8	115.7
Randolph	Sparta	220.4	107.9	220.6
Randolph	Steeleville	133.2	126.0	131.4
Richland	Noble*	90.4	88.6	187.0
Richland	Olney	152.3	143.0	144.8
Richland	Richland County Residual	70.4	82.4	70.4
Shelby	Moweaqua	93.9	97.6	85.3
Shelby	Shelby County Residual	87.3	84.5	73.6
Shelby	Shelbyville*	148.8	158.9	101.6
Shelby	Windsor	85.1	89.1	80.3
St Clair	Freeburg	85.8	95.5	83.0
St Clair	Kaskaskia Water District	80.0	74.4	80.0
St Clair	S L M Water Commission (SLM)	143.7	126.6	143.6
St Clair	Shiloh	--	57.4	63.2
St Clair	St. Clair County Residual	147.2	108.7	147.2
Washington	Ashley	67.7	86.9	59.3
Washington	Nashville*	237.2	239.7	306.9
Washington	Okawville	102.1	105.6	99.7
Washington	Washington County Residual	103.2	98.7	103.2

County	System Name/Area	Reported GPCD	Model-estimated GPCD	Calibrated Model GPCD
Wayne	Fairfield*	156.9	169.3	174.1
Wayne	Wayne City	127.3	168.5	127.0
Wayne	Wayne County Residual	56.8	61.2	56.9

*The final calibrated GPCD rates for these sites correspond to the revised estimates of water use and population served which were performed when preparing the final forecast.

4.2.4 Water Withdrawals by Source

The main sources of water supply in the 22-county study area include Kaskaskia River and tributaries, surface water from outside the Kaskaskia basin as well as groundwater either from within and outside the Kaskaskia basin. Table 4.8 shows the percentage shares of 2005 water withdrawals by the public systems and county remainder areas.

Table 4.8 Percentage Shares by Source of 2005 Water Withdrawals in the Kaskaskia Study Area

Public Water System/ Supply Area	Percent Groundwater - In Basin	Percent Groundwater - Out Basin	Percent Surface Water - In Basin	Percent Surface Water - Out Basin
Altamont	0.0	0.0	0.0	100.0
Arcola	0.0	100.0	0.0	0.0
Arthur	100.0	0.0	0.0	0.0
Ashley	0.0	0.0	100.0	0.0
Bethany	100.0	0.0	0.0	0.0
Breese	0.0	0.0	100.0	0.0
Carlyle	0.0	0.0	100.0	0.0
Centralia	0.0	0.0	100.0	0.0
Charleston	0.0	0.0	0.0	100.0
Clay City	0.0	0.0	0.0	100.0
Coulterville	0.0	0.0	100.0	0.0
Effingham	0.0	0.0	0.0	100.0
Evansville	0.0	0.0	100.0	0.0
Fairfield	0.0	0.0	0.0	100.0
Flora	0.0	0.0	0.0	100.0
Freeburg	0.0	0.0	100.0	0.0
Gateway Regional WC	0.0	0.0	100.0	0.0
Greenville	0.0	0.0	100.0	0.0
Hecker	0.0	0.0	100.0	0.0
Highland	0.0	0.0	100.0	0.0
Hillsboro	0.0	0.0	100.0	0.0
Kaskaskia Water District	0.0	0.0	100.0	0.0
Kincaid	0.0	0.0	0.0	100.0

Public Water System/ Supply Area	Percent Groundwater - In Basin	Percent Groundwater - Out Basin	Percent Surface Water - In Basin	Percent Surface Water - Out Basin
Kinmundy	0.0	0.0	100.0	0.0
Litchfield	0.0	0.0	100.0	0.0
Louisville	0.0	100.0	0.0	0.0
Lovington	100.0	0.0	0.0	0.0
Mattoon	0.0	0.0	0.0	100.0
Mount Olive	0.0	0.0	0.0	100.0
Moweaqua	0.0	100.0	0.0	0.0
Mulberry Grove	0.0	0.0	100.0	0.0
Nashville	0.0	0.0	100.0	0.0
Neoga	0.0	0.0	0.0	100.0
New Baden	0.0	0.0	100.0	0.0
Newton	0.0	100.0	0.0	0.0
Noble	0.0	0.0	0.0	100.0
Oakland	0.0	100.0	0.0	0.0
Okawville	0.0	0.0	100.0	0.0
Olney	0.0	0.0	0.0	100.0
Pana	0.0	0.0	100.0	0.0
Patoka	0.0	0.0	100.0	0.0
Ramsey	100.0	0.0	0.0	0.0
Red Bud	100.0	0.0	0.0	0.0
SLM Water Commission	0.0	0.0	100.0	0.0
Saint Marie	0.0	100.0	0.0	0.0
Salem	0.0	0.0	100.0	0.0
Shelbyville	100.0	0.0	0.0	0.0
Shiloh				
Sparta	0.0	0.0	47.5	52.5
St Elmo	100.0	0.0	0.0	0.0
Steeleville	0.0	100.0	0.0	0.0
Sullivan	100.0	0.0	0.0	0.0
Taylorville	0.0	90.3	0.0	9.7
Teutopolis	0.0	45.8	0.0	54.2
Toledo	0.0	100.0	0.0	0.0
Trenton	0.0	0.0	100.0	0.0
Troy	100.0	0.0	0.0	0.0
Tuscola	0.0	100.0	0.0	0.0
Vandalia	0.0	0.0	100.0	0.0
Villa Grove	0.0	100.0	0.0	0.0
Wamac	0.0	0.0	100.0	0.0
Wayne City	0.0	0.0	0.0	100.0
Windsor	33.3	66.7	0.0	0.0
Residual Bond	0.0	0.0	18.7	81.3
Residual Christian	0.0	86.0	0.0	14.0
Residual Clay	0.0	9.9	0.0	90.1
Residual Clinton	33.2	0.0	66.8	0.0
Residual Coles	2.3	69.5	0.0	28.2

Public Water System/ Supply Area	Percent Groundwater - In Basin	Percent Groundwater - Out Basin	Percent Surface Water - In Basin	Percent Surface Water - Out Basin
Residual Cumberland	0.0	100.0	0.0	0.0
Residual Douglas	11.1	88.9	0.0	0.0
Residual Effingham	5.9	36.2	0.0	57.9
Residual Fayette	50.6	0.0	49.4	0.0
Residual Jasper	0.0	79.4	0.0	20.6
Residual Macoupin	0.0	0.0	0.0	100.0
Residual Madison	7.6	0.0	60.5	31.9
Residual Marion	0.0	2.7	97.3	0.0
Residual Monroe	0.0	0.0	0.0	100.0
Residual Montgomery	53.3	12.9	33.8	0.0
Residual Moultrie	86.5	13.5	0.0	0.0
Residual Randolph	6.3	4.3	8.8	80.6
Residual Richland	0.0	65.9	0.0	34.1
Residual Shelby	81.7	18.3	0.0	0.0
Residual St Clair	10.0	0.0	23.8	75.2
Residual Washington	0.0	0.0	100.0	0.0
Residual Wayne	0.0	24.6	0.0	75.4

4.3 FUTURE WATER DEMAND

4.3.1 Future Population Growth

The main driver of future water demand in the public-supply sector is population served. The data on future increases in resident population of the study area counties were obtained from DCEO. Table 4.9 shows the projected increase in total population in each of the 22 counties by 2030 and 2050.

The 2030 to 2050 extension of the DCEO population forecasts for the 22-county area was accomplished by applying growth rates in each county during the 2025-2030 period for the extended years until 2025. Also the DCEO population forecast for St. Clair County was adjusted to match the 2010 Census numbers and applying growth rates of Madison County. The original forecast had negative growth rates.

Table 4.9 Resident Population Projections 2000-2050 for 22-County Study Area

County	2000	2005	2030	2050	2000-2050 Change	Percent Change
Bond	17,664	17,583	20,064	21,510	3,846	21.8
Christian	35,431	36,254	40,601	41,325	5,894	16.6
Clay	14,592	14,684	15,927	16,998	2,406	16.5
Clinton	35,593	37,278	44,621	45,308	9,715	27.3

County	2000	2005	2030	2050	2000-2050 Change	Percent Change
Coles	53,285	53,896	59,746	61,377	8,092	15.2
Cumberland	11,275	11,429	13,182	14,333	3,058	27.1
Douglas	19,955	20,713	24,607	27,729	7,774	39.0
Effingham	34,322	35,980	44,752	49,129	14,807	43.1
Fayette	21,837	21,807	22,570	22,962	1,125	5.2
Jasper	10,135	10,137	10,403	10,910	775	7.6
Marion	41,762	42,566	47,285	51,640	9,878	23.7
Montgomery	30,704	30,573	32,124	36,414	5,710	18.6
Moultrie	14,317	15,129	17,588	19,083	4,766	33.3
Randolph	33,951	34,129	37,004	40,136	6,185	18.2
Richland	16,181	16,220	17,867	19,268	3,087	19.1
Shelby	22,931	23,080	24,471	25,459	2,528	11.0
Washington	15,178	15,314	16,793	17,797	2,619	17.3
Wayne	17,184	16,815	16,690	17,459	275	1.6
Total 18 counties	446,297	453,587	507,295	538,837	92,540	20.7
Macoupin	49,103	49,622	59,442	64,912	15,809	32.2
Madison	259,391	261,758	296,342	315,120	55,729	21.5
Monroe	27,667	30,162	43,111	48,389	20,722	74.9
St. Clair	256,532	254,993	297,211	316,045	59,513	23.2
Total 4 partial counties	592,693	596,535	642,348	744,466	151,773	25.6
Total 22-counties	1,038,990	1,050,122	1,149,643	1,283,303	244,313	23.5

Source: Illinois Department of Commerce and Economic Opportunity.2005 estimates shown for comparison.

The values in Table 4.9 show that for the 22-county area, total resident population is expected to increase between 2000 and 2050 from 1,038,990 to 1,283,303. This represents an increase of 244,313 persons (or 23.5 percent). The highest population increase is projected for Madison and St. Clair Counties. Other counties with large population increases include Effingham, Marion, Clinton, and Coles counties. The smallest increases are projected for Wayne and Jasper counties. Future increases in total resident population will also result in increases in population served by public water supply systems.

Table 4.10 shows the projected changes in future population served in each of the 62 principal water supply systems included in the study. The values in Table 4.8 show that for the combined 62 systems, total population served is expected to increase between 2005 and 2050 from 283,524 to 325,412. This represents an increase of 56,779 persons (or 20 percent). In addition, population served in the 22 county residual areas will also increase as total resident population of each county increases. The estimates of population served in county residual areas are shown in Table A4.3 in the Annex. The population served in county residual areas is projected to increase from 275,224 in 2005 to 324,926 in 2050 (a 18.1 percent increase).

Table 4.10 Projections of Population Served by 62 Principal Water Supply Systems

Water Supply System	2005	2010	2030	2050	2005-2050 Change	Percent Change, %
Altamont	2,501	2,663	3,098	3,398	897	35.9
Arcola	2,652	2,791	3,142	3,536	884	33.3
Arthur	2,300	2,396	2,669	2,894	594	25.8
Ashley	650	671	712	754	104	16.0
Bethany	1,268	1,321	1,471	1,595	327	25.8
Breese	4,500	4,826	5,368	5,450	950	21.1
Carlyle	3,425	3,673	4,086	4,148	723	21.1
Centralia	14,200	14,451	15,760	17,198	2,998	21.1
Charleston	21,500	21,889	23,811	24,459	2,959	13.8
Clay City	1,000	1,010	1,084	1,156	156	15.6
Coulterville	1,230	1,241	1,333	1,445	215	17.5
Effingham	20,510	21,840	25,407	27,868	7,358	35.9
Evansville	750	757	813	881	131	17.5
Fairfield	4,661	4,611	4,626	4,838	177	3.8
Flora	4,766	4,812	5,166	5,511	745	15.6
Freeburg	4,398	4,658	5,126	5,451	1,053	23.9
Greenville	7,264	7,355	8,276	8,868	1,604	22.1
Hecker	484	527	684	767	283	58.5
Highland	9,799	10,015	11,079	11,777	1,978	20.2
Hillsboro	3,887	3,907	4,209	4,623	736	18.9
Kaskaskia Water D.	14,462	15,316	16,856	17,925	3,463	23.9
Kinkaid	1,400	1,470	1,565	1,593	193	13.8
Kinmundy	892	908	990	1,080	188	21.1
Litchfield	3,726	3,745	4,035	4,431	705	18.9
Louisville	1,000	1,010	1,084	1,156	156	15.6
Lovington	1,222	1,273	1,418	1,537	315	25.8
Mattoon	14,481	14,743	16,037	16,474	1,993	13.8
Mount Olive	2,160	2,226	2,580	2,816	656	30.4
Moweaqua	2,000	2,017	2,120	2,205	205	10.3
Mulberry Grove	700	709	798	855	155	22.1
Nashville	3,090	3,188	3,385	3,587	497	16.1
Neoga	1,854	1,895	2,135	2,320	466	25.1
New Baden	3,490	3,743	4,163	4,227	737	21.1
Newton	3,069	3,052	3,149	3,302	233	7.6
Noble	342	346	376	406	64	18.7
Oakland	1,090	1,110	1,207	1,240	150	13.8
Okawville	1,355	1,398	1,485	1,573	218	16.1
Olney	9,000	9,100	9,906	10,677	1,677	18.6
Pana	5,800	6,089	6,485	6,601	801	13.8
Patoka	633	644	703	767	134	21.2
Ramsey	1,000	1,003	1,035	1,053	53	5.3
Red Bud	3,442	3,472	3,730	4,043	601	17.5
Salem	7,945	8,085	8,818	9,622	1,677	21.1
Shelbyville	6,841	6,898	7,251	7,543	702	10.3

Water Supply System	2005	2010	2030	2050	2005-2050 Change	Percent Change, %
Shiloh	0	0	0	0	0	0.0
SLM Water Comm.	18,838	19,951	21,957	23,348	4,510	23.9
Sparta	4,486	4,526	4,861	5,269	783	17.5
St. Elmo	1,456	1,460	1,507	1,533	77	5.3
St. Marie	260	259	267	280	20	7.7
Steeleville	2,077	2,095	2,251	2,440	363	17.5
Sullivan	4,846	5,048	5,623	6,097	1,251	25.8
Taylorville	15,482	16,252	17,311	17,620	2,138	13.8
Teutopolis	2,000	2,130	2,478	2,718	718	35.9
Toledo	1,200	1,227	1,382	1,501	301	25.1
Trenton	2,630	2,821	3,137	3,185	555	21.1
Troy	9,950	10,170	11,250	11,958	2,008	20.2
Tuscola	4,448	4,681	5,271	5,931	1,483	33.3
Vandalia	6,975	6,994	7,218	7,343	368	5.3
Villa Grove	2,534	2,667	3,003	3,379	845	33.3
Wamac	1,378	1,402	1,529	1,669	291	21.1
Wayne City	1,100	1,088	1,092	1,142	42	3.8
Windsor	1,125	1,134	1,192	1,240	115	10.2
Total -- 62 systems	283,524	290,420	312,598	340,303	56,779	20.0

Projections for the systems were estimates obtained by prorating county-level population projections.

4.3.2 Future Changes in Explanatory Variables

The future values of the six explanatory variables (i.e., temperature, precipitation, employment/population ratio, price, income and conservation trend) will determine the future rates of per capita water withdrawals in the public-supply sector in each study area. In preparing the growth scenarios the future values have to be estimated by making calculations based on specified assumptions. The selection of the future values is described below.

4.3.2.1 Summer Season Temperature and Precipitation

Per capita water withdrawals are affected by summer weather conditions. A higher or lower average of maximum summer temperatures will result in higher or lower per capita water usage as determined by elasticity of +0.9775. Similarly, a higher or lower total of summer season precipitation will result in lower or higher per capita water usage as determined by elasticity of -0.0584. The future values of summer season temperature and precipitation were assumed to represent "normal" weather. This means that the values used for each future year will be average values from each of the 16 weather stations for the 30-year period from 1971 to 2000. The maximum-daily temperature values are shown in Table 4.11.

Table 4.11 Normal Values of May-September Average of Maximum Daily Temperature for 16 Weather Stations Used in the Study

Station No.	Location	County	Max. Temp. 2000	Max. Temp. 2005	1971-2000 Normal
110137	Alton Melvin Price L&D	Madison	81.0	85.0	82.4
110510	Belleville SIU Rsch	St. Clair	85.6	87.6	84.4
111290	Carlyle RSVR	Clinton	80.7	83.4	82.3
111436	Charleston	Coles	81.1	84.8	82.5
112687	Effingham	Cumberland	80.9	85.8	81.4
112687	Effingham	Effingham	80.9	85.8	81.4
112687	Effingham	Jasper	80.9	85.8	81.4
112931	Fairfield Radio WFIW	Wayne	81.4	84.6	83.0
113109	Flora 5 NW	Clay	82.0	85.4	83.4
114108	Hillsboro	Macoupin	83.1	86.6	85.4
114108	Hillsboro	Montgomery	83.1	86.6	85.4
115841	Morrisonville	Christian	81.0	83.1	81.2
116011	Nashville 1 E	Washington	81.9	84.4	83.2
116446	Olney 2S	Richland	82.4	83.6	82.5
117636	Salem	Marion	81.1	84.6	82.8
118147	Sparta 1 W	Monroe	82.1	85.0	82.8
118147	Sparta 1 W	Randolph	82.1	85.0	82.8
118740	Tuscola^	Douglas	80.2	82.6	83.2
118781	Vandalia	Bond	81.0	84.1	81.9
118781	Vandalia	Fayette	81.0	84.1	81.9
119354	Windsor	Moultrie	82.1	86.3	82.1
119354	Windsor	Shelby	82.1	86.3	82.1

^ Station No. 118740; Location Urbana used for temperature for year 2000.

Total summer precipitation values are shown in Table 4.12. The data indicate that the year 2000 had total summer season precipitation which was generally above normal. Whereas during the summer of 2005, total precipitation was much lower than normal values, thus indicating the presence of drought.

Table 4.12 Normal Values of 2000 and 2005 May-September Total Precipitation (Inches) for 16 Weather Stations Used in the Study

Station No.	Location	County	Summer Precip. 2000	Summer Precip. 2005	1971-2000 Normal
110137	Alton Melvin Price L&D	Madison	17.9	20.1	17.3
110510	Belleville SIU Rsch	St. Clair	24.7	20.1	18.0
111290	Carlyle RSVR	Clinton	34.6	17.0	18.3
111436	Charleston	Coles	35.1	16.3	19.5
112687	Effingham	Cumberland	36.1	14.2	19.2
112687	Effingham	Effingham	36.1	14.2	19.2
112687	Effingham	Jasper	36.1	14.2	19.2
112931	Fairfield Radio WFIW	Wayne	26.4	15.4	19.0

Station No.	Location	County	Summer Precip. 2000	Summer Precip. 2005	1971-2000 Normal
113109	Flora 5 NW	Clay	30.9	14.5	19.1
114108	Hillsboro	Macoupin	27.0	15.9	18.6
114108	Hillsboro	Montgomery	27.0	15.9	18.6
115841	Morrisonville	Christian	18.3	13.3	16.7
116011	Nashville 1 E	Washington	28.4	18.9	17.4
116446	Olney 2S	Richland	34.5	19.1	19.6
117636	Salem	Marion	28.2	16.9	19.1
118147	Sparta 1 W	Monroe	27.7	19.2	18.8
118147	Sparta 1 W	Randolph	27.7	16.0	18.8
118684	Tuscola	Douglas	15.1	16.7	19.6
118781	Vandalia	Bond	28.7	16.7	17.4
118781	Vandalia	Fayette	28.7	16.7	17.4
119354	Windsor	Moultrie	28.7	13.6	18.4
119354	Windsor	Shelby	28.7	15.7	18.4

4.3.2.2. Employment-to-Population Ratios

The future ratios of employment to population were obtained by dividing the future projections of employment by projected population. The projections of future employment were obtained from the Illinois Department of Employment Security website.

4.3.2.3 Marginal Price of Water

Future changes in retail water prices will result in changes of per capita water usage as determined by the estimated price elasticity of -0.0612. 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 gallons and 6,000 gallons per month.

Future values of marginal price 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 real price with respect to inflation. There is an expectation in the water supply industry, however, that in the future the retail prices for water will increase faster than inflation because of several factors – water quality issues will require more investment in treatment processes, the increasing cost of energy, and the other increasing water system costs, especially infrastructure replacement costs.

Recent trends in water prices were determined from a survey of water rates in Illinois (Dziegielewski, Kiefer and Bik, 2004). The data for 219 water systems in Illinois showed only a 3 percent increase in median value of total water bill at the consumption level of 5,000 gallons per month between 1990 and 2003 (increasing from $18.18 in 1990 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. The modest increase in price is a result of a number of systems which kept the nominal prices of water unchanged. Real water price declined (due to inflation) in 112 systems and was increased in 107 systems. The average increase in the 107 systems in terms of total bill was 25 percent, and 39.6 percent in average marginal price (or 2.6 percent per year).

Other sources (in the published literature) also reported increases in the price of municipal water. The NUS Consulting (2007) reported that the average price of water in 51 systems located throughout the United States increased by 6 percent for the period of July 1, 2006 to July 1, 2007. Earth Policy Institute (2007) reported an increase of 27 percent in the United States during the last 5 years. Based on the changes in inflation during the five year period (CPI 2000 = 172.2, CPI 2005 = 195.3), the increase in real price would be approximately 12 percent (or 2.3 percent per year).

For the purpose of this study, it is assumed that changes in future rates will span the range from (1) gradually increasing water rates following the recent trend in Illinois of 0.9 percent per year, to (2) increasing the marginal price by 2.5 percent per year. The 2.5 percent increase in marginal price represents an inflation-adjusted increase of 5 to 6 percent per year. The 2.5 percent increase would represent a pricing strategy which provides an increased incentive to conserve water.

4.3.2.4 Median Household Income

Future changes in median household income will result in changes of per capita water usage as determined by the estimated income elasticity of +0.3008. In the historical data for 1990, 1995, 2000, and 2005, the average trend in median household income (expressed in constant 2005 dollars) was an increase of 0.15 percent per year. Future income is likely to grow, following economic growth in the study area. However, official projections of future income growth at the county or system levels were not available.

One projection of income growth for the State of Illinois was obtained from the Illinois Region Econometric Input/Output Model (IREIM) developed by Hewings (1999). These projections indicate that for the State of Illinois the average annual growth in personal income between 1997 and 2022 is projected to increase at the rate of 1.5 percent per year. Because the growth in median household income is generally less than the expected growth in total personal income, the assumed rates of growth are lower.

The assumed annual growth rate of median household income for the current trends scenario is 0.7 percent. The assumed values for less resource intensive and most resource intensive scenarios are 0.5 and 1.0 percent per year, respectively.

4.3.3 Water Demand Under Three Scenarios

The three future scenarios are designed to capture future conditions of water demand for public supply water withdrawals under three different sets of conditions. The scenarios include a less resource intensive outcome, a current trends (or baseline case) scenario, and a more resource intensive outcome. While the scenario outcomes provide a range of future withdrawals, they do not represent forecasts or predictions, and do not set upper and lower bounds for future water use. Different assumptions or different future conditions could result in future withdrawals that are within or outside of this range. The scenario outcomes are estimates of future withdrawals that could occur under the conditions estimated to exist under the assumptions described below.

In addition to the specific assumptions that are listed below, all planned water supply developments are included in the scenarios.

The first is the construction of a centralized water-supply system that will encompass systems and communities in Marion, Clay, Wayne, and Fayette Counties. This water-supply system, Gateway Regional Water Company, membership includes Fayette Water Company, FMC Water Company, Northeast Marion County Water Company, Raccoon Water Company, Western Wayne Water Company, Clay County Water Company, City of Flora, Village of Alma, Village of Iuka, Village of Xenia, Village of Vernon, and the Village of Patoka. The new system affects the counties systems in two ways, (1) it increases the population served in the counties and decreases the domestic self-supplied population and (2) changes the source water for Fayette Water Company and the Village of Iuka from groundwater to surface water; shifts the source of surface water for the Western Wayne Water Company and the Clay County Water Company, the City of Flora, and the Village of Xenia from non-Kaskaskia basin to Kaskaskia basin surface water; and shifts surface water sources with the Kaskaskia basin from non-Kaskaskia River to Kaskaskia River surface water.

The second public supply change is in Effingham, Jasper and Shelby Counties where the EJ Water, Lake Sara Water Company, Effingham, Shelbyville and Lincoln Prairie Water Company have formed a consortium known as Holland Regional Water System. Prior to formation of this consortium, EJ Water and Shelbyville accessed groundwater in Japer and Shelby Counties, respectively. Lincoln Prairie Water Company purchased groundwater from Shelbyville while Lake Sara Water Company purchased surface water from Effingham. The new source for Holland Regional Water System will be Lake Shelbyville (located on the Kaskaskia River). The IDNR allocation of Kaskaskia water is 5.0 mgd and 7,5 mgd for peak day. Additional water for the consortium includes a supply from Wabash River (approxiomately 2.0 mgd plant) and additional wells operated by EJ Water.

4.3.3.1 Scenario 1 – Current Trends/Baseline Case (CT)

The intent of this scenario is to define future conditions as an extension of the recent trends in the factors which influence water demand and using the official projections of population prepared by the Illinois DCEO. The specific assumptions of this scenario are:

1. Population growth in the service areas of the 62 principal water-supply systems will follow the prorating county-level population projections.

2. Population changes in county remainder areas are derived by subtracting system-level projections from the county total projections for each of the 22 counties.

3. Changes in employment relative to population will follow the employment projections.

4. Marginal prices of water after 2005 will be increasing at the annual rate of 1.5 percent.

5. Annual growth of median household income during the 2005-2050 period will be 0.7 percent.

6. Future rates of per capita water usage will be affected by the annual "conservation" trend of 0.54 percent per year which was estimated from historical data.

7. Summer temperature and precipitation will represent normal values derived from the historical data for the 30-year period from 1971 to 2000.

4.3.3.2 Scenario 2 – Less Resource Intensive Case (LRI)

The intent of this scenario is to define a set of conditions which would lead to less water use by the public-supply sector. Other conditions not included in this analysis could also lead to less water use.

The specific assumptions for the Less Resource Intensive (LRI) scenario are:

1. Population growth in the study areas will follow population projections as described in Section 4.3.1. Population changes in county remainder areas are adjusted to reflect the county population projections.

2. Changes in employment relative to population will remain at the 2005 value for each public water supply study area.

3. Marginal prices of water will increase at the rate of 2.5 percent per year (in constant 2005 dollars) in order to provide water conservation incentives.

4. Annual growth of median household income during the 2005-2050 period will be 0.5 percent (in constant 2005 dollars).

5. Future rates of per capita water usage will be affected by the annual "conservation" trend of 0.81 percent per year, which is 50 percent higher than the trend in historical data.

6. Summer temperature and precipitation will represent normal values derived from the historical data for the 30-year period from 1971 to 2000.

4.3.3.3 Scenario 3 – More Resource Intensive Case (MRI)

The intent of this scenario is to define future conditions which would lead to more water usage by the public water-supply sector. Such an outcome would result if the population growth is shifted toward less densely urbanized areas in the collar counties.

The specific assumptions for the More Resource Intensive (MRI) scenario are:

1. Population growth in the study areas will follow population projections as described in Section 4.3.1.

2. Employment to population ratio will remain at the 2005 value for each PWS study area.

3. Marginal prices of water will grow from the 2005 values (in constant 2005 dollars) at a rate of 0.9 percent per year.

4. Annual growth of median household income during the 2005-2050 period will be 1.0 percent (in constant 2005 dollars).

5. Future per capita rates of water usage will be affected by one-half of the historical conservation trend, or 0.27 percent per year.

6. Summer temperature and precipitation will represent normal values derived from the historical data for the 30-year period from 1971 to 2000.

4.4 SCENARIO RESULTS

4.4.1 Total Public-Supply Withdrawals

The results of the assumptions for each of the three scenarios on water withdrawals in the 22-county study area are summarized in Table 4.11 below. The values of future total and per capita water withdrawals and purchases at the system level for the three scenarios are presented in Tables A4.5 to A4.10 in the Annex to this chapter.

Under the current trend (CT) scenario, the future total water withdrawals for public water supply would increase from 58.1 mgd in 2005 (under actual 2005 weather conditions) to 66.9 mgd in 2050 (under normal weather conditions). After adjusting the actual 2005 withdrawals to normal weather conditions, the future withdrawals are expected to increase by 23.5 percent from the weather-normalized 2005 withdrawals of 56.5 mgd to 66.9 mgd in 2050. This 10.4 mgd increase is the result of a 13.2 percent increase in population served and 4.7 percent decrease in weather-normalized per capita values of water withdrawals. The per capita water withdrawal data for three scenarios were generated by the regression model. Total withdrawals are obtained by multiplying future population served by model-generated values of per capita water withdrawals.

Under the Less Resource Intensive (LRI) scenario, the future weather-normalized total water withdrawals for public water supply would increase by 12.2 percent, from the normal weather demand of 56.5 mgd in 2005, to 63.4 mgd in 2050. This 6.9 mgd increase is the result of a 13.2 percent increase in population served between 2005 and 2050, and a 0.9 percent decrease in per capita water withdrawals during the same period.

Finally, under the More Resource Intensive (MRI) scenario, the future water withdrawals for public water supply would increase by 27.3 percent, from the normal weather demand of 56.5 mgd in 2005, to 71.9 mgd in 2050. This 15.4 mgd increase is the result of 13.2 percent increase in total population served between 2005 and 2050, and a 12.5 percent increase in per capita water withdrawals during the same period.

