ILLINOIS INTEGRATED WATER QUALITY REPORT AND SECTION 303(d) LIST - 2010

Clean Water Act Sections 303(d), 305(b) and 314

Water Resource Assessment Information and Listing of Impaired Waters

Volume II: Groundwater

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Illinois Environmental Protection Agency
Bureau of Water

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EXECUTIVE SUMMARY

This 2010 Integrated Report continues the reporting format first adopted in the 2006 reporting cycle. However, for the 2010 cycle the Integrated Report is being divided into two volumes: Volume I covering surface water and Volume II covering groundwater. Prior to 2006, assessment information was reported separately in the Illinois Water Quality [Section 305(b)] Report and Illinois Section 303(d) List. The Integrated Report format is based on federal guidance for meeting the requirements of Sections 305(b), 303(d) and 314 of the Clean Water Act (CWA).

The basic purpose of this report (Volume II) is to provide information to the federal government and the citizens of Illinois on the condition of groundwater in the state. This information is provided in detail in Section C and in Appendix A.

Groundwater quality and quantity are linked. Analyses of groundwater data collected from 1990 to the present continue to show an overall statistically significant increasing trend of community water supply (CWS) wells[1] with volatile organic compound detections per year. In addition concentrations of chlorides in the CWS probabilistic network wells utilizing sand and gravel and shallow bedrock (i.e., Silurian Dolomite) aquifers in Northeastern Illinois (N.E. IL) show a 35 percent increase in concentration compared to the state wide ambient value. These trends represent an overall increasing trend of groundwater degradation. At the same time, future groundwater shortages are predicted in N.E. IL (Meyer, Roadcap, et. al., 2009 CMAP, 2010)

A pilot project to assess the Mahomet Aquifer as part of a national effort to design a National Ground-Water Monitoring Network (NGWMN) has been initiated by a team of state and federal agencies in Illinois and Indiana. Thus, this report includes a special focus on the quality of groundwater from CWS probabilistic network wells in the Mahomet-Teays bedrock valley. For further background on this project see the Advisory Committee on Water Information (ACWI) Subcommittee on Ground Water (SOGW) web page at: http://acwi.gov/sogw/index.html

[1] "Community water supply" means a public water supply which serves or is intended to serve at least 15 service connections used by residents or regularly serves at least 25 residents.

The results show that of the 354 CWS probabilistic network wells:

- **28 (8 percent (%)** were determined to be Not Supporting ("poor") due to the elevated levels of nitrate and VOCs that include trichloroethylene and tetrachloroethylene. All of these wells draw their water from shallow sand & gravel aquifers, except for one, which is using a deep well from the Cambrian/Ordovician bedrock aquifer in the northern part of the state);
- **90 (25%)** were determined to be Not Supporting ("fair") due to statistically significant increases chloride (Cl-) above background, detections of VOCs, nitrate (total nitrogen) greater than 3 mg/l, but have not exceeded the health-based Groundwater Quality Standards (GWQS); and
- **236 (67 %)** were determined to be Fully Supporting ("good"), which show no detections of any of the above analytes.

Additionally, trend analyses for VOC's also shows that there is a statistically significant increase in the number of CWS wells with VOC detections, despite the fact that the number of CWS analyzed for VOC's over the same time period declined, and the detection limit remained constant.

Illinois groundwater resources are being degraded. Degradation occurs based on the potential or actual diminishment of the beneficial use of the resource. When contaminant levels are detected (caused or allowed) or predicted (threat) to be above concentrations that cannot be removed via ordinary treatment techniques, applied by the owner of a private drinking water system well, potential or actual diminishment occurs. At a minimum, private well treatment techniques consist of chlorination of the raw source water prior to drinking.

PART A: INTRODUCTION

A-1. Reporting Requirements

The 2010 Integrated Report is based on guidance from United States Environmental Protection Agency (USEPA) which is intended to satisfy the requirements of sections 305(b), 303(d) and 314 of the Federal Water Pollution Control Act Amendments of 1972 (PL 92-500) and subsequent amendments (hereafter, collectively called the "Clean Water Act" or "CWA") in a single combined report. For this reporting cycle the Integrated Report is being divided into two volumes: Volume I covering surface water and Volume II covering groundwater.

Accordingly, Section 102 of the CWA requires:

SEC. 102 [33 U.S.C. 1252] Comprehensive Programs for Water Pollution Control:

(a) The Administrator shall, after careful investigation, and in cooperation with other Federal agencies, State water pollution control agencies, interstate agencies, and the municipalities and industries involved, prepare or develop comprehensive programs for preventing, reducing, or eliminating the pollution of the navigable waters **and ground waters** and improving the sanitary condition of surface and **underground waters**. In the development of such comprehensive programs due regard shall be given to the improvements which are necessary to conserve such waters for the protection and propagation of fish and aquatic life and wildlife, recreational purposes, and the **withdrawal of such waters for public water supply**, agricultural, industrial, and other purposes. For the purpose of this section, the Administrator is authorized to make joint investigations with any such agencies of the condition of any waters in any State or States, and of the discharges of any sewage, industrial wastes, or substance which may adversely affect such waters. (Emphasis added)

Further, Section 104(a)(5) of the CWA [33 U.S.C. 1254]) requires:

5) in cooperation with the States, and their political subdivisions, and other Federal agencies establish, equip, and maintain a water quality surveillance system for the purpose of monitoring the quality of the navigable waters **and ground waters** and the contiguous zone and the oceans and the Administrator shall, to the extent practicable, conduct such surveillance by utilizing the resources of the National Aeronautics and Space Administration, the National Oceanic and Atmospheric Administration, the United States Geological Survey, and the Coast Guard, **and shall report on such quality in the report required under subsection (a) of section 516; and [104(a)(5) amended by PL 102-285] (Emphasis added)**

Section 516 of the CWA requires U.S. EPA to provide a report to Congress on the quality of water, including groundwater. States are required to report biennially on the quality of water with an emphasis on navigable waters pursuant to Section 305(b) of the CWA, and compared to the objectives established in Section 304(a)(1) of the CWA. Section 304(a)(1)(A) of the CWA requires that water quality criteria developed must also consider pollutants that originate from groundwater:

> "The Administrator, after consultation with appropriate Federal and State agencies and other interested persons, shall develop and publish, within one year after the date of enactment of this title (and from time to time thereafter revise) criteria for water quality accurately reflecting the latest scientific knowledge (A) on the kind and extent of all identifiable effects on health and welfare including, but not limited to, plankton, fish, shellfish, wildlife, plant life, shore lines, beaches, esthetics, and recreation which may be expected from the presence of pollutants in any body of water, **including ground water**…"

Thus, for these reasons, and the hydrologic connection between groundwater and surface water, that the Illinois EPA has established an integrated monitoring strategy, and includes a volume in our Section 305(b) Report on ambient groundwater monitoring results.

Illinois reports the resource quality of its waters in terms of the degree to which the beneficial uses[2] of those waters are attained and the reasons (causes and sources) beneficial uses may not be attained. In addition, states are required to provide an assessment of the water quality of all publicly owned lakes, including the status and trends of such water quality as specified in Section 314(a)(1) of the CWA.

