GROUNDWATER QUANTITY ISSUES

Prepared by the Groundwater Quantity
Committee of the Illinois State
Water Plan Task Force

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Listing of Groundwater Quantity

"White Paper" Issues

Legal Issues

*Abbreviations

DWR - Division of Water Resources
SWS - State Water Survey
IEPA - Illinois Environmental Protection Agency
DENR - Dept. of Energy and Natural Resources
SGS - State Geological Survey
DOA - Dept. of Agriculture
WRC - Water Resources Center

LAWS IN OTHER MIDWESTERN STATES

Summary

Groundwater quantity management laws are reviewed for the States of Iowa, Indiana, Minnesota, Wisconsin, and Illinois. All new groundwater users must report in all five states. Iowa and Minnesota have the most comprehensive system for the management and regulation of both groundwater and surface water uses. Well development guidelines have been set in Iowa, Indiana, and Illinois. These guidelines generally recommend the depth of wells and minimum pump settings. Iowa, Indiana, and Minnesota have a conflict resolution procedure for nonregulated impacted wells that applies statewide. Illinois' conflict resolution procedure applies to only four counties with potentially high groundwater useage. Illinois is the only State that does not require an annual reporting of water useage when laws were enacted.

STATE OVERVIEW - IOWA

Iowa requires permits for all surface and groundater uses greater than 25,000 gallons per day. Annual water useage must be reported by all regulated users. The State of Iowa has declared that its water resources are public resources of the State under the control of the State. The State's regulatory program applies statewide with special provisions for certain aquifers. Water use priorities are set by statute and water conservation as well as emergency restrictions can be set as needed by the State. Surface water impacts are also controlled statewide. A well interference resolution and compensation procedure is available to nonregulated users. Impacted wells must first be inspected by a registered well driller and informal negotiations and settlements must be attempted prior to State involvement. All new nonregulated wells, including flowing artesian, must meet well development guidelines in order to be eligible for compensation. Nonregulated wells in place prior to July 1, 1986 do not have to meet guidelines to receive compensation.

Statutory and Program Provisions - Iowa

1) Citation

IAC Sec. 567, Ch. 50-54

Acts 1985 (71 G.A.) Ch. 7, Sec. 11.

2) Lead Agency and Contact

Iowa Department of Natural Resources
Robert D. Drustrup 515/281-8690 (wrote rules)
Victor Okereke 515/281-8952

3) Registration

Report Form For Water Use By All Regulated Users

A Special Report Form For Irrigation Use

A Special Report Form For Aggregate Production or Mining Water Use

4) Permits

Required for all water uses greater than 25,000 gpd and granted for a maximum 10-year period.

State permit may require 1) test drilling, 2) yield testing, 3) controlled aquifer test with supervision, and 4) inventory of nearby wells.

Irrigation permits are required and
1) Irrigation season specified
2) Authorized annual amount per acre
3) Scheduling
4) System check valve

5) Threshold Levels

25,000 gpd including poultry, livestock, and domestic animals.

6) Exemptions

1) Drainage at construction sites
2) Test pumping only requires request/registration by letter or phone.
3) Dredging when water is directly returned.
4) Uses non-regulated prior to 7/1/85 exempt from certain protected flows until 7/1/91 if permit application received by 7/2/86.

7) Priorities or Preferences

- Conditions may be set to protect ordinary household, livestock, and domestic uses, also fish and wildlife, recreational use and other public uses.

- Municipal, municipal type and agricultural research have priority in the Dakota geologic formation.

Lowest to top priority water use:

1) Interstate transfer
2) Recreational and aesthetic
3) Row crops and grains
4) Other irrigation
5) Industrial
6) Public electrical power
7) Livestock
8) Human consumption

8) Geographical Extent

Apply statewide

Special rules for Jordan sandstone aquifer
a) 200 gpm limit on irrigation use
b) 2000 gpm limit on industrial use
c) 200 foot max. collective long-term decline

Special rules for Dakota formation of cretaceous system
a) must inventory nearby wells
b) must install monitoring wells
c) must protect sustained use (no excessive water level declines)

9) Prior Use (Grandfathered) Rights

Procedures to designate protected sources to preserve the water resource.

10) Well Standards

1) must have access port for water level measurements.
2) aquifer tests and observation wells may be required to keep permits.

Well guidelines for new wells after 7/1/86. Wells must allow for future well interference of 10 feet or 50% of the pumping drawdown of the well, which ever is greater. In no situation must the non-pumping water level be protected below the top of a confined aquifer or half the normal saturated thickness of an unconfined aquifer.

New flowing wells should be constructed to accomodate a pump when static water level is at top of confined aquifer or 100 feet below surface, whichever is higher.

11) Well Interference Resolution and/or Compensation

Applies to wells, quarries, and gravel pits.

1) Informal negotiations must first be attempted.
2) Only applies when a nonregulated well is impacted.
3) Written proof of good faith negotiations and reason for failure.
4) Proposed withdrawals reviewed by Department.
5) Complainant must pay for well inspection by well driller.
6) Emergency powers to restrict regulated users.
7) Settlement requires compensation by regulated well owners.

Test pumping costs borne by parties to the conflict, tests conducted by registered P.E. or hyrogeologists.

- Compensation does not have to bring a well up to guidelines but future liability remains.

12) Emergency Provisions

Permits can be suspended or restricted.

13) Public Resource Declaration

Water occurring in a basin (groundwater) or watercourse, or other body of water in the State, is public water and public wealth of the people of the State...control is vested in the State.

14) Water Conservation

(None)

15) Surface Water Impacts

Withdrawals from unconsolidated aquifers adjacent to streams draining less than 50 sq. mi. must not be greater than 200 gpm if closer than 1/4 mile.

Any withdrawal closer than 1/8 mile to stream is considered to be from stream and protected flow restrictions apply.

If drainage area greater than 50 sq. mi. then 1/8 mile (see above) applies and 1/4 mile to 1/8 mile withdrawals must cease when 7-day, 10-year stream flow is reached.

16) Funding Mechanism

Permit application fee set at $25.
Program funded through GRF.

17) Staffing Requirements

Total program for all water permits handled by 2 to 3 people. Really need 4 total. They also use staff in 6 regional offices.

18) Allowable (Reasonable) Use Definitions

(None)

19) Diversion Restrictions

See Priorities (Item No. 7)

20) Planning Requirements

Department has duty and authority to assess water needs of all users at five year intervals.

21) Interagency Coordination

(None)

22) Local and Regional Government Roles

(None)

STATE OVERVIEW - INDIANA

Indiana requires that all water uses with a capacity of greater than 100,000 gallons per day must register their use and report usage annually. A well interference resolution and compensation procedure is provided for by law. An onsite investigation of an impacted well must be conducted by the State in a timely fashion. All new wells with a capacity less than 100,000 gallons per day must meet State set well development guidelines in order to receive compensation from a large user. Existing small wells are not required to meet guidelines in order to receive compensation.

Statutory/Program Provisions - Indiana

1) Citation

Ind. Code 13-2-2.5 amended 7/1/88 for groundwater. Also Ind. Code 13-2-6.1 for water resource management.

2) Lead Agency and Contact

Department of Natural Resources, Division of Water
Mark Basch 317/232-0154 or 317/232-4160

3) Registration

All 100,000 gpd withdrawals are registered and report use annually.

4) Permits

(None)

5) Threshold Levels

100,000 gpd is a significant withdrawal.

6) Exemptions

(None)

7) Priorities or Preferences

(None)

8) Geographical Extent

Statewide

9) Prior Use (Grandfathered) Rights

(None)

10) Well Standards

Are set by rules. New wells must conform to receive compensation.
Well drillers must advise well owners of these rules.
- New wells minimum 4 inches in diameter.
- Unconsolidated and unconfined wells must penetrate at least 50% of saturated thickness. Pump set to allow 20 feet of drawdown.
- Confined and unconsolidated must penetrate 50% of aquifer thickness and pump set to allow for 30 feet of drawdown.
- Bedrock wells must penetate 10 feet into aquifer and allow for a minimum of 50 feet of drawdown.

11) Well Interference Resolution and/or Compensation

- Written complaint required for onsite investigation by State of an impacted non-significant user.
- If impact is found a groundwater emergency may be declared by director and restrictions placed on large users.
- Significant user shall provide reasonable and timely compensation to impacted small user.
- New wells must meet well development rules to receive compensation.

12) Emergency Provisions

If an impact to a small well is found a groundwater emergency may be declared by the DNR Director and restrictions placed on large users.

13) Public Resource Declaration

Reasonable-beneficial use

14) Water Conservation

(None)

15) Surface Water Impacts

(None)

16) Funding Mechanism

General Revenue Fund

17) Staffing Requirements

Have 2 staff in water rights office and would like to have 3-4. A separate registration office has 3-4 staff.

18) Allowable (Reasonable) Use Definitions

Policy states that use of the resource must be in accordance with the principle of reasonable beneficial use.

19) Diversion Restrictions

(None)

20) Planning Requirements

Commission shall conduct assessments, inventories and planning.

21) Interagency Coordination

(None)

22) Local and Regional Government Roles

(None)

STATE OVERVIEW - WISCONSIN

All water uses greater than 100,000 gallons per day must obtain a State permit and report water usage annually. A well interference and resolution procedure is available only when large withdrawals impact a public water supply utility. Well development guidelines are available only for health and safety, not quantity. The State of Wisconsin has declared in statute that "waters of the state are valuable public natural resources held in trust by the state."

Statutory/Program Provisions - Wisconsin

1) Citation

S.144.025(2)(e), Stats., and S. NR 112.26

2) Lead Agency and Contact

Wisconsin Department of Natural Resources
Bill Furbish - High capacity well program office 608/266-9264.

3) Registration

1) Static water level reporting by farmers may be required each month of irrigation season.
2) Monthly water use records required.

4) Permits

Required where rate of withdrawal is in excess of 100,000 gpd. No costs or fees for permits.

5) Threshold Levels

100,000 gallons per day.

6) Exemptions

(None)

7) Priorities or Preferences

(None)

8) Geographical Extent

Statewide

9) Prior Use (Grandfathered) Rights

(None)

10) Well Standards

None other than health and safety.

11) Well Interference Resolution and/or Compensation

Large withdrawals cannot adversely impact any public water supply utility.

12) Emergency Provisions

(None)

13) Public Resource Declaration

"Legislature finds that the waters of the state are valuable public natural resources held in trust by this state and state has duty as trustee to manage its waters effectively for the use and enjoyment of present and future residents and for the protection of the environment."

14) Water Conservation

The 1985 Act was set up to promote the conservation (i.e. preservation) of the waters of the state.

15) Surface Water Impacts

(None)

16) Funding Mechanism

General Revenue

17) Staffing Requirements

Program managed with 1-2 staff.

18) Allowable (Reasonable) Use Definitions

(None)

19) Diversion Restrictions

The 1985 Act requires registration of major withdrawals from the waters of the state and requires the approval of the DNR for major interbasin diversions and consumptive uses of water.

20) Planning Requirements

The 1985 Act requires development of a state water quantity resources plan.

21) Interagency Coordination

(None)

22) Local and Regional Government Roles

(None)

STATE OVERVIEW - MINNESOTA

Minnesota has required since 1937, that uses greater than 10,000 gallons per day or 1,000,000 gallons per year must obtain permits and report usage annually. An annual registration fee is required. The State of Minnesota has set water use priorities in statute. Water conservation and surface water impacts are considered. A well interference resolution and compensation procedure is available. Negotiations are strongly encouraged to reach settlements for well interference problems. New domestic wells do not receive protection under the compensation program.

