Chapter 5

Self-supplied Irrigation and Agriculture (IR&AG)

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5.1 Background

Throughout the world, irrigation (water for agriculture, or growing crops) is one of the most important uses of water. Almost 60 percent of all the world's freshwater withdrawals go towards irrigation uses [USGS, 2005]. In the United States alone, withdrawals were an estimated 137,000 million gallons per day (MGD) in 2000. The majority of these withdrawals (86%) and irrigated acres (75%) were in the 17 contiguous Western States [USGS, 2005]. Irrigated acreage in these states were located in areas where average annual precipitation typically is less than 20 inches. In 2000, the state of Illinois was estimated to use less than 200 MGD for irrigation. In the East-Central Illinois Region, irrigation is important primarily in the western portion of the region where relatively sandy soils make irrigation economically beneficial.

The irrigation and agriculture (IR&AG) sector includes self-supplied water withdrawals for cropland and golf course irrigation as well as water for livestock. In the U. S. Geological Survey (USGS) inventories of water demand, the designation of irrigation water demand 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 USGS inventories of agricultural livestock water withdrawals include water for animals, feedlots, dairies, fish farms, and other on-farm needs [Avery, 1999]. In East-Central Illinois livestock water withdrawals are small relative to irrigation withdrawals, usually less than 3% of the total withdrawals in this sector.

Irrigation represents a significant component of total water demand for this sector, especially in the counties with large proportions of land in irrigated cropland. Table 5.1 shows that in 2002 in the East-Central Illinois 15-county region 82.1 percent of the total land is cropland while only 2.4 percent of the total land is irrigated. In 2002, Mason County had the highest total (91,811 acres) and percentage (26.6%) of irrigated cropland in the East-Central Illinois study region [USDA, 2002]. While all 15 counties have over 65 percent of land that is cropland, only 3 counties have over 1 percent of irrigated land (Table 5.1). These three counties are Mason, Tazewell, and Cass counties. These counties are all located in the western part of the region along the Illinois River where the soils are relatively sandy and do not retain water like soils in the eastern part of the region.

This chapter first discusses the methodology and water withdrawals for livestock and then explains the methodology and water withdrawals for cropland irrigation and golf course irrigation. The final sections present the assumptions for both livestock and irrigation withdrawals for the three scenarios and results for each of the scenarios.

Table 5.1: Total land area, cropland, and irrigated cropland in East-Central Illinois counties in 2002.

County	Land area[a] (acres)	Harvested Cropland[b] (acres)	Harvested Cropland (%)	Irrigated cropland (acres)	Irrigated cropland (%)
Cass	240,576	166,247	69.1	12,250[b]	5.1
Champaign	637,958	559,248	87.7	5,049[b]	0.8
DeWitt	254,451	192,809	75.8	840[c]	0.4
Ford	310,976	276,567	88.9	688[b]	0.2
Iroquois	714,515	648,406	90.7	2,627[b]	0.4
Logan	395,610	342,890	86.7	1,591[b]	0.4
Macon	371,532	302,838	81.5	15[b]	0.0
Mason	344,922	259,687	75.3	91,811[b]	26.6
McLean	757,459	659,423	87.1	920[b]	0.1
Menard	201,120	139,523	69.4	2,098[b]	1.0
Piatt	281,613	251,066	89.2	451[b]	0.2
Sangamon	555,635	436,471	78.6	781[b]	0.1
Tazewell	415,270	301,970	72.7	30,748[b]	7.4
Vermilion	575,411	428,904	74.5	273[c]	0.1
Woodford	337,888	283,467	83.9	738[b]	0.2
Total	6,394,936	5,249,516	82.1	150,880	2.4

Sources: [a]http://quickfacts.census.gov/; [b]US Census of Agriculture (2002); [c]US Geological Survey (2005).

Table 5.2: Estimated amount of unit water demand by animal type per day.

Animal type	Estimated water demand (gallons per day per animal)
Dairy cattle	35.00
Beef cattle	12.00
Horses	12.00
Hogs	4.00
Sheep	2.00
Chickens	0.60

Source: Avery, 1999.

5.2 Livestock

The USGS inventories of agricultural livestock water withdrawals include water for animals, feedlots, dairies, fish farms, and other on-farm needs. The categories of livestock water withdrawals include water used to care for all cattle, sheep, goats, hogs, and poultry, including such animal specialties as horses [Avery, 1999].

Water withdrawals for livestock use were estimated using the USGS unit-use coefficient method. For this calculation, 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 USGS estimated daily demand of water by each animal type is shown in Table 5.2. These five animal types account for the majority of water use by livestock in the study area. The table shows that dairy cattle consume the most water of the five species listed; over twice the amount for beef cattle. This means that if a county has a large population of dairy cattle, the water withdrawals may be larger than a county with twice the number of beef cattle, horses, or hogs.

5.2.1 Livestock historical withdrawals

The historical number of livestock are reported by the U.S. Department of Agriculture in the Census of Agriculture (Ag Census). The Ag Census collects information on the number of livestock for each census year (1982, 1987, 1992, 1997, and 2002). Table 5.3 shows the reported number of livestock for beef cattle, dairy cows, hogs, horses, and sheep for 2002. Livestock data for all historical year is shown in Appendix E. In the East-Central Illinois study area only one fish hatchery exists and because the withdrawals in a hatchery are more akin to commercial & industrial use, the hatchery was included in the commercial and industrial sector of this study. Table 5.3 shows that hogs are the largest livestock population in the region; over six times the number of beef cattle, the next largest population. Dairy cows, the largest water user, has the smallest population in the region with 5,313. McLean County has the largest number of livestock in the region. The county has the largest population of sheep, dairy cow, and hogs. McLean County also has the third largest population of beef cattle. It should be noted that the USGS uses the Ag Census data (years 1982, 1987, 1992, 1997, and 2002) but calculates the water withdrawals for the year 1985, 1990, 1995, 2000, and 2005. This method assumes that the data change little between the census data and the published data.

The population of livestock shown in Table 5.3 were multiplied by the water use for each animal shown in Table 5.2. The resulting total historical withdrawals are shown in Table 5.4. The historical withdrawals for livestock are a minor withdrawal within the irrigation and agriculture sector; ranging from 4.20 - 6.14 MGD. Table 5.4 also shows that within the region, livestock withdrawals have decreased over the past 25 years approximately 2 MGD. This decrease may be due to the conversion of pasture to urban lands or croplands.

5.2.2 Future livestock water withdrawals

The process described in Section 5.2 was used to estimate the future water withdrawals for the region. The future livestock populations were generated based on the baseline rates of growth as projected by the U.S. Department of Agriculture Economic Research Service (USDA). The growth rates for livestock are national growth rates due to a lack of information specific to the region or even Illinois. Table 5.5 shows the livestock populations in 2050. Since growth rate data were limited, the growth rates for each animal type were decreased linearly by half from projected growth rates for the period 2010 to 2050. The projections for each animal for each future model year are provided in Appendix E. The estimated future water withdrawals for livestock based upon these numbers are provided in the results section of this chapter, Section 5.5 and in more detail in Appendix E.

5.3 Irrigation

Water withdrawals for irrigation were calculated using the Illinois State Water Survey (ISWS)/ USGS method of multiplying the number of irrigated acres times the annual rainfall deficit.

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

Table 5.3: Estimated numbers of livestock in the East-Central Illinois study area in 2002.

County	Number of beef cattle	Number of dairy cows	Number of hogs	Number of horses	Number of sheep	Number of chickens
Cass	9,409	D	82,080	176	214	D
Champaign	5,062	D	21,158	522	371	3,772
DeWitt	3,591	D	22,107	228	111	536
Ford	5,675	12	29,874	93	296	D
Iroquois	18,682	1,007	32,137	514	908	D
Logan	6,037	D	80,755	188	458	237
Macon	3,584	D	6,397	346	189	214
Mason	6,225	D	13,521	216	357	106
McLean	10,282	2,840	92,321	759	2,179	503
Menard	5,400	109	30,859	206	115	285
Piatt	2,181	113	8,072	286	230	177
Sangamon	10,705	252	50,810	1,536	401	1,463
Tazewell	8,809	608	74,762	656	578	478
Vermilion	8,236	167	19,056	504	358	504
Woodford	6,958	205	82,337	358	1,387	D
Total	110,836	5,313	646,246	6,588	8,152	8,275

D = data withheld due to data disclosure limitations.

Source: U.S. Department of Agriculture Census (2002).

Table 5.4: USGS estimated water withdrawals (MGD) for livestock 1985-2005.

County	Withdrawals for livestock (MGD)				
	1985	1990	1995	2000	2005[a]
Cass	0.53	0.52	0.54	0.56	0.44
Champaign	0.28	0.27	0.21	0.16	0.15
DeWitt	0.12	0.10	0.07	0.06	0.13
Ford	0.25	0.26	0.25	0.22	0.19
Iroquois	0.63	0.56	0.57	0.47	0.40
Logan	0.44	0.47	0.48	0.44	0.40
Macon	0.16	0.14	0.14	0.09	0.07
Mason	0.25	0.19	0.27	0.23	0.13
McLean	0.67	0.64	0.55	0.60	0.61
Menard	0.38	0.34	0.33	0.22	0.19
Piatt	0.19	0.14	0.11	0.10	0.07
Sangamon	0.58	0.52	0.48	0.45	0.36
Tazewell	0.64	0.69	0.58	0.61	0.44
Vermilion	0.40	0.37	0.28	0.19	0.19
Woodford	0.62	0.59	0.58	0.46	0.43
Total	6.14	5.79	5.45	4.88	4.20

Source: U.S. Geological Survey, [a]2005 data are provisional.

MGD = million gallons per day.