Section 303(d) of the CWA and corresponding regulations in Title 40 of the Code of Federal Regulations, require states to

- Identify water quality-limited waters where effluent limitations and other pollution control requirements are not sufficient to implement any water quality standard,
- Identify pollutants causing or expected to cause water quality standards violations in those waters,
- Establish a priority ranking for the development of Total Maximum Daily Load[3] (TMDL) calculations including waters targeted for TMDL development within the next two years, and,
- Establish TMDLs for all pollutants preventing or expected to prevent the attainment of water quality standards.

This list of water quality limited waters is often called the 303(d) List.

To the extent possible, this 2010 Illinois Integrated Report is based on USEPA's *Guidance for 2006 Assessment, Listing and Reporting Requirements Pursuant to Sections 303(d), 305(b) and*

[2] Beneficial uses, also called designated uses, are discussed in more detail in Section B-2 Groundwater Protection Programs, Illinois Groundwater Quality Standards.
[3] Total Maximum Daily Load calculations determine the amount of a pollutant a water body can assimilate without exceeding the state's water quality standards or impairing the water body's designated uses.

314 of the Clean Water Act issued July 29, 2005 and additional guidance contained in USEPA memorandums from the Office of Wetlands, Oceans and Watersheds regarding Clean Water Act Sections 303(d), 305(b), and 314 Integrated Reporting and Listing Decisions.

A-2. Major Changes from the 2008 Report Methodology and Format

As stated above, the 2010 Integrated Report was divided into two volumes: Volume I covering surface water and Volume II covering groundwater. This was done to accommodate the increased size of the integrated report, which has been greatly expanded to include more water quality information. This two volume format also improves the organizational structure of the report and makes it easier for the reader to find the specific information that may be of concern.

In all other aspects Illinois EPA is using the same methodology and format in 2010 as in 2008 with no significant changes.

PART B: BACKGROUND INFORMATION

B-1. Total Waters

There are approximately 5,534 groundwater dependent public water supplies in the state, of which 1,022 are community water supplies. The Illinois Department of Public Health estimates approximately 400,000 residences of the state are served by private wells. To assess the groundwater resources of the state, the Illinois EPA utilizes three primary aquifer classes that were developed by O'Hearn and Schock (1984). These three principal aquifers are sand and gravel, shallow bedrock and deep bedrock aquifers. O'Hearn and Schock defined a principal aquifer as having a potential yield of 100,000 gallons per day per square mile and having an area of at least 50 miles. Approximately 58 percent (32,000 square miles) of the state is underlain by principal aquifers. Of these, about 33 percent (18,500 square miles) are major shallow groundwater sources. The following are numbers of community water supply (CWS) wells that withdraw from these aquifers: Out of 3,517 active CWS wells, 46 % (1,619) utilize sand & gravel aquifer; 27 % (934) utilize a shallow bedrock aquifer; 24 % (825) utilize a deep bedrock aquifer, and 3% (139) are undetermined.

Table B-1. Illinois Atlas.

Topic	Value	Scale	Source
State Population in year 2009	12,910,409		US Census Bureau
State Surface Area (sq. mi.)	57,918		US Census Bureau
Active CWS Facilities	1,755	N/A	SDWIS
Surface Facilities	96	N/A	SDWIS
Groundwater Facilities	1,022	N/A	SDWIS
Mixed Facilities	7	N/A	SDWIS
Purchase Facilities	630	N/A	SDWIS
Active CWS Wells	3,517	N/A	SDWIS
Confined Wells	2,323	N/A	SDWIS
Unconfined Wells	1,194	N/A	SDWIS

SDWIS = Safe Drinking Water Information System

B-2. Groundwater Protection Programs

Illinois Groundwater Quality Standards

Since the inception of the Illinois Environmental Protection Act (Act) (415 ILCS 5) in 1970, it has been the policy of the State of Illinois to restore, protect, and enhance the groundwater of the State as a natural and public resource. To this end, Illinois has established the Illinois Groundwater Standards (35.Ill.Adm.Code 620). For a detailed explanation and listing of Illinois' Groundwater Standards see the Illinois Pollution Control Board's webpage at: http://www.ipcb.state.il.us. Further, Section 12(a) of the Act [415 ILCS 5/12(a)] also applies to groundwater.

Groundwater Management Zone

Within any class of groundwater, a groundwater management zone may be established as a three dimensional region containing groundwater being managed to mitigate impairment caused by the release of contaminants from a site: That is subject to a corrective action process approved by the Agency; or for which the owner or operator undertakes an adequate corrective action in a timely and appropriate manner.

Groundwater Protection

For a full description of Illinois' groundwater protection programs see the Illinois Groundwater Protection Act Biennial Report at: http://www.epa.state.il.us/water/groundwater/groundwater-protection/index.html or contact the Groundwater Section at 217/ 785-4787 to obtain a hard copy.

B-3. Cost/Benefit Assessment

Section 305(b) requires the state to report on the economic and social costs and benefits necessary to achieve Clean Water Act objectives. Information on costs associated with water quality improvements is complex, and not readily available for developing a complete cost/benefit assessment. The individual program costs of pollution control activities in Illinois, the general surface water quality improvements made, and the average groundwater protection program costs follow.

Cost of Pollution Control and Groundwater/Source Water Protection Activities

The Illinois EPA Bureau of Water distributed a total of $121.0 million in loans during 2008 for construction of municipal wastewater treatment facilities. Other Water Pollution Control program and Groundwater/Source Water Protection costs for Bureau of Water activities conducted in 2008 are summarized in Table B-6.

Table B-3. Water Pollution Control Program Costs for the Illinois Environmental Protection Agency's Bureau of Water, 2008.

Activity	Total
Monitoring	$5,277,300
Planning	$1,517,400
Point Source Control Programs	$14,011,000
Nonpoint Source Control Programs	$9,469,000
Groundwater/Source-Water Protection	$2,102,400
Total	$32,377,100

Groundwater Improvements

Protecting and managing groundwater are critical. Groundwater is an important natural resource that not only provides Illinois' citizens water for drinking and household uses, but also supports industrial, agricultural, and commercial activities throughout the state.

Unfortunately, industrial, agricultural and commercial activities can often produce volatile organic compounds. They are usually produced in large volumes and are associated with products such as plastics, adhesives, paints, gasoline, fumigants, refrigerants, and dry-cleaning fluids. They can reach groundwater through many sources and routes, including leaking storage tanks, landfills, infiltration of urban runoff and wastewater, septic systems, and injection through wells. Volatile organic compounds are an important group of environmental contaminants to monitor and manage in groundwater because of their widespread and long-term use, as well as their ability to persist and migrate in groundwater.

For a detailed discussion of groundwater protection improvements, please refer to the recently published Interagency Coordinating Committee on Groundwater Biennial Comprehensive Status and Self-Assessment Report on Illinois Groundwater Protection Program at: http://www.epa.state.il.us/water/groundwater/groundwater-protection/index.html.

PART C: GROUNDWATER MONITORING AND ASSESSMENT

C-1. Resource-Quality Monitoring Program

Hydrologic Background

To assess the groundwater resources of the state, the Illinois EPA utilizes three primary aquifer classes (O'Hearn and Schock, 1984). These three "principal aquifers" are sand and gravel, shallow bedrock and deep bedrock aquifers, as illustrated in figures C-1 thru C-3. A principal aquifer is defined as having a potential yield of 100,000 gallons per day per square mile and having an area of at least 50 miles.