4.4.2 Surface and Groundwater Withdrawals

The mix of water supply sources will change throughout the period from 2005 through 2050 because of differential growth rates among water systems with different mixes of supply sources. In all three scenarios, groundwater withdrawals are projected to increase faster than surface water withdrawals.

When comparing weather-normalized 2005 and 2050 withdrawals, the groundwater withdrawals would increase by 25.9 percent (1.5 mgd) under the CT scenario. The corresponding increases under LRI and MRI scenarios would be 19.0 percent (1.1 mgd), and 34.5 percent (2.0 mgd), respectively.

In comparison, Kaskaskia River basin withdrawals would increase by 17.4 percent (4.1 mgd) under the CT scenario, they would increase by 11.1 percent (2.6 mgd) under LRI scenario, and increase by and 26.0 percent (6.1 mgd) under the MRI scenario.

Table 4.13 Public Supply Water Demand Scenarios of 22-County Study Area

Scenario/ Year	Population Served	Per Capita GPCD	Total Withdrawals MGD	Kaskaskia Ground Water	Kaskaskia Surface Water	Non-Kaskaskia GW & SW
CT	*Current Trends – Baseline Scenario*					
2005 (Reported)	557,837	104.2	58.1	6.4	23.8	27.9
2005 (Normal)	557,837	101.2	56.5	5.8	23.5	27.1
2010	571,073	101.4	57.9	6.4	24.0	27.6
2015	587,283	101.9	59.8	6.6	24.7	28.5
2020	605,306	102.3	61.9	6.8	25.6	29.6
2025	617,061	102.7	63.4	6.9	26.2	30.3
2030	626,442	103.3	64.7	7.1	26.7	30.9
2035	635,999	104.0	66.1	7.2	27.3	31.6
2040	645,737	104.6	67.5	7.4	27.9	32.3
2045	655,658	105.2	69.0	7.5	28.5	33.0
2050	665,768	105.8	70.5	7.7	29.1	33.7
2005-2050 Change	107,931	4.6	14.0	1.9	5.6	6.6
2005-2050 %	19.3	4.6	24.8	32.6	23.6	24.4
LRI	*Less Resource Intensive Scenario*					
2005 (Reported)	557,837	104.2	58.1	6.4	23.8	27.9
2005 (Normal)	557,837	101.2	56.5	5.8	23.5	27.1
2010	571,073	99.9	57.0	6.3	23.6	27.2
2015	587,283	99.7	58.5	6.4	24.2	27.9
2020	605,306	99.5	60.2	6.6	24.9	28.7
2025	617,061	99.3	61.3	6.7	25.3	29.3
2030	626,442	99.2	62.2	6.8	25.7	29.7
2035	635,999	99.2	63.1	6.9	26.0	30.2
2040	645,737	99.2	64.0	7.0	26.4	30.6
2045	655,658	99.1	65.0	7.1	26.8	31.1
2050	665,768	99.1	66.0	7.2	27.2	31.6
2005-2050 Change	107,931	-2.1	9.5	1.4	3.7	4.5
2005-2050 %	19.3	-2.1	16.9	24.2	15.8	16.5
MRI	*More Resource Intensive Scenario*					
2005 (Reported)	557,837	104.2	58.1	6.4	23.8	27.9
2005 (Normal)	557,837	101.2	56.5	5.8	23.5	27.1
2010	571,073	103.0	58.8	6.5	24.3	28.0
2015	587,283	104.1	61.2	6.7	25.3	29.1
2020	605,306	105.3	63.7	7.0	26.4	30.4
2025	617,061	106.4	65.7	7.2	27.1	31.4
2030	626,442	107.8	67.5	7.4	27.9	32.3
2035	635,999	109.1	69.4	7.6	28.6	33.2
2040	645,737	110.5	71.3	7.8	29.4	34.1
2045	655,658	111.9	73.3	8.0	30.3	35.1
2050	665,768	113.3	75.4	8.2	31.1	36.1
2005-2050 Change	107,931	12.0	18.9	2.4	7.6	9.0
2005-2050 %	19.3	11.9	33.6	41.9	32.3	33.1

2005 (Reported) = actual reported values of water withdrawals for 2005. 2005 (Normal) = weather normalized withdrawals for 2005 obtained by substituting normal weather conditions in the regression model.

4.4.3 Differences between Scenarios

Table 4.14 shows the differences in estimated water withdrawals between the less resource intensive (LRI) and more resource intensive (MRI) scenarios during the 2005-2050 period as compared to the current trends (CT) scenario. It shows that the differences between the CT scenario and the LRI and MRI scenarios are slightly asymmetric. Total withdrawals would be 6.4 percent lower under LRI scenario, and 7.0 percent higher under MRI scenario, as compared to the CT scenario. These correspond to differences in water withdrawals between the CT scenario and the LRI and MRI scenarios of -4.5 mgd, and +4.9 mgd, respectively.

Table 4.14 Comparison of Changes in Withdrawals between Scenarios by Source

Source of Supply	2005 Normal (MGD)	2050 CT (MGD)	2050 Scenarios (MGD)	Scenarios -CT (MGD)	%
CT vs. LRI Scenario					
Groundwater – Kaskaskia	5.8	7.7	7.2	-0.5	-6.5
Surface Water – Kaskaskia	23.5	29.1	27.2	-1.9	-6.5
Groundwater – out of basin	8.1	10.1	9.5	-0.6	-5.9
Surface Water - out of basin	19.0	23.6	22.1	-1.5	-6.4
Total withdrawals	56.5	70.5	66.0	-4.5	-6.4
CT vs. MRI Scenario					
Groundwater - Kaskaskia	5.8	7.7	8.2	0.5	6.5
Surface Water - Kaskaskia	23.5	29.1	31.1	2.0	6.9
Groundwater – out of basin	8.1	10.1	10.8	0.7	6.9
Surface Water - out of basin	19.0	23.6	25.2	1.6	6.8
Total withdrawals	56.5	70.5	75.4	4.9	7.0

LRI – CT = LRI volume in 2050 minus CT volume in 2050; MRI – CT = MRI volume in 2050 minus CT volume in 2050, % = percent change relative to CT scenario volume

Major factors contributing to the differences in water withdrawals between the scenarios are the result of different assumptions about three influencing factors: the rate of growth in future income, future prices of water and future trends in water conservation.

ANNEX TO APPENDIX D

Chapter 4 Annex – Part 1: Tables

Table A4.1. Public-Supply Water Systems and Subsystems Included in the Study

ATWOOD	CLAY CITY	GREENVILLE
Garrett	Sailor Springs (1995)	Donnellson
		Mulberry Grove
BREESE	EFFINGHAM	Panama (1995)
Aviston	E.J. Water Corporation	Royal Lake Water District
Northern Breese Water Assc.	Heartville PWD	Smithboro
St. Rose PWD	Lake Sara Area Water Co-op	
	Snake Trail Water Assn.	HIGHLAND
CARLINVILLE	Teutopolis	Country Hills Water Inc.
Beckmeyer		Grantfork
Carlyle North Water Co, Inc.	E.J. WATER CORPORATION	Pierron
Carlyle Southwest PWD	Dieterich	St. Jacob
Clinton County Ease Public	Edgewood	
Hoffman Rural Water District	Louisville	HILLSBORO
Keyesport	Mason	Coffeen
	Midway Country Village MHP	Montgomery County Water
CLINTON COUNTY EAST PUBLIC	Watson WME Water Commission	Schram City Taylor Springs
Carlyle		
FMC Water Company	FAIRFIELD	KASKASKIA WATER DIST.
	Boyleston Waterworks Corp.	Shipman (2000 & 2005)
FMC WATER COMPANY	Golden Gate (1995)	Lenzburg
Patoka	New Hope Waterworks Corp.	Marissa
Vernon		New Athens
	FAYETTE WATER CO.	Tilden
CENTRALIA	Beecher City	Washington Co. Water Company
Hoffman	Brownstonw	
Hoffman Rural Water District Hoyleton Rural Water District	St. Elmo	WASHINGTON CO. WATER CO.
Irvington	ST. ELMO	Ashley
Junction City	Brownstone (1990 & 1995)	Dubois
Odin	St. Peter (1995)	Okawville
Raccoon Water Co.		Radom
Sandoval	FLORA	St. Libory (1990)
W.G. Murray Development Ctr.	Clay County Water Inc.	
Walnut Hill	Xenia	LITCHFIELD
WAMAC		Butler
	GILLESPIE	Henderson PWD
IRVINGTON	Benld	Rocky Hollow Water District
Richview	Dorchester	Three County PWD
	Eagerville	
CHARLESTON	Kaho PWD	THREE COUNTY PWD
Eastern Illinois University	Mount Clare	Sorento (2005)
Longacre Estates MHP	Sawyerville	
	Spring Creek Water Assn.	MATTOON
CHESTER	Wilsonville	Humboldt

Egyptian Water Company		Lakeland College
Ellis Grove		
Menard Correctional Center		

Table A4.1 Public-Supply Water Systems and Subsystems Included in the Study (cont.)

MOUNT OLIVE	ALBERS	VANDALIA
White City	Damiansville	Vandalia Correctional Ctr.
WHITE CITY	SALEM	VILLA GROVE
Staunton Res. Road Water COOP	Northeast Marion Water Co.	Camargo
NASHVILLE Hoyleton	NORTHEAST MARION WATER CO.	WAYNE CITY
Hoyleton-New Minden	Alma	Sims
New Minden		Western Wayne Water District
	SHELBYVILLE	
	Lincoln Prairie Water Co.	GATEWAY REIGONAL WATER COMPANY
NEWTON		Fayette Water Company
E.J. Water Corporation	SPARTA	FMC Water Company,
	Eden PWD	Northeast Marion County Water Company
OLNEY	Egyptian Water Company	Raccoon Water Company
Noble		Western Wayne Water Company
Parkersburg	EGYPTIAN WATER CO.	Clay County Water Company
Watergate Subd	Baldwin	Flora
West Liberty-Dundas Water Dist.		Alma
	STAUNTON	Iuka
SLM WATER COMMISSION	RR 1-IL Water Assn	Xenia
Freeburg	Williamson	Vernon
FSH Water Commission		Patoka
Lebanon	SULLIVAN	
Mascoutah	Mason Point	
New Baden	Moultrie Co. Rural Water Dist	HOLLAND REGIONAL WATER SYSTEM
New Memphis PWD		EJ Water
Summerfield	TAYLORVILLE	Lake Sara Water Company
Trenton	Kincaid	Effingham
Tri Township Water District	Langleyville PWD	Shelbyville
	Owaneco	Lincoln Prairie Water Company
FSH WATER COMMISSION		
Freeburg (1995)	KINCAID	
Hecker	Jeiseyville	
Smithon	Tovey (1995 & 2000)	
NEW BADEN	TOLEDO	
Albers	Jewett	

Table A4.2 Historical Values of Dependent and Independent Variables for 62 Systems

System Name	Year	MGD	GPCD	Temp.	Precip.	E/P Ratio	Price	Income
Greenville, Bond Co.	1990	0.71	159.6	80.52	22.38	0.470	4.63	31,654
	1995	1.03	166.6	81.26	21.00	0.509	5.64	34,988
	2000	1.07	171.9	80.98	28.70	0.535	5.43	40,313
	2005	1.29	177.3	84.08	16.69	0.446	4.80	39,238
Mulberry Grove, Bond Co.	1990	0.04	58.3	80.52	22.38	0.082	3.86	29,568
	1995	0.04	60.2	81.26	21.00	0.092	4.70	32,695
	2000	0.03	61.0	80.98	28.70	0.125	4.52	35,161
	2005	0.05	70.2	84.08	16.69	0.242	4.00	37,501
Kinkaid, Christian Co.	1990	0.22	81.5	80.04	18.71	0.026	4.30	33,738
	1995	0.26	84.6	80.96	19.50	0.026	4.07	37,123
	2000	0.14	84.5	80.98	26.96	0.028	4.37	40,033
	2005	0.13	91.5	83.08	13.27	0.045	4.73	41,833
Pana, Christian Co.	1990	1.41	97.5	80.04	18.71	0.499	3.17	25,562
	1995	1.04	63.0	80.96	19.50	0.467	3.50	29,899
	2000	0.80	98.9	80.98	26.96	0.383	3.51	33,484
	2005	0.60	103.8	83.08	13.27	0.383	3.99	32,577
Taylorville, Christian Co.	1990	2.67	121.3	80.04	18.71	0.377	4.30	34,853
	1995	1.74	125.6	80.96	19.50	0.429	4.07	35,417
	2000	2.37	125.4	80.98	26.96	0.421	4.37	38,712
	2005	2.18	140.5	83.08	13.27	0.576	4.73	37,694
Clay City, Clay Co.	1990	0.09	72.1	83.52	20.31	0.327	3.39	25,826
	1995	0.09	73.3	84.38	24.49	0.300	2.90	27,730
	2000	0.09	68.0	82.04	30.92	0.267	5.02	29,118
	2005	0.08	75.9	85.36	14.50	0.270	4.44	31,056
Flora, Clay Co.	1990	0.65	116.6	83.52	20.31	0.811	2.82	26,289
	1995	0.62	116.4	84.38	24.49	0.819	4.02	28,197
	2000	0.64	117.4	82.04	30.92	0.872	4.46	31,840
	2005	0.59	123.2	85.36	14.50	0.788	3.94	31,081
Louisville, Clay Co.	1990	0.08	11.4	83.52	20.31	0.306	3.10	24,350
	1995	0.10	113.6	84.38	24.49	0.334	3.46	26,716
	2000	0.12	107.3	82.04	30.92	0.299	4.74	28,552
	2005	0.12	122.4	85.36	14.50	0.357	4.19	30.453
Breese, Clinton Co.	1990	0.39	115.5	83.38	18.78	0.586	2.62	51,218
	1995	0.38	106.7	80.16	25.26	0.629	3.84	48,883
	2000	0.47	112.2	80.66	34.59	0.699	3.39	53,870
	2005	0.55	121.8	83.36	16.98	0.724	3.00	52,443
Carlyle, Clinton Co.	1990	0.51	194.4	83.38	18.78	0.478	3.15	37,378
	1995	0.45	186.8	80.16	25.26	0.505	2.69	37,249
	2000	0.60	196.4	80.66	34.59	0.566	2.37	41,455
	2005	0.73	214.1	83.36	16.98	0.603	2.10	40,346
New Baden, Clinton Co.	1990	0.21	102.8	83.38	18.78	0.112	3.30	44,699
	1995	0.25	101.0	80.16	25.26	0.157	3.14	47,868
	2000	0.33	102.0	80.66	34.59	0.185	3.79	51,857
	2005	0.38	111.0	83.36	16.98	0.219	3.35	50,470
Trenton, Clinton Co.	1990	0.12	68.7	83.38	18.78	0.309	3.43	47,987
	1995	0.25	65.1	80.16	25.26	0.317	3.49	48,347
	2000	0.33	68.8	80.66	34.59	0.397	3.35	54,385
	2005	0.38	73.1	83.36	16.98	0.373	2.99	52,919
Charleston, Coles Co.	1990	1.21	57.1	78.92	21.93	0.346	8.81	42,260

System Name	Year	MGD	GPCD	Temp.	Precip.	E/P Ratio	Price	Income
	1995	1.81	60.4	82.70	16.29	0.590	7.53	45,819
	2000	1.47	60.3	81.14	35.14	0.270	6.78	48,982
	2005	1.31	57.6	84.76	16.34	0.379	6.45	50,874

Mattoon, Coles Co.	1990	3.21	106.3	78.92	21.93	0.697	2.73	33,387
	1995	2.81	115.4	82.70	16.29	0.695	1.85	33,325
	2000	2.76	112.0	81.14	35.14	0.805	3.10	35,959
	2005	1.74	119.7	84.76	16.34	0.779	3.16	35,025
Oakland, Coles Co.	1990	0.11	63.2	78.92	21.93	0.229	3.15	32,828
	1995	0.14	69.1	82.70	16.29	0.207	2.69	36,016
	2000	0.13	66.0	81.14	35.14	0.188	2.37	38,490
	2005	0.08	69.3	84.76	16.34	0.178	5.60	41,052
Neoga, Cumberland Co.	1990	0.13	71.2	81.44	24.88	0.170	2.25	34,868
	1995	0.14	74.5	81.72	19.13	0.171	1.92	37,283
	2000	0.14	74.6	80.92	36.05	0.242	1.70	39,012
	2005	0.16	85.2	85.76	14.18	0.233	1.50	41,609
Toledo, Cumberland Co.	1990	0.10	97.6	81.44	24.88	0.216	2.25	34,615
	1995	0.11	98.6	81.72	19.13	0.231	1.92	32,227
	2000	0.11	94.1	80.92	36.05	0.284	1.70	29,507
	2005	0.10	80.7	85.76	14.18	0.309	1.50	31,470
Arcola, Douglas Co.	1990	0.22	116.9	82.54	19.46	0.625	7.49	42,706
	1995	0.33	111.3	83.70	20.35	0.612	13.20	40,402
	2000	0.32	111.8	80.18	15.10	0.621	11.65	43,111
	2005	0.32	119.1	82.58	15.98	0.621	10.30	41,956
Tuscola, Douglas Co.	1990	0.65	113.4	82.54	19.46	0.572	7.01	40,826
	1995	0.42	114.5	83.70	20.35	0.544	6.00	41,395
	2000	0.42	116.0	80.18	15.10	0.563	5.29	44,788
	2005	0.45	101.8	82.58	15.98	0.502	4.68	43,689
Villa Grove, Douglas Co.	1990	0.29	115.1	82.54	19.46	0.117	0.22	38,791
	1995	0.31	116.3	83.70	20.35	0.114	0.22	39,283
	2000	0.28	112.9	80.18	15.10	0.128	0.30	40,609
	2005	0.29	117.6	82.58	15.98	0.128	0.31	43,311
Altamont, Effingham Co.	1990	0.20	78.5	81.44	24.88	0.465	2.47	34,457
	1995	0.21	81.2	81.72	19.13	0.447	2.11	36,312
	2000	0.20	79.9	80.92	36.05	0.484	1.87	37,526
	2005	0.22	88.7	85.76	14.18	0.451	2.26	40,024
Effingham, Effingham Co.	1990	1.21	65.6	81.44	24.88	1.336	3.41	37,439
	1995	1.95	64.1	81.72	19.13	1.234	2.91	36,483
	2000	2.12	63.6	80.92	36.05	1.259	2.57	39,341
	2005	1.37	66.7	85.76	14.18	1.131	2.69	38,307
Teutopolis, Effingham Co.	1990	0.15	70.6	81.44	24.88	1.116	3.46	47,804
	1995	0.16	71.3	81.72	19.13	1.039	2.96	50,353
	2000	0.17	76.9	80.92	36.05	1.284	2.61	53,656
	2005	0.17	83.2	85.76	14.18	1.224	2.65	52,576
Ramsey, Fayette Co.	1990	0.09	79.8	80.52	22.38	0.105	4.95	24,452
	1995	0.09	86.5	81.26	21.00	0.125	4.40	29,431
	2000	0.09	88.0	80.98	28.70	0.121	4.24	33,688
	2005	0.09	88.3	84.08	16.69	0.153	3.97	35,932
St. Elmo, Fayette Co.	1990	0.15	91.3	80.52	22.38	0.314	5.18	29,288
	1995	0.17	96.7	81.26	21.00	0.335	4.43	32,356
	2000	0.10	92.3	80.98	28.70	0.225	4.48	34,772
	2005	0.14	98.0	84.08	16.69	0.283	4.50	37,086

Vandalia, Fayette Co.	1990	0.64	109.2	80.52	22.38	0.564	3.24	32,491
	1995	0.75	110.3	81.26	21.00	0.579	3.20	31,793
	2000	0.66	110.3	80.98	28.70	0.574	3.31	34,893
	2005	0.84	119.9	84.08	16.69	0.625	3.07	33,948
Newton, Jasper Co.	1990	0.37	102.9	81.44	24.88	0.987	6.49	27,479
	1995	0.36	103.2	81.72	19.13	0.849	5.55	30,676
	2000	0.34	92.5	80.92	36.05	0.615	5.63	34,240
	2005	0.31	101.4	85.76	14.18	0.572	4.98	33,305
Saint Marie, Jasper Co.	1990	0.03	109.9	81.44	24.88	0.119	4.95	34,737
	1995	0.03	118.7	81.72	19.13	0.228	4.40	36,046
	2000	0.03	116.9	80.92	36.05	0.291	4.24	36,751
	2005	0.03	138.1	85.76	14.18	0.378	3.97	39,196
Mount Olive, Macoupin Co.	1990	0.22	83.1	84.40	27.71	0.287	5.62	33,208
	1995	0.19	85.7	82.58	16.18	0.245	4.80	36,804
	2000	0.21	86.9	83.08	26.96	0.271	4.24	39,651
	2005	0.21	94.0	86.56	15.88	0.225	3.75	42,290
Highland, Madison Co.	1990	1.12	105.0	81.14	19.73	0.888	4.06	47,964
	1995	0.03	100.1	80.54	18.62	0.848	3.88	43,752
	2000	1.09	96.3	82.28	32.93	0.786	4.25	44,693
	2005	1.01	102.4	85.00	20.12	0.740	3.78	49,780
Troy, Madison Co.	1990	0.90	137.2	81.14	19.73	0.161	3.00	49,999
	1995	1.01	141.2	80.54	18.62	0.196	3.20	54,516
	2000	1.34	143.3	82.28	32.93	0.238	4.24	60,237
	2005	1.55	156.0	85.00	20.12	0.244	3.75	63,453
Centralia, Marion Co.	1990	2.38	191.9	83.54	22.89	0.761	3.99	34,141
	1995	2.55	189.1	83.10	33.08	0.819	4.25	33711
	2000	2.88	175.5	81.14	28.17	0.640	4.25	35,162
	2005	2.61	183.8	84.64	16.86	0.529	3.97	37,139
Kinmundy, Marion Co.	1990	0.08	88.1	83.54	22.89	0.073	1.79	26,223
	1995	0.14	88.4	83.10	33.08	0.067	1.78	29,470
	2000	0.11	86.0	81.14	28.17	0.068	3.39	32,227
	2005	0.08	91.7	84.64	16.86	0.074	5.00	34,000
Patoka, Marion Co.	1990	0.06	69.3	83.54	22.89	0.173	5.99	24,350
	1995	0.04	71.8	83.10	33.08	0.189	5.13	28,715
	2000	0.06	75.2	81.14	28.17	0.251	4.98	32,308
	2005	0.05	84.3	84.64	16.86	0.290	4.40	34,732
Salem, Marion Co.	1990	0.73	108.9	83.54	22.89	0.757	3.75	35,179
	1995	0.83	104.9	83.10	33.08	0.691	3.20	36,302
	2000	0.92	111.7	81.14	28.17	0.829	3.00	38,830
	2005	0.93	116.6	84.64	16.86	0.705	2.90	41,498
Wamac, Marion Co.	1990	0.10	52.9	83.54	22.89	0.173	2.73	28,005
	1995	0.09	52.0	83.10	33.08	0.189	2.79	28,726
	2000	0.09	52.8	81.14	28.17	0.251	2.88	29,569
	2005	0.09	63.6	84.64	16.86	0.290	2.90	41,389
Hecker, Monroe Co.	1990	0.03	77.6	82.96	27.03	0.077	3.46	45,546
	1995	0.03	78.6	82.36	22.81	0.121	4.43	47,234
	2000	0.03	78.7	82.14	27.73	0.162	5.24	49,000
	2005	0.04	86.1	84.98	19.24	0.242	5.31	49,802
Hillsboro, Montgomery Co.	1990	0.88	283.6	84.40	27.71	0.477	5.69	37,688
	1995	0.91	287.4	82.58	16.18	0.507	4.87	34,842
	2000	1.00	261.9	83.08	26.96	0.288	4.30	37,401
	2005	1.13	291.5	86.56	15.88	0.304	3.80	40,458
Litchfield, Montgomery Co.	1990	1.11	169.0	84.40	27.71	0.651	3.27	31,286

	1995	1.41	170.2	82.58	16.18	0.641	3.01	31,214
	2000	1.22	174.8	83.08	26.96	0.776	3.73	32,473
	2005	0.68	181.9	86.56	15.88	0.678	3.97	33,948
Arthur, Moultrie Co.	1990	0.26	78.0	80.78	21.77	0.900	3.78	32,971
	1995	0.24	83.1	82.12	17.24	0.858	3.23	38,079
	2000	0.27	97.0	82.12	28.72	1.228	2.85	42,331
	2005	0.26	110.8	82.54	16.02	1.399	2.52	45,154
Bethany, Moultrie Co.	1990	0.12	90.0	80.78	21.77	0.121	4.20	41,554
	1995	0.12	91.8	82.12	17.24	0.116	3.59	39,607
	2000	0.11	89.4	82.12	28.72	0.132	3.17	38,550
	2005	0.12	92.2	82.54	16.02	0.119	2.80	37,271
Lovington, Moultrie Co.	1990	0.15	71.7	80.78	21.77	0.078	3.98	33,668
	1995	0.11	76.9	82.12	17.24	0.124	3.81	36,250
	2000	0.09	77.0	82.12	28.72	0.110	2.73	38,577
	2005	0.10	83.8	82.54	16.02	0.182	2.42	39,939
Sullivan, Moultrie Co.	1990	0.61	119.9	80.78	21.77	0.711	3.97	36,076
	1995	0.49	133.2	82.12	17.24	0.668	4.61	51,174
	2000	0.66	123.0	82.12	28.72	0.666	2.18	37,539
	2005	0.62	128.1	82.54	16.02	0.618	1.93	39,399
Coulterville, Randolph Co.	1990	0.18	104.0	82.96	27.03	0.300	3.00	30,795
	1995	0.18	107.9	82.36	22.81	0.382	2.56	30,320
	2000	0.14	105.7	82.14	27.73	0.353	2.26	30,278
	2005	0.14	115.7	84.98	19.24	0.438	2.00	29,889
Evansville, Randolph Co.	1990	0.07	92.6	82.96	27.03	0.198	3.10	30,398
	1995	0.08	96.8	82.36	22.81	0.212	2.72	33,684
	2000	0.07	95.8	82.14	27.73	0.170	2.80	36,515
	2005	0.07	105.3	84.98	19.24	0.220	2.48	38,295
Red Bud, Randolph Co.	1990	0.32	107.1	82.96	27.03	0.613	3.10	42,889
	1995	0.32	108.2	82.36	22.81	0.599	2.72	44,155
	2000	0.32	109.0	82.14	27.73	0.638	2.80	45,571
	2005	0.40	115.7	84.98	19.24	0.653	2.48	44,490
Sparta, Randolph Co.	1990	0.61	232.1	82.96	27.03	0.845	3.10	35,054
	1995	0.56	229.7	82.36	22.81	0.763	2.72	36,831
	2000	0.52	214.3	82.14	27.73	0.598	2.80	38,604
	2005	0.99	220.6	84.98	19.24	0.535	3.13	39,575
Steeleville, Randolph Co.	1990	0.26	110.2	82.96	27.03	0.525	2.40	40,053
	1995	0.27	113.0	82.36	22.81	0.579	2.05	39,341
	2000	0.28	130.0	82.14	27.73	0.954	1.81	39,215
	2005	0.27	131.4	84.98	19.24	0.840	1.60	38,654
Noble, Richland Co.	1990	0.05	185.3	82.08	24.26	0.368	2.25	26,617
	1995	0.06	176.9	83.20	29.34	0.315	5.84	29,849
	2000	0.06	176.5	82.38	34.53	0.277	5.16	32,598
	2005	0.06	187.0	83.60	19.11	0.262	5.12	34,361
Olney, Richland Co.	1990	1.37	144.9	82.08	24.26	0.722	2.38	32,211
	1995	1.52	141.9	83.20	29.34	0.680	2.04	30,870
	2000	1.32	140.2	82.38	34.53	0.683	2.05	31,757
	2005	1.30	144.8	83.60	19.11	0.637	2.52	33,470
Moweaqua, Shelby Co.	1990	0.16	81.9	80.78	21.77	0.358	4.35	39,236
	1995	0.18	85.7	82.12	17.24	0.322	3.72	42,474
	2000	0.19	79.7	82.12	28.72	0.153	3.28	45,360
	2005	0.17	85.3	82.54	16.02	0.192	3.10	47,079
Shelbyville, Shelby Co.	1990	1.54	84.5	80.78	21.77	0.567	6.74	36,204
	1995	0.76	90.4	82.12	17.24	0.665	5.77	35,303