Table 5.5: Estimated numbers of livestock in the East-Central Illinois study area in 2050.

County	Number of beef cattle	Number of dairy cows	Number of hogs	Number of horses	Number of sheep	Number of chickens
Cass	12,764	0	106,956	214	176	0
Champaign	6,867	0	27,570	522	371	3,772
DeWitt	4,871	0	28,807	228	111	536
Ford	7,699	18	38,928	93	296	0
Iroquois	25,344	1,541	41,877	514	908	0
Logan	8,190	0	105,229	188	458	237
Macon	4,862	0	8,336	346	189	214
Mason	8,445	0	17,619	216	357	106
McLean	13,948	4,346	120,300	759	2,179	503
Menard	7,326	167	40,211	206	115	285
Piatt	2,959	173	10,518	286	230	177
Sangamon	14,522	386	66,209	1,536	401	1,463
Tazewell	11,950	930	97,420	656	578	478
Vermilion	11,173	256	24,831	504	358	504
Woodford	9,439	314	107,291	358	1,387	0
Total	150,358	8,131	842,101	6,626	8,114	8,275

Source: U.S. Department of Agriculture Economic Research Service

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

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,

the conversion factors represent: 325,851 gallons/acre-foot, 12 inches/foot, and 365 days/year.

The rainfall deficit is assumed to be the amount of water that is applied to cropland or golf courses to supplement precipitation in the growing season. The rainfall deficit is calculated according the ISWS/USGS method which is based on weekly precipitation records for the irrigation season from May 1 through August 31. The growing season for 2005 golf-course irrigation estimates was the second week in April to the end of September; for other historical years it was May 1 through August 31. Rainfall deficit is calculated by accumulating weekly deficits or surpluses over the consecutive weeks of the growing season for each county 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 for 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 is the rainfall deficit that is assumed to be the quantity of water, in inches, applied for irrigation that week.

5. The rainfall deficits for each week are then summed to determine the total irrigation water demand for the growing season.

The rainfall deficit calculation can be expressed mathematically as follows:

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

$$d_1 = r_1 - 1.25 \tag{5.1}$$

Where:

d_1= rainfall deficit in week 1.

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

$$d_1 = 0 \tag{5.2}$$

$$r_2^e = r_2 + ((r_1 - 1.25))/2 \tag{5.3}$$

$$d_2 = r_2^e - 1.25 \tag{5.4}$$

Where:

r_2^e = effective rainfall in week 2.

In week 2, again, the precipitation deficit will be 0 if r_2^e is greater than 1.25 inches, and the surplus will carry to the next week. The total seasonal rainfall deficit for 16 weeks (i.e., 4 months) is calculated as:

$$d_t = \sum_{i=1}^{16} d_i \tag{5.5}$$

Table 5.6 shows the historical values of calculated growing season rainfall deficit. The growing season in 2005 was generally drier than any of the other historical data years. Therefore, the 2005 rainfall deficits (calculated for the growing season) are generally higher than 1985-2000 historical data years.

5.3.1 Historical irrigation withdrawals

The amount of water applied for irrigation is a function of the number of acres of cropland and golf courses which are irrigated during the growing season. The data on irrigated cropland are collected and reported by the U.S. Department of Agriculture every five (5) years (1982, 1987, 1992, 1997, and 2002). Table 5.7 shows data from the four most recent censuses.

For Cass, Champaign, Mason, Menard, and Tazewell counties the Illinois Farm Service Agency

Table 5.6: Rainfall deficits in East-Central Illinois for 1985-2005 growing seasons.

County	Rainfall deficits (inches)				
	1985	1990	1995	2000	2005
Cass	9.29	4.43	10.04	8.63	15.31
Champaign	6.76	4.87	10.16	10.24	11.77
DeWitt	6.90	8.54	10.13	8.88	12.52
Ford	9.61	5.97	8.03	10.69	11.68
Iroquois	18.21	6.99	8.89	9.91	11.06
Logan	8.02	10.27	8.58	8.85	14.28
Macon	9.42	11.81	8.47	8.47	11.67
Mason	10.83	3.98	8.50	8.21	15.99
McLean	7.18	5.30	7.97	8.89	14.93
Menard	8.60	4.18	10.25	10.43	16.21
Piatt	7.54	5.14	9.35	8.88	11.68
Sangamon	8.60	4.18	10.25	10.43	13.60
Tazewell	8.46	2.53	10.66	12.23	14.50
Vermilion	8.60	5.28	9.26	9.34	10.90
Woodford	9.75	5.70	7.27	11.13	15.96

Source: 2005 data are provisional (USGS, 2007). All other values calculated from Illinois State Climatologist Office data.

Note: See Section 5.3.1
for discussion regarding difference between historical dates
of irrigated acres and historical dates of rainfall deficit.

collects data on irrigated cropland annually. However historical data was only available for 2007 from the Illinois Farm Service Agency. Therefore, in this report where tables or text are comparing all counties, the 2002 data are reported. For future estimates of irrigated acres, the 2007 data are used as the base year for the future estimates, if the data are available. If 2007 data are used, it is noted in the tables.

Table 5.7 shows inter-annual variation of irrigated cropland within a county. This variation may be attributed to one or a combination of the following factors.

- **Reporting.** The way farmers report irrigated acres may differ between different census years and individual farmers. Farmers within a county may report actual irrigated acres (the total number of acres actually irrigated) or potential irrigated acres (meaning the farmer reports the acreage as irrigated if he/she has the ability to irrigate, not if the acres actually were irrigated).

- **Precipitation.** In years of higher precipitation, when an irrigation system is not used, the farmer may not report the acres as irrigated, thus showing a decline in irrigated acres for that year. In some counties, such as Champaign County, there are growing seasons were irrigation is not needed because there is adequate precipitation throughout the growing season. The soils in the eastern portion of the study area are less sandy than soils on the western portion of the study area, which means the eastern farmers need less precipitation/irrigation water because the soils hold water (making it available for plant uptake) longer than soils in the western portion of the study area.

- **Irrigation system changes.** Between U.S. Agriculture Census reporting years, there may be some farmers who abandon an irrigation system(s) and other farmers who install an irrigation system(s). These changes in systems, and therefore acreage, may also account for some of the variability seen in the historical irrigated acres.

The historical data shown in Table 5.7 shows that Mason County has the largest number of irrigated acres (125,961 in 2007), this is over three times the acreage of the next largest irrigating county, Tazewell County (40,207 in 2007). Cass County has 17,774 acres, but the remaining counties all have less than 10,000 acres. Eight counties have less than 1,000 irrigated acres. This indicates that the irrigation water withdrawals in the East-Central Region will be focused in three counties, Mason, Tazewell, and Cass counties.

The 1982-2002 acreage shown in Table 5.7 was used in the USGS estimates of irrigation withdrawals. The USGS reported irrigation withdrawals every five years on the basis of rainfall deficits

Table 5.7: Irrigated cropland (in acres) in East-Central Illinois counties, 1987-2007.

County	Irrigated cropland (acres)				
	1987	1992	1997	2002	2007
Cass	2,424	7,787	8,746	12,250	17,774[b]
Champaign	1,957	8,175	6,092	5,049	6,542[b]
DeWitt	590[a]	630[a]	803	840[a]	–
Ford	300	1,515	693	688	–
Iroquois	1,221	1,175	4,424	2,627	–
Logan	270[a]	1,273	988	1,591	–
Macon	25	D	D	15	–
Mason	59,962	75,855	84,802	91,811	125,961[b]
McLean	958	D	961	920	–
Menard	340	936	927	2,098	2,933[b]
Piatt	111	220	255	451	–
Sangamon	229	335	394	781	–
Tazewell	16,390	22,625	30,487	30,748	40,207[b]
Vermilion	380	210	52	273[a]	–
Woodford	371	500[a]	319	738	–

D = data withheld due to data disclosure limitations. – = data not available.

Source: [a]U.S. Geological Survey; [b]Illinois Farm Service Agency;

all other data from U.S. Department of Agriculture Census.

and number of irrigated acres of cropland, as reported in the Ag Census. The USGS uses precipitation data from 1985, 1990, 1995, 2000, and 2005 and the reported irrigated acres from the Ag Census which is from 1982, 1987, 1992, 1997, and 2002. Therefore in this report, the historical water withdrawals are reported for 1985, 1990, 1995, 2000, and 2005 while the irrigated acres are reported for 1982, 1987, 1992, 1997, and 2002. The underlying assumption in this method is that the irrigated acres do not vary significantly in the three years between the Ag Census, where acreage is reported, and the USGS withdrawals estimation.

During 1985-2000, the USGS reported estimates included golf-course irrigation. For 2005, golf-course irrigation is reported separately from agricultural irrigation by the USGS. For 1982-2000 golf-course irrigation, irrigated acres were estimated by the USGS on the basis of length of the course and average width of a course.

Table 5.8 shows the reported irrigation withdrawals for 1985-2005. These historical data were obtained from published USGS reports with the exception of the withdrawals for Mason and Tazewell counties. The withdrawals for 1990, 1995, 2000, and 2005 for Mason and Tazewell counties were estimated from data obtained from the Imperial Valley Water Authority. The Imperial Valley Water Authority collects information on the number of irrigation systems and the amount of electricity used by all irrigation systems in the water authority. The estimated gallons used are based on the number of accounts, the kilowatt hours (KWh) used by irrigators using power from Menard Electric Coop, and the total number of systems listed on the irrigation plat map supplied by Central Illinois Irrigated Growers Association.

The data in Table 5.8 show what we expected, that Mason, Tazewell, and Cass counties had the largest withdrawals. Mason County, alone, withdrew over 68% of the total withdrawals in every historical data year. The only other counties that have over 2 MGD are Champaign, Iroquois, and Menard counties.