Figure C-1. Principal Sand and Gravel Aquifers in Illinois

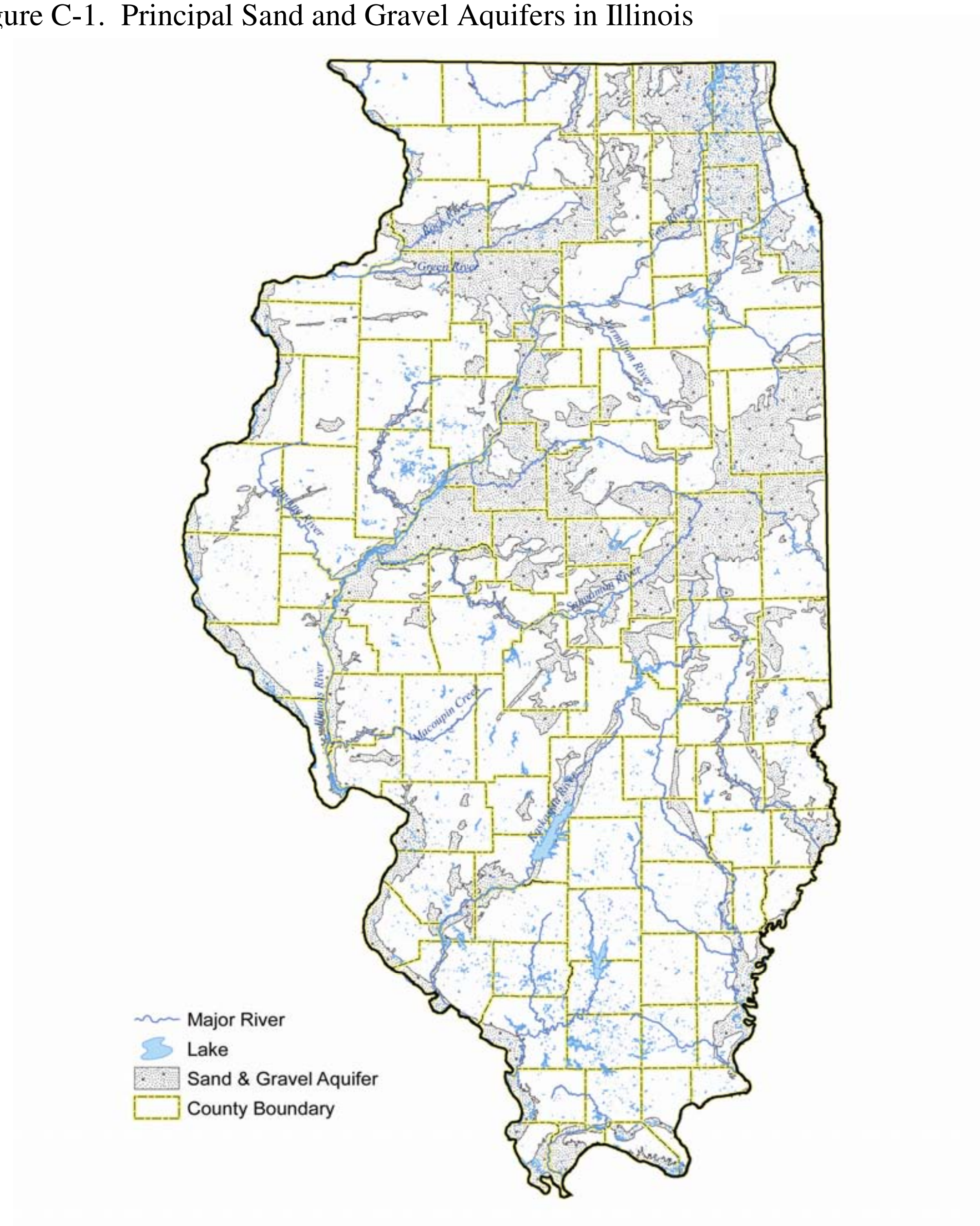


Figure C-2. Principal Shallow Bedrock Aquifers in Illinois

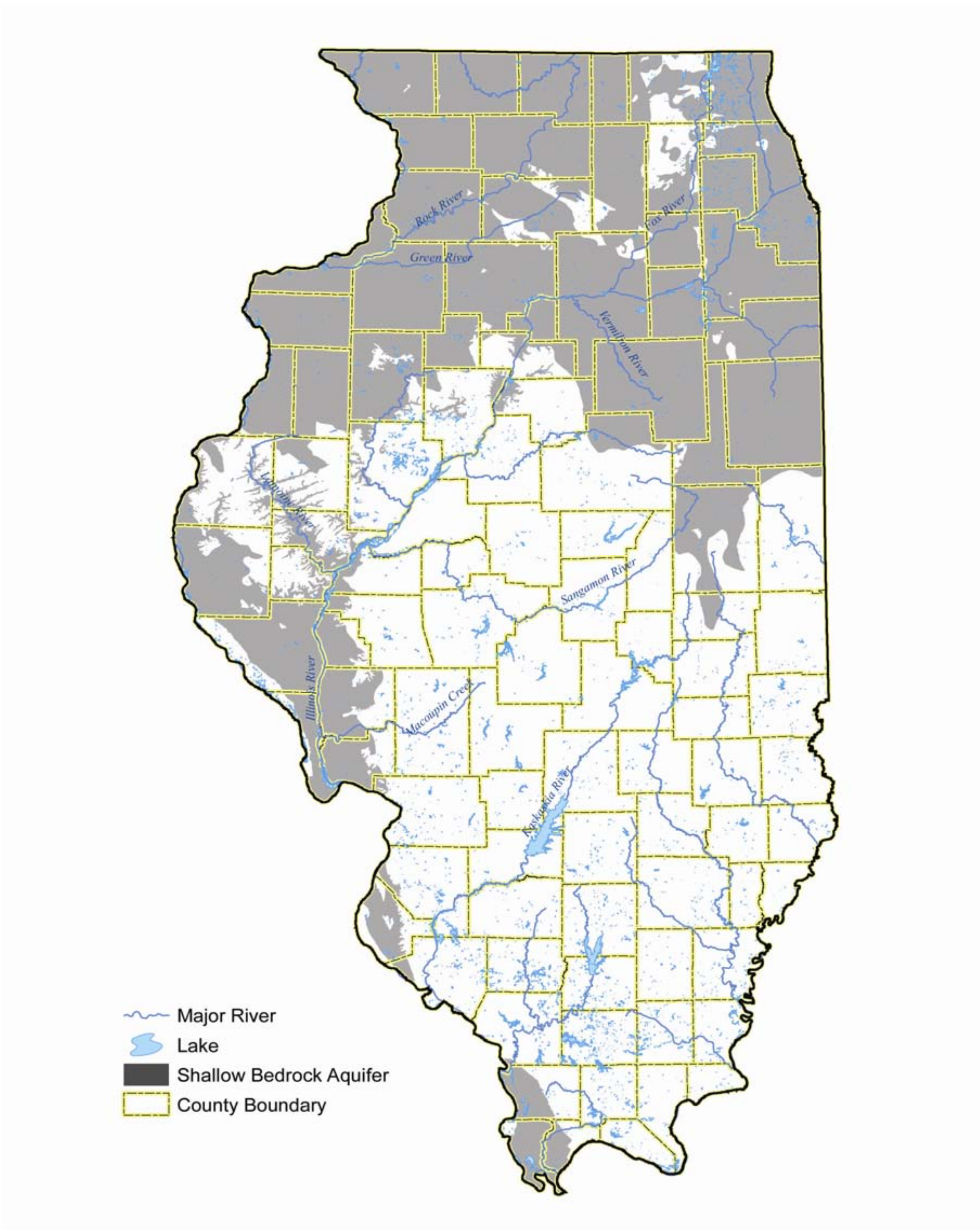
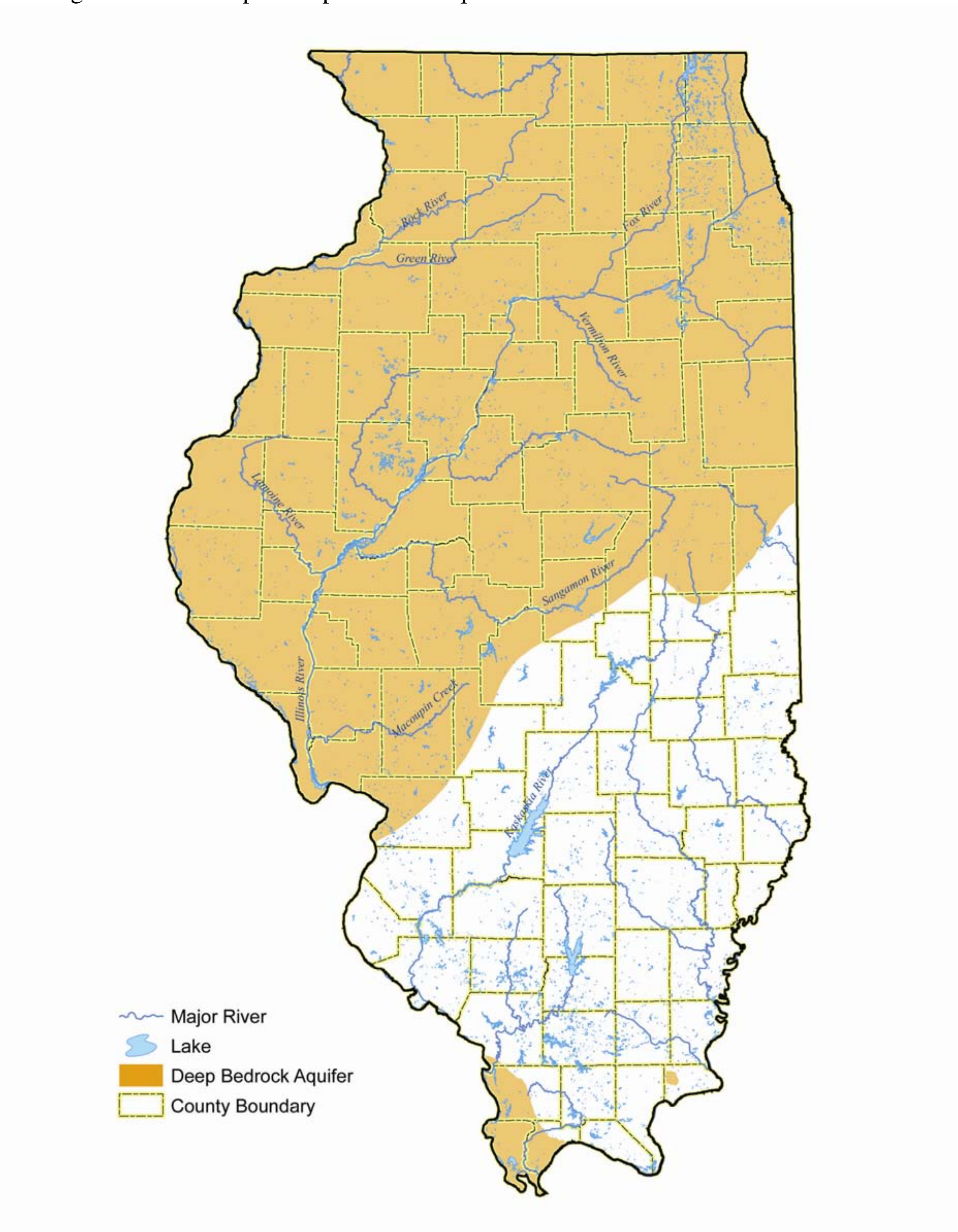


Figure C-3. Principal Deep Bedrock Aquifers in Illinois



Water resource availability can be expressed in a number of ways. In the groundwater field, the term "potential yield" or "safe yield" is often used (Wehrmann, 2003). Potential aquifer yield is the maximum amount of groundwater that can be continuously withdrawn from a reasonable number of wells and well fields without creating critically low water levels or exceeding recharge (Wehrmann, 2003). Statewide estimates of groundwater availability, based on aquifer potential yield estimates, were developed in the late 1960s (Illinois Technical Advisory Committee on Water Resources, ITACWR, 1967). The ITACWR report presented maps of the estimated potential yields, expressed as recharge rates in gallons per day per square mile (gpd/mi^2), of the principal sand and gravel and shallow bedrock aquifers of Illinois. For reference, a recharge rate of 100,000 gpd/mi^2 is equal to 2.1 inches/year. (Wehrmann, 2003).

The 1967 ITACWR report stated the following:

- The potential yield of the [sic] principal sand and gravel and bedrock aquifers in Illinois are estimated to be 4.8 and 2.5 billion gallons per day (bgd), respectively;
- The total groundwater potential in Illinois based on full development of either sand and gravel or bedrock aquifers, whichever has the higher recharge rate, is estimated to be 7.0 bgd;