Statutory/Program Provisions - Minnesota

1) Citation

Ms Sec. 105.44 subd 10 and 116D
Minn. rules 1987 parts 6115.0010 to 6115.0810
and 6115.1200 to 6155.1280

2) Lead Agency and Contact

Department of Natural Resources, Division of Waters.
Sarah Tufford 612/297-2431

3) Registration

Annual fee regardless of any use or not.
a) Irrigation $15 first 160 acres and $25 each additinoal 160 acres.
b) All other users $5 for each 10,000,000 gallons or portion thereof.
c) Max. fee set at $500 per permit.

Must record monthly and yearly useage. Flow meters required for use greater than 1500 gpm. Water level measurements and observation wells may be required.

4) Permits

Application fee is $30.
1) Must consider probable interference with neighboring wells.
2) Withdrawals limited to safe yield.
3) Conditional approval if hydrologic data is limited.
4) Irrigation requires special permits. Class A may require additional test data. Class B requires location of each domestic well with 1 1/2 mile and data on each domestic well.

Permits required since 1937.

5) Threshold Levels

Domestic use less than 10,000 gallons per day or 1,000,000 gallons per year.

6) Exemptions

1) No permits for domestic uses serving 25 persons or less.
2) No permits for test pumping or withdrawals not exceeding 10,000 gpd or 1,000,000 gals. per year.
3) Domestic use does not include commercial livestock using 10,000 gpd or 1,000,000 gals. per year.

7) Priorities or Preferences

Impacts to public water supply wells evaluated only for "portion which is used for domestic water supply."

"In no case shall a permittee be considered to have established a right of use or appropriation by obtaining a permit.

"Proportionate sharing applies to existing and proposed users of same priority class when resource is limited."

Priorities:
1) Domestic (excludes industrial and commercial use of public water supplies)
2) Any use less than 10,000 gpd.
3) Agricultural irrigation
4) Power production
5) All others.

8) Geographical Extent

Statewide but Class A application applies to aquifers with adequate G.W. data. Class B aquifers have inadequate data.

9) Prior Use (Grandfathered) Rights

None other than riparian uses prior to 1937.

10) Well Standards

(None)

11) Well Interference Resolution and/or Compensation

New Applications - If supply adequate and probable

interference on public water supply and domestic wells then:
a) applicant must get data on all impacted wells
b) aquifer tests may be required
c) commissioner may set restrictions or other compensation.

Existing Permits - Complaints filed by domestic well owner or public water supply.
a) Commissioner shall investigate and assess complaint and do a field investigation if necessary.
b) Commissioner may restrict or cancel permit if settlement not reached.

New Domestic Wells - Cannot receive compensation from pre-existing authorized permittees.

Negotiations are strongly encouraged to reach settlements.

12) Emergency Provisions

(None)

13) Public Resource Declaration

None for groundwater.

14) Water Conservation

May be required by commissioner if based on use data and analyses.
Also all new uses must have a contingency plan identified to deal with restrictions.

15) Surface Water Impacts

Wells not permitted if they adversely impact surface waters.

16) Funding Mechanism

GRF only

17) Staffing Requirements

Approximately 6 full time staff required.
(Now use 1-2 central office and 27 field office hydrologists)

18) Allowable (Reasonable) Use Definitions

(None)

19) Diversion Restrictions

Restricted if remaining water in state not adequate.

20) Planning Requirements

Water appropriation management plans may be required regionally.

21) Interagency Coordination

(None)

22) Local and Regional Government Roles

Copies of permit application must be sent to appropriate mayor, local soil and water conservation district or local water district.

Commissioner may delegate the permit process to a local, county or regional governmental unit. Permits must be less than 3,600,000 gals. per year.

STATE OVERVIEW - ILLINOIS

The State of Illinois requires that all new wells with a capacity greater than 100,000 gallons per day must register with the local Soil and Water Conservation District. The District, in cooperation with the State Surveys, must complete an impact analysis of the new well in consideration of other groundwater users.

All existing high capacity wells must also register in Kankakee, Iroquois, Tazewell and McLean Counties. A well interference resoluton and compensation procedure is available in these four counties. An impacted well must meet State's well development guielines in order for a complaint to be valid. Valid complaints can lead to the placement of water use restrictions on large users by the Illinois Department of Agriculture.

Statutory/Program Provisions - Illinois

1) Citation

Most recent amendments added by P.A. 85-905.

2) Lead Agency and Contact

Illinois Department of Agriculture
Terry Donohue 217/782-6297

3) Registration

All high capacity wells (100,000 gpd) in Kankakee, Iroquois, Tazewell and McLean Counties must register with the local soil and water
conservation districts.

4) Permits

All high capacity wells must file a notification to develop a well with the local soil and water district. The District with assistance from water survey and geological survey must review impact of proposed well on other G.W. users.

5) Threshold Levels

100,000 gpd.

6) Exemptions

(None)

7) Priorities or Preferences

None other than those set by "Rules of Reasonable Use."

8) Geographical Extent

Notification rules apply in all Illinois counties except Lake, McHenry, Cook, DuPage, Will and Kane Counties.

Restrictions and registration apply only to wells in Kankakee, Iroquois, Tazewell and McLean Counties.

9) Prior Use (Grandfathered) Rights

(None)

10) Well Standards

Recommended guidelines for the construction of wells and setting of pumps are defined in rules.

1) Artesian condition wells must penetrate 100% or 80 feet of aquifer and pumps set at 50% of penetration into aquifer.
2) Water table condition wells must penetrate 100% within 100 feet of surface or 50 feet, or 50% of aquifer for deeper systems.
3) Special guidelines for multiple aquifers.

11) Well Interference Resolution and/or Compensation

An impacted well owner may file a complaint. If investigation shows complaint is valid and impacted well meets guidelines the Department of Agriculture may restrict withdrawals on any wells affecting aquifer.

12) Emergency Provisions

(None)

13) Public Resource Declaration

See policy statement in Groundwater Quality Protection Act.

14) Water Conservation

(None)

15) Surface Water Impacts

(None)

16) Funding Mechanism

(None)

17) Staffing Requirements

Approximately four staff required to fully implement program. One staffer assigned to Districts and managed by IDOA and 2-3 staff in Surveys.

18) Allowable (Reasonable) Use Definitions

Yes

19) Diversion Restrictions

(None)

20) Planning Requirements

(None)

21) Interagency Coordination

Yes, between IDOA, ISWS, and ISGS.

22) Local and Regional Government Roles

Soil and Water Conservation Districts provide local point of contact.

GROUND-WATER USE AND EXPANSION

Summary

In general, there is enough ground water in Illinois to meet the demand. However, in some places and under certain conditions, the demand may exceed the supply. One factor that may need special attention in planning for equitable ground-water use and for wise aquifer management is agricultural irrigation, both present and potentially expanded. Irrigation has been the fastest growing category of ground-water use in Illinois in the last decade, going from 7 percent of total ground-water withdrawals in 1978 to 18 percent in 1984 and 15 percent in 1986. And in 1988, more water was used for irrigation than ever before, with statewide seasonal totals averaging between 12 and 25 inches of water applied, compared to the average 6-8 inches per year.

Irrigation can have a significant impact on ground-water resources during the growing season in areas where irrigation is widely practiced. While it is not clear that irrigation has caused any long-term ground-water depletion anywhere in Illinois, it is possible that localized problems of well interference will continue to occur, if not increase, in irrigated regions. This interference may be between irrigators, or it may be between one or more irrigators and nearby domestic well owners. These problems are most likely to occur during droughts, but they may gradually increase in occurrence during normal-weather years as irrigation spreads in popularity.

An ongoing ground-water balance study indicates that these problems are most likely to occur in parts of Kankakee, Iroquois, Mason, Tazewell, Lee, and Whiteside Counties; they are largely limited to the growing season months. Irrigation expansion is also most likely in those counties, as well as in parts of Clark, Crawford, Lawrence, Wabash, White, and Gallatin Counties. Expansion may also be *possible* in parts of Champaign, Ford, Macon, Piatt, and DeWitt Counties due to the presence of a substantial buried bedrock aquifer in that region; irrigation could be introduced in this area (in spite of the lack of sandy soils) largely to ensure adequate crop quality for seed corn and other specialty crop production.

Introduction

The availability and use of ground water in Illinois vary widely, both regionally and seasonally. Ground-water resources are abundant, but they are also finite and are not distributed uniformly. For the most part, ground-water resources are available to meet demand. However, in some places and under certain conditions, the demand may exceed the supply. As population, industry, and irrigated agriculture have grown in Illinois, ground water has been increasingly relied on as a ready source for water. But because our ground-water resources have limits, conflicts, competition, and shortages have occurred on occasion. These problems have emphasized the need for more comprehensive ground-water management and planning. One

aspect of that planning is the periodic formulation of a statewide ground-water balance. Ground-water balance studies may point out areas within the state where the demand for ground water exceeds (or could be reasonably expected to exceed) the average supply, or the amount normally held in storage. Such areas may need special attention (in the form of detailed hydrologic studies, etc.) so that the available ground water may be equitably distributed among all users without permanently depleting the aquifer.

The information in this paper summarizes an updated ground-water balance study for Illinois. The methods used were designed to identify ground-water problems (and potential problems) on a regional scale. The study does not attempt to identify more specific problems such as exact locations of well interference or supply interruption, which may be localized and temporary. The information on ground-water withdrawals for public water supplies and self-supplied industries was obtained from detailed data collected through the Illinois Water Inventory Program at the Illinois State Water Survey. Information on irrigation water use, however, was based entirely on estimates.

The Present Ground-Water Balance Picture

"Use/Yield" Analysis

To evaluate regional relationships between ground-water use and ground-water availability, a computerized data base of ground-water-withdrawal and potential-aquifer-yield data for each legal township in the state has been developed. Data for public water supply and self-supplied industrial ground-water use came from the Illinois Water Inventory Program. Irrigation water use data was estimated with a climatological soil water balance model, which was based on soil type, mean monthly temperature, calculated potential evapotranspiration rates, and monthly precipitation (*Bowman and Collins*, 1987).

Data on potential aquifer yield (ground-water supply) came from maps of the potential yield for sand and gravel and bedrock aquifers created as part of the 1967 Illinois Water Plan (*Technical Advisory Committee on Water Resources*, 1967), which equated the potential yield of an aquifer with its estimated recharge. Therefore, the average annual hydrologic balance between precipitation, evapotranspiration, runoff, and ground-water recharge is considered in the "potential yield" estimates.

Having information about both ground-water use and ground-water supply enabled us to compare the two quantities and look for areas where they do not balance, or where use exceeds supply. To do this, we computed a simple ratio of ground-water use to ground-water yield (supply); a ratio greater than 1.0 indicates a potential problem. The distribution of these use/yield ratios is shown in figure 1. Irrigation water use is <u>not</u> included in this map; the municipal and industrial water use data are based on the average for those uses over the last eight years. Clearly, the Chicago metropolitan area stands out as a major center of ground-water overpumpage from the deep sandstone aquifers.