	2000	0.82	90.7	82.12	28.72	0.740	6.39	36,703
	2005	0.70	101.6	82.54	16.02	0.882	6.25	38,878
Windsor, Shelby Co.	1990	0.09	74.0	80.78	21.77	0.186	5.99	33,984
	1995	0.10	77.4	82.12	17.24	0.173	5.13	35,732
	2000	0.09	76.0	82.12	28.72	0.153	4.52	37,423
	2005	0.09	80.3	82.54	16.02	0.158	4.00	38,303
Freeburg, St. Clair Co.	1990	0.28	79.5	83.38	18.78	0.421	2.92	51,057
	1995	0.32	80.1	84.32	25.47	0.408	2.50	53,286
	2000	0.36	76.5	82.28	28.42	0.379	3.96	58,161
	2005	0.37	83.0	87.58	20.13	0.326	4.28	63,614
Kaskaskia WD, St. Clair Co.	1990	0.94	71.6	83.38	18.78	0.462	2.25	43,587
	1995	1.11	71.9	84.32	25.47	0.504	2.43	44,021
	2000	1.07	71.3	82.28	28.42	0.531	2.15	44,807
	2005	1.16	80.0	87.58	20.13	0.607	2.00	44,894
SLM Water Co. St. Clair Co.	1990	1.74	128.4	83.38	18.78	0.462	2.62	51,097
	1995	2.05	129.9	84.32	25.47	0.504	2.56	51,605
	2000	2.32	127.6	82.28	28.42	0.531	2.60	52,526
	2005	2.71	143.6	87.58	20.13	0.607	2.30	52,627
Shiloh, St. Clair Co.	1990	0.24	57.1	83.38	18.78	0.421	3.19	51,248
	1995	0.29	58.8	84.32	25.47	0.408	3.06	58,871
	2000	0.29	58.3	82.28	28.42	0.379	2.85	65,237
	2005		63.2	87.58	20.13	0.326	2.69	69,438
Ashley, Washington Co.	1990	0.06	62.9	82.10	22.25	0.585	7.49	29,502
	1995	0.07	62.1	83.08	29.13	0.469	6.41	32,748
	2000	0.04	63.4	81.88	28.44	0.202	6.78	35,540
	2005	0.04	59.3	84.42	18.85	0.151	6.00	37,300
Nashville, Washington Co.	1990	0.62	225.5	82.10	22.25	0.857	5.24	36,868
	1995	0.64	248.0	83.08	29.13	0.981	4.48	42,584
	2000	0.51	271.2	81.88	28.44	1.230	7.12	47,603
	2005	0.95	306.9	84.42	18.85	1.335	6.30	51,192
Okawville, Washington Co.	1990	0.11	85.7	82.10	22.25	0.363	5.36	35,187
	1995	0.11	89.5	83.08	29.13	0.387	4.59	39,035
	2000	0.11	92.3	81.88	28.44	0.421	4.05	42,346
	2005	0.14	99.7	84.42	18.85	0.429	3.58	44,431
Fairfield, Wayne Co.	1990	0.93	155.5	82.08	18.72	0.572	4.47	27,434
	1995	0.90	163.4	85.04	21.93	0.608	3.82	27,731
	2000	0.86	159.6	81.40	26.42	0.631	3.37	29,171
	2005	0.81	174.1	84.62	15.35	0.620	2.98	30,771
Wayne City, Wayne Co.	1990	0.30	116.8	82.08	18.72	0.172	3.45	27,647
	1995	0.34	123.9	85.04	21.93	0.223	3.40	29,124
	2000	0.62	116.2	81.04	26.42	0.157	3.17	30,541
	2005	0.14	127.0	84.62	15.36	0.171	2.80	31,289

Table: A4.3 Allocation of Future Population Served to Water Supply Systems (CT Scenario)

System Name	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
Altamont	2,595	2,501	2,663	2,797	2,923	3,027	3,098	3,171	3,245	3,321	3,398
Arcola	2,652	2,652	2,791	2,908	3,002	3,051	3,142	3,237	3,333	3,433	3,536
Arthur	2,100	2,300	2,396	2,486	2,567	2,615	2,669	2,723	2,779	2,836	2,894
Ashley	650	650	671	689	701	702	712	722	733	744	754
Bethany	1,300	1,268	1,321	1,370	1,415	1,442	1,471	1,501	1,532	1,563	1,595
Breese	4,100	4,500	4,826	4,981	5,184	5,348	5,368	5,388	5,409	5,430	5,450
Carlyle	3,406	3,425	3,673	3,791	3,946	4,070	4,086	4,101	4,117	4,133	4,148
Centralia	16,000	14,200	14,451	14,847	15,219	15,419	15,760	16,108	16,463	16,826	17,198
Charleston	20,000	21,500	21,889	22,457	23,132	23,651	23,811	23,971	24,133	24,295	24,459
Clay City	929	1,000	1,010	1,036	1,058	1,067	1,084	1,102	1,120	1,138	1,156
Coulterville	1,230	1,230	1,241	1,264	1,288	1,306	1,333	1,360	1,388	1,416	1,445
Effingham	12,000	20,510	21,840	22,934	23,970	24,826	25,407	26,001	26,609	27,231	27,868
Evansville	800	750	757	771	785	797	813	829	846	863	881
Fairfield	5,338	4,661	4,611	4,595	4,596	4,574	4,626	4,678	4,731	4,784	4,838
Flora	5,276	4,766	4,812	4,938	5,040	5,083	5,166	5,250	5,336	5,423	5,511
Freeburg	4,136	4,398	4,658	4,807	4,971	5,048	5,126	5,206	5,286	5,368	5,451
Greenville	7,264	7,264	7,355	7,592	7,904	8,134	8,276	8,420	8,567	8,716	8,868
Hecker	475	484	527	570	617	665	684	704	725	746	767
Highland	8,224	9,799	10,015	10,333	10,680	10,911	11,079	11,250	11,423	11,598	11,777
Hillsboro	2,500	3,887	3,907	3,963	4,035	4,111	4,209	4,309	4,411	4,516	4,623
Kaskaskia Water Dist.	15,125	14,462	15,316	15,808	16,346	16,599	16,856	17,117	17,382	17,651	17,925
Kinkaid	1,647	1,400	1,470	1,493	1,544	1,559	1,565	1,572	1,579	1,586	1,593
Kinmundy	900	892	908	933	956	969	990	1,012	1,034	1,057	1,080
Litchfield	5,248	3,726	3,745	3,799	3,868	3,941	4,035	4,130	4,228	4,329	4,431
Louisville	1,242	1,000	1,010	1,036	1,058	1,067	1,084	1,102	1,120	1,138	1,156
Lovington	1,222	1,222	1,273	1,321	1,364	1,389	1,418	1,447	1,476	1,507	1,537
Mattoon	21,326	14,481	14,743	15,126	15,580	15,930	16,037	16,145	16,254	16,364	16,474
Mount Olive	2,150	2,160	2,226	2,323	2,431	2,525	2,580	2,637	2,696	2,755	2,816
Moweaqua	1,800	2,000	2,017	2,048	2,089	2,099	2,120	2,141	2,162	2,183	2,205
Mulberry Grove	700	700	709	732	762	784	798	811	826	840	855
Nashville	2,417	3,090	3,188	3,273	3,333	3,337	3,385	3,435	3,485	3,535	3,587
Neoga	1,775	1,854	1,895	1,947	2,022	2,091	2,135	2,180	2,225	2,272	2,320
New Baden	3,350	3,490	3,743	3,863	4,021	4,147	4,163	4,179	4,195	4,211	4,227
Newton	3,069	3,069	3,052	3,058	3,088	3,112	3,149	3,187	3,225	3,263	3,302
Noble	400	342	346	354	362	369	376	384	391	398	406

System Name	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
Oakland	1,101	1,090	1,110	1,139	1,173	1,199	1,207	1,215	1,223	1,232	1,240
Okawville	1,300	1,355	1,398	1,435	1,462	1,463	1,485	1,506	1,528	1,550	1,573
Olney	9,100	9,000	9,100	9,313	9,522	9,722	9,906	10,093	10,284	10,479	10,677
Pana	5,300	5,800	6,089	6,186	6,398	6,457	6,485	6,514	6,543	6,572	6,601
Patoka	639	633	644	662	678	687	703	718	734	750	767
Ramsey	1,000	1,000	1,003	1,012	1,023	1,030	1,035	1,039	1,044	1,048	1,053
Red Bud	3,400	3,442	3,472	3,538	3,604	3,655	3,730	3,806	3,883	3,962	4,043
Salem	7,730	7,945	8,085	8,307	8,515	8,627	8,818	9,012	9,211	9,415	9,622
Shelbyville	5,000	6,841	6,898	7,004	7,146	7,180	7,251	7,323	7,395	7,469	7,543
Shiloh											
SLM Water Comm.	16,948	18,838	19,951	20,592	21,293	21,622	21,957	22,297	22,642	22,992	23,348
Sparta	4,431	4,486	4,526	4,612	4,697	4,764	4,861	4,960	5,061	5,164	5,269
St. Elmo	1,400	1,456	1,460	1,473	1,490	1,500	1,507	1,513	1,520	1,526	1,533
St. Marie	262	260	259	259	262	264	267	270	273	276	280
Steeleville	2,077	2,077	2,095	2,135	2,175	2,206	2,251	2,297	2,343	2,391	2,440
Sullivan	4,350	4,846	5,048	5,237	5,408	5,510	5,623	5,738	5,855	5,974	6,097
Taylorville	10,047	15,482	16,252	16,513	17,079	17,235	17,311	17,388	17,465	17,542	17,620
Teutopolis	2,000	2,000	2,130	2,236	2,337	2,421	2,478	2,535	2,595	2,655	2,718
Toledo	1,189	1,200	1,227	1,260	1,308	1,353	1,382	1,411	1,440	1,470	1,501
Trenton	2,512	2,630	2,821	2,911	3,030	3,125	3,137	3,149	3,161	3,173	3,185
Troy	8,000	9,950	10,170	10,492	10,845	11,080	11,250	11,423	11,599	11,777	11,958
Tuscola	4,324	4,448	4,681	4,877	5,035	5,117	5,271	5,428	5,591	5,758	5,931
Vandalia	6,975	6,975	6,994	7,056	7,138	7,187	7,218	7,249	7,281	7,312	7,343
Villa Grove	2,734	2,534	2,667	2,778	2,868	2,915	3,003	3,093	3,185	3,281	3,379
Wamac	1,500	1,378	1,402	1,441	1,477	1,496	1,529	1,563	1,598	1,633	1,669
Wayne City	3,100	1,100	1,088	1,085	1,085	1,080	1,092	1,104	1,116	1,129	1,142
Windsor	1,243	1,125	1,134	1,152	1,175	1,181	1,192	1,204	1,216	1,228	1,240
Residual Bond	2,603	8,216	8,319	8,587	8,940	9,200	9,361	9,524	9,690	9,858	10,030
Residual Christian	6,424	6,496	6,819	6,928	7,166	7,232	7,264	7,296	7,328	7,360	7,393
Residual Clay	593	1,406	1,420	1,457	1,487	1,500	1,524	1,549	1,574	1,600	1,626
Residual Clinton	16,457	18,999	20,375	21,029	21,887	22,577	22,664	22,750	22,837	22,924	23,012
Residual Coles	20,325	37,432	38,109	39,098	40,273	41,178	41,455	41,734	42,016	42,299	42,584
Residual Cumberland	1,862	1,732	1,771	1,819	1,889	1,953	1,994	2,036	2,079	2,122	2,167
Residual Douglas	12,173	13,226	13,920	14,502	14,970	15,216	15,672	16,141	16,625	17,123	17,635
Residual Effingham	5,856	8,216	8,749	9,187	9,602	9,945	10,178	10,416	10,659	10,908	11,164
Residual Fayette	5,583	5,985	4,541	4,582	4,635	4,667	4,687	4,707	4,727	4,748	4,768
Residual Jasper	9,342	13,216	13,142	13,169	13,296	13,401	13,561	13,722	13,886	14,051	14,219

System Name	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
Residual Macoupin	5,525	5,586	5,757	6,008	6,286	6,529	6,673	6,821	6,971	7,125	7,282
Residual Madison	13,295	16,816	17,187	17,732	18,328	18,725	19,013	19,305	19,602	19,904	20,210
Residual Marion	11,249	18,086	19,314	19,842	20,340	20,608	21,063	21,527	22,003	22,488	22,985
Residual Monroe	7,614	8,945	9,735	10,528	11,402	12,294	12,650	13,016	13,393	13,781	14,180
Residual Montgomery	10,752	9,803	9,853	9,994	10,176	10,369	10,615	10,867	11,125	11,389	11,659
Residual Moultrie	5,933	3,345	3,484	3,615	3,733	3,803	3,881	3,960	4,041	4,124	4,208
Residual Randolph	16,342	17,861	18,019	18,361	18,700	18,969	19,355	19,749	20,151	20,561	20,979
Residual Richland	1,452	2,610	2,639	2,701	2,761	2,819	2,873	2,927	2,982	3,039	3,096
Residual Shelby	4,058	5,435	5,481	5,565	5,677	5,704	5,761	5,818	5,875	5,934	5,992
Residual St. Clair	64,018	53,691	52,205	53,882	55,716	56,579	57,454	58,344	59,247	60,164	61,095
Residual Washington	10,017	10,714	11,053	11,350	11,558	11,570	11,738	11,909	12,082	12,258	12,436
Residual Wayne	4,826	6,497	6,427	6,405	6,406	6,376	6,448	6,521	6,594	6,669	6,744
Total Study Area	507,307	557,837	571,073	587,283	605,306	617,061	626,442	635,999	645,737	655,658	665,768

Table A4.4 Current Trends (CT) Public-Supply Water Demand Scenario for Water Supply Systems MGD

Study Areas (Systems)	2005 Reported	2005 Normal	2010	2015	2020	2025	2030	2035	2040	2045	2050
Altamont	0.22	0.21	0.22	0.23	0.25	0.26	0.26	0.27	0.28	0.29	0.29
Arcola	0.32	0.31	0.33	0.35	0.36	0.37	0.38	0.40	0.41	0.42	0.44
Arthur	0.25	0.25	0.26	0.27	0.28	0.29	0.30	0.31	0.31	0.32	0.33
Ashley	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05
Bethany	0.12	0.12	0.12	0.13	0.13	0.13	0.14	0.14	0.14	0.15	0.15
Breese	0.55	0.54	0.58	0.60	0.63	0.65	0.66	0.66	0.67	0.68	0.68
Carlyle	0.73	0.72	0.78	0.80	0.84	0.87	0.88	0.89	0.90	0.91	0.91
Centralia	2.61	2.53	2.59	2.67	2.76	2.81	2.89	2.96	3.05	3.13	3.22
Charleston	1.31	1.26	1.29	1.33	1.38	1.42	1.44	1.45	1.47	1.49	1.51
Clay City	0.08	0.07	0.07	0.08	0.08	0.08	0.08	0.08	0.08	0.09	0.09
Coulterville	0.14	0.14	0.14	0.14	0.15	0.15	0.15	0.16	0.16	0.17	0.17
Effingham	1.37	1.28	1.37	1.44	1.51	1.58	1.62	1.67	1.72	1.77	1.82
Evansville	0.08	0.08	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.09	0.09
Fairfield	0.81	0.79	0.78	0.78	0.79	0.79	0.80	0.81	0.83	0.84	0.86
Flora	0.59	0.56	0.57	0.59	0.61	0.61	0.63	0.64	0.66	0.67	0.68
Freeburg	0.36	0.35	0.38	0.39	0.41	0.41	0.42	0.43	0.44	0.45	0.46
Greenville	1.29	1.25	1.27	1.32	1.38	1.43	1.46	1.50	1.53	1.57	1.60
Hecker	0.04	0.04	0.04	0.05	0.05	0.06	0.06	0.06	0.06	0.07	0.07
Highland	1.00	0.98	1.01	1.04	1.09	1.11	1.14	1.16	1.19	1.21	1.24
Hillsboro	1.13	1.11	1.12	1.14	1.17	1.19	1.23	1.27	1.30	1.34	1.38
Kaskaskia Water Dist.	1.16	1.12	1.19	1.24	1.29	1.31	1.34	1.37	1.40	1.43	1.46
Kinkaid	0.13	0.12	0.13	0.13	0.14	0.14	0.14	0.14	0.14	0.15	0.15
Kinmundy	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.09	0.10	0.10	0.10
Litchfield	0.68	0.66	0.67	0.68	0.70	0.71	0.74	0.76	0.78	0.80	0.83
Louisville	0.12	0.12	0.12	0.12	0.13	0.13	0.13	0.13	0.14	0.14	0.14
Lovington	0.10	0.10	0.11	0.11	0.11	0.12	0.12	0.12	0.13	0.13	0.13
Mattoon	1.73	1.67	1.71	1.76	1.82	1.87	1.90	1.92	1.94	1.97	1.99
Mount Olive	0.20	0.20	0.21	0.22	0.23	0.24	0.24	0.25	0.26	0.26	0.27
Moweaqua	0.17	0.17	0.17	0.17	0.18	0.18	0.18	0.19	0.19	0.19	0.19
Mulberry Grove	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.06
Nashville	0.95	0.94	0.97	1.00	1.03	1.03	1.05	1.08	1.10	1.12	1.14
Neoga	0.16	0.15	0.15	0.16	0.16	0.17	0.17	0.18	0.18	0.19	0.19
New Baden	0.39	0.38	0.41	0.43	0.45	0.46	0.47	0.47	0.47	0.48	0.48
Newton	0.31	0.29	0.29	0.29	0.30	0.30	0.31	0.31	0.32	0.32	0.33
Noble	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.07	0.07	0.08	0.08
Oakland	0.08	0.07	0.07	0.08	0.08	0.08	0.08	0.08	0.08	0.09	0.09
Okawville	0.14	0.13	0.14	0.14	0.15	0.15	0.15	0.15	0.16	0.16	0.16
Olney	1.30	1.28	1.30	1.34	1.38	1.41	1.45	1.48	1.52	1.56	1.60
Pana	0.60	0.58	0.61	0.63	0.65	0.66	0.67	0.67	0.68	0.69	0.69
Patoka	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.07
Ramsey	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Red Bud	0.40	0.39	0.39	0.40	0.41	0.42	0.43	0.44	0.45	0.47	0.48
Salem	0.93	0.90	0.92	0.95	0.98	1.00	1.02	1.05	1.08	1.11	1.14
Shelbyville	0.69	0.68	0.69	0.71	0.73	0.73	0.74	0.76	0.77	0.78	0.79
Shiloh	-	-	-	-	-	-	-	-	-	-	-
SLM Water Comm.	2.71	2.62	2.79	2.90	3.01	3.07	3.14	3.20	3.27	3.34	3.41
Sparta	0.99	0.97	0.98	1.00	1.03	1.05	1.07	1.10	1.13	1.16	1.19
St. Elmo	0.14	0.14	0.14	0.14	0.14	0.15	0.15	0.15	0.15	0.15	0.15

Study Areas (Systems)	2005 Reported	2005 Normal	2010	2015	2020	2025	2030	2035	2040	2045	2050
St. Marie	0.04	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04
Steeleville	0.27	0.27	0.27	0.28	0.28	0.29	0.30	0.30	0.31	0.32	0.33
Sullivan	0.62	0.61	0.64	0.67	0.69	0.71	0.73	0.75	0.77	0.79	0.81
Taylorville	2.18	2.10	2.21	2.26	2.35	2.38	2.41	2.43	2.46	2.48	2.50
Teutopolis	0.17	0.16	0.17	0.18	0.18	0.19	0.20	0.20	0.21	0.21	0.22
Toledo	0.10	0.09	0.09	0.10	0.10	0.10	0.11	0.11	0.11	0.12	0.12
Trenton	0.19	0.19	0.20	0.21	0.22	0.23	0.23	0.23	0.24	0.24	0.24
Troy	1.55	1.52	1.56	1.62	1.68	1.72	1.76	1.80	1.83	1.87	1.91
Tuscola	0.45	0.45	0.48	0.50	0.52	0.53	0.55	0.57	0.59	0.61	0.63
Vandalia	0.84	0.81	0.82	0.83	0.84	0.85	0.86	0.87	0.88	0.89	0.90
Villa Grove	0.30	0.30	0.31	0.33	0.34	0.35	0.36	0.37	0.39	0.40	0.41
Wamac	0.09	0.09	0.09	0.09	0.09	0.09	0.10	0.10	0.10	0.11	0.11
Wayne City	0.14	0.14	0.13	0.13	0.14	0.14	0.14	0.14	0.14	0.14	0.15
Windsor	0.09	0.09	0.09	0.09	0.09	0.10	0.10	0.10	0.10	0.10	0.10
Residual Bond	0.54	0.52	0.53	0.55	0.57	0.59	0.61	0.62	0.64	0.65	0.67
Residual Christian	0.69	0.66	0.70	0.71	0.74	0.75	0.76	0.77	0.77	0.78	0.79
Residual Clay	0.08	0.08	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.09	0.09
Residual Clinton	1.56	1.53	1.65	1.71	1.79	1.86	1.88	1.90	1.91	1.93	1.95
Residual Coles	1.06	1.02	1.04	1.07	1.11	1.14	1.16	1.17	1.18	1.20	1.21
Residual Cumberland	0.20	0.19	0.19	0.20	0.20	0.21	0.22	0.22	0.23	0.24	0.24
Residual Douglas	1.23	1.23	1.30	1.36	1.41	1.44	1.49	1.54	1.60	1.66	1.71
Residual Effingham	0.55	0.52	0.55	0.58	0.61	0.64	0.66	0.68	0.70	0.72	0.74
Residual Fayette	0.59	0.57	0.43	0.44	0.45	0.45	0.46	0.46	0.47	0.47	0.48
Residual Jasper	0.90	0.84	0.83	0.84	0.85	0.86	0.88	0.89	0.91	0.93	0.94
Residual Macoupin	0.47	0.46	0.48	0.50	0.53	0.55	0.57	0.58	0.60	0.61	0.63
Residual Madison	0.98	0.96	0.99	1.02	1.06	1.09	1.12	1.14	1.16	1.19	1.21
Residual Marion	1.04	1.01	1.08	1.12	1.15	1.17	1.20	1.24	1.27	1.31	1.34
Residual Monroe	0.76	0.74	0.81	0.88	0.96	1.04	1.07	1.11	1.15	1.19	1.23
Residual Montgomery	1.03	1.01	1.02	1.04	1.06	1.09	1.12	1.15	1.18	1.22	1.25
Residual Moultrie	0.26	0.26	0.27	0.28	0.29	0.30	0.31	0.31	0.32	0.33	0.34
Residual Randolph	1.77	1.72	1.75	1.79	1.83	1.87	1.92	1.97	2.02	2.07	2.12
Residual Richland	0.18	0.18	0.18	0.19	0.19	0.20	0.20	0.21	0.21	0.22	0.22
Residual Shelby	0.40	0.39	0.40	0.41	0.42	0.42	0.43	0.44	0.44	0.45	0.46
Residual St. Clair	7.90	7.66	7.49	7.77	8.08	8.25	8.42	8.60	8.78	8.96	9.15
Residual Washington	1.11	1.09	1.13	1.17	1.20	1.21	1.23	1.25	1.28	1.31	1.33
Residual Wayne	0.37	0.36	0.36	0.36	0.36	0.36	0.37	0.37	0.38	0.38	0.39

Table A4.5 Less Resource Intensive (LRI) Public-Supply Water Demand Scenario for Water Supply Systems MGD

Study Areas (Systems)	2005 Reported	2005 Normal	2010	2015	2020	2025	2030	2035	2040	2045	2050
Altamont	0.22	0.20	0.22	0.23	0.24	0.25	0.25	0.26	0.26	0.27	0.28
Arcola	0.31	0.31	0.33	0.34	0.35	0.36	0.37	0.38	0.39	0.40	0.41
Arthur	0.25	0.25	0.26	0.27	0.28	0.28	0.29	0.29	0.30	0.30	0.31
Ashley	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Bethany	0.12	0.11	0.12	0.12	0.13	0.13	0.13	0.13	0.14	0.14	0.14
Breese	0.54	0.53	0.57	0.59	0.61	0.63	0.63	0.63	0.64	0.64	0.64
Carlyle	0.73	0.71	0.76	0.79	0.82	0.84	0.85	0.85	0.85	0.85	0.86
Centralia	2.59	2.51	2.55	2.62	2.68	2.71	2.77	2.83	2.89	2.95	3.01
Charleston	1.30	1.25	1.27	1.30	1.34	1.37	1.38	1.39	1.39	1.40	1.41
Clay City	0.08	0.07	0.07	0.07	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Coulterville	0.14	0.14	0.14	0.14	0.14	0.15	0.15	0.15	0.15	0.16	0.16
Effingham	1.36	1.26	1.34	1.41	1.47	1.52	1.56	1.59	1.63	1.67	1.70
Evansville	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.09	0.09	0.09
Fairfield	0.81	0.78	0.77	0.77	0.76	0.76	0.77	0.78	0.78	0.79	0.80
Flora	0.58	0.56	0.56	0.58	0.59	0.59	0.60	0.61	0.62	0.63	0.64
Freeburg	0.36	0.35	0.37	0.38	0.39	0.40	0.41	0.41	0.42	0.42	0.43
Greenville	1.28	1.24	1.25	1.29	1.34	1.38	1.40	1.43	1.45	1.48	1.50
Hecker	0.04	0.04	0.04	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.06
Highland	1.00	0.97	0.99	1.02	1.06	1.08	1.09	1.11	1.13	1.14	1.16
Hillsboro	1.12	1.10	1.10	1.12	1.13	1.15	1.18	1.21	1.24	1.26	1.29
Kaskaskia Water Dist.	1.15	1.11	1.18	1.21	1.25	1.27	1.29	1.31	1.33	1.35	1.37
Kinkaid	0.13	0.12	0.13	0.13	0.13	0.14	0.14	0.14	0.14	0.14	0.14
Kinmundy	0.08	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.09	0.09	0.09
Litchfield	0.67	0.66	0.66	0.67	0.68	0.69	0.71	0.72	0.74	0.76	0.77
Louisville	0.12	0.12	0.12	0.12	0.12	0.12	0.13	0.13	0.13	0.13	0.13
Lovington	0.10	0.10	0.10	0.11	0.11	0.11	0.12	0.12	0.12	0.12	0.12
Mattoon	1.72	1.65	1.68	1.72	1.77	1.81	1.82	1.83	1.84	1.85	1.87
Mount Olive	0.20	0.20	0.20	0.21	0.22	0.23	0.23	0.24	0.24	0.25	0.25
Moweaqua	0.17	0.17	0.17	0.17	0.17	0.17	0.18	0.18	0.18	0.18	0.18
Mulberry Grove	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.06
Nashville	0.94	0.93	0.96	0.98	1.00	1.00	1.01	1.03	1.04	1.05	1.07
Neoga	0.16	0.15	0.15	0.15	0.16	0.16	0.17	0.17	0.17	0.18	0.18
New Baden	0.38	0.38	0.40	0.42	0.43	0.45	0.45	0.45	0.45	0.45	0.45
Newton	0.31	0.29	0.29	0.29	0.29	0.29	0.29	0.30	0.30	0.30	0.31
Noble	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.07	0.07	0.07
Oakland	0.07	0.07	0.07	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Okawville	0.13	0.13	0.14	0.14	0.14	0.14	0.14	0.15	0.15	0.15	0.15
Olney	1.29	1.27	1.28	1.31	1.34	1.37	1.39	1.42	1.44	1.47	1.50
Pana	0.60	0.58	0.60	0.61	0.63	0.64	0.64	0.64	0.64	0.65	0.65
Patoka	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.06
Ramsey	0.09	0.08	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Red Bud	0.39	0.38	0.39	0.39	0.40	0.41	0.41	0.42	0.43	0.44	0.45
Salem	0.92	0.89	0.91	0.93	0.95	0.96	0.98	1.00	1.03	1.05	1.07
Shelbyville	0.69	0.68	0.68	0.69	0.71	0.71	0.72	0.72	0.73	0.73	0.74
Shiloh	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SLM Water Comm.	2.68	2.60	2.75	2.84	2.93	2.97	3.01	3.06	3.10	3.15	3.20
Sparta	0.98	0.96	0.96	0.98	1.00	1.01	1.03	1.05	1.07	1.09	1.11