- Principal sand and gravel aquifers underlie only about 25 percent of the total land area in Illinois;
- About 3.1 bgd, or about 65 percent of the total potential yield of the principal sand and gravel aquifers in the state, is concentrated in less than 6 percent of the total land area in Illinois and is located in alluvial deposits that lie directly adjacent to major rivers such as the Mississippi, Illinois, Ohio, and Wabash;
- About 0.5 bgd, or about 10 percent of the total potential sand and gravel yield is from the principal sand and gravel aquifers in the major bedrock valleys of the buried Mahomet valley in east-central Illinois and in the river valleys of the Kaskaskia, Little Wabash, and Embarras Rivers in southern Illinois;
- Of the total estimated yield of bedrock aquifers in the State, 1.7 bgd, or 68 percent, is available from the shallow bedrock aquifers, mainly dolomites in the northern third of the State;
- The potential yield of the shallow dolomite varies. In areas where the more permeable shallow dolomites lie directly beneath the glacial drift, the potential yield ranges from 100,000 to 200,000 gpd/mi^2;
- In areas where less permeable dolomites lie directly beneath the drift or are overlain by thin beds of less permeable rocks of Pennsylvanian age, the potential yield ranges from 50,000 to 100, 000 gpd/mi^2; and
- Where the overlying Pennsylvanian rocks are thick, the potential yield is less than 50,000 gpd/mi^2."