Table 5.8 also shows that the 2005 reported water withdrawals are generally higher than other historical years. This is, in part, due to the drier growing season than other historical years. In fact, the irrigation and agricultural withdrawal estimates for the drought scenario (Chapter 6) closely approximate the 2005 historical withdrawals.

5.3.2 Future irrigated acres

The number of future irrigated acres includes both cropland and golf course acres that are irrigated. The estimates of irrigated cropland and golf course acres are discussed below.

Table 5.8: Irrigation water withdrawals (MGD) in East-Central Illinois for 1985-2005.

County	Water withdrawals for agriculture irrigation (MGD)				
	1985	1990	1995	2000	2005[a]
Cass	0.37	1.29	5.28	4.56	16.40
Champaign	0.13	0.81	5.32	4.50	4.93
DeWitt	0.00	0.13	0.38	0.52	0.79
Ford	0.04	0.09	0.62	0.48	0.71
Iroquois	0.46	0.19	0.73	2.45	2.20
Logan	0.00	0.06	0.64	0.65	1.72
Macon	0.00	0.02	0.26	0.18	0.30
Mason	24.64	34.62[b]	62.09[b]	67.61[b]	159.64[b]
McLean	0.16	0.06	0.26	0.75	1.51
Menard	0.00	0.11	0.52	0.52	2.61
Piatt	0.00	0.13	0.15	0.12	0.41
Sangamon	0.06	0.07	0.49	0.39	1.29
Tazewell	5.54	7.91[b]	14.19[b]	15.45[b]	36.82[b]
Vermilion	0.00	0.00	0.25	0.18	0.24
Woodford	0.25	0.11	0.26	0.24	1.03
Total	31.65	45.60	91.44	98.60	230.6

MGD = million gallons per day. Sources: U.S. Geological Survey; [a] 2005 is provisional data. [b]Mason and Tazewell counties 1990, 1995, 2000 and 2005 data are from Imperial Valley Water Authority. See text for discussion regarding difference between historical dates of withdrawals and historical dates of irrigated acres.

5.3.2.1 Irrigated cropland

In the future, the number of irrigated cropland acres can change to a greater or smaller proportion of the available cropland. Currently, 82.1 percent of total land in the 15-county study area is used as cropland and only 2.9 percent of total cropland is irrigated (representing approximately 2.4 percent of total land area; see Table 5.1).

For future estimates of irrigated cropland, it was assumed that irrigated cropland for all counties (except Mason, Tazewell, and Cass counties) would increase at the historical region-wide rate of 1.05 percent per year. The regional growth rate was calculated from historical data trends for all but three counties; Mason, Tazewell, and Cass counties. The region-wide growth rate was linearly decreased by 0.5 percent from 2010 to 2050 resulting in the total acreage seen in Table 5.9.

For Mason, Tazewell, and Cass counties the Imperial Valley Water Authority, Illinois Farm Services Agency, and Illinois Farm Bureau personnel provided estimates of the future amount of total irrigated acres. By 2050, Mason County was assumed to have an increase of 22,000 irrigated acres; Tazewell County an increase of 8,000 irrigated acres; and Cass County an increase of 3,000 irrigated acres. For these 3 counties it was assumed that 90 percent of the growth in irrigated acres would occur by 2020 and that the irrigated acres would reach the assumed maximum acreage by 2050.

5.3.2.2 Golf courses

For golf course irrigation, the future level of water withdrawals will increase as new golf courses are built. The existing golf course inventories show that there are approximately 72 golf courses in the 15 county study area (as compared to the approximately 750 golf courses in the State of Illinois). Data on "year built" of these golf courses indicate that, since 1950, approximately eight (8) golf courses were build per decade in the study area (Table 5.10). Assuming the average size of irrigated golf course area is 30 acres, the future irrigated golf course area is estimated by assuming the number of golf-courses which will be built per decade in each county. Table 5.11 shows the number of irrigated golf course acres that will be added to IR&AG sector every five years from 2010-2050.

5.3.3 Weather variables - Rainfall deficit

Some of the most important determinants of water demand are related to weather. Consequently, in order to estimate future water withdrawals, the weather variable (i.e., rainfall deficit) must also be estimated. Weather data may be dealt with in a variety of ways when looking into the future.

Table 5.9: Estimates of irrigated cropland for 2002, 2007, 2020, and 2050.

County	Irrigated cropland (acres)				Increase in acreage
	2002	2007[a]	2020	2050	
Cass	12,250	17,774	20,474	20,774	3,000[b,c]
Champaign	5,049	6,542	7,368	8,194	1,652[b]
DeWitt	840	–	991	1,080	240
Ford	688	–	811	885	197
Iroquois	2,627	–	3,097	3,378	751
Logan	1,591	–	1,876	2,046	455
Macon	15	–	18	19	4
Mason	91,811	125,961	145,761	147,961	22,000[b,c]
McLean	920	–	1,085	1,183	263
Menard	2,098	2,933	3,303	3,674	741[b]
Piatt	451	–	532	580	129
Sangamon	781	–	921	1,004	223
Tazewell	30,748	40,207	47,407	48,207	8,000[b,c]
Vermilion	273	–	322	351	78
Woodford	738	–	870	949	211

Source: U.S. Department of Agriculture; [a]data are from the Illinois Farm Service Agency. [b]increase in acreage is calculated from the base 2007 data. [c]total increase in acreage are based on Imperial Valley Water Authority, Illinois Farm Services Agency, and/or Farm Bureau local data.

Table 5.10: Golf courses built in each decade from 1900-2007 in East-Central Illinois.

County	1900s	1910s	1920s	1930s	1940s	1950s	1960s	1970s	1980s	1990s	2000s	Total
Cass	0	0	1	0	0	0	0	0	0	0	0	1
Champaign	1	0	1	0	0	3	2	1	0	1	0	9
DeWitt	0	0	1	0	0	0	0	0	0	0	0	1
Ford	0	0	0	0	0	0	0	0	0	1	0	1
Iroquois	0	0	0	0	0	0	0	0	0	0	0	0
Logan	0	1	0	0	0	0	0	0	0	0	0	1
McLean	0	2	3	0	0	0	1	2	2	2	1	13
Macon	1	2	2	0	0	1	2	1	0	0	1	10
Mason	0	0	0	0	0	0	2	0	0	2	0	4
Menard	0	0	0	0	0	0	1	0	0	0	0	1
Piatt	0	0	1	0	0	0	0	0	0	0	0	1
Sangamon	2	0	2	1	0	1	0	1	0	4	0	11
Tazewell	0	0	1	0	0	1	5	3	0	0	1	11
Vermilion	0	0	2	0	1	1	1	0	0	3	0	8
Woodford	0	0	0	0	0	0	0	0	0	0	0	0
Total	4	5	14	1	1	7	14	8	2	13	3	72

Sources: http://www.golfguideweb.com/illinois/illinois.html and http://www.golflink.com/golf-courses/.

Table 5.11: Assumed increase in golf course acres irrigated every five years in East-Central Illinois.

County	2005 (acres)	2050 (acres)	Increase in irrigated golf course acres every 5 years
Cass	19	19	0
Champaign	367	533	18
DeWitt	37	37	0
Ford	40	64	3
Iroquois	77	77	0
Logan	59	59	0
Macon	267	386	13
Mason	37	132	11
McLean	369	558	21
Menard	59	80	2
Piatt	19	19	0
Sangamon	403	545	16
Tazewell	326	563	26
Vermilion	220	339	13
Woodford	139	139	0
Total	2,438	3,550	124

One approach is to use the climatic normals, as calculated by the National Center for Climatic Data (NCDC), as future weather. Climatic normals are defined as the "statistical average over a time period usually consisting of three consecutive decades"[Owenby et al., 2006]. The current climatic normals are defined for the period 1971-2000.

It was decided by the ISWS and technical committee of the East-Central Regional Water Supply Planning Committee (RWSPC) that the demand models would use climatic normal data as the future weather variables. A consequence of this averaging of the past weather data means that no inter-annual variation is taken into account in the water demand models. Figure 5.1 shows historical recorded data for temperature and precipitation compared to climatic normals; the future data (shown as ?) shows that the future weather is not predictable and how it may vary in relation to the climatic normals used in this study. In effect, this assumes that the average weather from the 30-year period can be used to estimate the future demand. On the one hand, this approach firmly connects the forecast to the historical record. On the other hand, by representing the future as the average of the 30-years of record we lose the extremes that cause some of the variation in demand.

The climatic normal method was chosen so that the general trend of water demand could be understood. By using normal weather data in the future, the annual variation in the historic reported withdrawals due to weather, is not seen in the future estimates. Because normal climatic data were used in estimating future water withdrawals, for any given year in the future (or the past) the water demand estimates will not match the actual water withdrawn. What is revealed by this study is the *average* water withdrawals from 2010 to 2050.

For irrigation, the amount of water withdrawn in any given year depends directly on precipitation during the growing season (May 1 to August 31). For the reasons explained above, the estimates of irrigation withdrawals for future years are based on the normal rainfall deficit. The normal rainfall deficit depends on the distribution of weekly precipitation during the summer irrigation season of approximately 16 weeks. The rainfall deficit for each county is estimated for each irrigation season from 1985 to 2005 using the ISWS/USGS method as described in Section 5.3. It is assumed that these years approximated the climatic normal (1971-2000). Table 5.12 shows the estimates of rainfall deficit for each county in the 15-county study region used to generate future withdrawals from 2010 to 2050.