Irrigation

Agricultural irrigation may be, because of its intense concentration in discrete regions and because of the large quantities of ground-water consumed, the single most influential factor in changing the complexion of the seasonal ground-water balance in regions where irrigation is widely practiced. Ground-water withdrawals over the last 10 years have increased more for irrigation than for any other use. Recent increased occurrence of ground-water conflicts in Illinois has called attention to the large amounts of ground water used for irrigation. More ground water was used for irrigation in 1988 than ever before, with statewide seasonal totals averaging between 12 and 25 inches of water applied, compared to the average 6-8 inches per year (*Bowman and Simmons*, in preparation). This has intensified interest in managing and even restricting ground-water withdrawals. At the same time, the amount of cropland under irrigation continues to increase in Illinois and neighboring midwestern states, bringing new importance to irrigation in many local agricultural economies.

Irrigation has been practiced mainly in places in Illinois with sandy soils that have low moisture-holding capacities. These places are mainly in Mason and Tazewell Counties along the Illinois River, in Lee and Whiteside Counties along the Green River, in Kankakee and Iroquois Counties on the wind-blown sand dunes, and in Clark, Crawford, Lawrence, Wabash, White, and Gallatin Counties along the Wabash River flood plain. Irrigation has also been used to a lesser extent on soils with heavier textures to offset the effects of drought. There are presently an estimated 200,000 irrigated acres in Illinois. Nearly all of that land is irrigated from wells pumping ground water, most of which comes from relatively shallow, unconsolidated sand and gravel aquifers. Presently, there are an estimated 1,400 irrigation wells in Illinois. New wells and some expansion in irrigated acreage is anticipated in the aftermath of the 1988 drought; growth may be as high as an estimated 25 percent. Figures 2 and 3 show the distribution of irrigation wells and the distribution of irrigated (sandy) soils.

Figure 4 shows the distribution of use/yield ratios with average (30-year mean) annual irrigation water use added to the eight-year average municipal and industrial withdrawals shown in figure 1. The irrigation water use, estimated to be about 310 million gallons per day, was based on a 92-day irrigation season from June to August. This is, therefore, the seasonal analysis of irrigation's effect on regional ground-water balances. By comparing figure 1 with figure 4, it is apparent that some increased potential for localized overpumpage problems may exist during the growing season in the most heavily irrigated parts of the state (Mason, Lee, Whiteside, Tazewell, Kankakee, and Iroquois Counties). Translated, this means there may be an increased chance for occasional well interference problems in these areas, which would *probably* be isolated and temporary in nature.

Figure 4b shows a more accurate evaluation of irrigation's impact on ground-water resources in the Mason County region. In this analysis, the impact was buffered by allowing ground water in the Havana Lowlands to migrate between townships in the general direction of flow in that aquifer. In other words, excess water in certain townships was used to reduce the

deficit in others. This better represents the actual hydrologic conditions in that region, and helps explain why Mason County, in figure 4, appeared to have a more serious overpumpage problem than is known to exist in that area.

The Kankakee-Iroquois region (where many ground-water use conflicts occurred in 1988) does not appear overly stressed in figure 4 because the ground-water supply is represented as a *total* of sand and gravel *and* bedrock aquifer yield, not just the yield from the bedrock aquifer which is the source for most irrigation pumpage in the Kankakee-Iroquois region.

The annual, or long-term, effects of average irrigation water use are shown in figure 5, in which irrigation water use was spread over the entire year to reflect the ability of hydrologic systems to compensate for heavy seasonal irrigation pumpage with recharge at other times of the year.

On the basis of these results, it appears that present irrigation water use in a normal-weather year may cause some temporary, localized water supply problems in the most heavily irrigated townships during the growing season months. However, the aquifers appear to have the long-term ability to withstand this amount of irrigation water use without being permanently depleted.

Reviewing Recent Ground-Water Use Trends

Tables 1 and 2 show ground-water withdrawals for public water supplies and self-supplied industries, respectively, by county for the years 1980 to 1987. In general, public water supply withdrawals have remained fairly constant in time; industrial withdrawals have shown slightly more fluctuation, probably resulting from economic variations outside the scope of this discussion. One trend that does appear in the public water supply data is the shift to Lake Michigan water in Cook County between 1985 and 1987. Figure 6 shows the same municipal and industrial totals by Crop Reporting District to show general regional trends, and figure 7 is a reference map of Crop Reporting District locations.

Some Projections for Change

Municipal Ground-Water Use

It is expected that as the "collar" counties (Kane, DuPage, Will, and Cook) continue to explore alternatives to deep aquifer pumpage, the long-standing overpumpage problem there may gradually begin to reverse. In addition, as new drinking water standards take effect, towns currently relying on treated surface water for human consumption may have to explore ground-water alternatives. Towns now using ground-water with quality problems (either from naturally occurring sources such as barium and radium, or from contamination and pollution introduced from an outside source) may have to discontinue that practice and turn to surface water supplies. These kinds of alterations have the potential for changing the ground-water balance only on a very localized scale.

In general, future public water supply demands are expected to reflect population trends. Population projections, which vary widely across the state, generally call for very slow increases.

Self-Supplied Industrial Ground-Water Use

Total self-supplied industrial ground-water use for the last eight years is shown in figure 8. The solid, straight line is a linear regression of water use versus time and the curved lines represent the statistical confidence (95 percent) in the trend. There is a slight upward trend due mainly to increased ground-water use in the petroleum and metal industries in Standard Metropolitan Statistical Area (SMSA) 9 (Madison, St. Clair, Clinton, and Monroe Counties), and in the food industry in SMSA 7 (Peoria, Woodford, and Tazewell Counties).

Average ground-water use for each of the industries is shown in a pie chart in figure 9. The chemical industry, found mainly in the Chicago area, is expected to sustain gradual growth according to projections by the Illinois Department of Energy and Natural Resources. However, it is not clear that ground-water use will see corresponding growth since water use does not appear to be highly correlated with output from that industry. The food industry, found mainly in SMSA 7, is also expected to sustain gradual growth through the year 2005. Unlike the chemical industry, water use is correlated with food industry production. Therefore, it is possible that additional ground-water demand by the food industry in SMSA 7 could compete for increased demand for agricultural irrigation in the same region. The petroleum and primary metal industries, found mainly in SMSA 9, are expected to drop off slightly and level out, respectively.

In general, based on the trend over the last eight years, total ground-water withdrawals for self-supplied industries in this state may increase slightly, on the order of 1 or 2 percent per year.

Ground-Water Use for Agricultural Irrigation

Agricultural irrigation is expected to continue to expand in Illinois, primarily on the sandy soils, but also with increasing intensity on heavier-textured soils as well (*Stout et al.*, 1983; *Sipp et al.*, 1984; *Walker et al.*, 1981). For the next couple of years, it is likely that expansion will occur at an accelerated rate in response to the recent drought, with increases over that time period totaling as much as 25 percent (based on informal estimates compiled from irrigators, well drillers, irrigation system salesmen, and county extension advisors). Figure 10 shows the delineation of soils in Illinois that are considered to be irrigable (*Bowman and Simmons*, in preparation). The analysis is based on average water availability in the upper meter, subsoil drainage, and subsoil permeability. The soils that are most irrigable are those having low water availability with well-drained and rapidly-permeable subsoils. Soils with low water availability but poorly-drained subsoils (such as in "claypan" conditions) may be suitable for sub-irrigation practices; such conditions are present in large portions of southern Illinois where fresh ground-water supplies are very limited.

According to this analysis, there are about 12.2 million acres of irrigable soils in Illinois, approximately 1.6 million of those being highly suited for irrigation (*Bowman and Simmons*, in preparation). This estimate is based on soil characteristics and does not account for ground-water availability. Figure 11 shows irrigable soils where there is also an adequate supply of ground-water to support high capacity irrigation wells. An adequate ground-water supply was defined as having at least 150,000 gallons per day per square mile, which is roughly equivalent to a well producing about 500 gallons per minute. In figure 11, there are about 7.2 million acres of soils that could be irrigated from ground water, of which 1.56 million are highly suitable. Of course, some of these areas have been urbanized and are no longer being used as cropland.

It is difficult to speculate with any degree of certainty about future irrigation expansion in Illinois. However, it is probably safe to assume that it will occur fastest on the sandy soils, where irrigation is already practiced and where its profitability has already been established. However, the introduction of specialty crops such as seed corn and vegetables may stimulate irrigation expansion throughout Illinois, as those crops require a reliable water supply throughout the growing season to maintain adequate crop quality. Such crops tend to be less tolerant of dry spells, so irrigation offers the insurance needed to balance the risk of growing them. Expansion of irrigation under these conditions will likely be slower than on the sandy soils of the state.

References

Bowman, J.A. and M.A. Collins. 1987. *Impacts of Irrigation and Drought on Illinois Ground-Water Resources*. Illinois State Water Survey Report of Investigation 109.

Bowman, J.A. and F.W. Simmons. *Irrigation Practices and Water Use in Illinois*. In preparation.

Technical Advisory Committee on Water Resources. 1967. *Water for Illinois: A Plan for Action*.

Table 1. Total Ground-Water Withdrawals (MGD)
for Public Water Supplies by County (1980-87)

County	1980	1981	1982	1983	1984	1985	1986	1987
Adams	0.91	0.91	1.89	1.23	1.49	1.45	1.11	1.42
Alexander	0.24	0.33	0.32	0.33	0.36	0.33	0.35	0.36
Bond	0.06	0.07	0.06	0.06	0.06	0.06	0.07	0.07
Boone	3.35	3.69	3.38	3.54	3.79	3.04	3.72	3.30
Brown	0.06	0.06	0.06	0.07	0.06	0.06	0.06	0.06
Bureau	3.85	3.54	3.44	2.88	3.39	3.67	3.43	3.68
Calhoun	0.61	0.45	0.54	0.54	0.58	0.59	0.34	0.47
Carroll	1.44	1.36	1.40	1.47	1.48	1.52	1.55	1.63
Cass	1.74	1.28	1.27	1.28	1.46	1.37	2.03	2.01
Champaign	18.15	16.22	18.24	19.14	19.58	19.93	20.23	20.68
Christian	1.73	1.12	1.29	0.53	1.11	1.30	1.41	2.63
Clark	1.40	1.30	1.26	1.15	1.24	1.26	1.32	1.33
Clinton	0.21	0.22	0.21	0.21	0.23	0.22	0.22	0.23
Coles	0.20	0.28	0.33	0.36	0.36	0.36	0.38	0.34
Cook	85.32	82.59	85.17	88.96	84.55	73.90	40.37	35.90
Crawford	2.02	1.82	1.53	1.71	2.38	2.05	1.86	1.79
Cumberland	0.23	0.22	0.25	0.26	0.27	0.26	0.26	0.27
DeKalb	7.64	7.40	7.16	7.13	7.23	7.08	3.45	8.29
DeWitt	1.85	1.59	1.55	1.55	1.52	1.42	1.43	1.65
Douglas	1.05	1.06	1.13	1.10	0.99	1.18	1.09	1.07
DuPage	68.36	68.49	72.36	75.61	78.88	80.62	79.98	83.85
Edgar	0.37	0.36	0.35	0.31	0.40	0.38	0.35	0.33
Edwards	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.02
Effingham	0.27	0.32	0.62	0.20	0.23	0.21	0.24	0.29
Fayette	0.15	0.15	0.05	0.11	0.10	0.17	0.14	0.17
Ford	1.36	1.35	1.45	1.42	1.50	1.36	1.41	1.42
Fulton	0.95	0.98	0.99	1.04	1.02	0.95	0.89	0.99
Gallatin	0.02	0.58	0.69	0.69	0.54	2.45	2.54	2.58
Greene	0.35	0.37	0.37	0.36	0.39	0.39	0.39	0.40
Grundy	2.12	2.24	2.18	2.25	2.22	2.32	2.31	2.44
Hamilton	0.02	0.03	0.03	0.14	0.01	0.02	0.02	0.02
Hancock	0.20	0.22	0.22	0.20	0.19	0.46	0.17	0.20
Hardin	0.15	0.14	0.10	0.13	0.08	0.09	0.15	0.14
Henderson	7.2	6.74	6.35	7.01	6.95	6.66	5.62	5.97
Henry	4.04	3.98	4.10	4.51	3.81	3.74	4.17	4.10
Iroquois	1.87	1.89	1.93	2.10	2.23	2.06	2.09	2.13
Jackson	0.17	0.93	0.08	0.08	0.10	0.10	0.09	0.11
Jasper	0.35	0.36	0.30	0.35	0.41	0.41	0.42	0.40
Jersey	0.89	0.99	0.84	0.87	1.03	0.85	0.90	0.77
JoDaviess	2.73	2.79	2.73	1.71	1.74	1.79	2.12	2.18
Johnson	0.01	0.01	0.01	0.01	0.03	0.03	0.03	0.06
Kane	32.77	32.21	32.14	29.43	29.42	28.66	27.04	28.15
Kankakee	1.61	1.55	1.74	1.88	1.99	2.07	2.30	2.11
Kendall	1.96	1.72	1.64	1.72	1.82	1.92	1.63	1.76
Knox	1.24	1.29	1.36	1.50	1.32	1.33	1.21	1.28
Lake	15.84	14.79	14.66	14.88	14.38	14.02	16.08	15.36
LaSalle	11.07	11.16	10.95	10.36	10.45	10.39	9.39	10.24
Lawrence	1.08	1.19	1.24	1.17	1.21	1.21	1.30	1.24
Lee	3.67	3.21	3.32	3.61	4.40	3.60	3.50	3.81