Future groundwater shortages are predicted in Northeastern Illinois (N.E. IL) (Meyer, Roadcap, et. al., 2009) and In addition, although shortages are not predicted, the Mahomet Aquifer in Champaign Urbana shows significant drawn down trends (Roadcap, and Wehrmann, 2009 and MAC, 2009) .

Approximately 58 percent (32,000 square miles) of the state is underlain by principal aquifers; of these, about 33 percent (18,500 square miles) are shallow groundwater sources. The following are numbers of community water supply wells that withdraw from these aquifers:

Out of 3,517 active CWS wells:

- 46 percent (1,619) utilize a sand and gravel aquifer;
- 27 percent (934) utilize a shallow bedrock aquifer;
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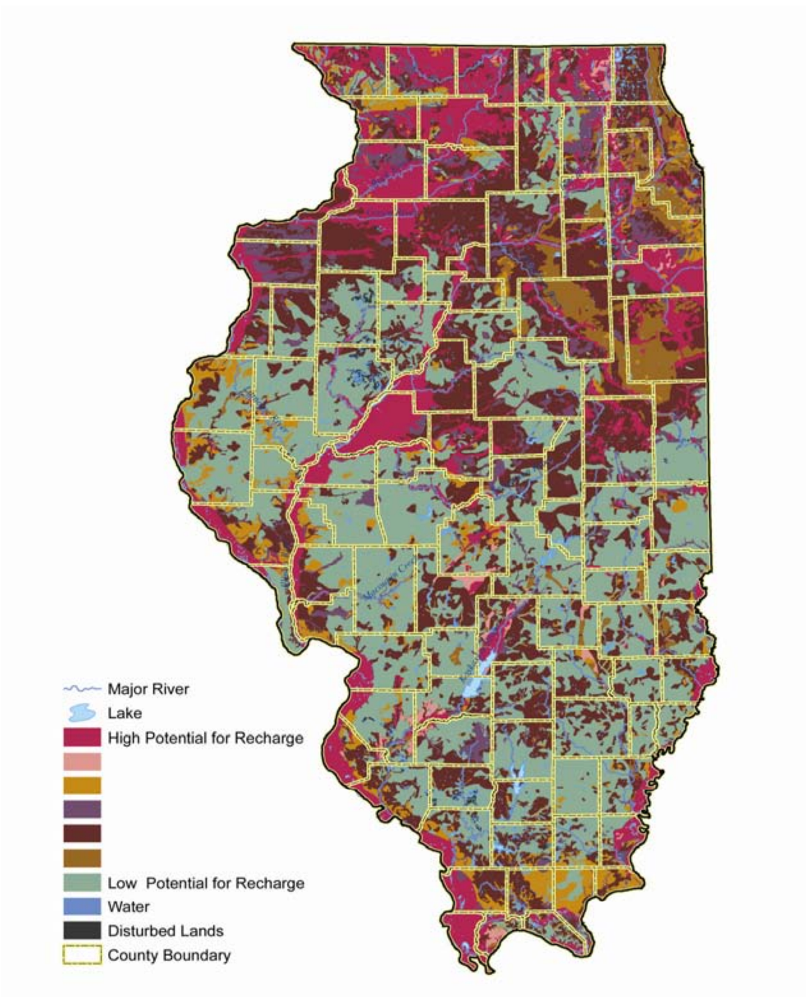
- 3 percent (139) are undetermined.

There are approximately 5,550 groundwater dependent public water supplies in the state, of which 1,022 are community water supplies (CWS). The Illinois Department of Public Health estimates approximately 400,000 residences of the state are served by private wells[4].

Figure C-4. Potential for Aquifer Recharge in Illinois



Water that moves into the saturated zone and flows downward, away from the water table is recharge. Generally, only a portion of recharge will reach an aquifer. The overall recharge rate is affected by several factors, including intensity and amount of precipitation, surface evaporation, vegetative cover, plant water demand, land use, soil moisture content, depth and shape of the water table, distance and direction to a stream or river, and hydraulic conductivity of soil and geologic materials (Walton, 1965).

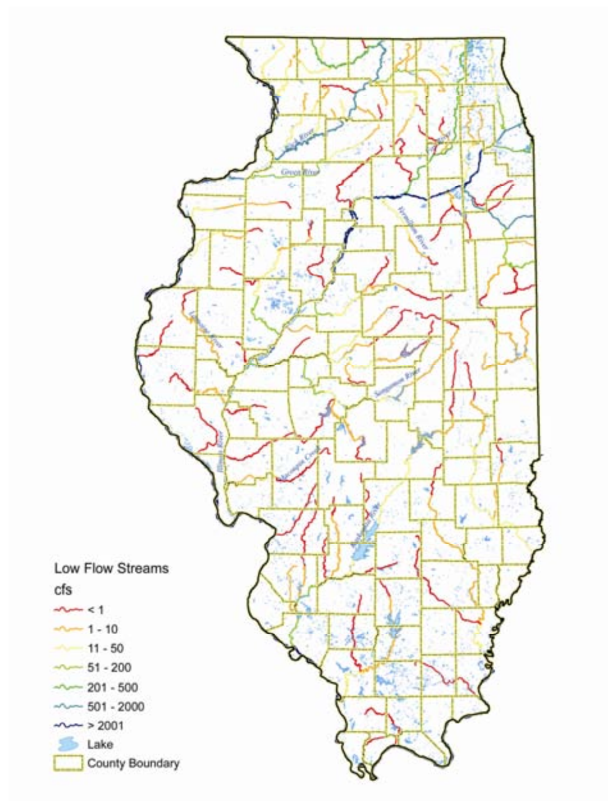
Figure C-4 illustrates the potential for aquifer recharge, defined as the probability of precipitation reaching the uppermost aquifer. The map is based on a simplified function of depth to the aquifer,

[4] "Private Water System" means any supply which provides water for drinking, culinary, and sanitary purposes and serves an owner-occupied single family dwelling. (Section 9(a)(5) of the Illinois Groundwater Protection Act [415 ILCS 55/9(a)(5)])

occurrence of major aquifers, and the potential infiltration rate of the soil. This simplification assumes that recharge rates are primarily a function of leakage from an overlying aquitard (fine grained non-aquifer materials). Moreover, recharge may also be occurring from outside of a watershed boundary. Additionally, pumping stresses from potable water supply wells located adjacent to watershed boundaries may change the natural groundwater flow directions. Therefore, aquifer boundaries may not be consistent with surface watershed boundaries.

Additional and more detailed information is available via Illinois EPA's Environmental Facts Online (ENFO): [http://www.epa.state.il.us/enfo/.](http://www.epa.state.il.us/enfo/) Groundwater contribution to stream flow in the form of base flow was analyzed for 78 drainage basins in Illinois (O'Hearn and Gibb, 1980). This study determined that median base flow per square mile of drainage area generally increases from the south west to the northeast at all three flow durations. Figure C-5 shows the 3 year low flow streams. This provides a good indictor of groundwater base flow in surface water.

Figure C-5. Three-Year Low Flow Streams in Illinois



Increased withdrawal of groundwater is having a direct impact on surface water quantity. Groundwater modeling studies conducted in Kane County show that as of 2003 stream flow capture by groundwater pumping had reduced natural groundwater discharge to streams in and near Kane County by about 17 percent (Meyer, Roadcap, et. al., 2009).