Study Areas (Systems)	2005 Reported	2005 Normal	2010	2015	2020	2025	2030	2035	2040	2045	2050
St. Elmo	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14
St. Marie	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04
Steeleville	0.27	0.26	0.27	0.27	0.28	0.28	0.28	0.29	0.30	0.30	0.31
Sullivan	0.62	0.61	0.63	0.65	0.67	0.69	0.70	0.71	0.73	0.74	0.76
Taylorville	2.16	2.08	2.18	2.21	2.28	2.30	2.31	2.32	2.33	2.34	2.35
Teutopolis	0.16	0.15	0.16	0.17	0.18	0.19	0.19	0.19	0.20	0.20	0.21
Toledo	0.10	0.09	0.09	0.09	0.10	0.10	0.10	0.10	0.11	0.11	0.11
Trenton	0.19	0.19	0.20	0.21	0.21	0.22	0.22	0.22	0.22	0.22	0.22
Troy	1.54	1.50	1.53	1.58	1.63	1.67	1.69	1.71	1.74	1.77	1.79
Tuscola	0.45	0.45	0.47	0.49	0.50	0.51	0.53	0.54	0.56	0.57	0.59
Vandalia	0.83	0.81	0.81	0.81	0.82	0.83	0.83	0.83	0.83	0.84	0.84
Villa Grove	0.30	0.29	0.31	0.32	0.33	0.34	0.35	0.36	0.37	0.38	0.39
Wamac	0.09	0.08	0.09	0.09	0.09	0.09	0.09	0.10	0.10	0.10	0.10
Wayne City	0.14	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.14	0.14	0.14
Windsor	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.10	0.10
Residual Bond	0.53	0.52	0.52	0.54	0.56	0.57	0.58	0.59	0.60	0.61	0.62
Residual Christian	0.68	0.66	0.69	0.70	0.72	0.73	0.73	0.73	0.73	0.74	0.74
Residual Clay	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.09	0.09	0.09
Residual Clinton	1.55	1.52	1.63	1.68	1.74	1.80	1.80	1.81	1.81	1.82	1.83
Residual Coles	1.05	1.01	1.02	1.05	1.08	1.10	1.11	1.12	1.12	1.13	1.14
Residual Cumberland	0.20	0.18	0.19	0.19	0.20	0.21	0.21	0.21	0.22	0.22	0.23
Residual Douglas	1.22	1.21	1.28	1.33	1.37	1.39	1.43	1.47	1.52	1.56	1.61
Residual Effingham	0.55	0.51	0.54	0.57	0.60	0.62	0.63	0.64	0.66	0.67	0.69
Residual Fayette	0.58	0.56	0.43	0.43	0.43	0.44	0.44	0.44	0.44	0.44	0.44
Residual Jasper	0.89	0.83	0.82	0.82	0.83	0.84	0.84	0.85	0.86	0.87	0.88
Residual Macoupin	0.47	0.46	0.47	0.49	0.51	0.53	0.54	0.56	0.57	0.58	0.59
Residual Madison	0.98	0.95	0.97	1.00	1.03	1.06	1.07	1.09	1.10	1.12	1.14
Residual Marion	1.03	1.00	1.06	1.09	1.12	1.13	1.16	1.18	1.21	1.23	1.26
Residual Monroe	0.75	0.73	0.80	0.86	0.93	1.00	1.03	1.06	1.09	1.12	1.15
Residual Montgomery	1.02	1.00	1.00	1.01	1.03	1.05	1.07	1.10	1.12	1.15	1.17
Residual Moultrie	0.26	0.25	0.27	0.27	0.28	0.29	0.29	0.30	0.31	0.31	0.32
Residual Randolph	1.75	1.71	1.72	1.75	1.78	1.81	1.84	1.88	1.91	1.95	1.99
Residual Richland	0.18	0.18	0.18	0.18	0.19	0.19	0.20	0.20	0.20	0.21	0.21
Residual Shelby	0.40	0.39	0.39	0.40	0.41	0.41	0.41	0.42	0.42	0.42	0.43
Residual St. Clair	7.84	7.60	7.38	7.60	7.85	7.97	8.08	8.20	8.32	8.45	8.57
Residual Washington	1.10	1.08	1.12	1.15	1.17	1.17	1.18	1.20	1.21	1.23	1.25
Residual Wayne	0.37	0.36	0.35	0.35	0.35	0.35	0.35	0.36	0.36	0.36	0.37

Table A4.6 More Resource Intensive (MRI) Public-Supply Water Demand Scenario for Water Supply Systems - MGD

Study Areas (Systems)	2005 Reported	2005 Normal	2010	2015	2020	2025	2030	2035	2040	2045	2050
Altamont	0.22	0.21	0.22	0.24	0.25	0.26	0.27	0.28	0.29	0.30	0.32
Arcola	0.32	0.32	0.34	0.36	0.37	0.38	0.40	0.42	0.43	0.45	0.47
Arthur	0.26	0.25	0.27	0.28	0.29	0.30	0.31	0.32	0.33	0.34	0.35
Ashley	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05
Bethany	0.12	0.12	0.12	0.13	0.13	0.14	0.14	0.15	0.15	0.16	0.16
Breese	0.55	0.54	0.59	0.62	0.65	0.68	0.69	0.70	0.71	0.72	0.73
Carlyle	0.74	0.73	0.79	0.82	0.87	0.90	0.92	0.93	0.95	0.96	0.98
Centralia	2.63	2.56	2.63	2.74	2.84	2.91	3.01	3.11	3.22	3.33	3.45
Charleston	1.32	1.27	1.31	1.36	1.42	1.47	1.50	1.52	1.55	1.58	1.61
Clay City	0.08	0.07	0.08	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.09
Coulterville	0.14	0.14	0.14	0.15	0.15	0.16	0.16	0.17	0.17	0.18	0.18
Effingham	1.38	1.29	1.39	1.47	1.56	1.63	1.69	1.75	1.81	1.88	1.95
Evansville	0.08	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.10	0.10	0.10
Fairfield	0.82	0.79	0.79	0.80	0.81	0.82	0.83	0.85	0.87	0.89	0.92
Flora	0.59	0.57	0.58	0.60	0.62	0.64	0.66	0.67	0.69	0.71	0.73
Freeburg	0.37	0.36	0.38	0.40	0.42	0.43	0.44	0.45	0.47	0.48	0.49
Greenville	1.30	1.26	1.29	1.35	1.42	1.48	1.53	1.57	1.62	1.67	1.72
Hecker	0.04	0.04	0.05	0.05	0.05	0.06	0.06	0.06	0.07	0.07	0.07
Highland	1.01	0.99	1.02	1.07	1.12	1.16	1.19	1.22	1.25	1.29	1.32
Hillsboro	1.14	1.12	1.14	1.17	1.20	1.24	1.28	1.33	1.38	1.43	1.48
Kaskaskia Water Dist.	1.17	1.13	1.21	1.27	1.33	1.36	1.40	1.44	1.48	1.52	1.56
Kinkaid	0.13	0.12	0.13	0.14	0.14	0.15	0.15	0.15	0.15	0.16	0.16
Kinmundy	0.08	0.08	0.08	0.09	0.09	0.09	0.09	0.10	0.10	0.10	0.11
Litchfield	0.68	0.67	0.68	0.70	0.72	0.74	0.77	0.80	0.82	0.85	0.88
Louisville	0.12	0.12	0.12	0.13	0.13	0.13	0.14	0.14	0.14	0.15	0.15
Lovington	0.10	0.10	0.11	0.11	0.12	0.12	0.13	0.13	0.13	0.14	0.14
Mattoon	1.75	1.68	1.73	1.80	1.88	1.94	1.98	2.02	2.05	2.09	2.13
Mount Olive	0.20	0.20	0.21	0.22	0.23	0.25	0.25	0.26	0.27	0.28	0.29
Moweaqua	0.17	0.17	0.17	0.18	0.18	0.19	0.19	0.20	0.20	0.20	0.21
Mulberry Grove	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.07
Nashville	0.96	0.95	0.99	1.03	1.06	1.07	1.10	1.13	1.16	1.19	1.22
Neoga	0.16	0.15	0.15	0.16	0.17	0.18	0.18	0.19	0.19	0.20	0.21
New Baden	0.39	0.38	0.42	0.43	0.46	0.48	0.49	0.49	0.50	0.51	0.52
Newton	0.31	0.29	0.29	0.30	0.31	0.31	0.32	0.33	0.33	0.34	0.35
Noble	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.08
Oakland	0.08	0.07	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.09	0.09
Okawville	0.14	0.13	0.14	0.15	0.15	0.15	0.16	0.16	0.17	0.17	0.17
Olney	1.31	1.29	1.32	1.37	1.42	1.47	1.51	1.56	1.61	1.66	1.71
Pana	0.61	0.59	0.62	0.64	0.67	0.68	0.69	0.71	0.72	0.73	0.74
Patoka	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.07	0.07	0.07
Ramsey	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.10	0.10	0.10	0.10
Red Bud	0.40	0.39	0.40	0.41	0.42	0.44	0.45	0.47	0.48	0.50	0.51
Salem	0.93	0.91	0.93	0.97	1.01	1.03	1.07	1.10	1.14	1.18	1.22
Shelbyville	0.70	0.69	0.70	0.72	0.75	0.76	0.78	0.79	0.81	0.83	0.85
Shiloh	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SLM Water Comm.	2.73	2.65	2.84	2.96	3.10	3.19	3.27	3.36	3.46	3.55	3.65
Sparta	1.00	0.97	0.99	1.02	1.06	1.08	1.12	1.16	1.19	1.23	1.27
St. Elmo	0.14	0.14	0.14	0.14	0.15	0.15	0.15	0.16	0.16	0.16	0.16

Study Areas (Systems)	2005 Reported	2005 Normal	2010	2015	2020	2025	2030	2035	2040	2045	2050
St. Marie	0.04	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Steeleville	0.28	0.27	0.27	0.28	0.29	0.30	0.31	0.32	0.33	0.34	0.35
Sullivan	0.63	0.62	0.65	0.68	0.71	0.74	0.76	0.78	0.81	0.84	0.86
Taylorville	2.19	2.12	2.25	2.31	2.42	2.47	2.51	2.55	2.59	2.64	2.68
Teutopolis	0.17	0.16	0.17	0.18	0.19	0.20	0.21	0.21	0.22	0.23	0.24
Toledo	0.10	0.09	0.09	0.10	0.10	0.11	0.11	0.12	0.12	0.12	0.13
Trenton	0.19	0.19	0.20	0.21	0.23	0.23	0.24	0.24	0.25	0.25	0.25
Troy	1.57	1.53	1.58	1.65	1.73	1.79	1.84	1.89	1.94	1.99	2.05
Tuscola	0.46	0.45	0.48	0.51	0.53	0.55	0.57	0.60	0.62	0.65	0.67
Vandalia	0.84	0.82	0.83	0.85	0.87	0.89	0.90	0.91	0.93	0.95	0.96
Villa Grove	0.30	0.30	0.32	0.34	0.35	0.36	0.38	0.39	0.41	0.43	0.44
Wamac	0.09	0.09	0.09	0.09	0.10	0.10	0.10	0.10	0.11	0.11	0.12
Wayne City	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.15	0.15	0.15	0.16
Windsor	0.09	0.09	0.09	0.09	0.10	0.10	0.10	0.10	0.11	0.11	0.11
Residual Bond	0.54	0.52	0.54	0.56	0.59	0.62	0.63	0.65	0.67	0.69	0.71
Residual Christian	0.69	0.67	0.71	0.73	0.76	0.78	0.79	0.81	0.82	0.83	0.85
Residual Clay	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.09	0.09	0.10	0.10
Residual Clinton	1.58	1.55	1.68	1.75	1.85	1.93	1.96	1.99	2.02	2.05	2.09
Residual Coles	1.06	1.02	1.05	1.09	1.13	1.17	1.19	1.22	1.24	1.26	1.28
Residual Cumberland	0.20	0.19	0.19	0.20	0.21	0.22	0.23	0.24	0.24	0.25	0.26
Residual Douglas	1.24	1.24	1.32	1.39	1.45	1.49	1.55	1.62	1.69	1.76	1.84
Residual Effingham	0.56	0.52	0.56	0.60	0.63	0.66	0.69	0.71	0.73	0.76	0.79
Residual Fayette	0.59	0.57	0.44	0.45	0.46	0.47	0.48	0.48	0.49	0.50	0.51
Residual Jasper	0.90	0.84	0.85	0.86	0.88	0.90	0.92	0.94	0.96	0.99	1.01
Residual Macoupin	0.48	0.47	0.49	0.51	0.54	0.57	0.59	0.61	0.63	0.65	0.68
Residual Madison	0.99	0.97	1.00	1.05	1.10	1.13	1.16	1.20	1.23	1.26	1.30
Residual Marion	1.05	1.02	1.10	1.14	1.18	1.21	1.26	1.30	1.34	1.39	1.44
Residual Monroe	0.77	0.75	0.82	0.90	0.99	1.08	1.12	1.17	1.22	1.27	1.32
Residual Montgomery	1.04	1.01	1.03	1.06	1.09	1.12	1.17	1.21	1.25	1.30	1.34
Residual Moultrie	0.26	0.26	0.27	0.29	0.30	0.31	0.32	0.33	0.34	0.35	0.36
Residual Randolph	1.78	1.74	1.78	1.83	1.89	1.94	2.00	2.06	2.13	2.20	2.27
Residual Richland	0.19	0.18	0.19	0.19	0.20	0.21	0.21	0.22	0.23	0.23	0.24
Residual Shelby	0.40	0.40	0.41	0.42	0.43	0.44	0.45	0.46	0.47	0.48	0.49
Residual St. Clair	7.97	7.73	7.61	7.95	8.31	8.54	8.78	9.02	9.27	9.53	9.80
Residual Washington	1.12	1.10	1.15	1.20	1.23	1.25	1.28	1.32	1.35	1.39	1.43
Residual Wayne	0.37	0.36	0.36	0.37	0.37	0.37	0.38	0.39	0.40	0.41	0.42

Table A4.7 Current Trends (CT) Public-Supply Water Demand Scenario for Water Supply Systems-Per Capita Usage - GPCD

Study Areas (Systems)	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
Altamont	82.7	83.1	83.5	84.0	84.4	84.9	85.3	85.8	86.3	86.7
Arcola	118.5	119.0	119.7	120.3	120.9	121.6	122.2	122.9	123.6	124.3
Arthur	109.1	109.7	110.2	110.8	111.4	112.0	112.6	113.2	113.9	114.5
Ashley	58.6	58.9	59.2	59.5	59.8	60.2	60.5	60.8	61.2	61.5
Bethany	90.8	91.3	91.7	92.2	92.7	93.2	93.7	94.2	94.7	95.3
Breese	119.6	120.2	120.8	121.4	122.1	122.7	123.4	124.1	124.7	125.4
Carlyle	210.2	211.2	212.3	213.4	214.6	215.7	216.9	218.1	219.3	220.5
Centralia	178.4	179.3	180.2	181.1	182.1	183.1	184.1	185.1	186.1	187.1
Charleston	58.7	59.0	59.3	59.6	59.9	60.3	60.6	60.9	61.3	61.6
Clay City	73.0	73.3	73.7	74.1	74.5	74.9	75.3	75.7	76.1	76.5
Coulterville	112.9	113.5	114.1	114.6	115.3	115.9	116.5	117.1	117.8	118.5
Effingham	62.2	62.5	62.8	63.2	63.5	63.8	64.2	64.5	64.9	65.3
Evansville	102.7	103.3	103.8	104.3	104.9	105.4	106.0	106.6	107.2	107.8
Fairfield	168.6	169.4	170.3	171.2	172.1	173.0	174.0	174.9	175.9	176.9
Flora	118.5	119.1	119.7	120.3	120.9	121.6	122.2	122.9	123.6	124.3
Freeburg	80.4	80.8	81.3	81.7	82.1	82.6	83.0	83.5	83.9	84.4
Greenville	172.2	173.1	174.0	174.9	175.8	176.8	177.7	178.7	179.7	180.7
Hecker	83.9	84.4	84.8	85.2	85.7	86.2	86.6	87.1	87.6	88.1
Highland	100.1	100.6	101.1	101.6	102.2	102.7	103.3	103.9	104.4	105.0
Hillsboro	284.7	286.1	287.6	289.1	290.7	292.2	293.8	295.4	297.1	298.7
Kaskaskia WD	77.6	77.9	78.3	78.8	79.2	79.6	80.0	80.5	80.9	81.4
Kinkaid	88.3	88.7	89.2	89.6	90.1	90.6	91.1	91.6	92.1	92.6
Kinmundy	89.0	89.4	89.9	90.3	90.8	91.3	91.8	92.3	92.8	93.3
Litchfield	177.7	178.6	179.5	180.4	181.4	182.4	183.4	184.4	185.4	186.4
Louisville	117.7	118.3	118.9	119.5	120.1	120.8	121.5	122.1	122.8	123.5
Lovington	82.6	83.0	83.4	83.8	84.3	84.7	85.2	85.7	86.1	86.6
Mattoon	115.3	115.9	116.5	117.1	117.7	118.3	119.0	119.6	120.3	120.9
Mount Olive	91.8	92.2	92.7	93.2	93.7	94.2	94.7	95.2	95.7	96.3
Moweaqua	84.1	84.5	84.9	85.4	85.8	86.3	86.8	87.2	87.7	88.2
Mulberry Grove	68.2	68.5	68.9	69.2	69.6	70.0	70.4	70.7	71.1	71.5
Nashville	303.5	305.0	306.5	308.1	309.8	311.4	313.1	314.9	316.6	318.4
Neoga	79.4	79.8	80.2	80.7	81.1	81.5	82.0	82.4	82.9	83.3
New Baden	109.0	109.6	110.1	110.7	111.3	111.9	112.5	113.1	113.7	114.4
Newton	94.6	95.1	95.5	96.0	96.6	97.1	97.6	98.1	98.7	99.2
Noble	184.0	185.0	185.9	186.9	187.9	188.9	189.9	191.0	192.0	193.1
Oakland	66.8	67.1	67.4	67.8	68.2	68.5	68.9	69.3	69.7	70.0
Okawville	98.6	99.1	99.6	100.1	100.7	101.2	101.8	102.3	102.9	103.4
Olney	142.5	143.2	144.0	144.7	145.5	146.3	147.1	147.9	148.7	149.5
Pana	100.1	100.6	101.1	101.6	102.2	102.7	103.3	103.9	104.4	105.0
Patoka	81.8	82.2	82.6	83.1	83.5	83.9	84.4	84.9	85.3	85.8
Ramsey	85.7	86.2	86.6	87.1	87.5	88.0	88.5	89.0	89.4	89.9
Red Bud	112.8	113.4	114.0	114.6	115.2	115.8	116.4	117.1	117.7	118.4
Salem	113.1	113.7	114.3	114.9	115.5	116.1	116.7	117.4	118.0	118.7
Shelbyville	100.1	100.6	101.1	101.6	102.2	102.7	103.3	103.8	104.4	105.0
Shiloh	61.3	61.6	61.9	62.3	62.6	62.9	63.3	63.6	64.0	64.3
SLM Water Comm.	139.3	140.0	140.7	141.4	142.2	143.0	143.7	144.5	145.3	146.1
Sparta	215.1	216.2	217.3	218.5	219.6	220.8	222.0	223.2	224.5	225.7

Study Areas (Systems)	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
St. Elmo	95.2	95.7	96.2	96.7	97.2	97.7	98.2	98.8	99.3	99.9
St. Marie	128.9	129.6	130.2	130.9	131.6	132.3	133.0	133.8	134.5	135.3
Steeleville	128.2	128.9	129.5	130.2	130.9	131.6	132.3	133.0	133.8	134.5
Sullivan	126.2	126.8	127.5	128.1	128.8	129.5	130.2	130.9	131.7	132.4
Taylorville	135.5	136.2	136.9	137.6	138.3	139.1	139.8	140.6	141.4	142.1
Teutopolis	77.6	77.9	78.3	78.8	79.2	79.6	80.0	80.5	80.9	81.4
Toledo	75.3	75.7	76.0	76.4	76.8	77.3	77.7	78.1	78.5	79.0
Trenton	71.8	72.2	72.5	72.9	73.3	73.7	74.1	74.5	74.9	75.3
Troy	152.4	153.2	154.0	154.8	155.6	156.5	157.3	158.2	159.0	159.9
Tuscola	101.3	101.8	102.3	102.8	103.4	103.9	104.5	105.1	105.6	106.2
Vandalia	116.5	117.1	117.7	118.3	118.9	119.6	120.2	120.9	121.5	122.2
Villa Grove	117.0	117.6	118.2	118.8	119.4	120.1	120.7	121.4	122.1	122.8
Wamac	61.7	62.0	62.4	62.7	63.0	63.4	63.7	64.0	64.4	64.8
Wayne City	123.0	123.6	124.2	124.9	125.5	126.2	126.9	127.6	128.3	129.0
Windsor	79.1	79.5	79.9	80.3	80.7	81.2	81.6	82.1	82.5	83.0
Residual Bond	63.3	63.6	63.9	64.3	64.6	65.0	65.3	65.7	66.0	66.4
Residual Christian	101.9	102.4	102.9	103.5	104.0	104.6	105.1	105.7	106.3	106.9
Residual Clay	55.0	55.3	55.6	55.8	56.1	56.4	56.8	57.1	57.4	57.7
Residual Clinton	80.7	81.1	81.5	82.0	82.4	82.9	83.3	83.8	84.2	84.7
Residual Coles	27.2	27.3	27.4	27.6	27.7	27.9	28.0	28.2	28.3	28.5
Resid. Cumberland	106.8	107.4	107.9	108.5	109.1	109.7	110.3	110.9	111.5	112.1
Residual Douglas	92.6	93.1	93.6	94.1	94.6	95.1	95.6	96.1	96.7	97.2
Residual Effingham	62.9	63.2	63.5	63.9	64.2	64.5	64.9	65.2	65.6	66.0
Residual Fayette	95.0	95.4	95.9	96.4	96.9	97.5	98.0	98.5	99.1	99.6
Residual Jasper	63.2	63.5	63.8	64.2	64.5	64.9	65.2	65.6	65.9	66.3
Residual Macoupin	82.6	83.1	83.5	83.9	84.4	84.8	85.3	85.8	86.2	86.7
Residual Madison	57.2	57.5	57.8	58.1	58.4	58.7	59.0	59.3	59.7	60.0
Residual Marion	55.7	56.0	56.2	56.5	56.8	57.1	57.5	57.8	58.1	58.4
Residual Monroe	82.8	83.2	83.6	84.1	84.5	85.0	85.4	85.9	86.4	86.9
Resid. Montgomery	102.6	103.1	103.6	104.1	104.7	105.3	105.8	106.4	107.0	107.6
Residual Moultrie	76.9	77.3	77.7	78.1	78.5	78.9	79.3	79.8	80.2	80.7
Residual Randolph	96.5	97.0	97.5	98.0	98.5	99.0	99.6	100.1	100.7	101.2
Residual Richland	69.3	69.6	70.0	70.3	70.7	71.1	71.5	71.9	72.3	72.7
Residual Shelby	72.5	72.9	73.2	73.6	74.0	74.4	74.8	75.2	75.6	76.0
Residual St. Clair	142.8	143.5	144.2	145.0	145.7	146.5	147.3	148.1	148.9	149.8
Resid. Washington	102.1	102.6	103.1	103.7	104.2	104.8	105.3	105.9	106.5	107.1
Residual Wayne	55.3	55.6	55.9	56.2	56.5	56.8	57.1	57.4	57.7	58.0

Table A4.8 LRI Public-Supply Water Demand Scenario for Water Supply Systems
Per Capita Usage - GPCD

Study Areas (Systems)	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
Altamont	82.0	81.8	81.7	81.6	81.6	81.5	81.4	81.4	81.3	81.2
Arcola	117.4	117.2	117.1	117.0	116.8	116.7	116.6	116.6	116.5	116.4
Arthur	108.2	108.0	107.9	107.8	107.6	107.5	107.5	107.4	107.3	107.2
Ashley	58.1	58.0	58.0	57.9	57.8	57.8	57.7	57.7	57.6	57.6
Bethany	90.0	89.9	89.8	89.7	89.6	89.5	89.4	89.3	89.3	89.2
Breese	118.5	118.3	118.2	118.1	117.9	117.8	117.7	117.6	117.6	117.5
Carlyle	208.3	208.0	207.8	207.5	207.3	207.2	207.0	206.8	206.7	206.5
Centralia	176.8	176.5	176.3	176.1	175.9	175.8	175.6	175.5	175.4	175.3
Charleston	58.2	58.1	58.0	58.0	57.9	57.9	57.8	57.8	57.7	57.7
Clay City	72.3	72.2	72.1	72.0	72.0	71.9	71.8	71.8	71.7	71.7
Coulterville	111.9	111.7	111.6	111.5	111.4	111.3	111.2	111.1	111.0	110.9
Effingham	61.7	61.6	61.5	61.4	61.4	61.3	61.3	61.2	61.2	61.1
Evansville	101.8	101.7	101.6	101.4	101.3	101.3	101.2	101.1	101.0	101.0
Fairfield	167.1	166.8	166.6	166.4	166.3	166.1	166.0	165.9	165.8	165.6
Flora	117.4	117.2	117.1	117.0	116.8	116.7	116.6	116.6	116.5	116.4
Freeburg	79.7	79.6	79.5	79.4	79.3	79.3	79.2	79.2	79.1	79.0
Greenville	170.7	170.5	170.3	170.1	169.9	169.8	169.6	169.5	169.4	169.3
Hecker	83.2	83.1	83.0	82.9	82.8	82.7	82.7	82.6	82.5	82.5
Highland	99.2	99.1	98.9	98.8	98.7	98.6	98.6	98.5	98.4	98.4
Hillsboro	282.2	281.8	281.4	281.1	280.8	280.6	280.4	280.2	280.0	279.8
Kaskaskia WD	76.9	76.8	76.7	76.6	76.5	76.4	76.4	76.3	76.3	76.2
Kinkaid	87.5	87.4	87.2	87.1	87.1	87.0	86.9	86.8	86.8	86.7
Kinmundy	88.2	88.1	87.9	87.9	87.8	87.7	87.6	87.5	87.5	87.4
Litchfield	176.1	175.9	175.6	175.4	175.3	175.1	175.0	174.8	174.7	174.6
Louisville	116.7	116.5	116.3	116.2	116.1	116.0	115.9	115.8	115.7	115.7
Lovington	81.8	81.7	81.6	81.5	81.4	81.4	81.3	81.2	81.2	81.1
Mattoon	114.3	114.1	114.0	113.8	113.7	113.6	113.5	113.4	113.4	113.3
Mount Olive	91.0	90.8	90.7	90.6	90.5	90.4	90.4	90.3	90.2	90.2
Moweaqua	83.3	83.2	83.1	83.0	82.9	82.9	82.8	82.7	82.7	82.6
Mulberry Grove	67.6	67.5	67.4	67.3	67.3	67.2	67.1	67.1	67.0	67.0
Nashville	300.8	300.3	300.0	299.6	299.3	299.1	298.8	298.6	298.4	298.2
Neoga	78.7	78.6	78.5	78.4	78.4	78.3	78.2	78.2	78.1	78.1
New Baden	108.1	107.9	107.8	107.6	107.5	107.4	107.3	107.3	107.2	107.1
Newton	93.8	93.6	93.5	93.4	93.3	93.2	93.1	93.1	93.0	92.9
Noble	182.4	182.2	181.9	181.7	181.5	181.4	181.2	181.1	181.0	180.8
Oakland	66.2	66.1	66.0	65.9	65.9	65.8	65.7	65.7	65.6	65.6
Okawville	97.7	97.6	97.5	97.4	97.3	97.2	97.1	97.0	97.0	96.9
Olney	141.3	141.0	140.9	140.7	140.6	140.4	140.3	140.2	140.1	140.0
Pana	99.2	99.1	98.9	98.8	98.7	98.6	98.6	98.5	98.4	98.4
Patoka	81.1	81.0	80.9	80.8	80.7	80.6	80.5	80.5	80.4	80.4
Ramsey	85.0	84.9	84.7	84.7	84.6	84.5	84.4	84.4	84.3	84.2
Red Bud	111.8	111.7	111.5	111.4	111.3	111.2	111.1	111.0	110.9	110.9
Salem	112.1	112.0	111.8	111.7	111.6	111.5	111.4	111.3	111.2	111.2
Shelbyville	99.2	99.0	98.9	98.8	98.7	98.6	98.5	98.5	98.4	98.3
Shiloh	60.8	60.7	60.6	60.5	60.5	60.4	60.4	60.3	60.3	60.3
SLM Water Co.	138.1	137.9	137.7	137.5	137.4	137.3	137.2	137.1	137.0	136.9

Study Areas (Systems)	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
Sparta	213.3	212.9	212.7	212.4	212.2	212.0	211.9	211.7	211.5	211.4
St. Elmo	94.4	94.2	94.1	94.0	93.9	93.8	93.8	93.7	93.6	93.6
St. Marie	127.8	127.6	127.4	127.3	127.2	127.1	127.0	126.9	126.8	126.7
Steeleville	127.1	126.9	126.7	126.6	126.5	126.4	126.3	126.2	126.1	126.0
Sullivan	125.1	124.9	124.7	124.6	124.5	124.4	124.3	124.2	124.1	124.0
Taylorville	134.3	134.1	133.9	133.8	133.6	133.5	133.4	133.3	133.2	133.1
Teutopolis	76.9	76.8	76.7	76.6	76.5	76.4	76.4	76.3	76.3	76.2
Toledo	74.6	74.5	74.4	74.3	74.3	74.2	74.1	74.1	74.0	74.0
Trenton	71.2	71.1	71.0	70.9	70.8	70.8	70.7	70.7	70.6	70.6
Troy	151.1	150.9	150.7	150.5	150.4	150.2	150.1	150.0	149.9	149.8
Tuscola	100.4	100.2	100.1	100.0	99.9	99.8	99.7	99.6	99.6	99.5
Vandalia	115.5	115.3	115.2	115.0	114.9	114.8	114.7	114.6	114.5	114.5
Villa Grove	116.0	115.8	115.7	115.5	115.4	115.3	115.2	115.1	115.1	115.0
Wamac	61.2	61.1	61.0	60.9	60.9	60.8	60.8	60.7	60.7	60.7
Wayne City	121.9	121.7	121.5	121.4	121.3	121.2	121.1	121.0	120.9	120.8
Windsor	78.4	78.3	78.2	78.1	78.0	77.9	77.9	77.8	77.8	77.7
Residual Bond	62.7	62.6	62.6	62.5	62.4	62.4	62.3	62.3	62.2	62.2
Residual Christian	101.0	100.8	100.7	100.6	100.5	100.4	100.3	100.3	100.2	100.1
Residual Clay	54.5	54.4	54.4	54.3	54.3	54.2	54.2	54.1	54.1	54.0
Residual Clinton	80.0	79.9	79.8	79.7	79.6	79.6	79.5	79.4	79.4	79.3
Residual Coles	26.9	26.9	26.9	26.8	26.8	26.8	26.8	26.7	26.7	26.7
Resid. Cumberland	105.9	105.7	105.6	105.5	105.4	105.3	105.2	105.1	105.1	105.0
Residual Douglas	91.8	91.7	91.6	91.5	91.4	91.3	91.2	91.2	91.1	91.0
Resid. Effingham	62.3	62.2	62.2	62.1	62.0	62.0	61.9	61.9	61.8	61.8
Residual Fayette	94.1	94.0	93.9	93.8	93.7	93.6	93.5	93.4	93.4	93.3
Residual Jasper	62.6	62.5	62.5	62.4	62.3	62.3	62.2	62.2	62.1	62.1
Resid. Macoupin	81.9	81.8	81.7	81.6	81.5	81.4	81.4	81.3	81.3	81.2
Residual Madison	56.7	56.6	56.5	56.5	56.4	56.4	56.3	56.3	56.2	56.2
Residual Marion	55.2	55.1	55.0	55.0	54.9	54.9	54.8	54.8	54.7	54.7
Residual Monroe	82.1	81.9	81.8	81.7	81.7	81.6	81.5	81.5	81.4	81.3
Resid. Montgomery	101.7	101.5	101.4	101.3	101.2	101.1	101.0	100.9	100.8	100.8
Residual Moultrie	76.2	76.1	76.0	75.9	75.8	75.8	75.7	75.7	75.6	75.6
Resid. Randolph	95.7	95.5	95.4	95.3	95.2	95.1	95.0	95.0	94.9	94.8
Residual Richland	68.6	68.5	68.5	68.4	68.3	68.2	68.2	68.1	68.1	68.0
Residual Shelby	71.9	71.7	71.7	71.6	71.5	71.4	71.4	71.3	71.3	71.2
Residual St. Clair	141.5	141.3	141.1	141.0	140.8	140.7	140.6	140.5	140.4	140.3
Resid. Washington	101.2	101.0	100.9	100.8	100.7	100.6	100.5	100.4	100.4	100.3
Residual Wayne	54.8	54.8	54.7	54.6	54.6	54.5	54.5	54.4	54.4	54.4