Table 1 (continued)

County	1980	1981	1982	1983	1984	1985	1986	1987
Livingston	1.64	1.61	1.58	1.66	1.62	1.66	1.62	1.73
Logan	4.36	3.95	3.33	3.13	3.34	3.46	3.39	3.77
McDonough	0.64	0.64	0.68	0.67	0.83	0.78	0.81	0.48
McHenry	10.86	10.35	10.86	11.23	11.75	12.21	12.28	13.27
McLean	4.63	4.74	4.65	4.93	5.07	4.99	5.01	5.43
Macon	0.95	0.98	1.04	1.27	1.19	1.21	1.15	1.24
Macoupin	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Madison	10.44	9.99	9.98	10.77	11.69	11.20	12.46	11.68
Marion	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03
Marshall	0.87	1.37	1.17	1.25	0.18	1.27	1.23	1.27
Mason	1.13	1.03	1.06	1.09	1.05	0.94	0.92	1.03
Massac	1.66	5.03	4.96	1.30	1.44	1.53	1.21	1.13
Menard	0.76	0.68	0.71	0.71	0.76	0.72	0.75	0.81
Mercer	1.01	1.01	0.90	0.93	0.90	0.92	0.91	0.91
Monroe	0.14	0.08	0.05	0.09	0.10	0.12	0.12	0.15
Montgomery	0.53	0.53	0.59	0.56	0.52	0.53	0.47	0.51
Morgan	0.01	0.08	0.09	0.08	0.08	0.07	0.07	0.07
Moultrie	0.33	0.33	0.35	0.37	0.39	0.36	0.99	0.38
Ogle	5.74	4.31	5.39	5.33	5.15	5.39	5.40	6.16
Peoria	18.27	17.45	16.65	14.30	15.76	16.55	15.51	17.02
Perry	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.06
Piatt	1.05	1.27	0.96	1.30	2.15	1.33	1.41	1.38
Pike	0.82	0.76	0.76	0.63	0.77	0.79	0.86	0.86
Pulaski	0.63	0.70	0.62	0.71	0.71	0.72	0.60	0.63
Putnam	0.41	0.40	0.46	0.47	0.39	0.37	0.40	0.50
Randolph	0.76	0.85	0.85	0.84	0.84	0.85	0.87	0.81
Richland	0.12	0.12	0.13	0.14	0.10	0.09	0.08	0.08
Rock Island	2.15	2.72	2.73	2.89	2.83	2.91	2.81	2.77
St. Clair	0.19	0.20	0.19	0.21	0.20	0.20	0.18	0.17
Saline	0.01	0.01	0.01	0.00	0.00	0.01	0.00	0.00
Sangamon	2.17	2.13	1.58	2.22	2.29	2.23	2.21	2.62
Schuyler	0.47	0.44	0.43	0.46	0.45	0.73	0.46	1.18
Scott	3.54	4.28	3.04	3.74	4.70	4.50	4.72	4.76
Shelby	1.26	1.38	1.45	1.31	1.02	1.03	0.96	1.13
Stark	0.54	0.46	0.39	0.44	0.43	0.43	0.42	0.65
Stephenson	6.25	5.77	5.63	5.68	5.72	2.88	6.12	5.97
Tazewell	14.03	13.52	12.88	13.55	13.32	13.09	13.10	14.53
Union	1.27	1.19	1.20	1.15	1.30	1.34	1.44	2.29
Vermilion	1.43	1.36	1.34	1.44	1.36	1.43	1.16	1.46
Wabash	0.77	0.79	0.87	0.65	0.76	0.78	0.71	1.08
Warren	3.19	3.03	2.68	2.62	2.62	2.86	2.21	2.22
Washington	0.09	0.09	0.09	0.11	0.11	0.11	0.11	0.12
Wayne	0.12	0.14	0.15	0.17	0.19	0.11	0.08	0.09
White	1.07	1.25	1.27	1.35	1.26	1.33	1.13	1.13
Whiteside	5.20	4.69	4.50	4.56	4.66	4.54	4.23	5.31
Will	30.90	29.96	30.00	30.53	30.55	30.51	30.76	31.79
Winnebago	38.23	36.74	32.30	34.69	33.78	35.16	34.10	35.57
Woodford	1.51	1.65	1.58	1.39	1.55	1.42	1.51	1.64
TOTAL	475.832	464.847	465.495	470.009	476.007	465.122	428.171	447.556

Table 2. Total Ground-Water Withdrawals (MGD)
for Self Supplied Industries by County (1980-87)

County	1980	1981	1982	1983	1984	1985	1986	1987
Adams	10.56	8.51	9.33	10.24	9.66	11.13	11.28	10.97
Alexander	0.01	0.03	0.02	0.01	0.01	0.01	0.03	0.02
Bond	0.03	0.01	0.01	0.11	0.04	0.04	0.01	0.01
Boone	0.62	0.66	0.55	0.34	1.38	1.38	0.15	0.15
Bureau	0.20	0.23	3.81	3.88	3.82	3.94	0.12	0.15
Calhoun	0.00	0.00	0.00	0.34	0.00	0.00	0.00	0.00
Carroll	0.20	2.00	2.31	1.88	1.60	6.99	2.32	2.32
Cass	1.16	1.03	0.96	0.93	0.83	0.77	0.82	0.82
Champaign	7.17	4.20	4.34	5.03	5.49	5.82	4.24	5.24
Christian	1.29	0.99	0.96	0.38	0.56	0.46	0.51	0.50
Clark	0.08	0.12	0.18	0.18	0.20	0.19	0.23	0.23
Clay	1.05	1.02	1.25	1.19	1.15	0.56	0.82	0.82
Clinton	0.46	0.82	0.66	0.54	0.56	0.49	0.39	0.60
Coles	0.21	0.23	0.18	0.20	0.25	0.12	0.12	0.12
Cook	13.78	11.73	16.47	17.02	16.10	15.57	12.43	13.30
Crawford	2.88	4.38	4.33	2.61	5.99	4.38	0.76	4.53
Cumberland	0.30	0.29	0.22	0.21	0.21	0.21	0.20	0.20
DeKalb	0.84	0.46	0.37	0.47	0.52	0.43	0.43	0.45
Douglas	0.11	0.12	0.01	0.01	0.03	0.11	0.06	0.06
DuPage	2.48	2.33	2.32	2.08	1.93	2.04	1.74	1.52
Edgar	0.06	0.06	0.06	0.06	0.05	0.04	0.01	0.04
Edwards	0.36	0.30	0.46	0.49	0.77	0.88	0.49	0.49
Effingham	0.36	0.38	0.36	0.16	0.27	0.28	0.23	0.25
Fayette	5.23	5.27	0.54	5.70	6.57	7.35	1.28	1.26
Ford	0.05	0.07	0.02	0.00	0.00	0.00	0.00	0.00
Franklin	0.39	0.39	0.37	0.57	0.53	0.50	0.25	0.25
Fulton	0.44	0.34	0.34	0.33	0.14	0.08	0.08	0.10
Gallatin	0.45	0.56	0.33	1.02	1.53	1.62	1.08	3.45
Greene	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00
Grundy	9.94	8.58	7.45	8.51	7.88	7.99	8.46	8.71
Hamilton	0.70	0.68	0.69	0.60	0.56	0.56	0.51	0.51
Hancock	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Hardin	1.07	1.08	1.64	1.16	1.13	1.11	1.09	1.17
Henry	0.03	0.02	0.03	0.04	0.03	0.03	0.02	0.03
Iroquois	0.12	0.12	0.13	0.09	0.10	0.10	0.09	0.06
Jackson	0.06	0.08	0.06	0.06	0.06	0.06	0.06	0.05
Jasper	0.55	0.52	0.72	0.60	0.60	0.59	1.10	0.59
Jefferson	0.35	0.43	0.45	0.49	0.49	0.46	0.86	0.46
Jersey	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00
JoDaviess	1.88	1.80	1.70	1.76	1.82	1.75	1.51	1.83
Kane	2.72	2.23	2.18	2.15	1.20	1.71	1.86	1.65
Kankakee	0.54	0.49	0.19	0.18	0.21	0.21	0.87	1.00
Kendall	0.76	0.71	0.75	0.74	0.82	0.82	0.68	0.01
Knox	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00
Lake	3.33	2.30	2.25	2.38	2.34	2.59	1.97	2.42
LaSalle	6.36	5.39	5.15	5.84	6.40	6.22	5.40	6.53
Lawrence	4.80	8.48	5.34	2.62	6.38	6.70	0.01	7.62
Lee	0.44	0.51	0.31	0.31	0.31	0.10	0.07	0.09
Livingston	0.09	0.09	0.05	0.06	0.06	0.06	0.05	0.05

Table 2 (continued)