5.4 Scenarios

The future water demand for agriculture and irrigation can change depending on the future changes in independent variables (*i.e.* irrigated acres, livestock population, and precipitation deficit). The

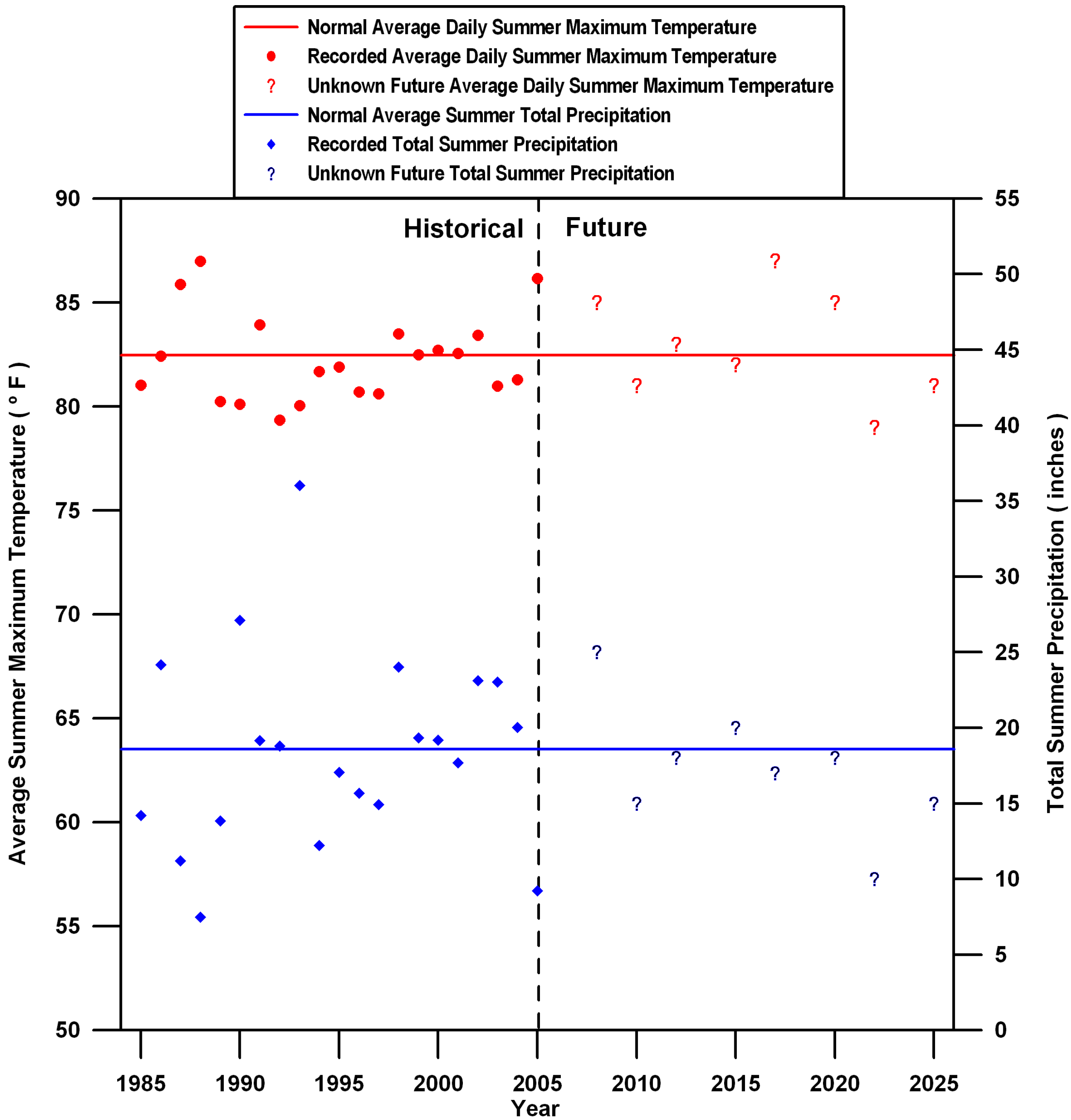

Figure 5.1: Example of inter-annual variation in temperature and precipitation compared to climatic normals.

Table 5.12: Annual rainfall deficit as calculated from climatic normals.

County	Normal rainfall deficit (inches)
Cass	9.86
Champaign	9.17
DeWitt	9.21
Ford	9.45
Iroquois	10.55
Logan	9.92
Macon	10.34
Mason	9.81
McLean	10.34
Menard	10.15
Piatt	9.1
Sangamon	10.15
Tazewell	10.63
Vermilion	9.17
Woodford	10.2

Table 5.13: Summary of irrigated acres for the baseline (BL), less resource intensive (LRI), and more resource intensive (MRI) scenarios in East-Central Illinois.

Year	BL Scenario irrigated acres	LRI Scenario irrigated acres	MRI Scenario irrigated acres
2005	180,255	180,255	180,255
2010	210,274	200,459	220,094
2015	222,602	211,977	233,241
2020	234,834	223,418	246,276
2025	236,082	224,444	247,760
2030	237,207	225,378	249,089
2035	238,196	226,214	250,245
2040	239,042	226,946	251,214
2045	239,739	227,572	251,986
2050	240,284	228,091	252,558
Difference from 2005 to 2050			
Unit (acres)	60,029	47,836	72,303
Percent %	33.3	26.5	40.1

number of irrigated acres has a large impact on the total amount of withdrawals estimated for each scenario. Table 5.13 shows the irrigated acres associated with each of the baseline, less resource intensive, and more resource intensive scenarios. All three scenarios use normal precipitation deficit as the weather variable. The following sections describe the other assumptions used for each of the scenarios.

5.4.1 Scenario 1 - Baseline (BL)

The baseline scenario assumes:

1. Irrigated cropland acres increases at the regional rate of 1.05 percent per year for all counties except Cass, Mason, and Tazewell counties.

2. Irrigated cropland acres in Cass, Mason, and Tazewell counties increases by 1.1, 1.3, and 0.97 percent per year, respectively, up to 2020. From 2020 to 2050 the growth rate in irrigated cropland for Cass, Mason, and Tazewell counties increase by 0.05, 0.07, and 0.05

percent per year, respectively.

3. The number of golf course irrigated acres increase at the rates shown in Table 5.11.

4. Statewide rate of growth in livestock occurs as described in Section 5.2.2.

5.4.2 Scenario 2 - Less resource intensive (LRI)

The less resource intensive scenario assumes:

1. Irrigated cropland acres increases at 75 percent of the regional rate or 0.79 percent per year for all counties except Cass, Mason, and Tazewell counties.

2. The irrigated cropland acres for Cass, Mason, and Tazewell counties is decreased by 5 percent of the baseline scenario acreage for every study year (2010, 2020,..., 2050).

3. Irrigated golf course acres increases by 75 percent as compared to the rates shown in Table 5.11.

4. Statewide rate of growth in livestock occurs as described in Section 5.2.2.

5.4.3 Scenario 3 - More resource intensive (MRI)

The more resource intensive scenario assumes:

1. Irrigated cropland acres increases at 125 percent of the regional rate or 1.31 percent per year for all counties except Cass, Mason, and Tazewell counties.

2. The irrigated cropland acres for Cass, Mason, and Tazewell counties is increased by 5 percent of the baseline scenario acreage for every study year (2010, 2020,..., 2050).

3. The growth rate of the irrigated cropland acreage increases by 25 percent, increasing acreage of golf course irrigation by 25 percent as compared to the rates shown in Table 5.11.

4. Statewide rate of growth in livestock occurs as described in Section 5.2.2.

5.5 Results

The results of the assumptions for each of the three scenarios are summarized in Tables 5.14, 5.15, and 5.16. Figure 5.2 shows the total withdrawals for all three scenarios for the 15-county region.

The baseline scenario estimates show that for average weather in 2050 the water demands will reach approximately 190 MGD. Most of these withdrawals (over 95%) are due to the irrigated cropland in the region. Golf course and livestock withdrawals account for less than 5% of the total withdrawals.

In the LRI scenario, the total withdrawals in 2005 are lower than the baseline scenario, 177.2 MGD. The MRI scenario increases the water withdrawals to approximately 196 MGD. It is important to note that on any given year, if a drought were to occur the water withdrawals will be much higher than the reported amounts in these summary tables (see Chapter 6 for a discussion about the effects of drought).

The results for each county for the baseline scenario are provided Figures 5.3–5.10. Twelve of the fifteen counties are estimated to withdraw 6 MGD or less by the year 2050 in the baseline scenario. The three largest withdrawals will come from Cass (16 MGD), Tazewell (39 MGD), and Mason (108 MGD) counties. All three of these counties are in the western portion of the study area where soils are sandy (these soils hold less water). Additionally, these three counties currently have the highest percentage of irrigated cropland.

The regional summary (Chapter 7) will compare the irrigation and agriculture withdrawals to other sectors.

5.5.1 Groundwater versus surface water withdrawals

The data generated from this demand study will be delivered to the ISWS as digital data. For those withdrawals where the exact location of the withdrawals point is known within the irrigation and agriculture sector, the future withdrawal estimates will be allocated to that withdrawal point. Generally, the only known points of withdrawal are for golf courses; the cropland irrigation and livestock withdrawal points are generally unknown. For those demands where exact location points are unknown, the ISWS will determine the locations.

The allocation of the future self-supplied IR&AG demands between groundwater and surface water withdrawals is generally assumed to remain at the 2005 level for each study area. Table5.17 shows the estimated percentages of surface water and groundwater for each county. The vast majority of the water withdrawals for irrigation and agricultural purposes are from groundwater.

Table 5.14: Total withdrawals for the baseline scenario for the irrigation and agriculture.