Table A4.9 MRI Public-Supply Water Demand Scenario for Water Supply Systems
Per Capita Usage – GPCD

Study Areas (Systems)	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
Altamont	83.4	84.4	85.4	86.4	87.5	88.5	89.6	90.7	91.7	92.9
Arcola	119.5	120.9	122.4	123.8	125.3	126.8	128.3	129.9	131.4	133.0
Arthur	110.1	111.4	112.7	114.1	115.4	116.8	118.2	119.7	121.1	122.6
Ashley	59.1	59.8	60.6	61.3	62.0	62.8	63.5	64.3	65.1	65.8
Bethany	91.6	92.7	93.8	94.9	96.0	97.2	98.4	99.6	100.8	102.0
Breese	120.6	122.0	123.5	125.0	126.5	128.0	129.5	131.1	132.7	134.3
Carlyle	212.1	214.6	217.1	219.7	222.3	225.0	227.7	230.5	233.2	236.1
Centralia	179.9	182.1	184.2	186.4	188.7	190.9	193.2	195.6	197.9	200.3
Charleston	59.2	59.9	60.7	61.4	62.1	62.9	63.6	64.4	65.2	65.9
Clay City	73.6	74.5	75.4	76.3	77.2	78.1	79.0	80.0	81.0	81.9
Coulterville	113.9	115.2	116.6	118.0	119.4	120.9	122.3	123.8	125.3	126.8
Effingham	62.8	63.5	64.2	65.0	65.8	66.6	67.4	68.2	69.0	69.9
Evansville	103.7	104.9	106.1	107.4	108.7	110.0	111.3	112.6	114.0	115.4
Fairfield	170.1	172.1	174.1	176.2	178.3	180.5	182.6	184.8	187.1	189.3
Flora	119.5	120.9	122.4	123.8	125.3	126.8	128.3	129.9	131.5	133.0
Freeburg	81.2	82.1	83.1	84.1	85.1	86.1	87.1	88.2	89.3	90.3
Greenville	173.8	175.8	177.9	180.0	182.2	184.4	186.6	188.9	191.1	193.5
Hecker	84.7	85.7	86.7	87.7	88.8	89.9	90.9	92.0	93.1	94.3
Highland	101.0	102.2	103.4	104.6	105.9	107.1	108.4	109.7	111.1	112.4
Hillsboro	287.2	290.6	294.1	297.6	301.2	304.8	308.5	312.2	315.9	319.8
Kaskaskia WD	78.2	79.2	80.1	81.1	82.0	83.0	84.0	85.0	86.1	87.1
Kinkaid	89.0	90.1	91.2	92.3	93.4	94.5	95.6	96.8	97.9	99.1
Kinmundy	89.8	90.8	91.9	93.0	94.1	95.2	96.4	97.6	98.7	99.9
Litchfield	179.3	181.4	183.5	185.7	187.9	190.2	192.5	194.8	197.2	199.6
Louisville	118.7	120.1	121.6	123.0	124.5	126.0	127.5	129.0	130.6	132.2
Lovington	83.3	84.3	85.3	86.3	87.3	88.4	89.4	90.5	91.6	92.7
Mattoon	116.3	117.7	119.1	120.5	121.9	123.4	124.9	126.4	127.9	129.5
Mount Olive	92.6	93.7	94.8	95.9	97.1	98.2	99.4	100.6	101.8	103.1
Moweaqua	84.8	85.8	86.8	87.9	88.9	90.0	91.1	92.2	93.3	94.4
Mulberry Grove	68.8	69.6	70.4	71.3	72.1	73.0	73.9	74.8	75.7	76.6
Nashville	306.1	309.8	313.4	317.2	321.0	324.8	328.7	332.7	336.7	340.8
Neoga	80.1	81.1	82.0	83.0	84.0	85.0	86.1	87.1	88.1	89.2
New Baden	110.0	111.3	112.6	113.9	115.3	116.7	118.1	119.5	121.0	122.4
Newton	95.4	96.5	97.7	98.9	100.0	101.3	102.5	103.7	105.0	106.2
Noble	185.7	187.9	190.1	192.4	194.7	197.0	199.4	201.8	204.2	206.7
Oakland	67.4	68.1	69.0	69.8	70.6	71.5	72.3	73.2	74.1	75.0
Okawville	99.5	100.7	101.8	103.1	104.3	105.6	106.8	108.1	109.4	110.7
Olney	143.8	145.5	147.2	149.0	150.7	152.5	154.4	156.2	158.1	160.0
Pana	101.0	102.2	103.4	104.6	105.9	107.2	108.4	109.7	111.1	112.4
Patoka	82.5	83.5	84.5	85.5	86.5	87.6	88.6	89.7	90.8	91.9
Ramsey	86.5	87.5	88.6	89.6	90.7	91.8	92.9	94.0	95.1	96.3
Red Bud	113.8	115.2	116.5	117.9	119.3	120.8	122.2	123.7	125.2	126.7
Salem	114.1	115.5	116.9	118.2	119.7	121.1	122.6	124.0	125.5	127.1
Shelbyville	101.0	102.1	103.4	104.6	105.8	107.1	108.4	109.7	111.0	112.4
Shiloh	61.9	62.6	63.3	64.1	64.9	65.6	66.4	67.2	68.0	68.9
SLM Water Comm.	140.5	142.2	143.9	145.6	147.3	149.1	150.9	152.7	154.6	156.4

Study Areas (Systems)	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
Sparta	217.0	219.6	222.2	224.9	227.6	230.3	233.1	235.9	238.7	241.6
St. Elmo	96.0	97.2	98.3	99.5	100.7	101.9	103.1	104.4	105.6	106.9
St. Marie	130.1	131.6	133.2	134.8	136.4	138.0	139.7	141.4	143.1	144.8
Steeleville	129.4	130.9	132.4	134.0	135.6	137.3	138.9	140.6	142.3	144.0
Sullivan	127.3	128.8	130.4	131.9	133.5	135.1	136.7	138.4	140.0	141.7
Taylorville	136.7	138.3	139.9	141.6	143.3	145.0	146.8	148.6	150.3	152.2
Teutopolis	78.2	79.2	80.1	81.1	82.0	83.0	84.0	85.0	86.1	87.1
Toledo	75.9	76.8	77.8	78.7	79.6	80.6	81.6	82.5	83.5	84.5
Trenton	71.8	72.6	73.5	74.3	75.2	76.1	76.9	77.9	78.8	79.7
Troy	153.8	155.6	157.5	159.3	161.2	163.2	165.2	167.1	169.2	171.2
Tuscola	102.1	103.4	104.6	105.8	107.1	108.4	109.7	111.0	112.4	113.7
Vandalia	117.5	118.9	120.3	121.8	123.2	124.7	126.2	127.7	129.3	130.8
Villa Grove	118.0	119.4	120.9	122.3	123.8	125.3	126.8	128.3	129.8	131.4
Wamac	62.3	63.0	63.8	64.5	65.3	66.1	66.9	67.7	68.5	69.3
Wayne City	124.0	125.5	127.0	128.5	130.1	131.6	133.2	134.8	136.4	138.1
Windsor	79.8	80.7	81.7	82.7	83.7	84.7	85.7	86.7	87.8	88.8
Residual Bond	63.9	64.6	65.4	66.2	66.9	67.8	68.6	69.4	70.2	71.1
Residual Christian	102.8	104.0	105.2	106.5	107.8	109.1	110.4	111.7	113.1	114.4
Residual Clay	55.5	56.1	56.8	57.5	58.2	58.9	59.6	60.3	61.0	61.8
Residual Clinton	81.4	82.4	83.4	84.4	85.4	86.4	87.5	88.5	89.6	90.7
Residual Coles	27.2	27.5	27.8	28.1	28.4	28.8	29.1	29.5	29.8	30.2
Resid. Cumberland	107.8	109.1	110.4	111.7	113.0	114.4	115.7	117.1	118.6	120.0
Residual Douglas	93.5	94.6	95.7	96.8	98.0	99.2	100.4	101.6	102.8	104.1
Residual Effingham	63.4	64.2	65.0	65.7	66.5	67.3	68.1	68.9	69.8	70.6
Residual Fayette	95.8	96.9	98.1	99.3	100.4	101.6	102.9	104.1	105.4	106.6
Residual Jasper	63.7	64.5	65.3	66.0	66.8	67.6	68.5	69.3	70.1	71.0
Residual Macoupin	83.4	84.4	85.4	86.4	87.4	88.5	89.5	90.6	91.7	92.8
Residual Madison	57.7	58.4	59.1	59.8	60.5	61.2	62.0	62.7	63.5	64.2
Residual Marion	56.2	56.8	57.5	58.2	58.9	59.6	60.3	61.0	61.8	62.5
Residual Monroe	83.5	84.5	85.5	86.5	87.6	88.6	89.7	90.8	91.9	93.0
Resid. Montgomery	103.5	104.7	105.9	107.2	108.5	109.8	111.1	112.4	113.8	115.2
Residual Moultrie	77.6	78.5	79.4	80.4	81.3	82.3	83.3	84.3	85.3	86.4
Residual Randolph	97.4	98.5	99.7	100.9	102.1	103.3	104.5	105.8	107.1	108.4
Residual Richland	69.9	70.7	71.5	72.4	73.3	74.1	75.0	75.9	76.8	77.8
Residual Shelby	73.1	74.0	74.9	75.8	76.7	77.6	78.5	79.5	80.4	81.4
Residual St. Clair	144.0	145.7	147.5	149.2	151.0	152.8	154.7	156.5	158.4	160.3
Resid. Washington	103.0	104.2	105.4	106.7	108.0	109.3	110.6	111.9	113.3	114.7
Residual Wayne	55.8	56.5	57.1	57.8	58.5	59.2	59.9	60.7	61.4	62.1

Appendix E

SELF-SUPPLIED DOMESTIC USE

5.1 BACKGROUND

Domestic water use 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). A major percentage of water for domestic purposes is provided by public water supply system – a portion of users rely on self-supplied water. Nearly all of the self-supplied domestic withdrawals are reported to be from groundwater sources. Domestic water use provided by public or private water systems was accounted for in Chapter 4. The focus of Chapter 5 is domestic water use by individuals who operate their own household water supply systems.

USGS estimates self-supplied domestic water use by multiplying the estimated self-supplied population in each county 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 persons served by public-supply facilities that is obtained from Illinois EPA and other sources. The self-supplied domestic water-use coefficient in Illinois has been increased several times since the USGS first began reporting self-supplied domestic water use in 1960. The coefficient used in the 2005 report was 90 gallons per person per day.

5.1.1. Reported Domestic Withdrawals

Self-supplied domestic withdrawals have been reported by the USGS for every county, for every data compilation year. Table 5.1 shows the USGS reported self-supplied domestic population for the years 1985, 1990, 1995, 2000 and 2005. The estimates of self-supplied population fluctuate across the USGS data compilation years. This is partly because

Table 5.1 USGS Reported Self-Supplied Domestic Population by County

County	1985	1990	1995	2000	2005
Bond	6,570	7,920	8,580	8,600	4,907
Christian	8,460	9,280	15,880	14,200	9,996
Clay	7,640	6,380	5,980	7,850	5,992
Clinton	10,200	7,380	16,260	15,160	7,165
Coles	13,200	6,370	1,470	6,660	1,965
Cumberland	6,660	6,220	6,060	6,570	6,093
Douglas	6,590	8,220	6,740	7,000	6,170
Effingham	10,760	14,740	27,200	16,240	14,501
Fayette	11,340	10,460	10,670	13,280	7,953
Jasper	7,010	7,590	2,990	3,000	2,930
Marion	600	8,940	2,320	2,300	1,754
Montgomery	8,350	11,610	8,110	9,000	8,766
Moultrie	4,870	4,260	4,420	4,610	3,370
Randolph	6,210	8,230	8,890	13,920	7,032
Richland	5,450	4,740	3,520	3,470	2,378
Shelby	10,520	12,910	8,570	8,650	6,242
Washington	1,910	2,890	9,890	11,830	7,272
Wayne	12,070	8,530	14,800	7,860	5,236
Macoupin	7,860	15,070	24,250	23,580	9,911
Madison	3,830	15,830	105,130	106,000	26,719
Monroe	11,490	9,310	17,300	20,000	8,760
Saint Clair	66,180	40,510	54,550	55,000	55,397
Total 22 counties	227,770	227,390	363,580	364,780	210,509

Table 5.2 shows historical changes in the estimated water withdrawals by self-supplied domestic sector from 1985 to 2005. In 2005, withdrawals of water from domestic sources totaled 18.93 mgd. Significant decreases in total self-supplied domestic withdrawals for Christian and Madison counties.

Table 5.2 USGS Reported Self-Supplied Domestic Water Withdrawals by County (in MGD)

County	1985	1990	1995	2000	2005
Bond	0.52	0.58	0.77	0.77	0.44
Christian	2.21	0.68	1.43	1.28	0.90
Clay	0.88	0.44	0.54	0.71	0.54
Clinton	1.34	0.56	1.46	1.36	0.65
Coles	0.22	0.44	0.13	0.60	0.18
Cumberland	0.44	0.43	0.55	0.59	0.55
Douglas	0.77	0.56	0.61	0.63	0.55
Effingham	0.82	1.01	2.45	1.46	1.30
Fayette	0.83	0.72	0.96	1.19	0.72
Jasper	0.47	0.52	0.27	0.27	0.26

County	1985	1990	1995	2000	2005
Marion	0.46	0.61	0.21	0.21	0.16
Montgomery	0.77	0.85	0.73	0.81	0.79
Moultrie	0.31	0.29	0.40	0.41	0.30
Randolph	0.83	0.62	0.80	1.25	0.63
Richland	0.37	0.32	0.32	0.31	0.21
Shelby	0.70	0.88	0.77	0.78	0.56
Washington	0.21	0.22	0.89	1.06	0.65
Wayne	0.90	0.68	1.33	0.71	0.47
Macoupin	0.81	1.10	2.18	2.12	0.89
Madison	2.28	1.16	9.46	9.54	2.40
Monroe	1.00	0.71	1.56	1.80	0.79
Saint Clair	6.72	3.11	4.91	4.95	4.99
Total 22 counties	23.86	16.49	32.73	32.81	18.93

5.2 FUTURE DEMAND

5.2.1 Water Demand Relationship

No valid model could be estimated to capture the relationship between per capita water usage rates in the domestic sector and key explanatory variables. Therefore the effects of future income and climatic conditions were estimated using the elasticities of income and weather variables from the public-supply model.

5.2.2 Projected Self-supplied Population

Since the majority of self-supplied population is served by domestic wells, the future self-supplied domestic population in each county was estimated using the self-supplied population in 2005, the projected increase in total county population since 2005, and the rate of installation of new domestic wells per 1,000 persons of the projected additional future population in each county. The historical data on domestic wells were analyzed in order to establish the trend in the number of new wells which are developed for each 1,000 persons of new population. The historical estimates are included in the Annex to this chapter as Table A5.1.

For the 22-county study area, total self-supplied population is expected to increase between 2005 and 2050 from 210,509 to 240,613. This represents an increase of 30,104 persons (see Table 5.3).

Table 5.3 Self-supplied Population Projections for 22 Study Area Counties

County	2005	2030	2050	2005-2050 Change
Bond	4,907	5,599	5,699	792
Christian	9,996	11,195	11,947	1,951
Clay	5,992	6,499	6,599	607
Clinton	7,165	8,576	8,830	1,665
Coles	1,965	2,178	2,368	403
Cumberland	6,093	7,028	7,919	1,826
Douglas	6,170	7,330	8,047	1,877
Effingham	14,501	18,036	18,350	3,849
Fayette	7,953	8,231	8,632	679
Jasper	2,930	3,007	3,284	354
Marion	1,754	1,948	2,142	388
Montgomery	8,766	9,497	10,305	1,539
Moultrie	3,370	3,918	4,249	879
Randolph	7,032	7,624	8,222	1,190
Richland	2,378	2,619	2,725	347
Shelby	6,242	6,618	7,014	772
Washington	7,272	7,974	8,342	1,070
Wayne	5,236	5,197	5,517	281
Macoupin	9,911	11,872	12,625	2,714
Madison	26,719	30,249	33,953	7,234
Monroe	8,760	12,521	11,095	2,335
Saint Clair	55,397	52,890	52,749	2,648
Total 22-Counties	210,509	230,607	240,613	30,104

5.2.3 Water Demand Under Three Scenarios

The three scenarios of self-supplied domestic water withdrawals include a current trend (baseline case) scenario, a less resource intensive outcome, and a more resource intensive outcome. In all three scenarios, the self-supplied population growth is estimated based on the number of new well installations per 1,000 people of future county population. Therefore, self-served population is assumed to follow the county total population growth. The specific assumptions for each scenario are listed below. The results of three scenarios are presented in Table 5.5.

5.2.3.1 Scenario 1 – Current Trends Case (CT)

The assumptions of the CT scenario are: (1) the annual growth of median household income during the 2005-2050 period will be 0.7 percent; and (2) future conservation rate will follow the estimated historical trend.

5.2.3.2 Scenario 2 – Less Resource Intensive Case (LRI)

The Less Resource Intensive scenario captures future conditions which would lead to less water withdrawals by self-supplied domestic sector. The assumptions of the LRI scenario are: (1) the annual growth of median household income during the 2005–2050 period will be 0.5 percent; and (2) the annual conservation effect will be increased by 50 percent.

5.2.3.3 Scenario 3 – More Resource Intensive Case (MRI)

The more resource intensive scenario demonstrates future conditions which would lead to more water withdrawals by self-supplied domestic sector. The main assumptions of this scenario are: (1) the annual growth of median household income during the 2005 – 2050 period will be 1.0 percent; and (2) the annual conservation effect will not continue during the 2005-2050 period.

5.2.4 Scenario Results

The results of the three scenarios for the 22-county study area are shown in Table 5.5. Under the current trends scenario, self-supplied domestic withdrawals are projected to increase from a weather normalized value of 18.95 mgd in 2005, to 23.23 mgd in 2050. This represents an increase of 4.29 mgd, or 22.6 percent.

Under the LRI scenario, the withdrawals would decrease to 18.80 mgd by 2050. This represents a decrease of 0.15 mgd, or 0.8 percent.

Under the MRI scenario, the withdrawals would increase to 33.89 mgd by 2050. This represents an increase of 14.94 mgd, or 78.9 percent.

Future self-supplied water withdrawals by county are shown in Table A5.2 in the Annex to this chapter.

Table 5.4 Self-Supplied Domestic Water Withdrawal Scenarios

Year	Self-supplied Population	Self-supplied GPCD	Self-supplied Withdrawals MGD
CT	*Current Trends – Baseline Scenario*		
2005	210,509	90.0	18.95
2010	191,951	90.7	17.41
2015	217,239	91.4	19.86
2020	198,015	92.1	18.24
2025	200,887	92.9	18.65
2030	230,607	93.6	21.58
2035	204,377	94.3	19.28
2040	206,627	95.1	19.64
2045	208,940	95.8	20.02
2050	240,613	96.5	23.23
2005-50 Change	30,104	6.55	4.29
2005-50 %	14.3	7.3	22.6
LRI	*Less Resource Intensive Scenario*		
2005	210,509	90.0	18.95
2010	191,951	88.6	17.01
2015	217,239	87.2	18.95
2020	198,015	85.9	17.00
2025	200,887	84.5	16.98
2030	230,607	83.2	19.19
2035	204,377	81.9	16.74
2040	206,627	80.6	16.66
2045	208,940	79.4	16.58
2050	240,613	78.1	18.80
2005-50 Change	30,104	-11.88	-0.15
2005-50 %	14.3	-13.2	-0.8
MRI	*More Resource Intensive Scenario*		
2005	210,509	90.0	18.95
2010	191,951	94.6	18.16
2015	217,239	99.4	21.60
2020	198,015	104.5	20.69
2025	200,887	109.8	22.06
2030	230,607	115.4	26.62
2035	204,377	121.3	24.79
2040	206,627	127.5	26.34
2045	208,940	134.0	28.00
2050	240,613	140.8	33.89
2005-50 Change	30,104	50.83	14.94
2005-50 %	14.3	56.5	78.9

APPENDIX E ANNEX

Table A5.1 Number of Domestic Wells Installed per Decade in the Study Area Counties

Year	1950-59	1960-69	1970-79	1980-89	1990-99	2000-09	Total
Bond	8	75	584	306	239	215	1,427
Christian	25	93	326	314	377	338	1,473
Clay	5	161	532	227	166	84	1,175
Clinton	21	158	822	539	294	89	1,923
Coles	162	179	347	179	211	76	1,154
Cumberland	34	76	383	162	167	94	916
Douglas	98	110	148	145	249	61	811
Effingham	95	203	1,057	380	455	160	2,350
Fayette	19	105	619	429	506	438	2,116
Jasper	35	65	59	97	127	77	460
Marion	3	141	503	303	104	10	1,064
Montgomery	63	61	494	343	290	161	1,412
Moultrie	119	82	119	122	152	73	667
Randolph	57	160	750	430	278	193	1,868
Richland	4	132	287	247	310	176	1,156
Shelby	114	205	524	386	527	363	2,119
Washington	73	107	571	95	63	30	939
Wayne	14	97	397	260	147	92	1,007
Macoupin	16	32	37	45	281	158	569
Madison	64	142	1,257	775	760	186	3,184
Monroe	10	191	571	455	647	305	2,179
St Clair	93	242	1,023	866	839	371	3,434
Total 22 Counties	1,132	2,817	11,410	7,105	7,189	3,750	33,403

Appendix F

SELF-SUPPLIED INDUSTRIAL AND COMMERCIAL WATER DEMAND

6.1 BACKGROUND

Industrial, commercial (I&C) and institutional water demand represents self-supplied water by industrial, commercial, and other nonresidential establishments. The industrial sub-sector 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).

This chapter focuses on self-supplied water withdrawals by industrial, commercial (and institutional) establishments within the 22-county area and withdrawals within the Kaskaskia River basin.

6.1.1. Historical Self-Supplied Withdrawals

Because self-supplied industrial and commercial water withdrawal points (i.e., wells and surface water intakes) are distributed throughout the counties in the study area, the geographical areas of analysis are individual establishments and counties. County-level totals of self-supplied withdrawals have been compiled and reported by the USGS since 1985. Table 6.1 shows the results of five periodic USGS compilations. The last column of the table shows the updated 2005 withdrawals based on the IWIP data on withdrawals by individual establishments.

Table 6.1 Historical Self-Supplied Industrial and Commercial Water Demand as Reported by the USGS (In MGD)

County	1985	1990	1995	2000	2005	2005 Adjusted
Bond	0	0	0	0	0	0
Christian	0	0.01	0.01	0	0	0
Clay	0	0	0	0	0	0
Clinton	0.03	0	0	0	0	0
Coles	0.09	0	0	0	0	0.0025
Cumberland	0	0	0	0	0	0
Douglas	7.22	5.49	3.35	0	1.95	0.2418
Effingham	0	0	0	0	0	0
Fayette	0	4.05	2.56	0	0	0
Jasper	0	0	0	0	0	0
Marion	0	0	0	0	0	0

County	1985	1990	1995	2000	2005	2005 Adjusted
Montgomery	0.44	0.44	0.43	0	0	0
Moultrie	0	0.99	0.80	0	0	0
Randolph	0	0	0	0	0	0
Richland	0	0	0.01	0	0	0
Shelby	0.30	0.29	0.29	0	0	0.2212
Washington	0	0	0.11	0	0	0
Wayne	0	0	0	0	0	0
Macoupin	0	0	0	0	0	0
Madison	42.74	58.58	81.45	40.54	32.86	5.7324
Monroe	0	0	0	0	0	0.0001
Saint Clair	14.15	10.91	22.28	13.61	0.72	0.7170
Total 22 counties	64.97	80.76	111.29	54.15	35.53	6.9149

Source: Published by the USGS National Water Use Information Program, various years. The data are based on the ISWS Illinois Water Information Program. MGD = million gallons per day. Some withdrawals are outside the Kaskaskia basin.

The data in Table 6.1 show some variability of the reported withdrawals at the county level across the data years. For 2005 non-zero withdrawals were reported by the USGS only for Douglas, Madison and Saint Clair counties. The variability of the reported withdrawals can be partially attributed to the method in which the self-supplied withdrawals are inventoried. Detailed explanations of USGS methodology for data compilations and quality assurance are available from a USGS document entitled *Narrative for 2005 Water-Use Compilation* (USGS, 2008).

Although the accuracy of the data in Table 6.1 may be limited, the long term trends in total industrial and commercial (I&C) self-supplied water withdrawals are readily apparent. For the entire 22-county study area, total self-supplied I&C withdrawals have been gradually increasing between 1985 and 1995 and then decreased considerably from the high 1995 value of 111.29 mgd to 35.53 mgd in 2005. According to the IWIP data, the 2005 total self-supplied withdrawals were 6.92 mgd.

In terms of individual counties, about 90 percent of total self-supplied I&C withdrawals were reported to take place in Madison and St. Clair counties and most likely nearly all of the withdrawals in these two counties are outside the Kaskaskia basin (Table 6.1). In 2005, the self-supplied withdrawals in the remaining 20 counties were reported to be 1.95 mgd – zero values were reported for 19 counties and the estimate of 1.95 mgd represents withdrawals for Douglas County.

6.1.2. Historical Public-Supply Deliveries to Commercial and Industrial Users

In addition to self-supplied water, industrial, commercial and institutional users also purchase water from public water supply systems. Table 6.2 shows the estimated deliveries of water to commercial and industrial users by public water supply systems.

Table 6.2 Historical Public-Supply Deliveries
to Industrial and Commercial Customers (In MGD)

County	1985	1990	1995	2000	2005
Bond	0.25	0.01	0.00	0.01	0.32
Christian	0.23	1.32	0.48	0.26	0.63
Clay	0.02	0.33	0.35	0.36	0.35
Clinton	0.05	0.03	0.24	0.20	0.38
Coles	1.16	2.93	2.49	0.54	0.92
Cumberland	0.06	0.02	0.06	0.04	0.02
Douglas	0.15	0.17	0.95	1.04	1.13
Effingham	0.19	0.07	0.26	0.50	0.90
Fayette	0.33	0.09	0.29	0.11	0.28
Jasper	0.04	0.00	0.00	0.18	0.42
Marion	1.41	1.20	0.50	1.50	2.59
Montgomery	0.60	0.51	0.44	0.67	0.10
Moultrie	0.02	0.02	0.07	0.04	0.30
Randolph	0.42	0.39	0.24	0.34	0.16
Richland	0.58	0.85	1.00	0.41	0.47
Shelby	0.09	0.01	0.09	0.09	0.04
Washington	0.03	0.31	0.31	0.37	0.32
Wayne	0.28	0.02	0.06	0.35	0.36
Macoupin	1.12	0.00	0.17	0.02	0.06
Madison	18.89	0.81	0.94	1.28	0.92
Monroe	0.09	0.00	0.00	0.00	0.12
Saint Clair	11.31	0.10	1.52	1.08	4.19
Total 22 counties	37.32	9.20	10.49	9.39	14.98

Source: The data are based on the ISWS Illinois Water Information Program. MGD = million gallons per day.

Total deliveries were reported to be 37.32 mgd in 1985 – apparently due to high values for the Madison and St. Clair counties (the high values were not repeated in the subsequent data years). In 2005, total commercial/industrial deliveries in the 22 counties were reported to be 14.98 mgd.

In terms of individual counties, about 35 percent of total public-supplied I&C deliveries took place in the four western counties (mostly in Madison and St. Clair counties). In 2005, the self-supplied withdrawals in the remaining 18 counties were reported to be 9.69 mgd.