County	1980	1981	1982	1983	1984	1985	1986	1987
Logan	0.00	0.06	0.06	0.06	0.06	0.06	0.01	0.01
McDonough	0.01	0.02	0.01	0.02	0.02	0.01	0.02	0.02
McHenry	2.45	2.39	4.02	2.87	2.70	2.31	2.29	2.13
McLean	0.54	0.49	0.58	0.71	0.90	0.65	0.23	0.06
Macon	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01
Macoupin	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Madison	33.47	28.40	67.62	33.22	39.83	32.67	35.85	34.10
Marion	10.74	9.98	10.71	9.03	10.82	11.09	0.66	0.65
Marshall	1.11	1.03	1.17	1.01	1.02	1.02	1.03	1.26
Mason	0.12	0.83	0.87	1.15	0.69	0.67	1.08	0.95
Massac	5.55	5.48	5.64	6.18	6.37	5.86	5.67	5.03
Monroe	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01
Montgomery	0.03	0.07	0.07	0.02	0.02	0.00	0.00	0.00
Morgan	4.57	4.31	5.11	4.96	5.49	5.04	5.68	5.77
Ogle	1.57	1.71	1.43	1.39	1.63	1.39	1.31	2.19
Peoria	8.94	7.98	7.39	9.77	14.81	15.55	7.28	10.34
Perry	0.01	0.01	0.01	0.01	0.03	0.04	1.28	1.29
Piatt	2.14	1.73	1.48	1.05	0.97	0.96	1.27	1.17
Pike	0.04	0.04	0.04	0.03	0.03	0.07	0.06	0.02
Putnam	0.16	0.16	0.13	0.20	0.19	0.19	0.19	0.21
Randolph	0.02	0.01	0.01	0.00	0.00	0.01	0.01	0.00
Richland	1.02	1.03	0.98	1.05	0.95	0.93	0.91	0.91
Rock Island	10.32	10.09	9.47	9.82	9.97	10.08	9.82	12.19
St. Clair	10.24	12.73	12.06	10.80	11.43	11.27	11.27	12.45
Saline	0.35	0.30	0.36	0.33	0.34	0.39	0.35	0.35
Sangamon	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
Shelby	0.03	0.32	0.51	0.35	0.35	0.34	0.29	0.32
Stephenson	2.31	2.16	1.89	2.21	2.11	1.46	2.03	2.07
Tazewell	7.75	6.82	5.57	5.64	5.88	5.55	5.44	8.32
Union	0.00	0.01	0.00	0.01	0.01	0.01	0.01	0.01
Vermilion	2.89	2.77	2.32	2.97	3.31	3.22	2.27	3.03
Wabash	1.66	1.62	1.74	1.57	1.53	1.46	0.38	1.52
Washington	0.41	0.38	0.43	0.37	0.40	0.38	0.36	0.36
Wayne	3.28	2.06	2.15	1.94	1.85	3.05	1.74	1.72
White	4.12	4.34	3.92	3.84	3.95	3.59	0.06	2.78
Whiteside	1.47	2.36	2.33	2.18	2.64	2.66	2.34	2.62
Will	9.74	10.67	10.63	8.20	7.58	6.94	7.60	7.07
Williamson	0.06	0.03	0.04	0.03	0.04	0.03	0.03	0.03
Winnebago	6.37	6.67	6.52	6.31	4.75	6.43	4.73	7.39
Woodford	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
TOTAL	218.020	209.033	247.111	212.867	234.089	231.931	177.85	209.113

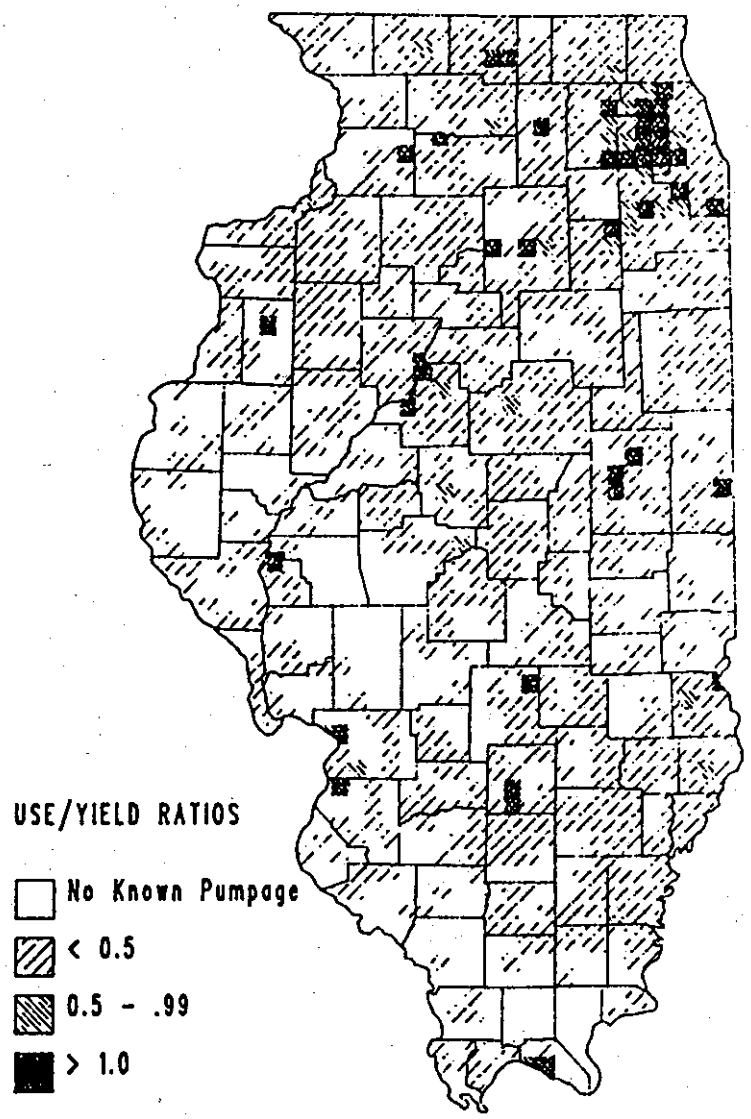


Figure 1. Use/Yield ratios for municipal and industrial pumpage (1989-1987 average) from all aquifers combined.

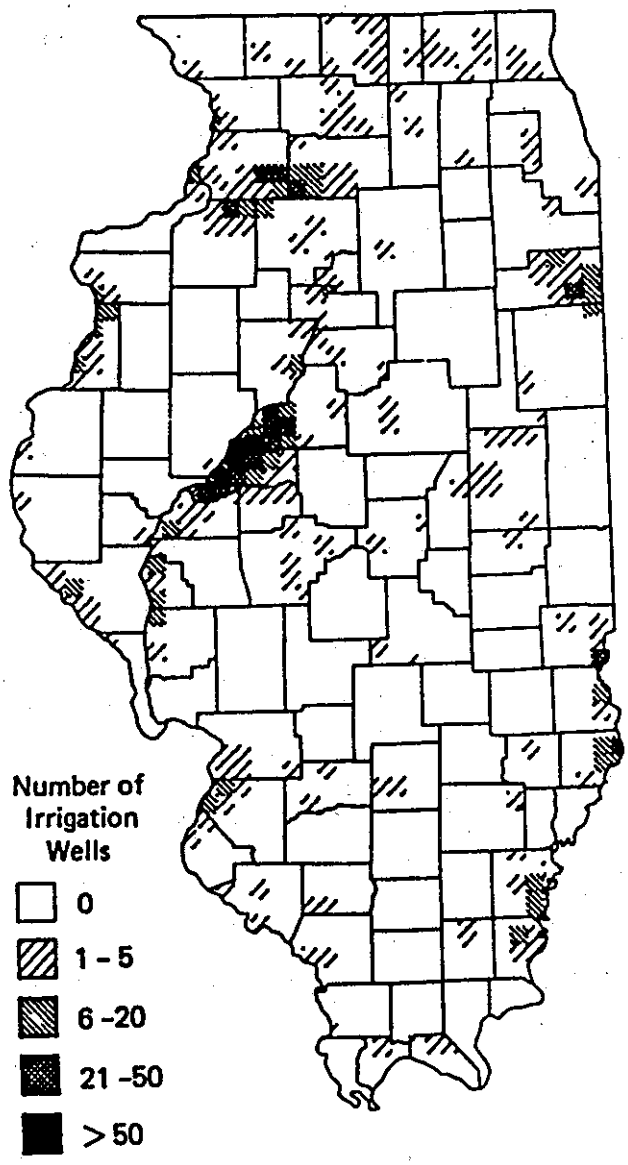


Figure 2. Distribution of wells believed to be irrigation wells.

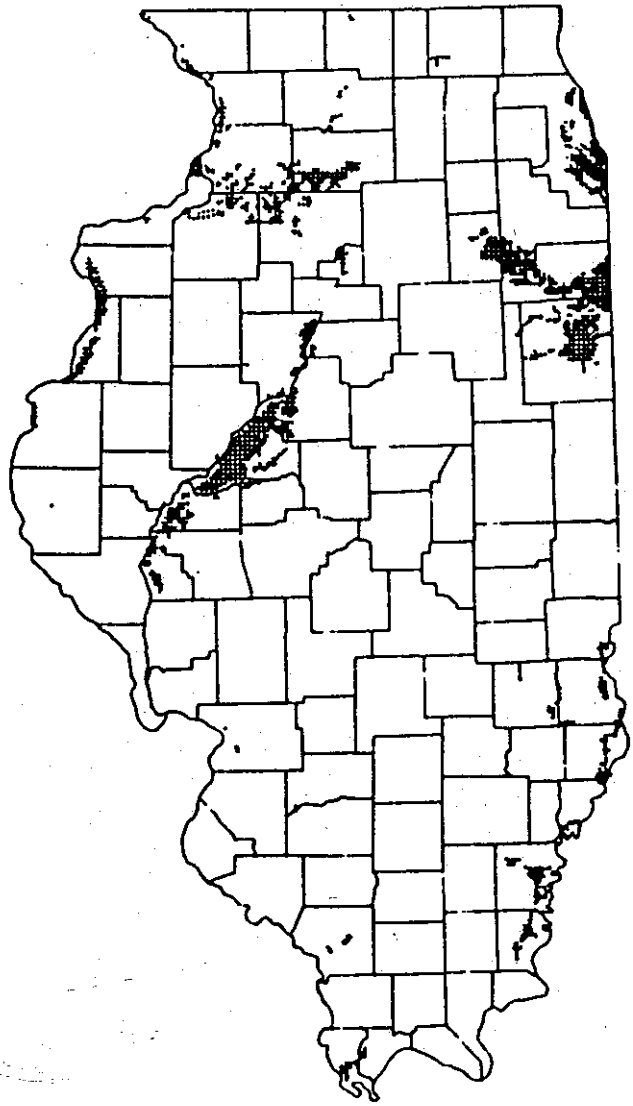


Figure 3. Distribution of sandy soils, the most commonly irrigated soils in the state.