Illinois Groundwater Monitoring Network

Section 13.1 of the Act (415 ILCS 5/13.1) requires the Illinois EPA to implement a groundwater monitoring network to assess current levels of contamination in groundwater and to detect future degradation of groundwater resources. Further, Section 7 of the IGPA (415 ILCS 55/7) requires the establishment of a statewide ambient groundwater monitoring network comprised of community water supply wells, non-community water supply wells, private wells, and dedicated monitoring wells. The ICCG serves as a groundwater monitoring coordinating council. The following provides a summary of the Illinois EPA's network of CWS wells.

Prototype Ambient Groundwater Monitoring

The collection of high quality chemical data is essential in assessing groundwater protection efforts. In 1984, the Illinois State Water Task Force published a groundwater protection strategy. This strategy lead to the addition of Section 13.1 to the Act (415 ILCS 5/13.1) which required the Illinois EPA to develop and implement a Groundwater Protection Plan (Plan) and to initiate a statewide groundwater-monitoring network. In response to these requirements, the Illinois EPA and the United States Geological Survey (USGS) Illinois District Office, located in Urbana, began a cooperative effort to implement a pilot groundwater monitoring network (i.e., ambient monitoring network) in 1984 (Voelker, 1986). CWS well ambient network design started with pilot efforts in 1984, moved to implementation of the ISWS network design (O'Hearn, M. and S. Schock. 1984) for several years, and was followed by sampling all of Illinois' CWS wells (3,000+) (Voelker, 1988 and 1989).

The prototype monitoring efforts included development of quality assurance and field sampling methods. Illinois EPA's quality assurance and field sampling methods, originally developed in 1984 in cooperation with the USGS, were compiled into a field manual in 1985 (Cobb and Sinnott,1987 and Barcelona, 1985). This manual has since been revised many times to include quality improvements. Monitoring at all stations sampled by Illinois EPA is completed by using Hydrolab® samplers to insure that in situ groundwater conditions are reached prior to sampling. Water quality parameters include: field temperature, field specific conductance, field pH, field pumping rate, inorganic chemical (IOC) analysis, synthetic organic compound (SOC), and VOC analysis. All laboratory analytical procedures are documented in the Illinois EPA Laboratories Manual.

In the year 2000, the Illinois EPA tasked the USGS to conduct a yearlong independent evaluation of our groundwater quality sampling methodology. The USGS concluded that Illinois EPA sampling program (sampling methodology guidelines, water quality meter calibration, and sampling performance) is considered to provide samples representative of aquifer water quality. Only minor revisions to the sampling program were suggested (Mills and Terrio 2003). In addition, Illinois EPA also participates in the annual USGS National Field Quality-Assurance Program.

Coordinated Ambient Monitoring

From the experience gained from these prototype networks, implemented pursuant to Section 13.1 of the Act, Illinois EPA designed a probabilistic monitoring network of CWS wells (Gibbons 1995). The design of this network was completed in coordination with the USGS, the Illinois State Geological Survey (ISGS), and the ISWS, with USGS performing the detailed design. The goal of the network is to represent contamination levels in the population of all active CWS wells. The network wells were selected by a random stratified probability-based approach using a 95 percent confidence level (CWS probabilistic network). This results in an associated plus or minus 5 percent precision and accuracy level. Further, the random selection of the CWS wells was stratified by depth, aquifer type and the presence of aquifer material within 50 feet of land surface to improve precision and accuracy. Illinois EPA used geological well log and construction log detail to perform this process.

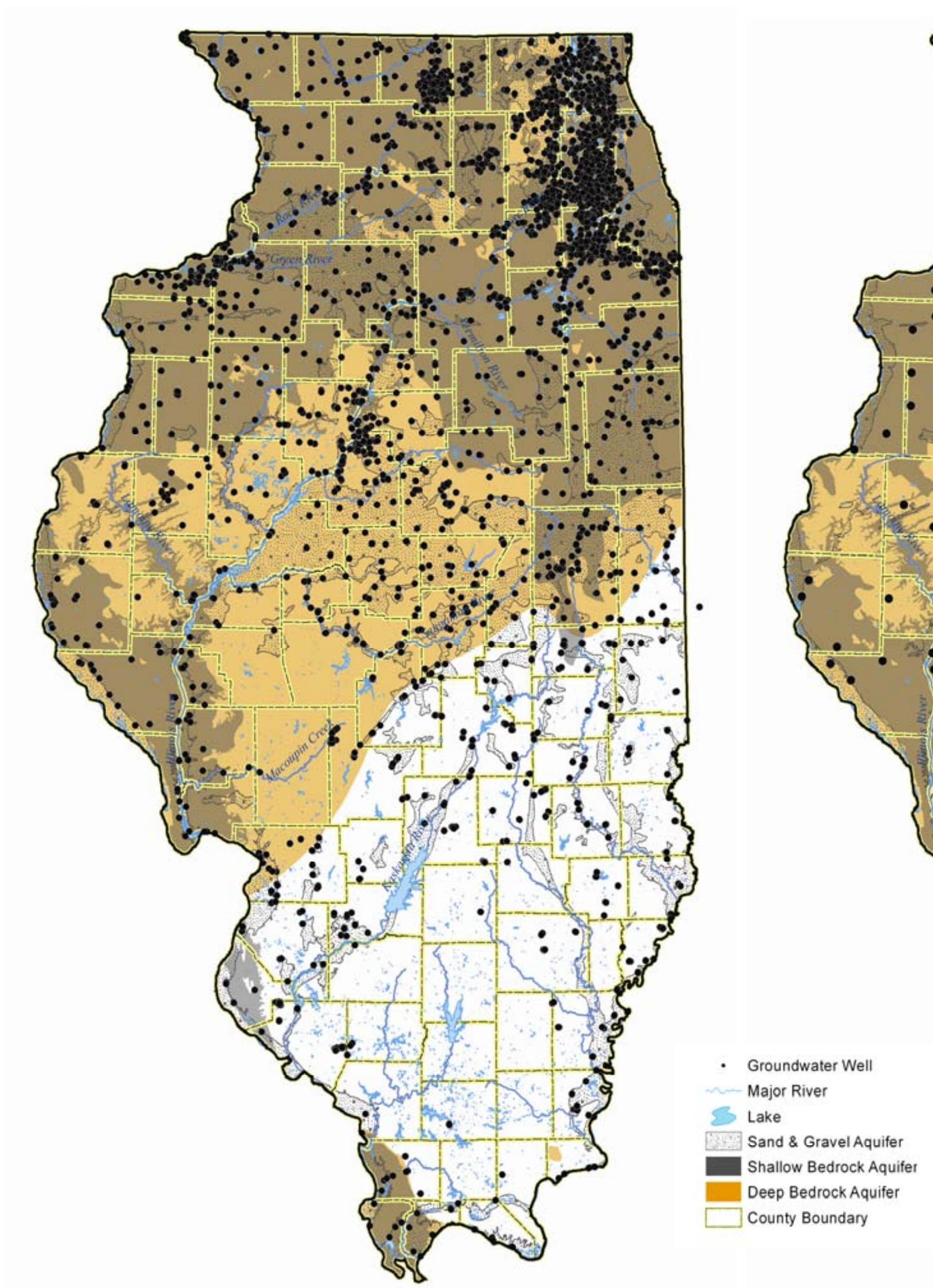
The random stratified selection process included nearly 3,000 CWS wells resulting in 354 fixed monitoring locations see Figure C-6. Additionally, in order to prevent spatial or temporal bias 17 random groups of 21 wells, with alternates, were selected from all the 354 fixed station wells. To further assure maximum temporal randomization within practical constraints, the samples from each sample period are collected within a three-week timeframe.