6.2 DATA AND ESTIMATION METHODS

6.2.1 Withdrawal Rates

The data on self-supplied water withdrawals for industrial/commercial establishments in each county were supplemented with data on employment to establish average rates of withdrawals per employee. Existing directories show 39 large business establishments in the 22-county study area. Self supplied withdrawals and the number of employees was reported by 13 different establishments (Table 6.3). The total self-supplied withdrawals were 8.55 mgd but only 0.48 mgd was withdrawn within the Kaskaskia Basin.

The calculated per employee usage rates varied from 3.4 gallons per employee per day (gped) to 36,865.2 gped. The variability of self-supplied I&C water withdrawals per employee for different SIC categories tend to be very high and therefore it is difficult to develop a model at the aggregate level of water-demand data. Table 6.4 shows both self-supplied withdrawals (updated) and water purchased in the six counties with non-zero self-supplied withdrawals.

Table 6.3 Reported Annual Withdrawals by Self-Supplied Commercial/Industrial Establishments in the 22-county Area.

County	Establishment Name	Data Year	Reported Withdrawals MGD	Number of Empl.	Per Employee Withdrawals GPED
Coles	Charleston Stone Company	2005	0.003	20	123.3
Douglas	Tuscola Stone Co Inc	2005	0.242	19	12,727.2
Madison	Bergmann Taylor Seeds Inc	2005	0.012	20	575.3
Madison (U. M./Mc.)	Chemetco Inc	2000	0.110	150	733.3
Madison (U. M. S.)	Alton Steel Co	2000	1.312	-	0.0
Madison (U. M. S.)	BP Products - North American	2005	1.637	80	20,457.1
Madison (U._M. S.)	C M Lohr Inc	2005	0.001	15	59.4
Madison (U. M. S.)	Olin Corp	2005	4.298	3,500	1,228.1
Monroe	Columbia Quarry	2005	0.000	15	3.7
Shelby	C F Industries - Effingham	2005	0.221	6	36,865.2
Shelby	Lakeland Fs Inc	2002	0.000	6	3.4
St.Clair	Kettler Casting Co Inc	2005	0.001	40	34.2
St. Clair (U. M./Mc)	Rockwood Pigments	2005	0.716	100	7,156.2
Totals	--	--	8.552	3,971	2,153.5
Total - Kaskaskia	--	--	0.478	126	3,797.0

U. M. Mc. = Upper Mississippi-Meramec basin, U. M. S. – Upper Mississippi-Salt basin

Table 6.4 County-Level Percent of Self-supplied Withdrawals and Fraction Withdrawn from Kaskaskia Basin

County*	Self-Supplied Withdrawals MGD	Kaskaskia Basin Withdrawals	Public Supply Deliveries	Percent Self-Supplied	Percent Self-supplied Kaskaskia Basin
Coles	0.003	0.003	0.92	0.27	100.0
Douglas	0.242	0.242	1.13	17.63	100.0
Madison	5.732	0.012	0.92	86.17	0.2
Monroe	0.0001	0.0001	0.12	0.05	100.0
Shelby	0.221	0.221	0.04	84.69	100.0
St. Clair	0.717	0.001	4.19	14.61	0.2
Total	6.915	0.478	7.32	48.58	6.9

*Self-supplied I&C withdrawals are reported as zero in the remaining 16 counties.

6.2.2 Water Use Relationships

Water withdrawals and purchases for industrial and commercial purposes are most often explained in economic terms, where water is treated as a factor of production. Ideally, econometric models of water demand could 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, or are not publicly available because of their proprietary nature. An alternative approach that has been commonly used is to estimate water demand based upon the size and type of products or services produced by the firm. This can be accomplished by using unit-use coefficients. Because the size of the firm is frequently represented by its number of employees, total water demand estimates for the I&C sector are frequently calculated in terms of the quantity of water per employee, for a specified type of business enterprise.

In order to estimate future I&C water withdrawals within the 22-county study area, county-level employment data were obtained and compared to total water use (self-supplied + purchased) by industrial and commercial establishments. The most detailed county-level employment data were those obtained from County Business Patterns and from the Illinois Department of Employment Security (IDES).

Table 6.5 shows the data on per-employee water demand at the county level for combined self-supplied and purchased quantities of I&C water in six counties for 2005. It shows that the per-employee rates of total water demand (self-supplied and purchased) show much less variability (ranging from 15 gped to 195.7 gped) than per-employee rates of self-supplied withdrawals in the subset of self-supplied firms as illustrated in Table 6.3.

Table 6.5 Combined Self-Supplied and Purchased Industrial and Commercial County-Level Per Employee Withdrawals in 2005

County	Total County Employ-ment	Total C&I Water Demand (MGD)	Unit Withdrawal Per Employee (GPED)
Coles	26,727	0.923	34.5
Douglas	7,010	1.372	195.7
Madison	96,798	6.652	68.7
Monroe	8,014	0.120	15.0
Shelby	5,122	0.261	51.0
St. Clair	93,066	4.907	52.7
Total/Avg.	236,737	14.235	60.1

MGD = million gallons per day, GPED = gallons per employee per day

The county-wide coefficients of per employee use in Table 6.5 were applied in calculating future I&C water use in each of the six counties. The percentage fractions from Table 6.4 were applied to calculate self-supplied withdrawals and withdrawals from the Kaskaskia River basin.

6.3 FUTURE WATER DEMAND

6.3.1 Future Employment and Productivity

The main driver of future water demand in the industrial and commercial sector is assumed to be the future level of production of goods and services as measured by total county employment. The future output of goods and services will also depend on labor productivity, and total future employment had to be adjusted for productivity.

The long-term growth in labor productivity in Illinois between 1977 and 2000 was 1.3 percent per year as reported by the U.S. Bureau of Labor Services of the U.S. Department of Labor (http://www.clevelandfed.org/Research/ commentary/2005/June.pdf). However, no information was available on the projections of future growth in productivity and, for the purpose of this study a long-term rate in productivity increases was assumed to be 1.0 percent per year. The assumption of 1.0 percent per year makes the estimates of future self-supplied I&C withdrawals conservative. Higher future increases in productivity would be translated into higher physical output per employee, and result in higher withdrawals.

The projections of future employment were obtained from the Illinois Department of Employment Security website. Table 6.6 shows the historical and projected total employment for each of the six counties in the study area. Between 2006 and 2030, total employment is projected to increase by 43,153 employees or by 17.5 percent. An additional increase in employment of 22,753 employees (or 7.9 percent) is projected for the 2030-2050 period.

Table 6.6 Projected Employments in Six Counties of the Study Area

County	2006	2016	Annual Rate, %	2030	2050	2006-2050 Change	Percent Change %
Coles	28,500	31,016	0.85	34,187	37,212	8,712	30.6
Douglas	7,469	7,516	0.06	7,570	7,618	149	2.0
Madison	99,486	106,176	0.65	114,432	122,140	22,654	22.8
Monroe	7,836	8,540	0.86	9,429	10,278	2,442	31.2
Shelby	5,252	5,401	0.28	5,578	5,736	484	9.2
St. Clair	98,008	107,056	0.89	118,507	129,473	31,465	32.1
Total	246,551	265,705	0.75	289,704	312,457	65,906	26.7

Source: Projected employment estimates for 2016 were obtained from IDES.
The annual compound growth rates were reduced by 25 % for 2020-2035, and by 50% for 2035-2050.

The IDES employment projections are prepared only for the period 2006-2016. The IDES projections were extended to 2050 for the purpose of this study by extending the 2006-2016 annual growth rates until 2020 and then gradually reducing the growth rates for the next three decades of the planning horizon.

6.3.2 New Self-Supplied Plants

In addition to the future increases in county-level employment, I&C sector withdrawals will increase if new water-intensive industries locate within the study area.

To account for new industries within the region at specific withdrawal points, biodiesel and ethanol facilities were used to represent new industrial users of water in the region. Water intensive facilities, such as ethanol/biodiesel production plants, are expected to increase total withdrawals throughout the region in the future. Although the ethanol and biodiesel production plants are expected to be a booming industry, their future is uncertain. For the purpose of this study, demands created by future ethanol and biodiesel facilities are used to understand how a new water demand may impact the region.

Table 6.7 lists proposals for five biodiesel plants to be located within the study area. Three of the proposed plants were to be located in Madison County. Two additional plants were to be located in Jasper and Randolph counties. Total biodiesel production of these plants would be 166.7 million gallons per year.

Table 6.7 New/Proposed Biodiesel and Ethanol Plants in the Study Area

City/County	Company	Plant Type/ Application-Permit Status	Capacity MG/year
Newton/ Jasper	National Trail Biodiesel Group, LLC	Soy bean oil. Application: May 30, 2006. Permit: August 30, 2006	33.0
Granite City/ Madison	Omni Bioenergy LLC	Virgin and recycled vegetable oil, animal fats, tallow and free fatty acids. Application: January 5, 2006. Permit: May 16, 2006. Permit Revision: October 30, 2006	39.5
Madison/ Madison	ABG North America	Vegetable Oil and Animal Grease. Application: August 28, 2006. Permit: January 30, 2007	43.0
South Roxana/ Madison	Midwest Biodiesel Products, Inc.	Soybean oil. Application: January 10, 2008; Permit issued April 4, 2008	31.2
Red Bud/ Randolph	First Equity US Baldwin Biodiesel Plant	Vegetable oil and/or tallow. Application: January 10, 2008. Permit: April 4, 2008	20.0

Table 6.8 lists ten dry mill ethanol plants that were proposed for the counties within the study area. Total annual production in these plants would be 1,014 million gallons of ethanol.

Table 6.8 New/Proposed Dry Mill Ethanol Plants in the Study Area

City/County	Company	Application-Permit Status	Capacity MG/year
Madison/ Madison	Abengoa Bioenergy of Illinois, LLC	Application: September 15, 2006; Permit: July 13, 2007	118
Alton/Madison	SWI Energy	Application: July 10, 2008	66
Greenville, Bond	Alternative Energy Sources, Inc.	Application: April 13, 2007; Permit: August 6, 2007	120
Litchfield/Montgomery	BioFuel Energy - Litchfield Trail	Application: February 21, 2007, Permit: December 13, 2007	120
Litchfield/Montgomery	VeraSun Litchfield LLC	Application: January 11, 2007 Permit: September 14, 2007	120
Tuscola/Douglas	Emerald Renewable Energy – Tuscola LLC,	Application: December 26, 2006 Permit: September 28, 2007	115
Baldwin/Randolph	US Energy Holdings (Baldwin Ethanol LLC) Baldwin	Application: August 25, 2006 Permit issued: April 20, 2007 Permit reissued: June 12, 2008	110
Sauget/St. Clair	Center Ethanol Production LLC	Application: March 7, 2006 Permit: August 18, 2006 Start up: Spring 2008	60
Salem/Marion	Midwest-Agri Energy LLC	Revised appl.: January 24, 2006 Permit: August 22, 2007	101
Wayne City, Wayne	Renewable Power LLC	Application: January 10, 2006 Permit: July 20, 2006	84

Based on a 2006 survey, ethanol plants could use 2.65 to 6.10 gallons of fresh water to produce a gallon of ethanol (Wu, 2008). The average usage rates of dry and wet mills were 3.45 and 3.92 gal./gal., respectively (Wu, 2008). In this study, it is assumed that 4.0 gallons of water per gallon of ethanol (gal./gal. ethanol) produced. Because of the rapid growth and water withdrawals of these facilities and/or other similar industries, these withdrawals need to be accounted for in future scenarios.

Biodiesel refining requires less water per unit of energy produced than bioethanol. Pate et al., 2007 reported the approximate consumptive use of about 1 gallon of fresh water per gallon of biodiesel and overall plant water use up to 3 gal/gal. In this study, it is assumed that 2.0 gallons of water per gallon of biodiesel (gal/gal) produced will be used.

6.3.3 Groundwater vs. Surface Water Withdrawals

The allocation of the future self-supplied I&C demand between groundwater and surface water withdrawals is assumed to remain at the 2005 share for each county. Table 6.9 shows the estimated fractions of surface water and groundwater for each county as reported in 2005.

Table 6.9 Percentage Allocation of I&C Surface Water and Groundwater Withdrawals in 2005

County	Groundwater %	Surface Water %
Coles	0.0	100.0
Douglas	0.0	100.0
Madison	60.4	39.6
Monroe	0.1	99.9
Shelby	0.0	100.0
St. Clair	37.8	62.2
Jasper	0.0	100.0
Marion	0.0	100.0

Source: USGS and IWIP data for 2005

6.3.4 Water Demand Under Three Scenarios

The three future scenarios define future conditions which would result in different levels of self-supplied commercial and industrial water use for the 22 County Kaskaskia study area.

For all three scenarios it is assumed that: (1) total county employment will follow the 2020-2050 projections, developed in this study based on IDES growth rates, (2) self-supplied portion of I&C water demand for each county will remain at the percentage levels observed in 2005, and (3) the proportions of groundwater and surface water in total self-supplied I&C withdrawals will remain at the percent fractions as reported for the year 2005.

The specific assumptions used in each scenario are described below.

6.3.4.1 Scenario 1- Current Trends (Baseline Case)

This scenario defines future conditions in terms of recent trends in demand drivers and explanatory variables. The main demand driver is total county employment as projected by IDES. The assumptions pertaining to production and other parameters are described below:

1. One ethanol plant in St. Clair County will begin production in 2010.
2. One biodiesel plant will be built in Randolph County by 2015.

6.3.4.2 Scenario 2 – Less Resource Intensive

This scenario defines conditions which would result in lower self-supplied I&C water withdrawals. The specific assumptions and parameters are described below:

1. No new water-intensive industry (like biodiesel or ethanol plants) will locate within the study area.
2. Both existing and new self-supplied withdrawals will adopt water conservation measures to achieve water savings of 0.3 percent per year.

6.3.4.3 Scenario 3 – More Resource Intensive

This scenario defines conditions which would result in higher self-supplied I&C water withdrawals. The specific assumptions pertaining to production and other parameters are described below:

1. Five biodiesel plants will be constructed within the study area between 2010 and 2025. The counties and completion years for these plants are:
    a. Jasper: 2020
    b. Madison: 2015(2) and 2025 (1)
    c. Randolph: 2010
2. Ten ethanol plants will be constructed within the study area between 2010 and 2030. The counties and completion years for these plants are:
    a. Madison: 2010 and 2015
    b. Montgomery: 2015 and 2020
    c. Bond: 2015
    d. Douglas: 2030
    e. Randolph: 2010
    f. St. Clair: 2010
    g. Marion: 2015
    h. Wayne: 2025
3. No additional water conservation in the self-supplied I&C sector will be achieved in the future.

6.4 SCENARIO RESULTS

The estimated future water withdrawals under each of the three scenarios for the entire 11-county study area are summarized in Table 6.10.

Under the current trends (or baseline) scenario, self-supplied commercial and industrial withdrawals are projected to increase from 6.92 mgd in 2005 to 9.58 mgd in 2050. This represents an increase of 2.66 mgd, or 38.4 percent. The total self supplied withdrawals in 2050 would be 7.69 mgd under the LRI scenario, and 20.84 mgd under the MRI scenario.

The Kaskaskia Basin share of withdrawals in 2005 was estimated to be only 0.48 mgd (or 7 percent). Under the current trends (CT) scenario these withdrawals would increase to 0.64 mgd (or 33.3 percent). The Kaskaskia Basin share would slightly decrease to 0.47 mgd under the LRI scenario but it would increase multiple times to 9.26 mgd if five new biodiesel plants and ten ethanol plants are built in the study area with two biodiesel plants and seven ethanol plants obtaining water from the basin.

Scenario values for total self-supplied industrial and commercial withdrawals as well as withdrawals by supply sources for individual counties are included in Tables A6.2 to A6.4 in the Annex to this chapter.

Table 6.10 I&C Water Demand Scenarios for 22-County Study Area

Year	Self-Supplied Withdrawals (6-counties)	New Industry MGD	Total I&C Withdrawals MGD	Kaskaskia Basin Withdrawals MGD
CT				
2005	6.92	0.00	6.92	0.48
2010	7.32	0.77	8.09	0.61
2015	7.56	0.77	8.33	0.62
2020	7.81	0.77	8.57	0.62
2025	8.00	0.77	8.77	0.63
2030	8.19	0.77	8.96	0.63
2035	8.40	0.77	9.16	0.63
2040	8.53	0.77	9.30	0.64
2045	8.67	0.77	9.44	0.64
2050	8.82	0.77	9.58	0.64
2005-50, Change	1.90	0.77	2.66	0.16
2005-50, %	27.5	--	38.4	33.3
LRI				
2005	6.92	0.00	6.92	0.48
2010	7.32	0.00	7.32	0.50
2015	7.21	0.00	7.21	0.50
2020	7.34	0.00	7.34	0.49
2025	7.46	0.00	7.46	0.49
2030	7.53	0.00	7.53	0.49
2035	7.60	0.00	7.60	0.48
2040	7.67	0.00	7.67	0.48
2045	7.68	0.00	7.68	0.47
2050	7.69	0.00	7.69	0.47
2005-50, Change	0.77	0.00	0.77	-0.01
2005-50, %	11.1	--	11.1	-2.1
MRI				
2005	6.92	0.00	6.92	0.48
2010	7.32	2.70	10.02	1.82
2015	7.56	8.13	15.69	5.56
2020	7.81	9.63	17.44	7.06
2025	8.00	10.77	18.76	7.99
2030	8.19	12.03	20.22	9.25
2035	8.40	12.03	20.42	9.25
2040	8.53	12.03	20.56	9.26
2045	8.67	12.03	20.70	9.26
2050	8.82	12.03	20.84	9.26
2005-50, Change	1.90	12.03	13.92	8.78
2005-50, %	27.5	--	201.2	1,829.2

Note: 2005 represent actual (reported) water withdrawals.

APPENDIX F ANNEX

Table A6.1 Industrial Establishments and Self-Supplied Withdrawals in the 22-county Study Area

County	Company/Establishment	Data Year	Water Withdrawal	Surface Water	Ground Water	Empl	Gallons/ Empl./Day
Bond	Keyesport Sand & Gravel Llc	2005				15	0.0
Christian	Pana Limestone Quarry Company	2005				22	0.0
Clinton	Carlyle Sand & Gravel-A Ltd	2009				4	0.0
Coles	Charleston Stone Company	2005	900,000	900,000	-	20	123.3
Coles	County Concrete Corporation	2005				3	0.0
Cumberland	C &H Gravel Company	2005				12	0.0
Cumberland	C &H Gravel Company Pit #4	2007				2	0.0
Cumberland	Swearingen Excavating	2009				2	0.0
Douglas	Tuscola Stone Co Inc	2005	88,263,000	88,200,000	63,000	19	12,727.2
Fayette	Central Illinois Materials Inc	2005				8	0.0
Fayette	Vandalia Sand & Gravel	2005				5	0.0
Madison	Alby Quarry	2005	-	-	-	15	0.0
Madison	Bergmann Taylor Seeds Inc	2005	4,200,000	-	4,200,000	20	575.3
Madison	Bluff City Minerals	2005				60	0.0
Madison	Gateway Sand & Gravel, Ltd	2005			-	4	0.0
Madison	Lohr Quarry	2005	-	-	-	7	0.0
Madison	Quality Sand, Inc	2005	-	-	-	22	0.0
Madison (U. Mississippi/Meramec)	Chemetco Inc	2000	40,150,000	-	40,150,000	150	733.3
Madison (U. Mississippi Salt)	Alton Steel Co	2000	478,800,000	-	478,800,000	-	0.0
Madison (U. Mississippi Salt)	Bp Products - North American	2005	597,348,000	-	597,348,000	80	20,457.1
Madison (U. Mississippi Salt)	C M Lohr Inc	2005	325,000	-	325,000	15	59.4
Madison (U. Mississippi Salt)	Olin Corp	2005	1,568,842,000	1,170,000,000	401,500,000	3,500	1,228.1

County	Company/Establishment	Data Year	Water Withdrawal	Surface Water	Ground Water	Empl	Gallons/ Empl./Day
Monroe	Columbia Quarry	2005	20,000		20,000	15	3.7
Montgomery	Hanson Material Service	2005				32	0.0
Montgomery	Nokomis Quarry Company	2005				15	0.0
Montgomery	Us Zinc Hillsboro	2000	-	-	-	8	0.0
Randolph	Martin Marietta Materials, Inc	2005				29	0.0
Shelby	C F Industries – Effingham	2005	80,734,800	-	80,734,800	6	36,865.2
Shelby	County Line San & Gravel Llc	2007				8	0.0
Shelby	Iola Quarry Inc	2005				15	0.0
Shelby	Lakeland Fs Inc	2002	7,500	-	-	6	3.4
Shelby	Prosser Construction Company	2005	-	-	-	3	0.0
St.Clair	Casper Stolle Quarry & Contracting	2005	-	-	-	16	0.0
St.Clair	Columbia Quarry Company	2005	-	-	-	32	0.0
St.Clair	Columbia Quarry Company Plant 9	2005	-	-	-	30	0.0
St.Clair	Falling Springs Quarry Company	2005	-	-	-	23	0.0
St.Clair	Kettler Casting Co Inc	2005	500,000	-	500,000	40	34.2
St.Clair (U. Mississippi Meramec)	Rockwood Pigments	2005	261,200,000		261,200,000	100	7,156.2
St.Clair(U. Mississippi Meramec)	Solvay Fluorides Inc	2005	-	-	-	31	0.0
St.Clair(U. Mississippi Meramec)	Trade Waste Incineration Inc	2003	-	-	-	150	0.0

Table A6.2 Total I&C Withdrawals by County (in MGD) -- CT Scenario

County	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
Bond	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Christian	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Clay	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Clinton	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coles	0.003	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cumberland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Douglas	0.242	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26
Effingham	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fayette	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jasper	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Marion	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Montgomery	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Moultrie	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Randolph	0.00	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
Richland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Shelby	0.221	0.23	0.23	0.24	0.24	0.24	0.24	0.25	0.25	0.25
Washington	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wayne	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Macoupin	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Madison	5.732	6.05	6.25	6.45	6.61	6.78	6.94	7.06	7.17	7.29
Monroe	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Saint Clair	0.717	1.44	1.48	1.51	1.54	1.57	1.60	1.62	1.64	1.67
Total 22 counties	6.915	8.09	8.33	8.57	8.77	8.96	9.16	9.30	9.44	9.58

Table A6.3 Total I&C Withdrawals by County (in MGD) -- LRI Scenario

County	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
Bond	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Christian	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Clay	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Clinton	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coles	0.003	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cumberland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Douglas	0.242	0.26	0.25	0.25	0.25	0.25	0.24	0.24	0.24	0.23
Effingham	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fayette	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jasper	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Marion	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Montgomery	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Moultrie	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Randolph	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Richland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Shelby	0.221	0.23	0.23	0.23	0.23	0.22	0.22	0.22	0.22	0.22
Washington	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wayne	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Macoupin	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Madison	5.732	6.05	5.96	6.06	6.17	6.23	6.29	6.35	6.35	6.36
Monroe	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Saint Clair	0.717	0.78	0.77	0.79	0.82	0.83	0.85	0.86	0.87	0.87
Total 22 counties	6.915	7.32	7.21	7.34	7.46	7.53	7.60	7.67	7.68	7.69

Table A6.4 Total I&C Withdrawals by County (in MGD) -- MRI Scenario

County	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
Bond	0.00	0.00	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32
Christian	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Clay	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Clinton	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coles	0.003	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cumberland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Douglas	0.242	0.26	0.26	0.26	0.26	1.52	1.52	1.52	1.52	1.52
Effingham	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fayette	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jasper	0.00	0.00	0.00	0.18	0.18	0.18	0.18	0.18	0.18	0.18
Marion	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Montgomery	0.00	0.00	1.32	2.63	2.63	2.63	2.63	2.63	2.63	2.63
Moultrie	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Randolph	0.00	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32
Richland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Shelby	0.221	0.23	0.23	0.24	0.24	0.24	0.24	0.25	0.25	0.25
Washington	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wayne	0.00	0.00	0.00	0.00	0.92	0.92	0.92	0.92	0.92	0.92
Macoupin	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Madison	5.732	6.77	8.67	8.88	9.25	9.42	9.58	9.70	9.81	9.93
Monroe	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Saint Clair	0.717	1.44	1.48	1.51	1.54	1.57	1.60	1.62	1.64	1.67
Total 22 counties	6.915	10.02	14.58	16.33	17.66	19.11	19.32	19.45	19.59	19.73

Appendix G

IRRIGATION, ENVIRONMENTAL AND AGRICULTURAL WATER DEMAND

7.1 BACKGROUND

The irrigation and agricultural (IR&AG) sector includes self-supplied withdrawals of water for irrigation of cropland and golf courses, as well as water for livestock and environmental purposes. In the USGS inventories of water demand, the designation of "irrigation" water withdrawals includes "all water artificially applied to farm and horticultural crops as well as self-supplied water withdrawal to irrigate public and private golf courses" (Solley et al., 1998). The irrigation and agricultural sector represents a significant component of total water demand, especially in the counties with large proportions of land in agricultural use.

Agricultural livestock water demand includes water for animals, feedlots, dairies, fish farms, and other on-farm needs. The categories of livestock water demand include water used to care for all cattle, sheep, goats, hogs, and poultry, including such animal specialties as horses, rabbits, bees, pets, fur-bearing animals in captivity, and fish in captivity (Avery, 1999).

The Illinois Water Inventory Program includes agricultural withdrawals for only large agricultural irrigation systems and urban irrigation landscapes such as parks and golf courses. Therefore, the reported data on water withdrawals are based on the inventory of the total acreage of irrigated area within each county. Similarly, water withdrawals for livestock are based on the reported numbers of livestock by type. A review of the historical data on irrigation and agriculture is presented in the following sections.

7.1.1 Irrigated Land and Reported Withdrawals

The data on irrigated land are collected and reported by the U.S. Department of Agriculture. Table 7.1 shows the data on irrigated land in the 22 counties which were reported in the four most recent years of the U.S. Censuses of Agriculture. The reported data show that in the 22-county area a total of 10,528 acres of land were under irrigation in 2007. Approximately 86 percent of total irrigated land in the study area was in five counties (Clinton, Wayne, Madison, Monroe and St. Clair). Between 1992 and 2007, the average annual rate of growth in irrigated cropland acreage was 0.5 percent.

The data in Table 7.1 represent irrigation of agricultural land including harvested cropland, pasture and other land. However, according to the census data, in the 22 counties shown in Table 7.1 all irrigated land represents harvested cropland. Since 1995, the USGS also reports data on the number of acres and irrigation withdrawals for golf courses.

Table 7.1 Irrigated Land (in Acres) in the 22 County Area by County

County	Irrigated Land (Acres)			
	1992	1997	2002	2007
Bond	43	21	5	5
Christian	240	(D)	39	31
Clay	(D)	(D)	*0*	D
Clinton	1,736	955	1,572	1,191
Coles	(D)	(D)	49	18
Cumberland	97	40	*40*	5
Douglas	(D)	115	191	D
Effingham	223	(D)	89	264
Fayette	150	72	130	114
Jasper	(D)	82	50	D
Marion	97	153	266	120
Montgomery	13	228	*230*	387
Moultrie	D	34	19	24
Randolph	298	136	*140*	404
Richland	54	D	*0*	45
Shelby	287	145	9	78
Washington	1,068	1323	1,641	D
Wayne	1,035	D	*1,030*	2,454
Macoupin	351	668	35	18
Madison	1,273	1,893	1,398	1,035
Monroe	1,448	1,575	1,178	3,260
Saint Clair	1,356	590	859	1,075
Total 22 counties	9,759	8,043	8,790	10,528

Sources: http://agcensus.mannlib.cornell.edu; http://www.nass.usda.gov/
Numbers in Italics represent USGS estimates used in the 2005 compilation. Reported acreage for Macoupin, Madison, Monroe and St. Clair counties pertains to total county areas, no data were available for partial counties.

The amount of water applied for irrigation is a function of the number of acres of cropland and golf course areas which are irrigated during the growing season. The estimates of historical irrigation of water demand are prepared by USGS by interpolating the census data on irrigated acres for the reporting years (i.e., 1985, 1990, 1995, 2000, and 2005) and then by determining irrigation withdrawals based on the rainfall deficit during the growing season. Table 7.2 below shows the interpolated 2005 number of irrigated acres and estimated water withdrawals for both cropland and golf courses.

According to the USGS data compilation for 2005, the 22 counties Illinois had withdrawn an estimated 8.12 mgd of water for irrigation of cropland (Table 7.2). The largest withdrawals were reported for counties with the largest acreage of irrigated cropland. Golf course irrigation took place on a total of 3,100 acres and the estimated withdrawals were 3.16 mgd. For this study the USGS numbers were updated using the most recent 2007 Census of Agriculture (Table 7.1). The updated estimates of water withdrawals were 7.68 mgd and 2.36 mgd, respectively (see columns 4 and 7 in Table 7.2).