Year	Cropland (MGD)	Golf course (MGD)	Livestock (MGD)	Total withdrawals (MGD)
2005 (Weather)	226.5	2.4	4.2	233.1
2005 (Normal)	133.4	1.8	4.2	139.4
2010	156.0	1.9	4.5	162.4
2015	165.2	2.0	4.7	171.9
2020	174.3	2.1	4.9	181.3
2025	175.2	2.2	5.1	182.5
2030	176.0	2.3	5.3	183.6
2035	176.7	2.4	5.4	184.5
2040	177.3	2.5	5.5	185.3
2045	177.9	2.5	5.6	186.0
2050	178.3	2.6	5.6	186.5
Difference from 2005 (Normal) to 2050				
MGD	44.8	0.8	1.4	47.0
Percent (%)	33.6	45.6	32.3	33.7

MGD = million gallons per day.

2005 (Weather) = 2005 withdrawals using actual rainfall deficit.

2005 (Normal) = 2005 withdrawals using normal rainfall deficit.

Note: See Section 5.3.3 for discussion of effects of using normal rainfall deficit.

Table 5.15: Total withdrawals for the less resource intensive scenario for the irrigation and agriculture.

Year	Cropland (MGD)	Golf course (MGD)	Livestock (MGD)	Total withdrawal (MGD)
2005 (Weather)	226.5	2.4	4.2	233.1
2005 (Normal)	133.4	1.8	4.2	139.4
2010	148.7	1.9	4.5	155.0
2015	157.3	2.0	4.7	163.9
2020	165.8	2.0	4.9	172.7
2025	166.5	2.1	5.1	173.8
2030	167.2	2.2	5.3	174.7
2035	167.8	2.2	5.4	175.5
2040	168.4	2.3	5.5	176.2
2045	168.8	2.4	5.6	176.8
2050	169.2	2.4	5.6	177.2
Difference from 2005 (Normal) to 2050				
MGD	35.8	0.6	1.4	37.8
Percent (%)	26.8	34.3	32.3	27.1

MGD = million gallons per day.

2005 (Weather) = 2005 withdrawals using actual rainfall deficit.

2005 (Normal) = 2005 withdrawals using normal rainfall deficit.

Note: See Section 5.3.3 for discussion of effects
of using normal rainfall deficit.

Table 5.16: Total withdrawals for the more resource intensive scenario for the irrigation and agriculture.

Year	Cropland (MGD)	Golf course (MGD)	Livestock (MGD)	Total withdrawals (MGD)
2005 (Weather)	226.5	2.4	4.2	233.1
2005 (Normal)	133.4	1.8	4.2	139.4
2010	163.3	1.9	4.5	169.7
2015	173.1	2.0	4.7	179.8
2020	182.8	2.2	4.9	189.9
2025	183.8	2.3	5.1	191.3
2030	184.8	2.4	5.3	192.5
2035	185.7	2.5	5.4	193.6
2040	186.4	2.6	5.5	194.5
2045	186.9	2.7	5.6	195.2
2050	187.4	2.9	5.6	195.8
Difference from 2005 (Normal) to 2050				
MGD	54.0	1.0	1.4	56.4
Percent (%)	40.4	57.1	32.3	40.4

MGD = million gallons per day.

2005 (Weather) = 2005 withdrawals using actual rainfall deficit.

2005 (Normal) = 2005 withdrawals using normal rainfall deficit.

Note: See Section 5.3.3 for discussion of effects of using normal rainfall deficit.

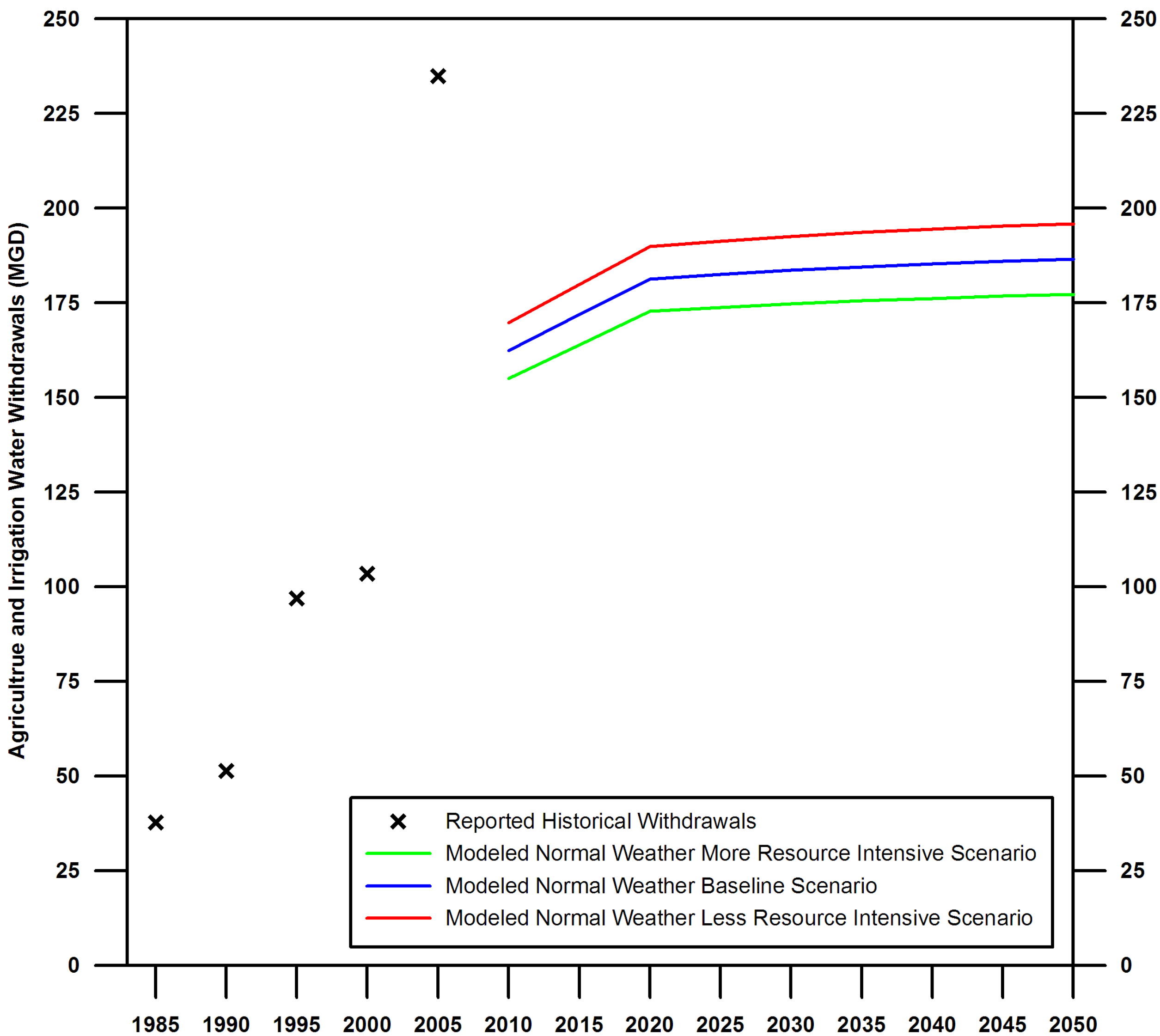

Figure 5.2: Historical and future irrigation and agriculture withdrawals for the baseline scenario, the less resource intensive scenario, and the more resource intensive scenario for East-Central Illinois.