This probabilistic network is designed to provide an overview of the groundwater conditions in the CWS wells; provide an overview of the groundwater conditions in the principle aquifers (e.g., sand and gravel, Silurian, Cambrian-Ordovician, etc.,); establish baselines of water quality within the principle aquifers; identify trends in groundwater quality in the principle aquifers; and evaluate the long-term effectiveness of the IGPA, CWA and Safe Drinking Water Act (SDWA) program activities in protecting groundwater in Illinois. Illinois EPA has also developed an integrated surface and groundwater monitoring strategy. Figure C-7 shows the probabilistic groundwater monitoring network wells and the surface water monitoring stations.

During the 1997 monitoring cycle, Illinois EPA initiated a rotating monitoring network of CWS wells. Illinois EPA rotates every two years from the probabilistic (fixed station) network to special intensive or regional studies.

Figure C-6. Active Community Water Supply Wells and Community Water Supply Probabilistic Network Wells

All CWS Wells in Illinois



CWS Probabilistic Network Wells in Illinois

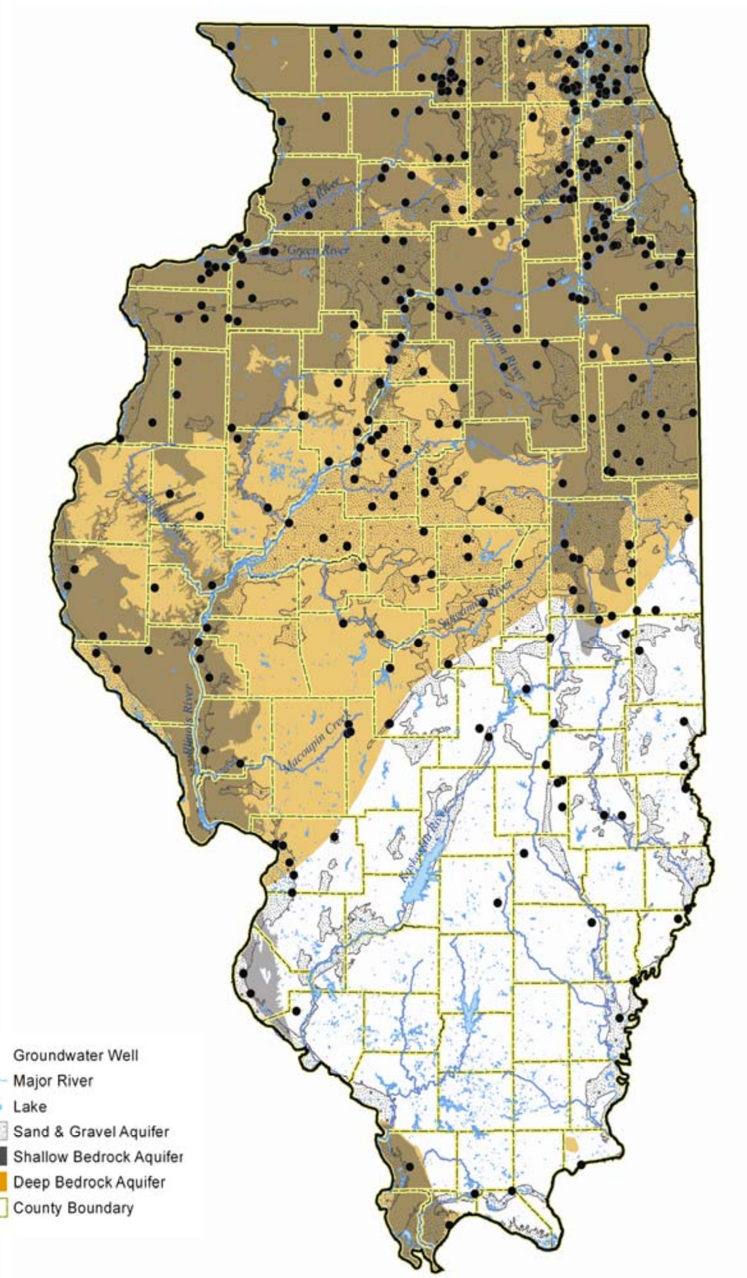
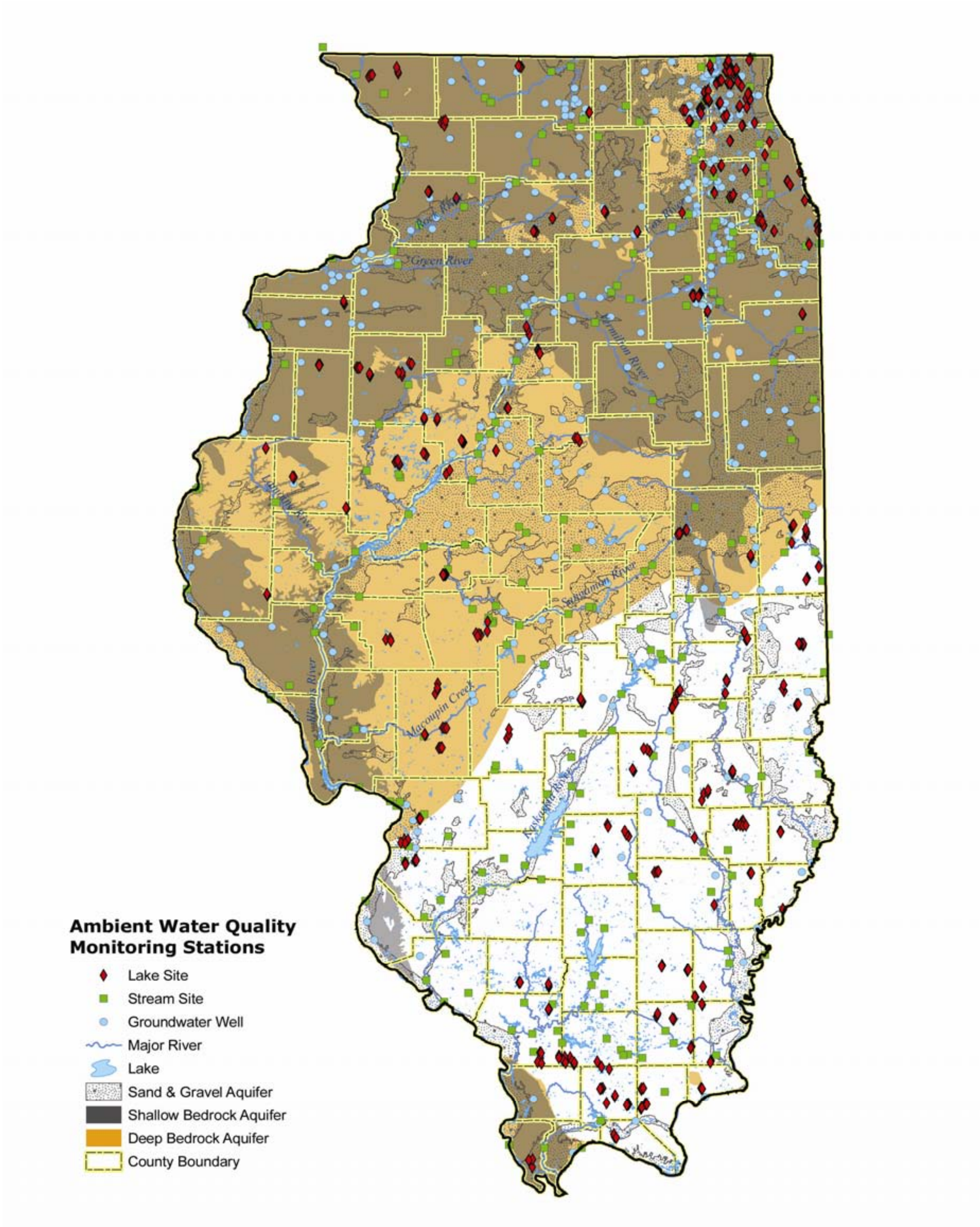