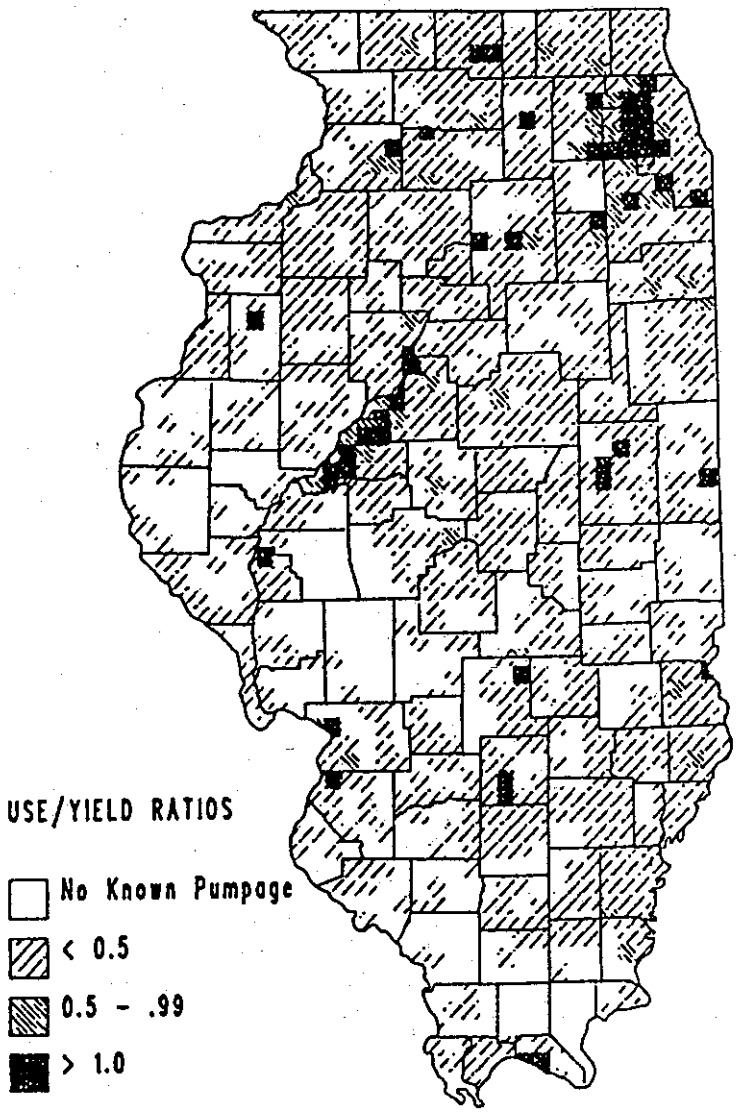


Figure 4. Use/yield ratios including 30-year mean estimated irrigation pumpage.

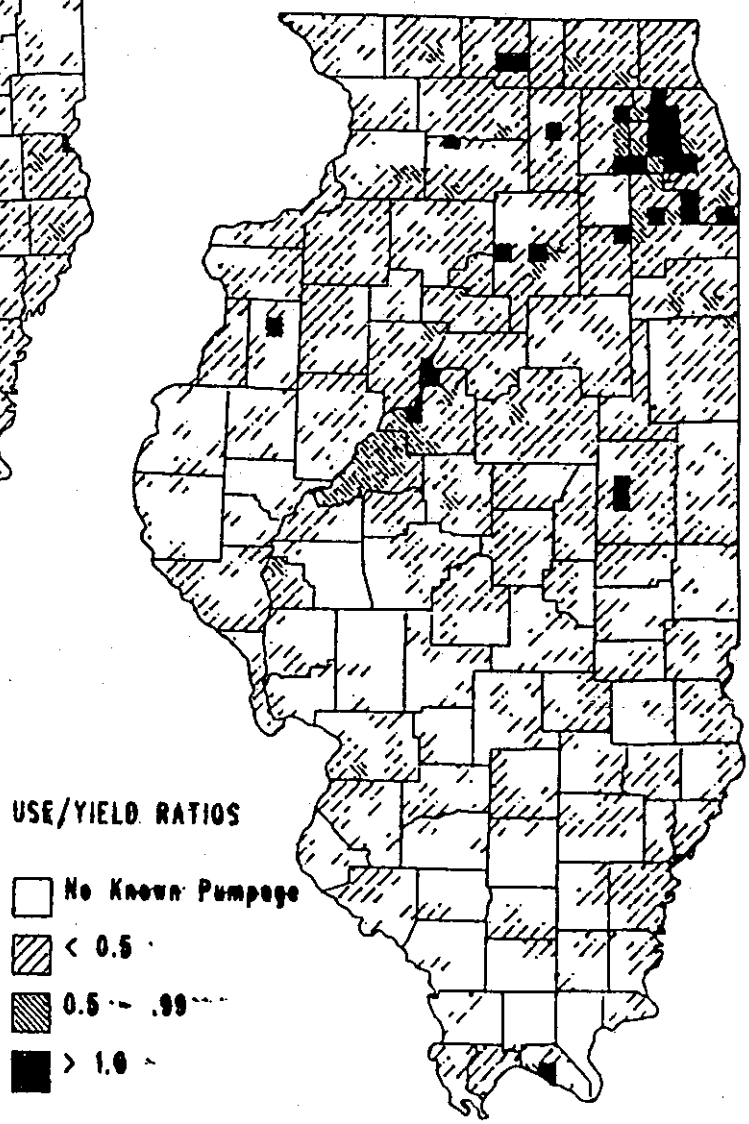


Figure 4b. Use/yield ratios with 30-year mean irrigation estimates; impact buffered in Mason County.

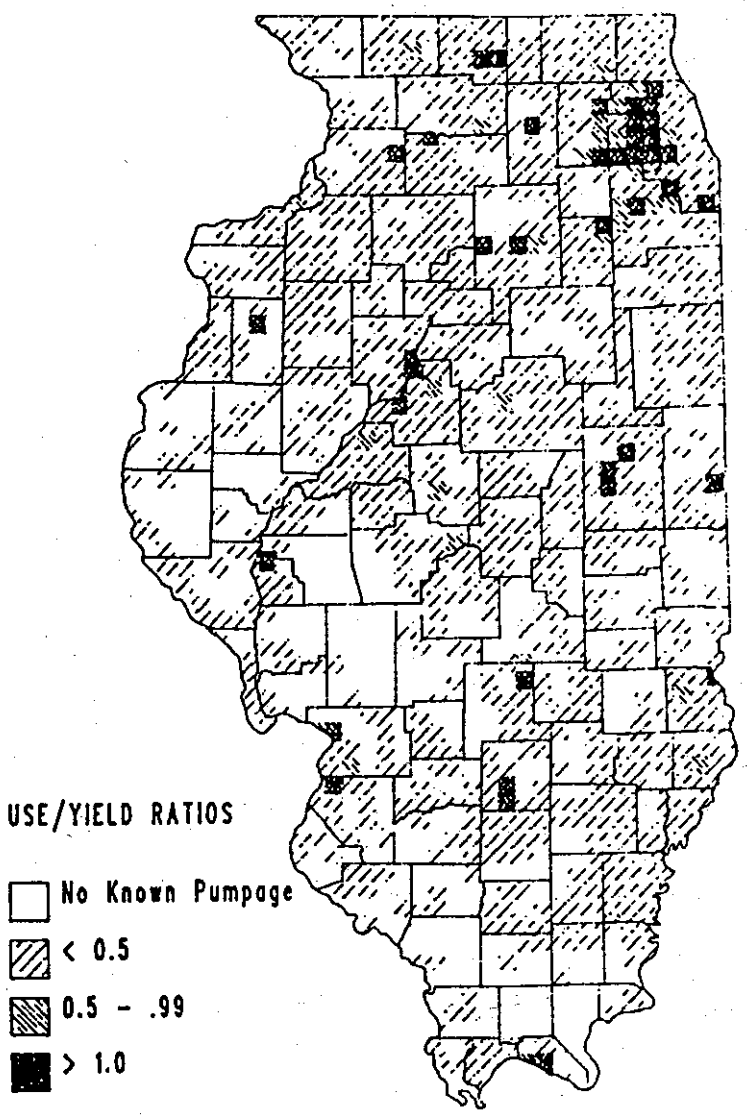


Figure 5. Use/yield ratios including 30-year mean estimated irrigation pumpage; annual impact analysis.