Table 7.2 Reported and Updated Cropland and Golf Course Irrigation Withdrawals for the 22 County Area in 2005

County	Cropland (acres)	Cropland MGD	Updated 2005 MGD	Golf Courses (acres)	Golf Courses MGD	Updated 2005 MGD
Bond	10	0.01	0.01	40	0.04	0.04
Christian	40	0.04	0.03	120	0.13	0.11
Clay	0	0.00	0.00	20	0.02	0.01
Clinton	1,570	1.55	1.12	180	0.19	0.17
Coles	50	0.05	0.02	220	0.24	0.19
Cumberland	40	0.04	0.01	0	0.00	0.00
Douglas	190	0.17	0.00	80	0.08	0.09
Effingham	90	0.09	0.31	80	0.10	0.10
Fayette	130	0.13	0.13	60	0.04	0.07
Jasper	50	0.05	0.00	20	0.02	0.02
Marion	270	0.24	0.09	120	0.12	0.09
Montgomery	230	0.22	0.37	100	0.10	0.10
Moultrie	20	0.02	0.02	80	0.09	0.06
Randolph	140	0.12	0.29	70	0.07	0.05
Richland	0	0.00	0.02	40	0.05	0.02
Shelby	10	0.01	0.08	80	0.09	0.08
Washington	1,640	1.52	1.11	90	0.09	0.06
Wayne	1,030	0.88	2.03	20	0.02	0.02
Macoupin	40	0.04	0.01	120	0.13	0.09
Madison	1,420	1.13	0.54	670	0.65	0.35
Monroe	1,180	1.03	0.61	260	0.25	0.13
Saint Clair	860	0.78	0.91	630	0.64	0.53
Total 22 counties	9,010	8.12	7.68	3,100	3.16	2.36

Source: USGS estimates of irrigation withdrawals. No estimates for partial county areas for Macoupin, Madison, Monroe and St. Clair counties were available.

7.1.2 Livestock Water Use

The U.S. Census of Agriculture also collects information on livestock. Table 7.3 shows the estimates of five categories of livestock for the data year 2007. The data indicates that in 2007 in the 22-county area there were: 76,283 beef cows, 45,682 dairy cows, 1,028,957 hogs and pigs, 17,885 horses and 9,766 sheep.

Table 7.4 shows the historical water withdrawals for livestock which were reported by the USGS. Accordingly, in 2005 total estimated withdrawals for livestock were 10.17 mgd. For the purpose of this study, the livestock water use was re-estimated based on the livestock counts from Table 7.3 and unit usage rates from Table 7.7. The resultant updated total withdrawals for 2005 were 6.86 mgd.

Table 7.3 Estimated Numbers of Livestock in the 22 County Area in 2007

County	Number of beef cows	Number of dairy cows	Number of hogs and pigs	Number of horses	Number of sheep
Bond	3,702	2,031	7987	344	369
Christian	4,771	-	35,096	517	537
Clay	D	D	49,068	480	747
Clinton	2,146	16,646	222,241	501	672
Coles	2,827	145	9,995	471	226
Cumberland	2,566	2,073	36,120	339	169
Douglas	1,006	1,349	2,725	1,770	147
Effingham	4,515	4,274	84,108	1,369	637
Fayette	5,651	1,692	3,637	810	862
Jasper	4,664	875	115,160	375	D
Marion	D	D	D	939	331
Montgomery	4,662	548	70,689	736	698
Moultrie	705	427	3,170	1,690	445
Randolph	5,958	1,605	8,122	460	557
Richland	2,173	572	54,670	383	93
Shelby	7,191	2,714	53,199	921	536
Washington	4,542	6,648	53,716	257	386
Wayne	D	D	56,019	1,011	261
Macoupin	7,408	997	81,456	810	704
Madison	6,156	1,453	14,388	1,580	516
Monroe	3,858	671	36,273	843	525
Saint Clair	1,785	962	31,108	1,279	348
Total 22 counties	76,286	45,682	1,028,947	17,885	9,766

Source: Data were obtained from 2007 Census of Agriculture. D = Numbers withheld due to data disclosure limitations. Data are for entire counties, no partial county data were available.

Table 7.4 Estimated Water Withdrawals for Livestock 1985 – 2005
in the 22 County Area (MGD)

County	1985	1990	1995	2000	2005	Updated 2005
Bond	0.47	0.42	0.33	0.19	0.16	0.15
Christian	0.25	0.23	0.26	0.25	0.22	0.21
Clay	0.27	0.25	0.19	0.30	0.26	0.20
Clinton	1.20	1.27	1.36	1.68	1.72	1.51
Coles	0.25	0.21	0.17	0.13	0.14	0.09
Cumberland	0.34	0.33	0.24	0.19	0.14	0.25
Douglas	0.24	0.22	0.18	0.10	0.17	0.09
Effingham	0.77	0.74	0.61	0.73	0.85	0.56
Fayette	0.48	0.40	0.38	0.32	0.28	0.15
Jasper	0.51	0.55	0.52	0.44	0.39	0.55
Marion	0.38	0.30	0.27	0.19	0.34	0.01
Montgomery	0.71	0.65	0.63	0.42	0.39	0.37
Moultrie	0.24	0.19	0.16	0.09	0.06	0.06
Randolph	0.00	0.53	0.43	0.36	0.34	0.17
Richland	0.28	0.29	0.29	0.34	0.12	0.27
Shelby	0.55	0.57	0.47	0.60	0.53	0.41
Washington	0.78	0.79	0.83	0.89	0.84	0.51
Wayne	0.56	0.49	0.42	0.37	0.46	0.24
Macoupin	1.04	0.90	0.98	0.57	0.65	0.46
Madison	0.67	0.62	0.58	0.37	0.45	0.20
Monroe	0.34	0.34	0.32	0.36	0.28	0.23
St Clair	0.51	0.42	0.36	0.19	1.38	0.20
Total 22 counties	10.84	10.71	9.98	9.08	10.17	6.86

*Source: USGS National Water Use Information Program, various years. Data are for entire counties, no partial county data were available. Re-estimated 2005 withdrawals for the purpose of this study were 6.86 mgd.

7.1.3 Water Withdrawals for Environmental Purposes

In addition to the irrigation and livestock watering uses of water reported by USGS, a relatively small quantity of water is withdrawn for environmental purposes such as forest and prairie preserves, park districts, game farms, and other environmental uses. These environmental uses were identified from the IWIP data base and were added to the irrigation and livestock withdrawals.

Table 7.5 shows the 2002 and 2005 reported withdrawals by the users available in the IWIP database. The total reported amounts of withdrawals for the years 2002 and 2005 in the 22-county study area were 9.835 mgd and 8.325 mgd respectively.

Table 7.5 Reported Environmental Water Withdrawals in the 22 County Area

County	2002 Withdrawals in Gal/year	2002 Withdrawals in MGD	2005 Withdrawals Gal./year	2005 Withdrawals in MGD
Bond	0	0	0	0.000
Christian	2,084,000	0.0057	1,945,000	0.005
Clay	0	0	0	0.000
Clinton	450,000	0.0012	7,200,000	0.020
Coles	809,487	0.0023	595,483	0.002
Cumberland	0	0	0	0.000
Douglas	99,960	0.0003	227,000	0.001
Effingham	0	0	0	0.000
Fayette	3,153,651,500	8.64	2,850,202,428	7.809
Jasper	45,500	0.0001	30,500	0.000
Marion	0	0	0	0.000
Montgomery	0	0	0	0.000
Moultrie	100,418,200	0.2751	110,618,200	0.303
Randolph	251,810	0.0007	41,975	0.000
Richland	0	0	0	0.000
Shelby	8,000,000	0.0219	0	0.000
Washington	10,850	0.0000	10,500	0.000
Wayne	2,600	0.0000	0	0.000
Macoupin	0	0	0	0.000
Madison	22,788,000	0.0624	33,005,000	0.090
Monroe	38,382,632	0.1052	34,697,899	0.095
St. Clair	262,800,000	0.72	0	0.000
Total	3,589,794,539	9.835	3,038,573,485	8.32

Source: IWIP data base. Data are for entire counties, no partial county data were available.

Although the total withdrawals are small, the historical data show a significant rate of increase in this subsector.

7.2 WATER DEMAND RELATIONSHIPS

7.2.1 Estimation of Irrigation Demand

The future demand for irrigation water is determined using the following formula:

$$Q_t = \frac{325{,}851}{12 \cdot 365} A_t \cdot d_t \qquad (7.1)$$

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 determined according the ISWS/USGS method which is based on weekly precipitation records for the growing season from May 1 to August 31. This growing season in irrigation estimates is shorter than the growing season used in the public-supply and industrial-commercial sector because crop irrigation requirements in September are minimal (and can be omitted in the calculations of rainfall deficit).

Rainfall deficit is calculated by accumulating weekly deficits or surpluses over the consecutive weeks of the growing season as follows:

(1) If more than 1.25 inches of rain falls during the first week of the growing 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 rainfall and 1.25 inches is the rainfall deficit that is assumed to be the quantity of water, in inches, applied by irrigation that week.

(3) For each subsequent week during the growing season, one-half of the cumulative rainfall during the previous week in excess of 1.25 inches is added to the rainfall amount for the week.

(4) If the cumulative rainfall amount for a week is less than 1.25 inches, then the difference between the actual rainfall and 1.25 inches is the rainfall deficit that is assumed to be the quantity of water, in inches, applied by irrigation that week.

(5) The rainfall deficits for each week are then added to determine the total irrigation water use during the growing season.

This procedure can be expressed as follows:

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

$$d_1 = r_1 - 1.25 \tag{7.2}$$

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

$$d_1 = 0$$
$$r_2^e = r_2 + (r_1 - 1.25)/2 \tag{7.3}$$
$$d_2 = r_2^e - 1.25$$

where:
r_2^e = effective rainfall in week 2.

In week 2, again, the precipitation deficit will be zero if r_2^e is greater than 1.25 inches, and the one-half of the precipitation surplus will carry to the next week.

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

$$d_t = \sum_{i=1}^{18} d_i \tag{7.4}$$

7.2.2 Precipitation Deficits during Normal Weather Year

The demand for irrigation water during future years will depend on the precipitation deficit during the growing season (May 1 to August 31). For future years, the estimates of irrigation water are based on a "normal" rainfall deficit which depends on the distribution of weekly precipitation during the summer irrigation season of approximately 18 weeks. Table 7.6 shows the values of summer season precipitation deficit which were used to prepare estimates of historical water use (as previously reported in Table 5.2). The values of precipitation deficit represent the total depth of water application in inches during the growing season.

Table 7.6 Estimated May-August “Normal” Precipitation and “Deficit” for Weather Stations Used in the Study.

County	Station Name	Normal May-Aug. Precipitation (inches)	2005 Precipitation Deficit (inches)	Normal Precipitation Deficit (inches)
Bond	Greenville 2 NE	15.52	-14.97	-10.75
Christian	Kincaid	14.95	-12.30	-11.07
Clay	Clay City 6 SSE	15.70	-9.33	-10.65
Clinton	Carlyle Reservoir	15.29	-12.64	-10.88
Coles	Charleston	16.28	-11.74	-10.33
Cumberland	Greenup	16.03	-11.74	-10.47
Douglas	Tuscola	16.48	-14.84	-10.21
Effingham	Beecher City	15.40	-15.98	-10.82
Fayette	Ramsey	15.08	-14.74	-11.01
Jasper	Newton 6 SSE	15.93	-11.47	-10.52
Marion	Salem	15.85	-9.54	-10.57
Montgomery	Hillsboro	15.39	-12.91	-10.83
Moultrie	Tuscola	16.48	-10.05	-10.21
Randolph	Chester	16.72	-9.51	-10.08
Richland	Olney	16.51	-6.36	-10.20
Shelby	Pana 3E	15.58	-13.36	-10.72
Washington	Nashville 4NE	14.17	-9.08	-11.51
Wayne	Fairfield Radio WFIW	16.11	-11.15	-10.42
Macoupin	Carlinville	15.14	-9.73	-10.97
Madison	Alton Melvin Price L&D	14.12	-7.02	-11.54
Monroe	Waterloo	15.43	-6.92	-10.80
Saint Clair	Belleville SIU Research	15.00	-11.36	-11.05

Source: http://www.ncdc.noaa.gov/

These values are assumed to approximate “normal” weather year deficits for these locations.

7.2.3 Water Demand by Livestock

Livestock water demand in each county is estimated by multiplying the total county population of each type of farm animal by an estimate of the amount of water consumed per animal. The estimated daily demand of water by each animal type for the year 2000, based on the USGS inventory, is shown in Table 7.7.

Table 7.7 Estimated Amount of Unit Water Demand by Animal Type

Animal Type	Estimated Water Demand, Gallons per Day per Animal
Dairy Cows	35.0
Beef Cattle	12.0
Horses & Mules	12.0
Hogs	4.0
Goats	3.0
Sheep	2.0
Turkeys	0.12
Chickens	0.06
Rabbits	0.05
Mink	0.03

Source: Avery, 1999

In estimating the county-level livestock water demand in Illinois, USGS accounted only for five of the ten animal types listed in Table 7.7. These were: hogs, beef-cattle, dairy cows, horses, and sheep. Therefore, only these five categories of livestock were used in preparing future water demands for livestock.

7.3 FUTURE IRRIGATION AND AGRICULTURAL WATER DEMAND

The future acreage of irrigated land is separated into cropland and golf courses. The estimates of future water demand in the irrigation and agriculture sector are a function of the future estimates of irrigated area and summer rainfall deficit. The assumptions about the future changes in irrigated acreage are discussed below.

7.3.1 Cropland Irrigation

The future number of irrigated cropland acres can change as a larger or smaller proportion of the available cropland is irrigated. Table 7.8 compares the availability of cropland for future irrigation in the 22 counties. The data in Table 7.8 show that in the 22-county, 3.58 percent of total land area is in urban use, 67.2 percent is in cropland, and only 0.13 percent of total land area is in irrigated cropland.

Table 7.8 Land Area, Urban Area, Cropland and Irrigated Cropland in the Study Area

County	County Land area (acres)	Urban area (acres)	Urban (percent)	Cropland (acres) 2007	Cropland (percent)	Irrigated. Cropland (acres) 2007	Irrigated Cropland (percent cropland)
Bond	243,328	5,821	2.39	203,316	83.6	5	0.002
Christian	453,798	11,699	2.58	414,783	91.4	31	0.007
Clay	300,320	3,021	1.01	178,258	59.4	D	-
Clinton	303,507	10,812	3.56	246,393	81.2	1,191	0.483
Coles	325,306	12,333	3.79	235,141	72.3	18	0.008
Cumberland	221,453	2,723	1.23	124,539	56.2	5	0.004
Douglas	266,790	7,926	2.97	252,838	94.8	D	--
Effingham	306,368	10,875	3.55	204,474	66.7	264	0.129
Fayette	458,553	7,401	1.61	254,549	55.5	114	0.045
Jasper	316,416	2,958	0.93	214,426	67.8	D	-
Marion	366,246	12,006	3.28	212,144	57.9	120	0.057
Montgomery	450,432	12,417	2.76	314,991	69.9	387	0.123
Moultrie	214,784	4,922	2.29	159,120	74.1	24	0.015
Randolph	370,189	12,877	3.48	202,344	54.7	404	0.200
Richland	230,490	3,526	1.53	185,617	80.5	45	0.024
Shelby	485,446	7,216	1.49	346,962	71.5	78	0.022
Washington	360,070	7,053	1.96	324,924	90.2	D	-
Wayne	456,896	4,546	0.99	284,346	62.2	2,454	0.863
Macoupin	552,685	16,751	3.03	336,959	61.0	18	0.005
Madison	464,013	70,835	15.27	284,553	61.3	1,035	0.364
Monroe	248,506	9,441	3.80	148,732	59.9	3,260	2.192
St. Clair	424,838	42,483	10.00	284,759	67.0	1,075	0.378
Total	7,820,434	279,643	3.58	5,251,661	67.2	10,528	0.200

Sources: http://www.nass.usda.gov/Census/; http://www.dnr.state.il.us; http://quickfacts.census.gov/; http://www.agr.state.il.us/gis/stats/landcover/. Data are for entire counties, no partial county data were available.

The data in Table 7.8 also indicate that, as of 2007, only 0.2 percent of total cropland was irrigated (i.e., 10,528 acres out of 5,251,661 acres of cropland). The historical estimates of irrigated cropland acres in each county (as reported in Table 7.1) represent only a small percentage of total cropland, and do not show a consistent increasing trend since 1997. Therefore, the number of irrigated cropland acres for each county is not limited by the availability of total cropland or the effects of increasing urbanization.

7.3.2 Golf Course Irrigation

Golf courses represent another irrigation sub-sector. Table 7.9 shows that there are 352 golf courses in the study area, as compared to the estimated total of about 750 golf courses in the State of Illinois (Golfwebguide.com).

The existing national golf course inventories (Table 7.10) show that there were approximately 15,990 golf courses in the U.S. as of the beginning of 2006, up from 12,846 golf courses in 1990 (Chicagolandgolf.com.). However, a recent national inventory of golf courses prepared by National Golf Foundation (NGF) revealed that there was a negative net growth in golf facilities in 2006, with the number of golf courses closed (146) greater than the number of openings (119) (Chicagolandgolf.com). The 22-county study area inventory shows a total of 79 golf courses and 24 new courses built between 1990 and 2000.

Table 7.9 Number of Golf Courses Built Per Decade in the Study Area

County	1890	1900	1910	1920	1930	1940	1950	1960	1970	1980	1990	2000	Total
Bond	0	0	0	0	1	0	0	0	0	0	0	0	1
Christian	0	0	0	0	1	0	0	1	0	0	0	0	2
Clay	0	0	0	0	0	0	1	0	0	0	0	0	1
Clinton	0	0	0	0	0	0	0	2	0	0	4	0	6
Coles	0	0	0	1	0	0	0	1	1	1	1	0	5
Cumberland	0	0	0	0	0	0	0	0	0	0	0	0	0
Douglas	0	0	0	0	1	1	0	0	0	0	1	0	3
Effingham	0	0	0	0	0	0	0	1	0	0	0	0	1
Fayette	0	0	0	0	0	0	0	1	1	0	0	0	2
Jasper	0	0	0	0	0	0	1	0	0	0	0	0	1
Marion	0	0	1	2	0	0	0	1	0	1	0	0	5
Montgomery	0	0	0	1	0	0	0	0	1	1	1	0	4
Moultrie	0	0	0	0	1	0	0	1	0	0	0	0	2
Randolph	0	0	1	0	0	0	0	1	0	0	1	0	3
Richland	0	0	0	0	0	0	0	0	1	0	0	0	1
Shelby	0	0	0	1	0	0	0	0	0	1	2	0	4
Washington	0	0	0	0	0	0	0	1	0	0	1	0	2
Wayne	0	0	0	0	0	0	1	0	0	0	0	0	1
Macoupin	0	0	0	3	0	0	0	1	0	0	2	0	6
Madison	0	0	1	1	1	0	0	0	0	1	2	0	6
Monroe	0	0	0	1	0	0	0	1	0	0	4	0	6
St. Clair	0	0	0	2	1	1	2	6	0	0	5	0	17
Total 22 co.	0	0	3	12	6	2	5	18	4	5	24	0	79

Source: http://www.golfguideweb.com/illinois/illinois.html

The future water demand by golf courses is a function of the future estimates of irrigated golf course area and summer rainfall deficit. The average size of the irrigated golf course area is 40 acres (Leonard, 1983). The USGS water use inventories utilize the average irrigated area of 40 acres per golf course. In addition, a study conducted by Golf Course Superintendent Association of America confirmed the average size of irrigated area in golf courses to be approximately 40 acres. Therefore, assuming the average size of an irrigated golf course to be 40 acres, the total future irrigated golf course area is estimated by assuming the number of golf-courses that will be built per decade in each county. An analysis of new golf courses opened in the study area shows that on average 6.6 new golf courses are being built per decade since 1890s and 8.25 courses per decade since 1970.

Table 7.10 New Golf Course Opening and Construction in U.S. and Illinois Market

Year	United states Total	Illinois Market			
		Public	Municipal	Private	Total
1990	-	1	1	2	4
1991	158	0	4	3	7
1992	206	4	4	2	10
1993	229	3	6	4	13
1994	244	6	6	2	14
1995	391	6	5	2	13
1996	267	6	3	1	10
1997	261	9	0	1	10
1998	298	7	2	1	10
1999	295	5	3	2	10
2000	292	9	1	1	11
2001	202	5	6	0	11
2002	138	7	4	1	12
2003	72	3	1	0	4
2004	56	1	1	0	2
2005	-5	2	2	0	4
2006	-62	1	0	1	2
Total	3176	75	49	23	147

Source: Chicago Golf Publishing Co., 2007

7.3.3 Water Demand under Three Scenarios

The future water demand for agriculture and irrigation can change depending on the future changes in demand drivers as well as assumptions about future gains in water-use efficiency. The following three scenarios are designed to capture future conditions of water demand in this sector. Like other sectors, the three scenarios are: Current Trends, Less Resource Intensive and More Resource Intensive. All three scenarios use normal weather conditions.

7.3.3.1 Scenario 1- Current Trends (CT)

1. This current trends or baseline scenario assumes the historical rate of growth of 0.6 percent per year in acreage of the irrigated cropland in the future.

2. For the current trends scenario, an increasing acreage of golf course irrigation is assumed at the rate of 6 new golf courses per decade (which is equivalent to the compounded growth rate of 0.73 percent per year).

3. The baseline rates of growth in livestock (1.35, 1.90 and 1.19 percent per year for beef cows, dairy cows and hogs, respectively) as projected by the USDA Economic Research Service are assumed for the CT scenario. The livestock growth rate is reduced by one-third between 2015 and 2030, and by one-half between 2030 and 2050.

4. The environmental demands are assumed to be constant.

7.3.3.2 Scenario 2 – Less Resource Intensive (LRI)

1. The LRI scenario assumes constant acreage of the irrigated cropland (no future increases).

2. This scenario also assumes a constant trend in constructing new golf courses.

3. The LRI scenario assumes the state-wide rate of growth in livestock. It also includes a trend in water efficiency of 0.3 percent demand reduction per year.

4. The environmental demands remain constant at the current level.

7.3.3.3 Scenario 3 – More Resource Intensive (MRI)

1. This scenario assumes the increasing acreage of the irrigated cropland at the most recent rate (1997-2007) of 0.9 percent per year.

2. An increasing acreage of golf course irrigation is assumed in the MRI scenario. Following the growth trend of building new golf courses in the past the rate of 1.0 percent per year (8 new golf courses per decade).

3. The state-wide rate of growth in livestock is followed in the MRI scenario.

4. Environmental demand will increase at the rate of 1.0 percent per year.

7.4 SCENARIO RESULTS

The results of the assumptions for each of the three scenarios are summarized in Table 7.11, below.

Under the CT scenario, total withdrawals would increase by 23.2 percent from 25.89 mgd in 2005 (adjusted for weather conditions) to 31.89 mgd in 2050. Under the LRI scenario, total withdrawals would increase only by 2.49 mgd (or 9.6 %). Under the MRI scenario, total withdrawals would increase by 12.68 mgd (or 49.0 %).

Table 7.11 Scenario Results for Water Withdrawals in Irrigation and Agricultural Sector

Year	Cropland (MGD)	Golf Course (MGD)	Livestock (MGD)	Environmental (MGD)	Total AG/E&I (MGD)
CT					
2005 (Reported)	7.68	2.36	6.86	8.32	25.23
2005 (Normal)	8.18	2.53	6.86	8.32	25.89
2010	8.43	2.62	7.41	8.32	26.78
2015	8.69	2.72	7.91	8.32	27.64
2020	8.95	2.82	7.91	8.32	28.00
2025	9.22	2.92	8.27	8.32	28.74
2030	9.50	3.03	8.65	8.32	29.50
2035	9.79	3.14	8.46	8.32	29.71
2040	10.09	3.26	8.75	8.32	30.41
2045	10.39	3.38	9.05	8.32	31.14
2050	10.71	3.50	9.36	8.32	31.89
2005-50, Change	2.53	0.98	2.5	0.0	6.00
LRI					
2005 (Reported)	7.68	2.36	6.86	8.32	25.23
2005 (Normal)	8.18	2.53	6.86	8.32	25.89
2010	8.18	2.53	7.41	8.32	26.43
2015	8.18	2.53	7.91	8.32	26.94
2020	8.18	2.53	7.91	8.32	26.94
2025	8.18	2.53	8.27	8.32	27.30
2030	8.18	2.53	8.65	8.32	27.67
2035	8.18	2.53	8.46	8.32	27.49
2040	8.18	2.53	8.75	8.32	27.78
2045	8.18	2.53	9.05	8.32	28.07
2050	8.18	2.53	9.36	8.32	28.38
2005-50, Change	0.0	0.0	2.49	0.0	2.49
MRI					
2005 (Reported)	7.68	2.36	6.86	8.32	25.23
2005 (Normal)	8.18	2.53	6.86	8.32	25.89
2010	8.56	2.66	7.41	8.75	27.36
2015	8.95	2.79	7.91	9.19	28.84
2020	9.36	2.93	7.91	9.66	29.86
2025	9.79	3.08	8.27	10.15	31.29
2030	10.24	3.24	8.65	10.67	32.79
2035	10.70	3.41	8.46	11.22	33.79
2040	11.20	3.58	8.75	11.79	35.31
2045	11.71	3.76	9.05	12.39	36.90
2050	12.24	3.95	9.36	13.02	38.57
2005-50, Change	4.56	1.43	2.49	4.70	12.68

Table 7.12 Total IR & AG Withdrawals by Source

Year	Total Surface water (MGD)	Total Groundwater (MGD)	Kaskaskia Surface Water (MGD)	Kaskaskia Groundwater (MGD)	Total IR&AG (MGD)
CT					
2005 (Reported)	10.93	14.30	9.32	5.54	25.23
2005 (Normal)	11.22	14.67	9.38	5.47	25.89
2010	11.33	15.45	9.42	5.80	26.78
2015	11.43	16.20	9.46	6.12	27.63
2020	11.55	16.46	9.51	6.19	28.01
2025	11.66	17.07	9.55	6.45	28.73
2030	11.78	17.72	9.60	6.71	29.50
2035	11.91	17.81	9.65	6.70	29.72
2040	12.03	18.38	9.70	6.93	30.41
2045	12.17	18.98	9.75	7.17	31.15
2050	12.30	19.59	9.80	7.41	31.89
2005-50,Change	1.08	4.92	0.42	1.94	6.00
LRI					
2005 (Reported)	10.93	14.30	9.32	5.54	25.23
2005 (Normal)	11.22	14.67	9.38	5.47	25.89
2010	11.22	15.21	9.32	5.54	26.43
2015	11.22	15.72	9.38	5.47	26.94
2020	11.22	15.72	9.38	5.73	26.94
2025	11.22	16.08	9.38	5.98	27.30
2030	11.22	16.45	9.38	5.97	27.67
2035	11.22	16.27	9.38	6.15	27.49
2040	11.22	16.56	9.38	6.34	27.78
2045	11.22	16.85	9.38	6.25	28.07
2050	11.22	17.16	9.38	6.39	28.38
2005-50,Change	0.00	2.49	0.00	0.92	2.49
MRI					
2005 (Reported)	10.93	14.30	9.32	5.54	25.23
2005 (Normal)	11.22	14.67	9.38	5.47	25.89
2010	11.79	15.58	9.85	5.83	27.37
2015	12.38	16.47	10.35	6.19	28.85
2020	13.00	16.86	10.87	6.31	29.86
2025	13.65	17.64	11.42	6.61	31.29
2030	14.34	18.45	12.00	6.92	32.79
2035	15.06	18.72	12.61	6.96	33.78
2040	15.82	19.49	13.24	7.25	35.31
2045	16.62	20.29	13.91	7.54	36.91
2050	17.45	21.12	14.62	7.85	38.57
2005-50,Change	6.23	6.45	5.24	2.38	12.68

APPENDIX G ANNEX

Table A7.1 Total IR & AG Withdrawals by County (in MGD) -- CT Scenario

County	2005	2005N	2010	2015	2020	2025	2030	2035	2040	2045	2050
Bond	0.20	0.19	0.20	0.22	0.22	0.23	0.24	0.24	0.25	0.26	0.27
Christian	0.35	0.33	0.36	0.38	0.38	0.40	0.41	0.41	0.42	0.44	0.45
Clay	0.22	0.22	0.24	0.25	0.25	0.26	0.27	0.26	0.27	0.28	0.29
Clinton	2.81	2.63	2.78	2.94	2.97	3.10	3.23	3.22	3.33	3.45	3.57
Coles	0.29	0.27	0.28	0.29	0.30	0.31	0.32	0.33	0.34	0.35	0.36
Cumberland	0.26	0.26	0.29	0.31	0.31	0.32	0.34	0.33	0.34	0.35	0.37
Douglas	0.18	0.15	0.15	0.16	0.16	0.16	0.17	0.17	0.18	0.19	0.19
Effingham	0.97	0.83	0.87	0.92	0.93	0.97	1.01	1.01	1.04	1.08	1.11
Fayette	8.15	8.11	8.13	8.15	8.15	8.17	8.18	8.18	8.20	8.21	8.22
Jasper	0.57	0.57	0.63	0.67	0.67	0.69	0.72	0.71	0.73	0.75	0.77
Marion	0.18	0.20	0.21	0.22	0.22	0.23	0.24	0.25	0.25	0.26	0.27
Montgomery	0.84	0.76	0.80	0.84	0.85	0.88	0.91	0.92	0.95	0.98	1.01
Moultrie	0.44	0.44	0.44	0.45	0.45	0.45	0.46	0.46	0.47	0.47	0.48
Randolph	0.50	0.52	0.55	0.58	0.59	0.61	0.64	0.64	0.67	0.69	0.71
Richland	0.31	0.33	0.36	0.38	0.39	0.40	0.42	0.41	0.43	0.44	0.45
Shelby	0.56	0.53	0.57	0.60	0.61	0.63	0.66	0.66	0.68	0.70	0.73
Washington	1.67	1.99	2.09	2.18	2.22	2.30	2.39	2.42	2.50	2.59	2.67
Wayne	2.29	2.15	2.23	2.30	2.37	2.44	2.52	2.58	2.66	2.74	2.82
Macoupin	0.56	0.57	0.61	0.65	0.65	0.68	0.71	0.70	0.72	0.74	0.77
Madison	1.18	1.76	1.81	1.88	1.93	1.99	2.06	2.11	2.18	2.25	2.32
Monroe	1.06	1.47	1.53	1.58	1.62	1.67	1.72	1.76	1.81	1.87	1.92
Saint Clair	1.64	1.60	1.66	1.72	1.76	1.83	1.89	1.94	2.00	2.07	2.13
Total	25.23	25.89	26.78	27.64	28.00	28.74	29.50	29.71	30.41	31.14	31.89