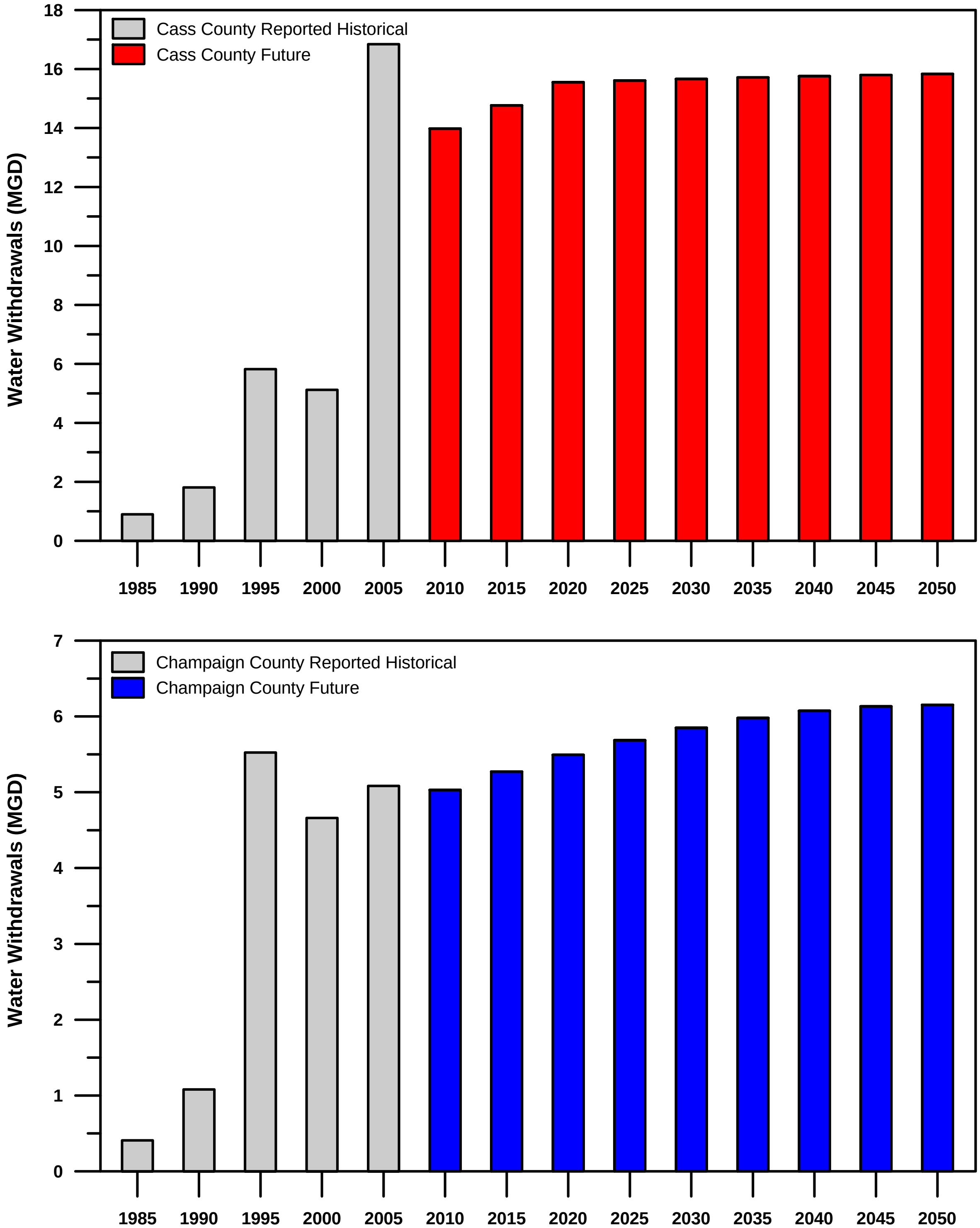

Figure 5.3: Irrigation and agriculture historical and future water withdrawals for Cass and Champaign counties in East-Central Illinois.

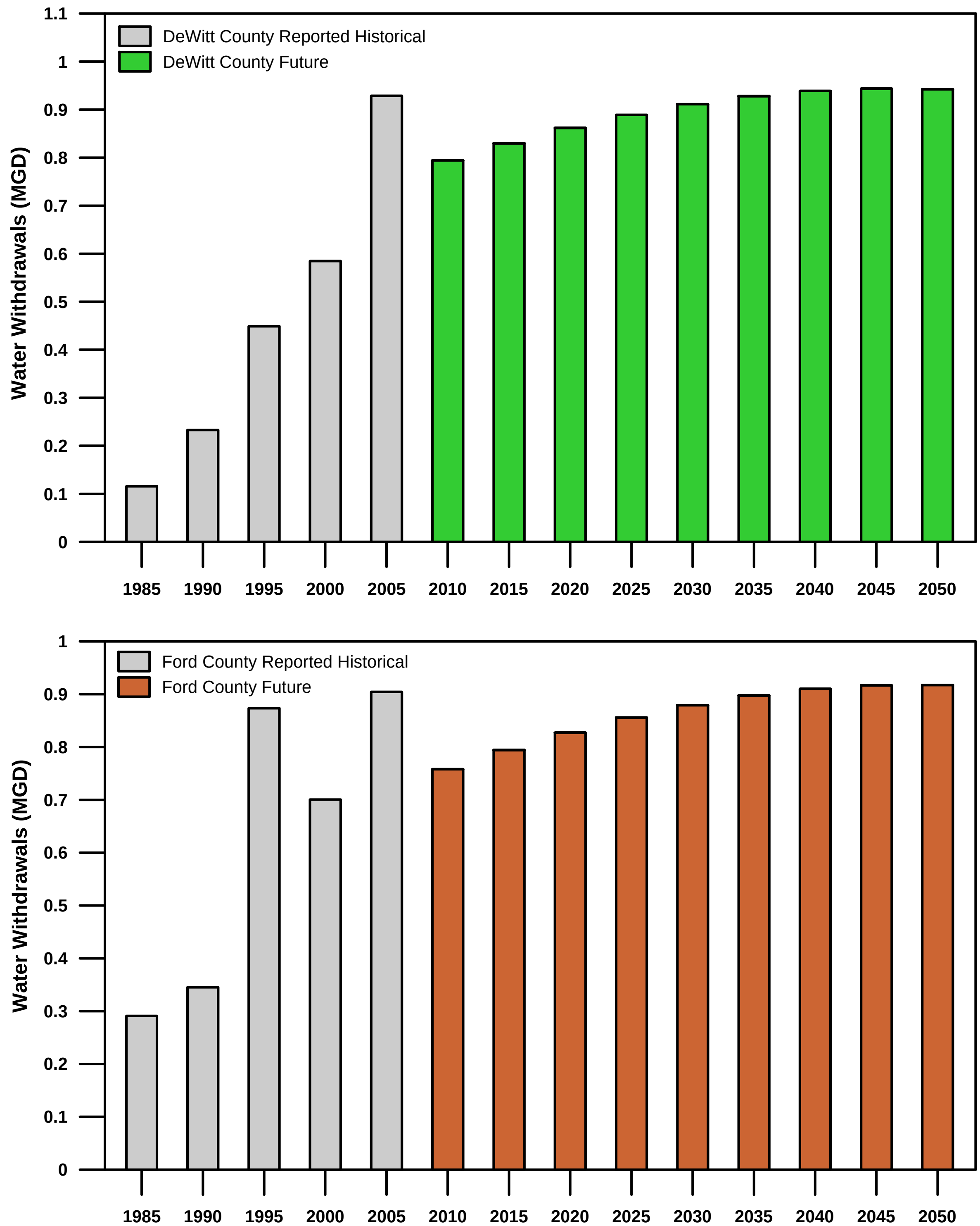

Figure 5.4: Irrigation and agriculture historical and future water withdrawals for DeWitt and Ford counties in East-Central Illinois.

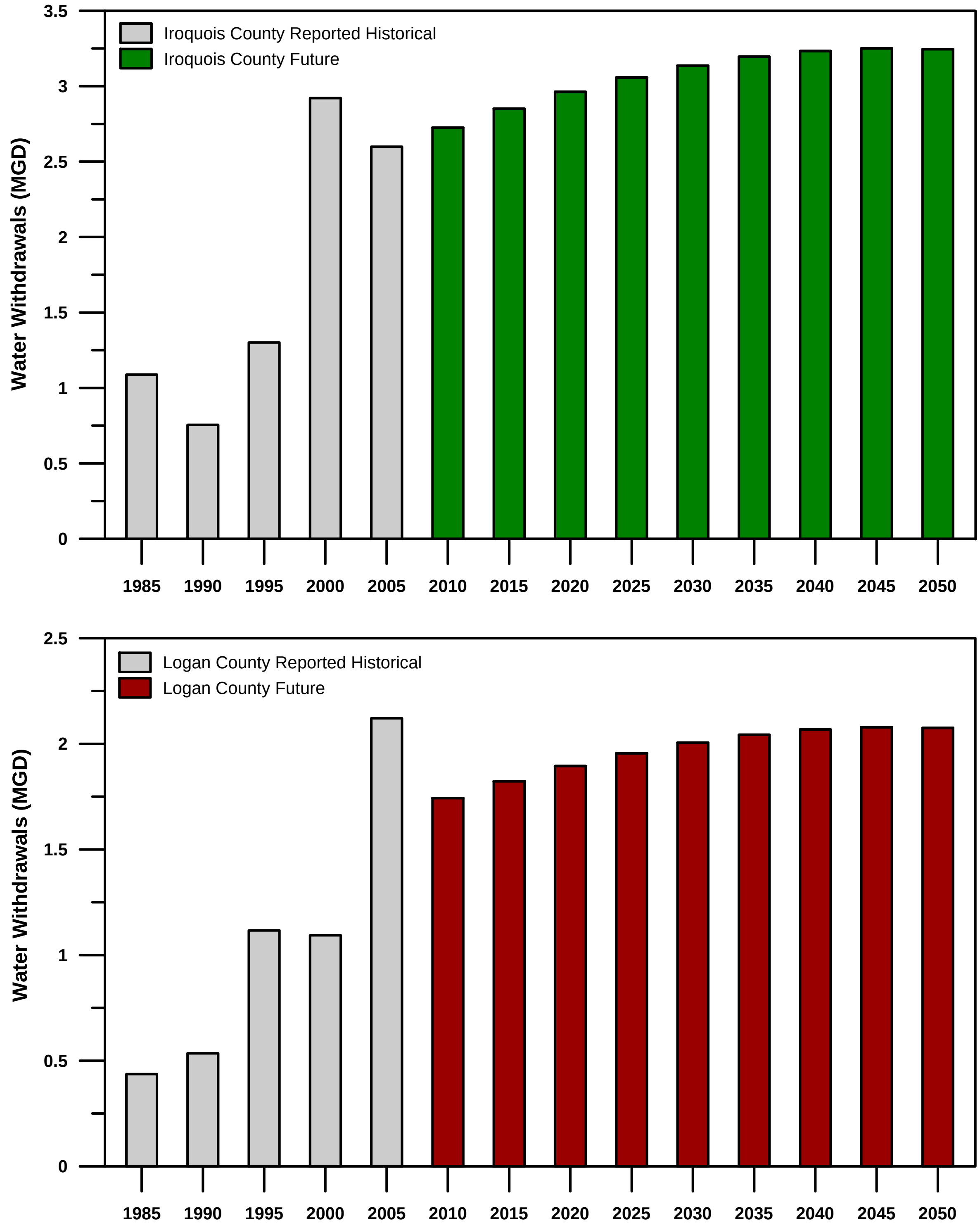

Figure 5.5: Irrigation and agriculture historical and future water withdrawals for Iroquois and Logan counties in East-Central Illinois.