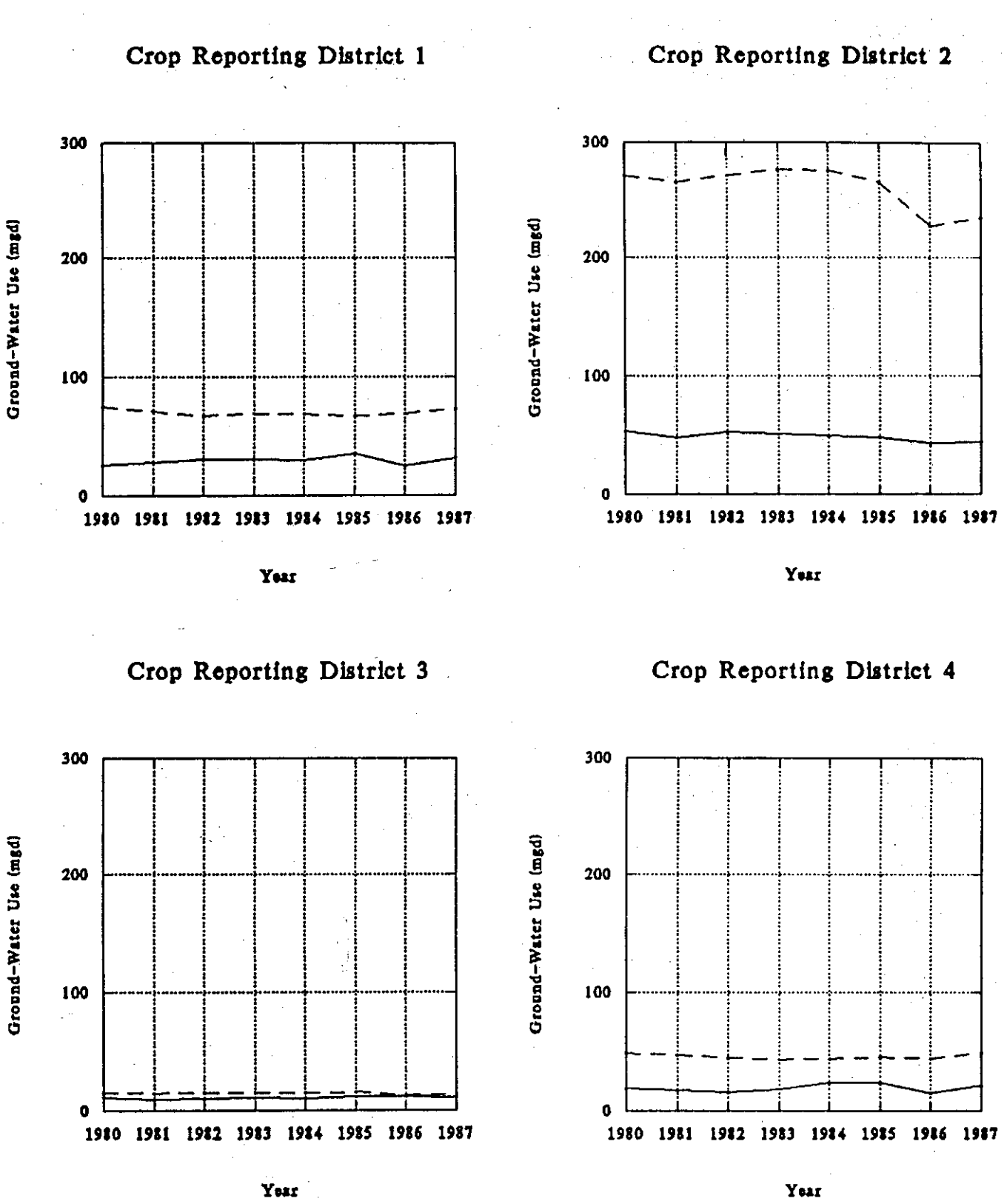
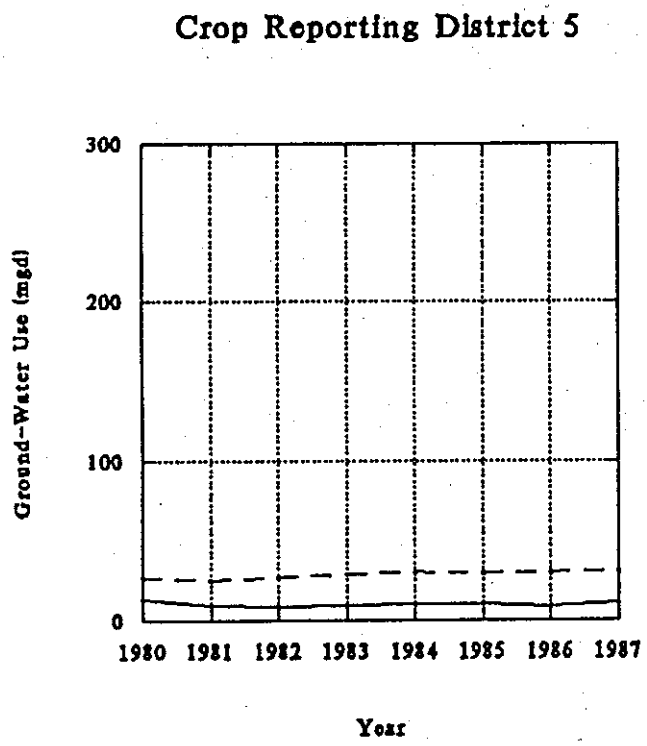
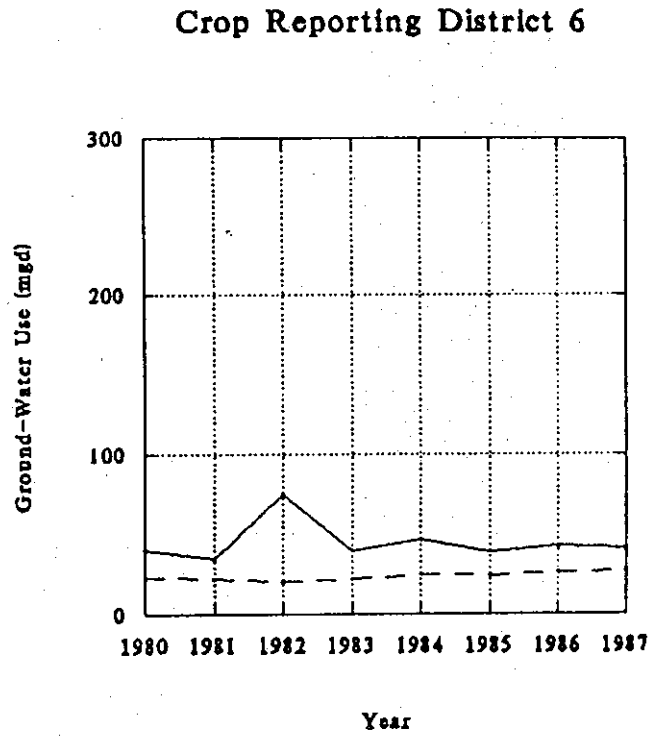
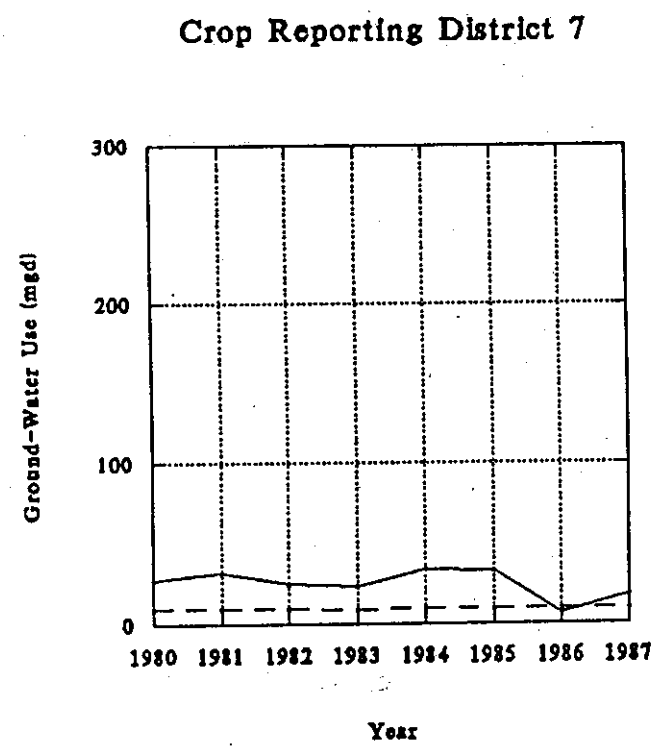


Figure 6. Self-supplied industrial and public water supply ground-water withdrawals by Crop Reporting District from 1980-1987







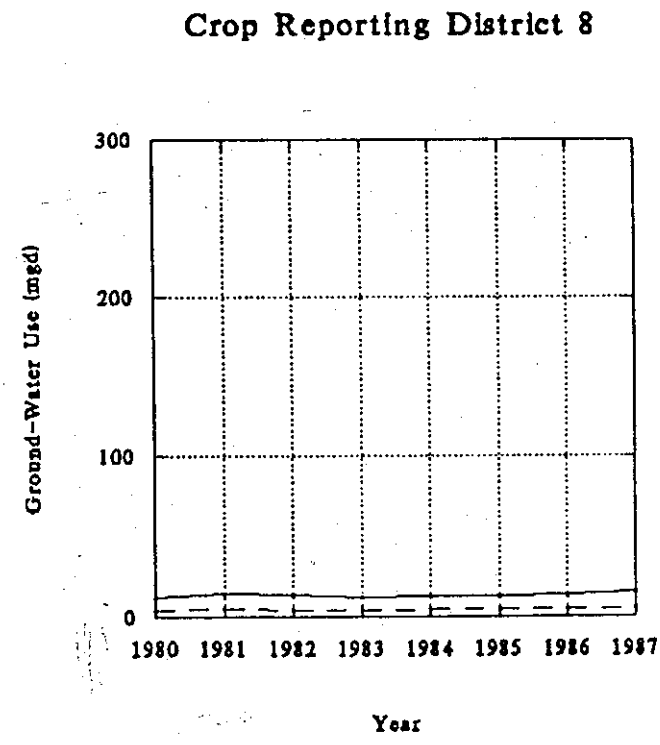


Figure 6. (continued)

Crop Reporting District 9

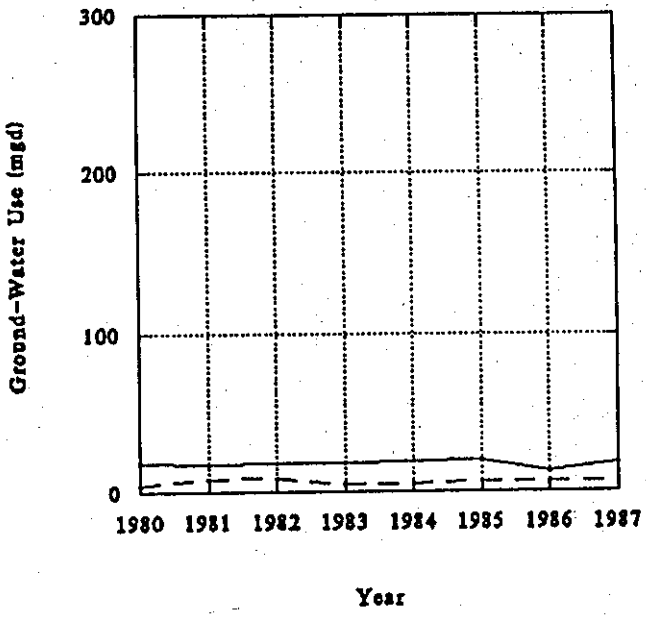


Figure 6. (continued)