Table A7.2 Total IR & AG Withdrawals by County (in MGD) -- LRI Scenario

County	2005	2005N	2010	2015	2020	2025	2030	2035	2040	2045	2050
Bond	0.20	0.19	0.20	0.21	0.21	0.22	0.23	0.23	0.24	0.24	0.25
Christian	0.35	0.33	0.35	0.37	0.37	0.38	0.39	0.38	0.39	0.40	0.40
Clay	0.22	0.22	0.23	0.25	0.25	0.26	0.27	0.26	0.27	0.27	0.28
Clinton	2.81	2.63	2.74	2.87	2.86	2.95	3.04	3.00	3.07	3.14	3.22
Coles	0.29	0.27	0.27	0.28	0.28	0.28	0.29	0.28	0.29	0.29	0.29
Cumberland	0.26	0.26	0.29	0.31	0.31	0.32	0.34	0.33	0.34	0.35	0.36
Douglas	0.18	0.15	0.14	0.15	0.15	0.16	0.16	0.16	0.16	0.17	0.17
Effingham	0.97	0.83	0.86	0.90	0.90	0.93	0.97	0.95	0.97	1.00	1.02
Fayette	8.15	8.11	8.13	8.14	8.14	8.15	8.16	8.15	8.16	8.17	8.18
Jasper	0.57	0.57	0.63	0.66	0.66	0.69	0.72	0.70	0.72	0.75	0.77
Marion	0.18	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Montgomery	0.84	0.76	0.79	0.81	0.81	0.83	0.85	0.84	0.85	0.87	0.88
Moultrie	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.45	0.45
Randolph	0.50	0.52	0.54	0.56	0.56	0.57	0.58	0.57	0.58	0.59	0.60
Richland	0.31	0.33	0.36	0.38	0.38	0.39	0.41	0.40	0.41	0.42	0.43
Shelby	0.56	0.53	0.56	0.59	0.59	0.62	0.64	0.63	0.64	0.66	0.68
Washington	1.67	1.99	2.04	2.08	2.08	2.11	2.15	2.13	2.15	2.18	2.21
Wayne	2.29	2.15	2.17	2.19	2.19	2.20	2.21	2.20	2.21	2.22	2.23
Macoupin	0.56	0.57	0.61	0.64	0.64	0.66	0.68	0.67	0.69	0.71	0.73
Madison	1.18	1.76	1.77	1.78	1.78	1.79	1.80	1.80	1.80	1.81	1.82
Monroe	1.06	1.47	1.49	1.51	1.51	1.52	1.53	1.52	1.53	1.54	1.55
Saint Clair	1.64	1.60	1.61	1.62	1.62	1.63	1.64	1.64	1.64	1.65	1.66
Total	25.23	25.89	26.44	26.94	26.94	27.30	27.68	27.49	27.78	28.08	28.39

Table A7.3 Total IR & AG Withdrawals by County (in MGD) -- MRI Scenario

County	2005	2005N	2010	2015	2020	2025	2030	2035	2040	2045	2050
Bond	0.20	0.19	0.20	0.22	0.22	0.23	0.24	0.24	0.25	0.26	0.27
Christian	0.35	0.33	0.36	0.38	0.39	0.40	0.42	0.43	0.44	0.46	0.48
Clay	0.22	0.22	0.24	0.25	0.25	0.26	0.27	0.27	0.27	0.28	0.29
Clinton	2.81	2.63	2.80	2.97	3.03	3.18	3.33	3.35	3.49	3.64	3.79
Coles	0.29	0.27	0.28	0.30	0.31	0.32	0.34	0.35	0.36	0.38	0.40
Cumberland	0.26	0.26	0.29	0.31	0.31	0.32	0.34	0.33	0.34	0.35	0.37
Douglas	0.18	0.15	0.15	0.16	0.16	0.17	0.18	0.18	0.19	0.20	0.21
Effingham	0.97	0.83	0.88	0.93	0.95	0.99	1.04	1.04	1.08	1.12	1.17
Fayette	8.15	8.11	8.53	8.97	9.42	9.90	10.40	10.92	11.47	12.05	12.66
Jasper	0.57	0.57	0.63	0.67	0.67	0.69	0.72	0.71	0.73	0.75	0.78
Marion	0.18	0.20	0.21	0.22	0.23	0.24	0.25	0.27	0.28	0.29	0.30
Montgomery	0.84	0.76	0.81	0.85	0.87	0.91	0.95	0.96	1.00	1.04	1.08
Moultrie	0.44	0.44	0.46	0.48	0.50	0.53	0.55	0.57	0.60	0.63	0.66
Randolph	0.50	0.52	0.56	0.59	0.61	0.64	0.67	0.68	0.71	0.74	0.78
Richland	0.31	0.33	0.36	0.39	0.39	0.41	0.42	0.42	0.43	0.45	0.47
Shelby	0.56	0.53	0.57	0.61	0.61	0.64	0.67	0.67	0.69	0.72	0.75
Washington	1.67	1.99	2.11	2.22	2.30	2.41	2.52	2.59	2.70	2.82	2.95
Wayne	2.29	2.15	2.26	2.37	2.46	2.57	2.69	2.79	2.92	3.04	3.18
Macoupin	0.56	0.57	0.61	0.65	0.66	0.69	0.72	0.71	0.74	0.76	0.79
Madison	1.18	1.76	1.84	1.93	2.01	2.11	2.21	2.30	2.41	2.52	2.64
Monroe	1.06	1.47	1.55	1.63	1.69	1.77	1.85	1.92	2.01	2.10	2.19
Saint Clair	1.64	1.60	1.68	1.76	1.83	1.92	2.01	2.09	2.19	2.29	2.39
Total	25.23	25.89	27.36	28.84	29.86	31.29	32.79	33.79	35.31	36.90	38.57

Appendix H

SENSITIVITY TO CLIMATE CHANGE AND DROUGHT

8.1 POSSIBLE EFFECTS

The estimates of future water withdrawals presented in the previous chapters assume normal weather conditions. Specifically, the values of air temperature and precipitation, which are used as explanatory variables in water-use model for public water supply, represent long-term averages based on the 30 year record from 1971 to 2000. Because the period of analysis for water demand scenarios extends until the year 2050, the average weather conditions may change in response to regional and global climate change. In addition several droughts may recur periodically.

8.1.1 Range of Climate Change Predictions

Climate models indicate that by 2050, there may be a possible average annual temperature departure of up to +6 °F from the 1971-2000 long-term normal in Illinois. Climate models also indicate a possible departure from 1971-2000 normal annual precipitation in Illinois in a range from -5 inches to +5 inches per year. Figures 6.1 and 6.2 below show the predictions of global climate model scenarios, grouped into three families (A1, A2, and B1).

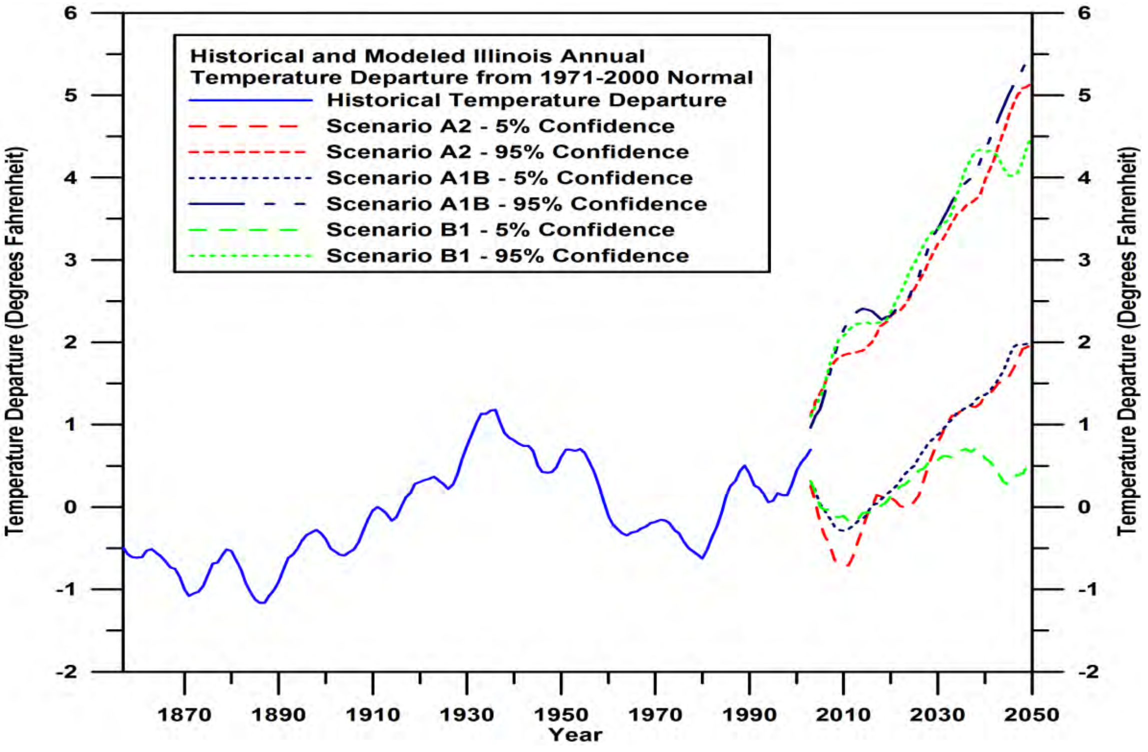

Figure 8.1Global Climate Model Scenarios on a Range of Scenarios of Departures from Normal Annual Temperature: 2005-2100. (Source: ISWS 2007b)

In both figures, 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. Each scenario family is divided into two groups – 5th percentile and 95th percentile. The percentiles designate values which were exceeded 5 percent and 95 percent, respectively (IPCC, 2007).

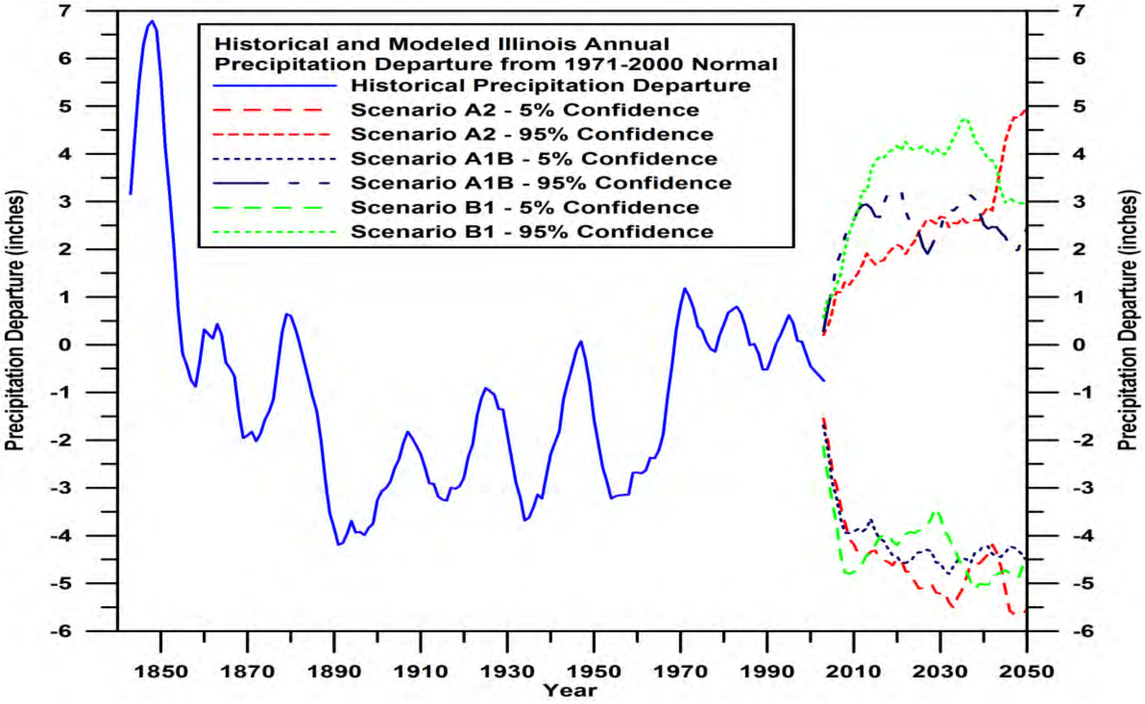

Figure 8.2 Global Climate Model Scenarios on a Range of Scenarios of Departures from Normal Annual Precipitation: 2005-2100.
(Source: ISWS 2007b)

Future withdrawals may be affected by these temperature and precipitation scenarios. Furthermore, the changes in annual temperature and precipitation also result in changes during the growing season. The temperature increase of 6 °F will also apply to the summer growing season. The distribution of precipitation is expected to range from +2.5 inches to -3.5 inches during the growing season. The effects of these changes will vary by user sector, depending on each sector's sensitivity of water withdrawals to air temperature and precipitation. The following sections identify the specific assumptions about the changes in weather variables, discussed separately for each of the major sectors of water users.

8.1.2 Quantifying Climatic Impacts on Different Sectors of Water Users

8.1.2.1 Public Supply Sector

The sensitivity of public-supply withdrawals to weather conditions is captured by two variables: average maximum-daily temperatures, and total precipitation during the five month growing season from May to September. This five month growing season is used based on summer precipitation. The estimated constant elasticity of the temperature variable is +0.9775, indicating that per capita water withdrawals (plus purchases) would be expected to increase by 0.9775 percent in response to a 1.0 percent increase in temperature. The estimated constant elasticity of summer season precipitation is -0.0584, indicating that average annual per capita water withdrawals (plus purchases) would be expected to decrease by 0.0584 percent in response to a 1.0 percent increase in precipitation.

8.1.2.2 Industrial and Commercial Sector

The sensitivity of industrial and commercial (I&C) sector's water withdrawals to weather conditions will be affected by total cooling degree-days and total precipitation during the five month summer season from May to September.

8.1.2.3 Irrigation and Agricultural Sector

For the purpose of sensitivity analysis with respect to climate change scenarios, future estimates of water demand for irrigation were further adjusted for the effects of decreased or increased precipitation, and the effect of increased temperature on evapotranspiration. The effect of the change in normal precipitation was translated into change in the precipitation deficit.

8.1.2.4 Self-Supplied Domestic Sector

The sensitivity of self-supplied domestic withdrawals to weather conditions is captured by two variables: average of maximum-daily temperatures and total precipitation during the five month growing season from May to September. The constant elasticity of the temperature variable and precipitation variable were assumed to be the same as those estimated for the public supply sector.

8.1.2.5 Power Generation Sector

Higher air temperatures will have an impact on the quantity of water withdrawn for thermoelectric cooling. In once-through cooling systems, warmer intake water may lead to increased rates of withdrawals in order meet the limitations on thermal pollution. Also, the performance of cooling towers will be affected by higher air temperatures. However, the actual impacts on water withdrawals cannot be easily quantified and are not included in the sensitivity analysis conducted here.

8.2 ESTIMATED EFFECTS OF CLIMATE CHANGE

8.2.1 Public Water Supply Sector

Given the 6 °F increase in annual average temperature by 2050, the summer growing season maximum daily temperature is assumed to increase by the same amount of 6 °F. According to the graph in Figure 8.1, there is approximately a linear increase in temperature departure between 2005 and 2050. Therefore, the temperature is increased linearly from zero in 2005 to a cumulative additional increase of 6 °F in 2050.

The annual range in precipitation scenario is ±5 inches. The winter, fall, and spring ranges are within -1.5 to +2.5 inches, and the summer season range is +2.5 to -3.5 inches. The graph on Figure 6.2 indicates that the precipitation change will take place early during the 2005-2050 period. Therefore, for the sensitivity analysis it is assumed that departure from precipitation will reach the +2.5 inches and -3.5 inches by 2020. The effects of the combinations of temperature and precipitation changes during the growing season are shown in Tables 8.1

Table 8.1 Impact of Combined Air Temperature and Precipitation Changes on Total Public-Supply Withdrawals

Year	Total Withdrawals MGD	Total Withdrawals (+6°F, +2.5”) MGD	Change %	Total Withdrawals (+6°F, -3.5”) MGD	Change %
2005	56.46	56.46	0.0	56.46	0.0
2010	57.91	58.19	0.5	58.55	1.1
2015	59.82	60.41	1.0	61.18	2.3
2020	61.94	62.86	1.5	64.08	3.5
2025	63.40	64.81	2.2	66.07	4.2
2030	64.74	66.66	3.0	67.96	5.0
2035	66.12	68.56	3.7	69.90	5.7
2040	67.53	70.53	4.4	71.90	6.5
2045	68.97	72.54	5.2	73.96	7.2
2050	70.45	74.62	5.9	76.08	8.0

Total withdrawals represent the Current Trends (CT) scenario.
Two climate change conditions are:
(1) 6 °F temperature increase and 2.5” precipitation increase (+6° F, +2.5”), and
(2) 6 °F temperature increase minus 3.5” and precipitation decrease (+6° F, -3.5”).

The combined effects of changes in both air temperature and precipitation show that, by 2050, the 6 °F increase in temperature, when combined with a 2.5 inches increase in precipitation, would result in a 4.17 mgd increase in demand (a 5.9 percent increase). The demand would increase by 5.63 mgd (or 8.0 percent) when the 6 °F increase in temperature would be combined with a 3.5 inches decrease in precipitation.

8.2.2 Irrigation and Agriculture

The change was calculated using the equation from Chapter 7. This relationship is:

$$d_t = -19.476 + 0.562 \cdot P_n \tag{8.1}$$

where d_t = precipitation deficit during summer season, and P_n = normal precipitation during the irrigation season, increased by 2.5 inches or decreased by 3.5 inches.

The correction for the departure of average temperature is based on the analysis of potential evapotranspiration and monthly temperature by Dr. Ken Kunkel and his staff at ISWS. It is approximated using the adjustment of 0.1 inches/degree F:

$$d_t^c = d_t + 0.1 \cdot (T_a - T_n) \tag{8.2}$$

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

In arriving at this relationship, Dr. Kunkel analyzed the soil moisture model data in order to examine the year-to-year variability in the ratio of actual to potential evapotranspiration (ET/PET) for each month of the growing season. In July and August, there are years when the model-estimated ratio is 1.0, thus indicating that the use of PET as actual ET is appropriate. In June, the highest ET/PET values were in the range of 0.90 to 0.95. In May, the highest ET/PET values were near or slightly above 0.70. The average value for May was 0.50. Assuming that a stretch of 1-2 weeks of dry weather in May would concern a farmer enough to irrigate, the higher value of 0.70 would be appropriate for May.

Because the development of a weighted coefficient for ET/PET ratio would require monthly data (while seasonally aggregated data are used in this study), no downward adjustment for actual ET was introduced (this means assuming the ET/PET value of 1.0 for all months of the irrigation season). This assumption contributes to slightly overestimated effects of temperature on irrigation water demand.

The effects of climate change on total water withdrawals in agricultural and irrigation sector are shown in Table 8.2.

By 2050, the 6 °F increase in air temperature combined with a 2.5 inches increase in precipitation would decrease total agricultural withdrawals by 1.05 mgd (or 3.3 percent) relative to unchanged normal weather (Table 8.2). When the 6 °F increase in air temperature is combined with a 3.5 inches decrease in precipitation, the 2050 withdrawals would increase by 3.34 mgd (or 10.5 percent) relative to normal weather withdrawals.

Table 8.2 Impact of Climate Change on Total Agricultural and Irrigation Withdrawals (Compared to CT Scenario)

Year	Total Withdrawals MGD	Total Withdrawals (+6°F, +2.5 in.) MGD	Change %	Total Withdrawals (+6°F, -3.5 in.) MGD	Change %
2005N	25.89	25.89	0.0	25.89	0.0
2010	26.78	26.37	-1.5	27.51	2.7
2015	27.64	26.80	-3.0	29.15	5.5
2020	28.00	26.70	-4.6	30.34	8.3
2025	28.74	27.47	-4.4	31.22	8.7
2030	29.50	28.27	-4.2	32.14	9.0
2035	29.71	28.52	-4.0	32.52	9.4
2040	30.41	29.27	-3.8	33.39	9.8
2045	31.14	30.04	-3.5	34.30	10.1
2050	31.89	30.84	-3.3	35.23	10.5

Total withdrawals represent the Current Trends (CT) scenario. Two climate change conditions are: (1) temperature increase plus precipitation increase, and (2) temperature increase plus precipitation decrease

8.2.3 Self-Supplied Domestic Sector

The effect of changes in temperature and precipitation are shown in Table 8.3.

Table 8.3 Impact of Climate Change on Self-Supplied Domestic Withdrawals

Year	Total Withdrawals MGD	Total Withdrawals (+6°F, +2.5 in.) MGD	Change %	Total Withdrawals (+6°F, -3.5 in.) MGD	Change %
2005N	18.95	18.95	-	18.95	-
2010	17.41	17.49	0.5	17.63	1.3
2015	19.86	20.05	1.0	20.37	2.6
2020	18.24	18.51	1.5	18.96	3.9
2025	18.65	19.07	2.2	19.53	4.7
2030	21.58	22.23	3.0	22.77	5.5
2035	19.28	20.01	3.8	20.49	6.3
2040	19.64	20.54	4.6	21.04	7.1
2045	20.02	21.09	5.3	21.60	7.9
2050	23.23	24.65	6.1	25.25	8.7

Total withdrawals represent the Current Trends (CT) scenario. Two climate change conditions are: (1) temperature increase plus precipitation increase, and (2) temperature increase plus precipitation decrease

The 6 °F increase in air temperature combined with a 2.5 inches increase in precipitation would increase self-supplied domestic withdrawals by 4.8 mgd (or 11.7 percent) relative to unchanged normal weather (Table 8.3). When the 6 °F increase in air temperature is combined with a 3.5 inches decrease in precipitation, the 2050 withdrawals increase by 8.2 mgd (or 19.8 percent) relative to normal weather withdrawals.

8.3 ESTIMATED EFFECTS OF DROUGHT

Another type of climate impact on water demand is the effect of periodic droughts. In the future, even in the absence of possible changes in the mean long-term annual temperature and precipitation, it can be expected that periodic droughts will occur. While the severity and duration of future droughts is not known, their impact on water demand can be determined by examining the historical climate records. The most severe historical droughts in Illinois took place in the 1930s and 1950s. These were multiyear droughts which were associated with growing season precipitation deficits during the driest year of approximately 40 percent below normal. For the purpose of this analysis, it was assumed that during future droughts the 1971-2000 precipitation for the growing season would be reduced by 40 percent to represent a worst-case historical drought.

8.3.1 Public Supply Sector

Table 6.4 shows the results for average-day water demand in the public-supply sector under the conditions of a worst-case historical drought.

Table 8.4 Impact of Drought-Induced Precipitation Deficit
on Total Public-Supply Withdrawals (compared to CT Scenario)

Year	Total Normal Weather Withdrawals, MGD	Total Withdrawals During Drought MGD	Change %
2005	56.46	56.46	0.00
2010	57.91	59.66	3.03
2015	59.82	61.63	3.03
2020	61.94	63.82	3.03
2025	63.40	65.32	3.03
2030	64.74	66.70	3.03
2035	66.12	68.12	3.03
2040	67.53	69.57	3.03
2045	68.97	71.06	3.03
2050	70.45	72.59	3.03

Total normal weather withdrawals represent the Current Trends (CT) scenario.
Summer precipitation deficit during a drought year is 40 percent of normal.

The results in Table 8.4 indicate that during a drought year (represented by the worst historical drought) total public supply withdrawals would increase by 3.03 percent. This percentage increase would be equivalent to additional 1.96 mgd by 2030, and 2.14 mgd by 2050.

8.3.2 Irrigation and Agricultural Sector

Water withdrawals by irrigation and agricultural sector will also be affected by periodic droughts in the future. Irrigation demands are very sensitive to the decreasing precipitation during the summer growing season. The assumption that during future droughts, the normal precipitation for the growing season would be reduced by 40 percent, representing a worst-case historical drought, would substantially increase the amount of water applied for crop and turf irrigation.

Table 8.5 shows the results for average-day water demand in the IR&AG sector during a worst-case historical drought.

Table 8.5 Impact of Drought-induced Precipitation Deficit
on Irrigation and Agricultural Withdrawals (Relative to CT Scenario)

Year	Total Normal Weather Withdrawals MGD	Total Withdrawals During Drought MGD	Change %
2005	25.89	25.89	0.0
2010	26.78	30.25	12.9
2015	27.64	31.22	12.9
2020	28.00	31.69	13.2
2025	28.74	32.55	13.3
2030	29.50	33.43	13.3
2035	29.71	33.77	13.7
2040	30.41	34.60	13.8
2045	31.14	35.46	13.9
2050	31.89	36.35	14.0

Total normal weather withdrawals represent the Current Trends (CT) scenario.
Summer precipitation deficit during a drought year is 40 percent of normal.

The results in Table 6.12 indicate that during a drought year (represented by the worst historical drought), self-supplied IR&AG withdrawals would increase by approximately 14 percent. This percentage increase would be equivalent to additional 3.47 mgd by 2010, and 4.46 mgd by 2050.

8.3.3 Domestic Self-Supplied Sector

Water withdrawals in the self-supplied domestic sector will also be affected by periodic droughts in the future. For the purpose of this analysis, it was assumed that during future droughts the 1971-2000 precipitation for the growing season would be reduced by 40 percent to represent a worst-case historical drought. Table 8.6 shows the results for average-day water demand in the self-supplied domestic sector during a worst-case historical drought.

The results in Table 8.6 indicate that during a drought year, which is characterized by a 40 percent deficit in summer precipitation, self-supplied domestic withdrawals would increase by 0.70 mgd (3 percent) by 2050.

Table 8.6 Impact of Drought
on Self-Supplied Domestic Withdrawals
(Compared on CT Scenario)

Year	Total Normal Weather Withdrawals, MGD	Total Drought Withdrawals MGD	Change %
2005	18.95	18.95	0.0
2010	17.41	17.94	3.0
2015	19.86	20.46	3.0
2020	18.24	18.80	3.0
2025	18.65	19.22	3.0
2030	21.58	22.23	3.0
2035	19.28	19.86	3.0
2040	19.64	20.24	3.0
2045	20.02	20.62	3.0
2050	23.23	23.93	3.0

8.4 SUMMARY OF CLIMATE EFFECTS

Table 8.7 summarizes the effects of climate changes on water withdrawals in four sectors.

The last column of Table 8.7 shows the changes in withdrawals relative to the withdrawals under the CT scenario. The largest change in total withdrawals by 2050 of 10.99 mgd would result from the combined effect of the temperature increase and decrease in summer precipitation.

Table 8.8 summarizes the increases in sectoral withdrawals during a reoccurrence of the worst historical drought.

Table 8.7 Effects of Possible Climate Change on Water Withdrawals in 22 County Kaskaskia Basin, Illinois (MGD)

Weather Scenario/ Sector	2005[1] Water Withdrawals MGD	2050 Water Withdrawals MGD	2005-2050 Change	Change from CT in 2050
CT Scenario				
Public supply	56.46	70.45	13.99	0.00
Self-supplied domestic	18.95	23.23	4.28	0.00
Irrigation and agriculture	25.89	31.89	6.00	0.00
All three sectors	101.30	125.57	24.27	0.00
CT ΔT +6F+2.5”				
Public supply	56.46	74.62	18.16	4.17
Self-supplied domestic	18.95	24.65	5.70	1.42
Irrigation and agriculture	25.89	30.84	4.95	-1.05
All three sectors	101.30	130.11	28.81	4.54
CT ΔT +6F–3.5”R				
Public supply	56.46	76.08	19.62	5.63
Self-supplied domestic	18.95	25.25	6.30	2.02
Irrigation and agriculture	25.89	35.23	9.34	3.34
All three sectors	101.30	136.56	35.26	10.99

[1] 2005 water withdrawals are adjusted for normal weather conditions. *ΔT* = temperature increase.
Small decimal value differences are due to independent rounding.

Table 8.8 Impacts of Drought Related Precipitation Deficit on Water Withdrawals

Weather Scenario/ Sector	2005[1] Water Withdrawals MGD	2050 Water Withdrawals MGD	2005-2050 Change	Change from CT in 2050
CT Scenario				
Public supply	56.46	70.45	13.99	0.00
Self-supplied domestic	18.95	23.23	4.28	0.00
Irrigation and agriculture	25.89	31.89	6.00	0.00
All three sectors	101.30	125.57	24.27	0.00
Drought Year (40% precipitation deficit)				
Public supply	56.46	72.59	16.13	2.14
Self-supplied domestic	18.95	23.93	4.98	0.70
Irrigation and agriculture	25.89	36.35	10.46	4.46
All three sectors	101.30	132.87	31.57	7.30

[1] 2005 water withdrawals are for climate normal adjusted conditions.
Small decimal value differences are due to independent rounding.

Appendix I

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