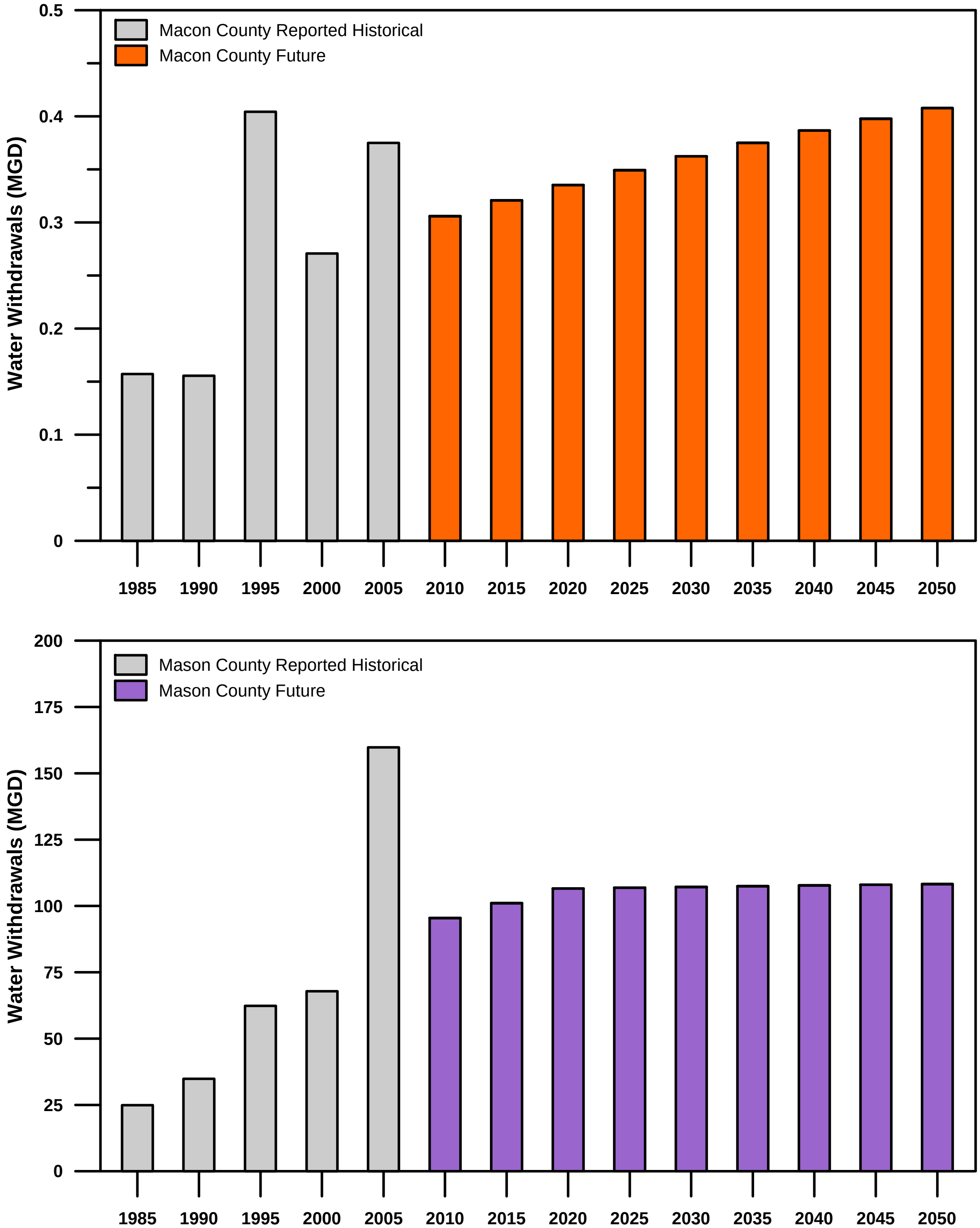

Figure 5.6: Irrigation and agriculture historical and future water withdrawals for Macon and Mason County study areas in East-Central Illinois.

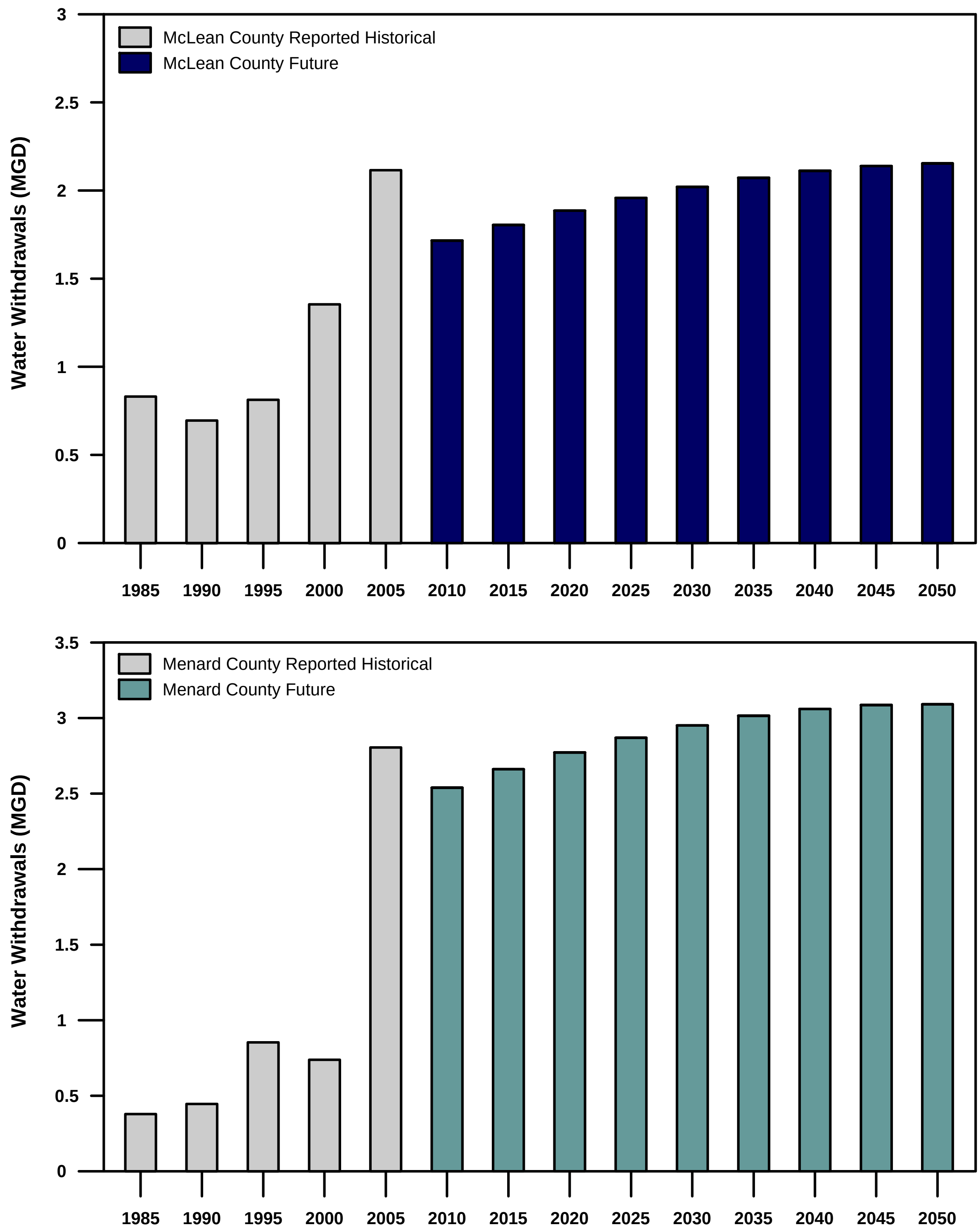

Figure 5.7: Irrigation and agriculture historical and future water withdrawals for McLean and Menard counties in East-Central Illinois.