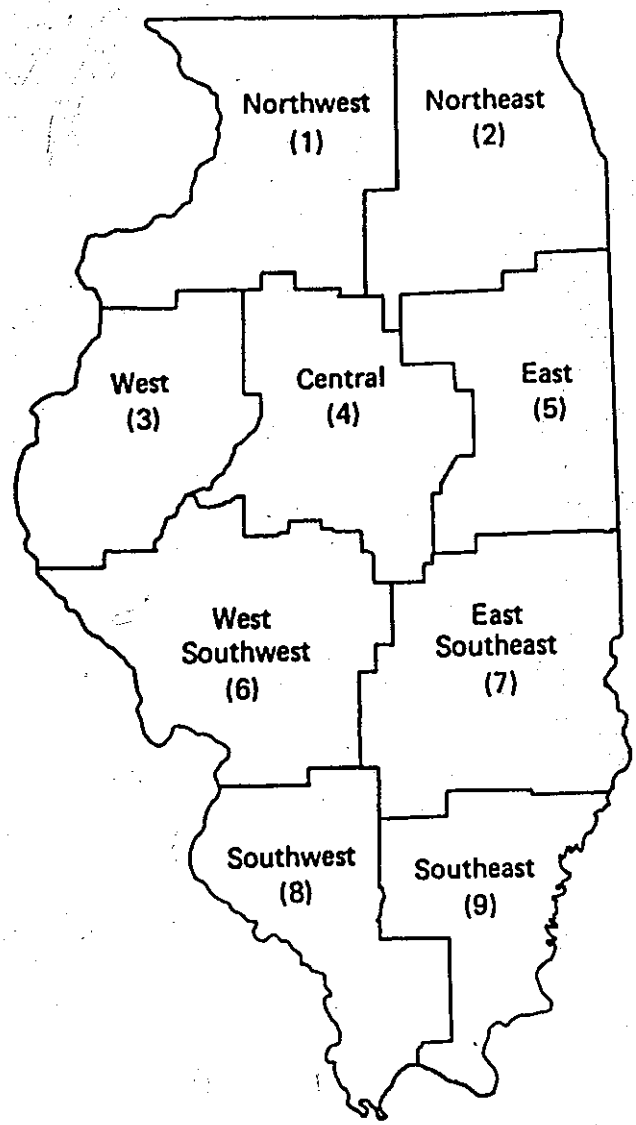


Figure 7. Crop Reporting Districts

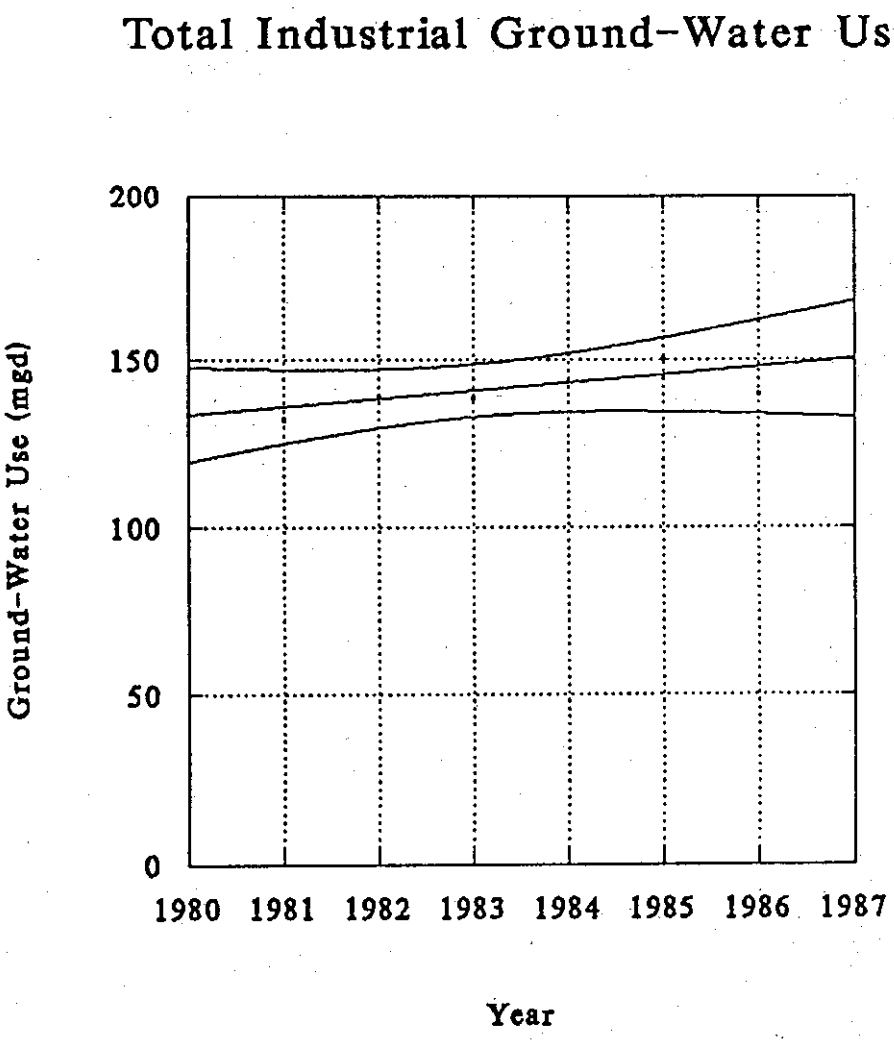


Figure 8. Statewide total self-supplied industrial ground-water withdrawals from 1980 - 1987.

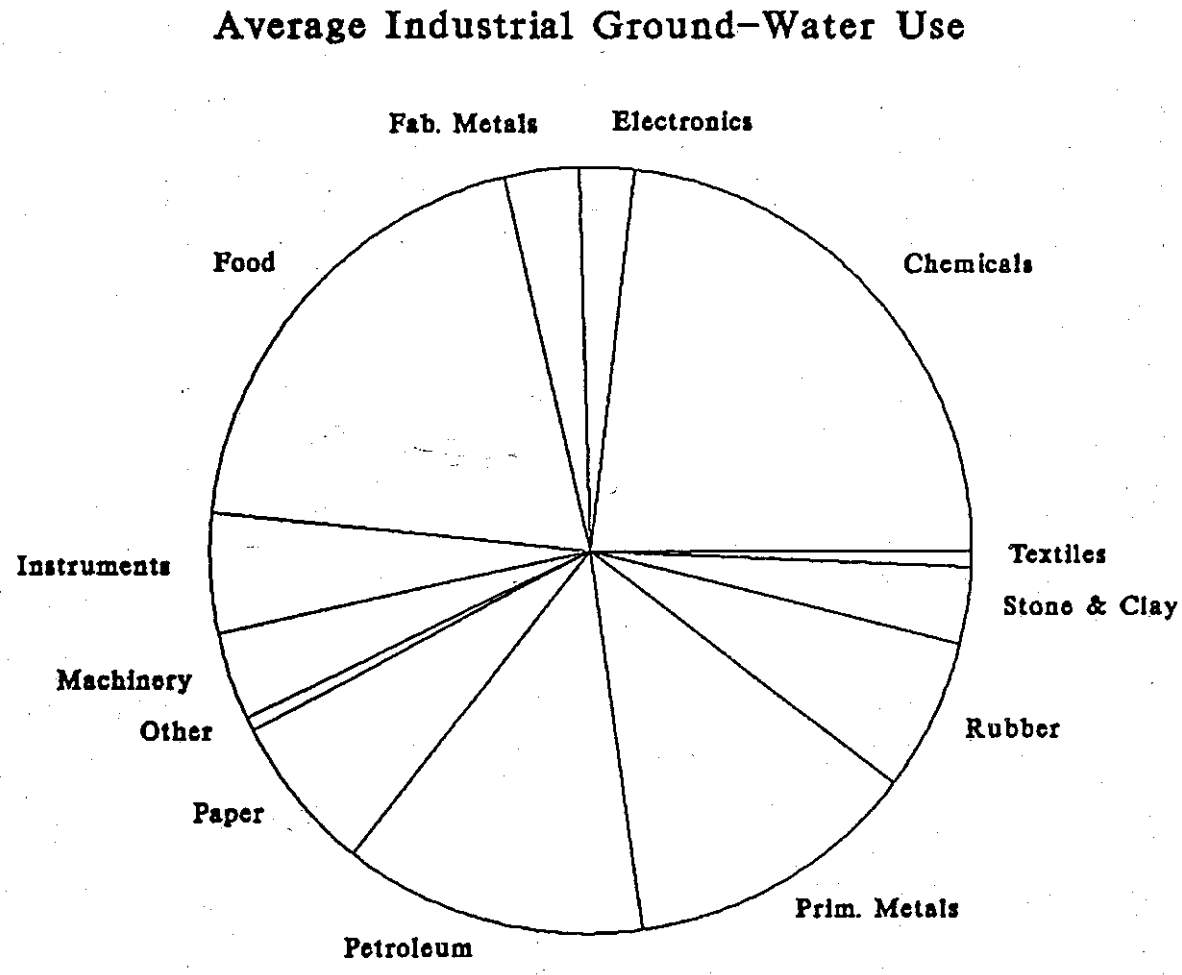


Figure 9. Proportions of total self-supplied industrial ground-water use by industry.

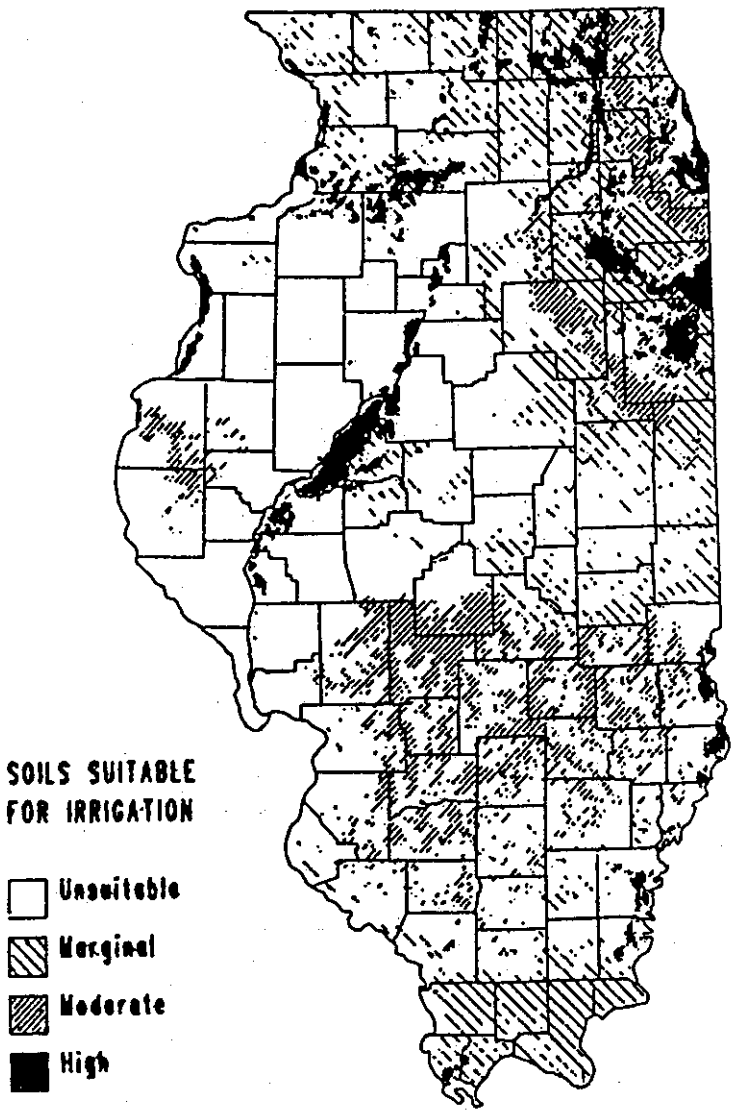


Figure 10. Soils suitable for irrigation based on soil characteristics.

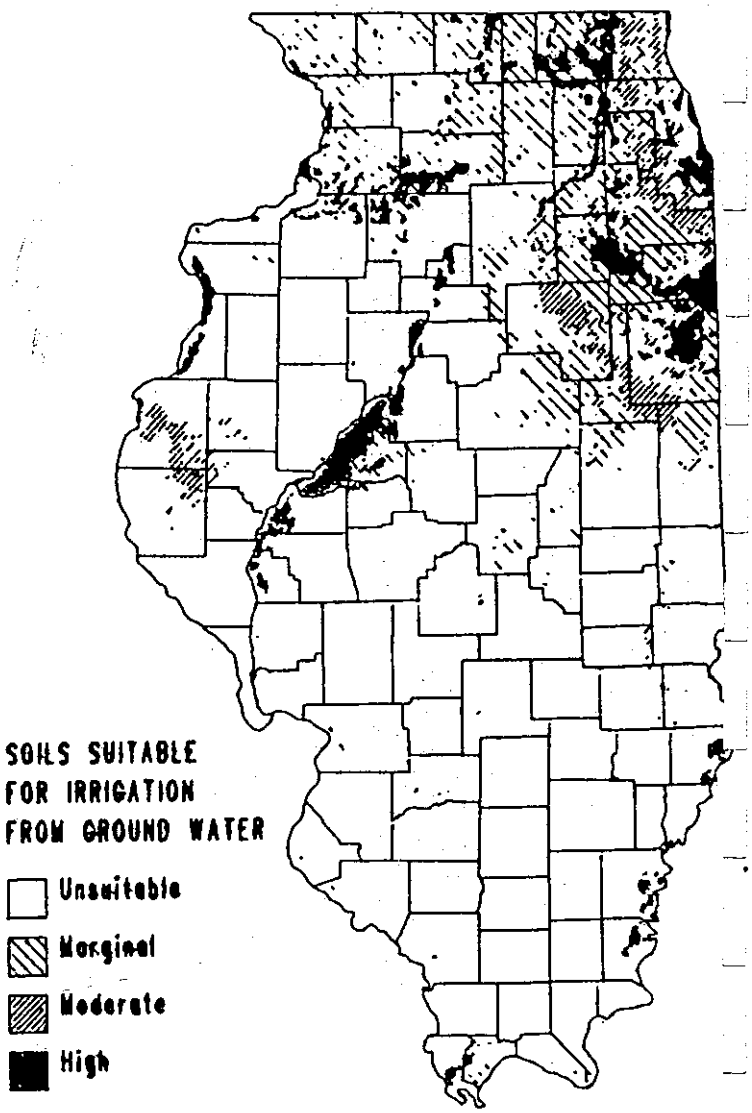


Figure 11. Soils suitable for irrigation based on soil characteristics and adequate available ground-water supply.