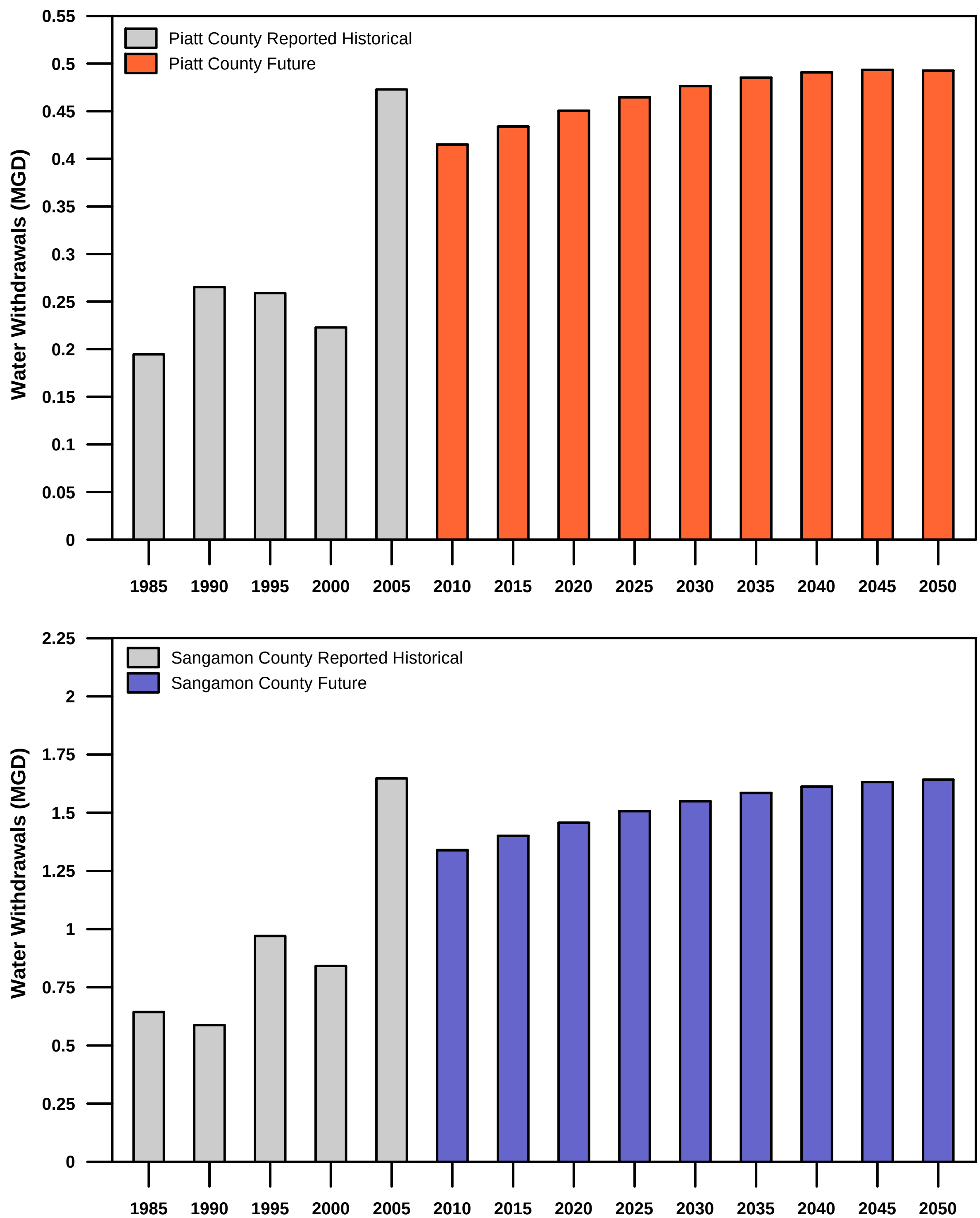

Figure 5.8: Irrigation and agriculture historical and future water withdrawals for Piatt and Sangamon counties in East-Central Illinois.

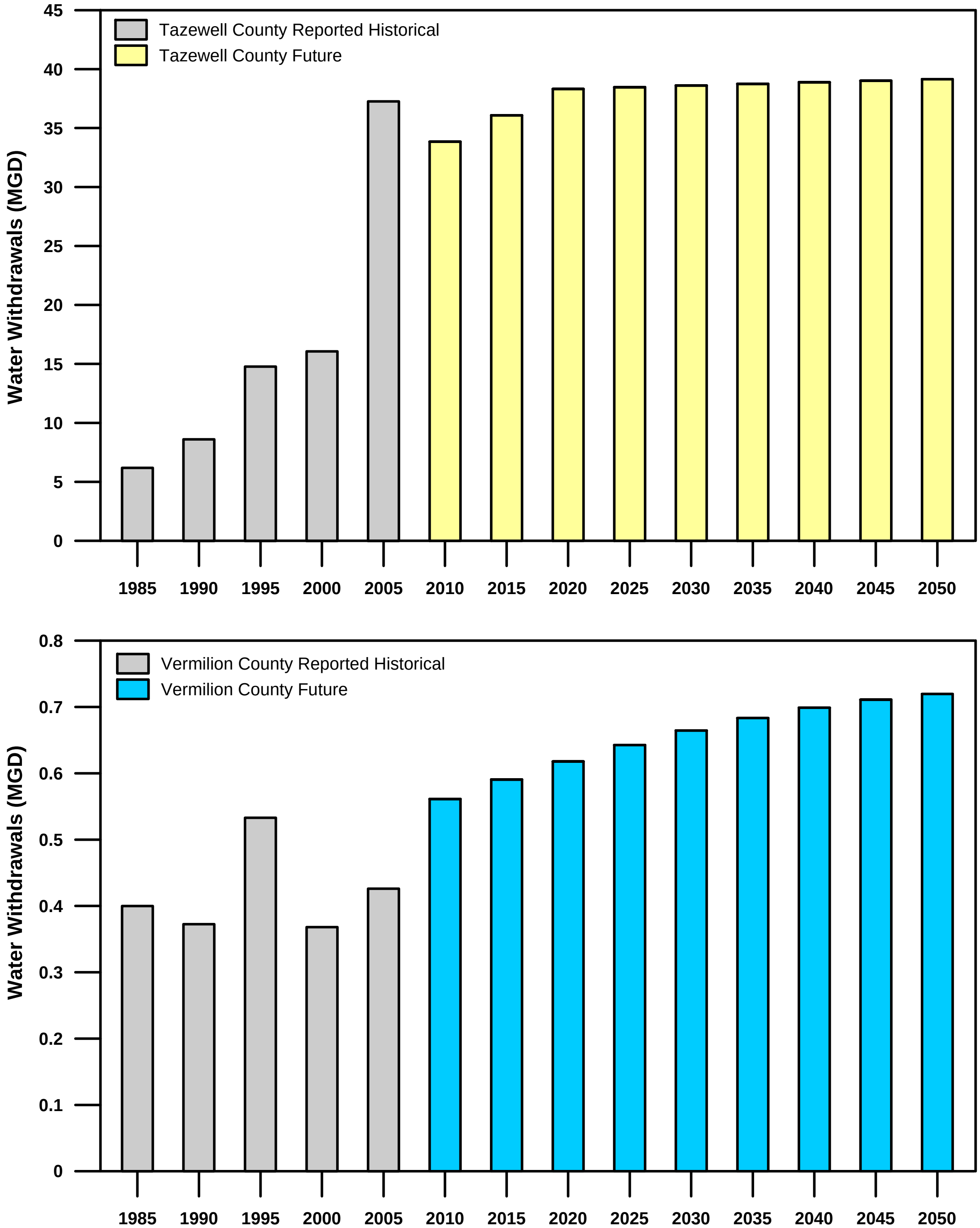

Figure 5.9: Irrigation and agriculture historical and future water withdrawals for Tazewell and Vermilion counties in East-Central Illinois.

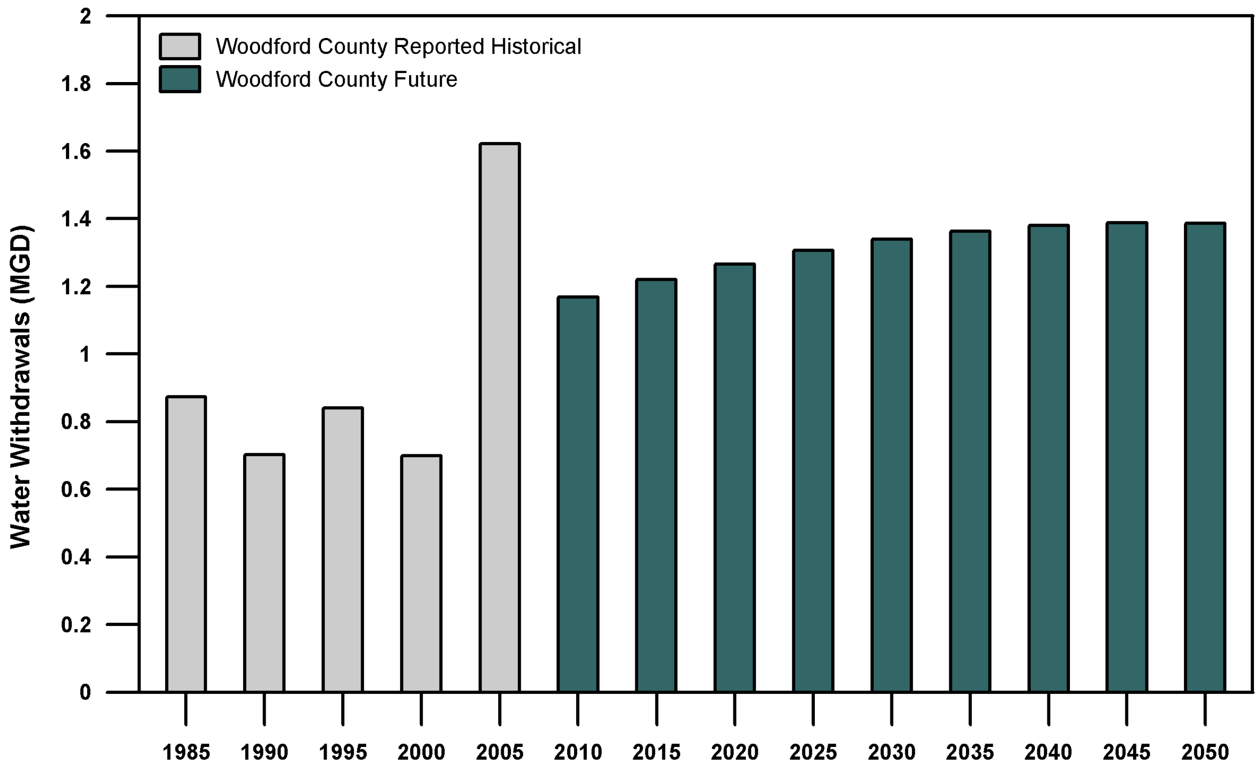

Figure 5.10: Irrigation and agriculture historical and future water withdrawals for Woodford County in East-Central Illinois.

Table 5.17: Source of water withdrawals for cropland irrigation.

County	Water Withdrawals	
	Groundwater (%)	Surface water (%)
Cass	95.6	4.4
Champaign	100	0.0
DeWitt	100	0.0
Ford	100	0.0
Iroquois	100	0.0
Logan	100	0.0
Macon	100	0.0
Mason	99.8	0.2
McLean	100	0.0
Menard	100	0.0
Piatt	100	0.0
Sangamon	94.6	5.4
Tazewell	100	0.0
Vermilion	0.0	100
Woodford	100	0.0
Total	99.5	0.5

Source: USGS provisional data (2005).

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