Figure C-7. Illinois EPA's integrated surface and groundwater monitoring network **si**tes



A cooperative was established with the USGS to evaluate the occurrence of pesticides and their transformation products in CWS wells (Mills and McMillan, 2004). A random stratified statistical method was used to select 117 wells from the 354 well fixed station network to ensure representation of the major aquifer types in Illinois. For details on the pesticide sub-network of the CWS probabilistic network, see Illinois Integrated Water Quality Report and Section 303(d) List-2008 at: http://www.epa.state.il.us/water/tmdl/303-appendix/2008/2008-final-draft-303d.pdf, and http://www.epa.state.il.us/water/groundwater/publications/herbicides-in-source-water-report.pdf.

The IGPA required the establishment of a statewide ambient groundwater monitoring network coordinated by the ICCG, and comprised of CWS wells; non-CWS[5] wells; private wells; and dedicated monitoring wells. Illinois also used a statistically-based approach for designing: a pilot rural private well monitoring network (Schock and Mehnert, 1992) and the Illinois Department of Agriculture (IDA) dedicated pesticide monitoring well network (Mehnert et al. 2005) http://www.epa.state.il.us/water/tmdl/303-appendix/2008/2008-final-draft-303d.pdf. The ICCG also coordinates with the USGS on groundwater monitoring http://www.epa.state.il.us/water/tmdl/303-appendix/2008/2008-final-draft-303d.pdf.

5 "Non-Community Water System" means a public water system which is not a community water system, and has at least 15 service connections used by nonresidents, or regularly serves 25 or more nonresident individuals daily for at least 60 days per year. (Section 9(a)(4) of the Illinois Groundwater Protection Act [415 ILCS 55/9(a)(4)]).

C-2. Assessment Methodology

Overall Use Support

Though there are many uses of groundwater in Illinois, the groundwater use assessments are based primarily upon CWS chemical monitoring analyses. The assessment of chemical monitoring data essentially relies on the Board's Class I: Potable Resource Groundwater standards.

The fixed station probabilistic network of CWS is utilized to predict the likelihood of attaining full use support in the major aquifers in Illinois. As previously described, the overall use support is based on compliance with Illinois' Class I GWQS. Class I standards include the nondegradation standards. The attainment of use support is described as Full and Nonsupport, as described below:

<u>Full Support</u>
Good - indicates that no detections occurred in organic chemical monitoring data and inorganic constituents assessed were at or below background levels for the groundwater source being utilized.

<u>Nonsupport</u>
Fair - indicates that organic chemicals were detected and therefore exceed the nondegradation standard, but measured levels are less than the numerical Class I GWQS, and inorganic constituents assessed were above background level (nondegradation standard) but less than the numerical Class I GWQS.

Poor - indicates that organic chemical monitoring data detections were greater than the Class I GWQS and inorganic chemicals assessed were greater than both the background concentration and Class I GWQS.

Organic results in the probabilistic network of CWS wells, which are commonly known to be anthropogenic in nature, were analyzed by well and year. It was determined that a detection of an organic contaminant would be recorded and not averaged. In this manor, the Illinois EPA is able to track the contamination and determine if a trend in that CWS well exists.

Individual Use Support

Groundwater in Illinois supports many uses. For over 50 years, the USGS has been collecting data on estimated water withdrawals by state, source of water, and category. According to the USGS[6], the major uses of groundwater in Illinois are domestic, public water supply, agricultural, livestock, industrial, and thermoelectric.

According to the USGS, Illinois uses approximately 15.2 billion gallons of fresh water per day. Only a small percentage – 1,210 million gallons per day (MGD), is from groundwater sources Figure C-13. Irrigation uses most of the groundwater with over 479 MGD (40%), followed by Public water supplies use - 406 MGD (34%). Industrial (self-supplied) withdraws slightly more than 128 MGD (11%), followed by Domestic, which includes private well usage, 101 MGD (8%), and Livestock/Aquaculture at 44 MGD (3%) Mining (both fresh and saline) accounts for 41 MGD (3%) and Thermoelectric sources round off the bottom of this list with approximately 7 MGD (1%) of groundwater usage in the State.

In addition, the ISWS conducts an annual survey of Illinois CWSs as to how much water they use in a year. These data are presented in Figure C-14 in MGD. For purposes of this discussion, only community CWS use will be considered for the following assessment. All other uses are assumed to be full with the exception of Domestic, which is assessed by the Illinois Department of Public Health.
The ISWS has updated an analysis of groundwater use to aquifer potential yield in Illinois and prepared a report summarizing

Figure C-13. Groundwater Withdrawals in Illinois (USGS 2005)

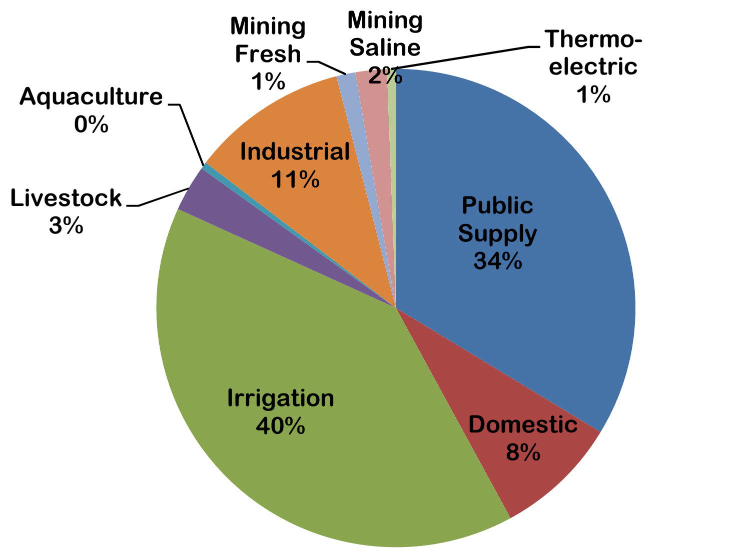
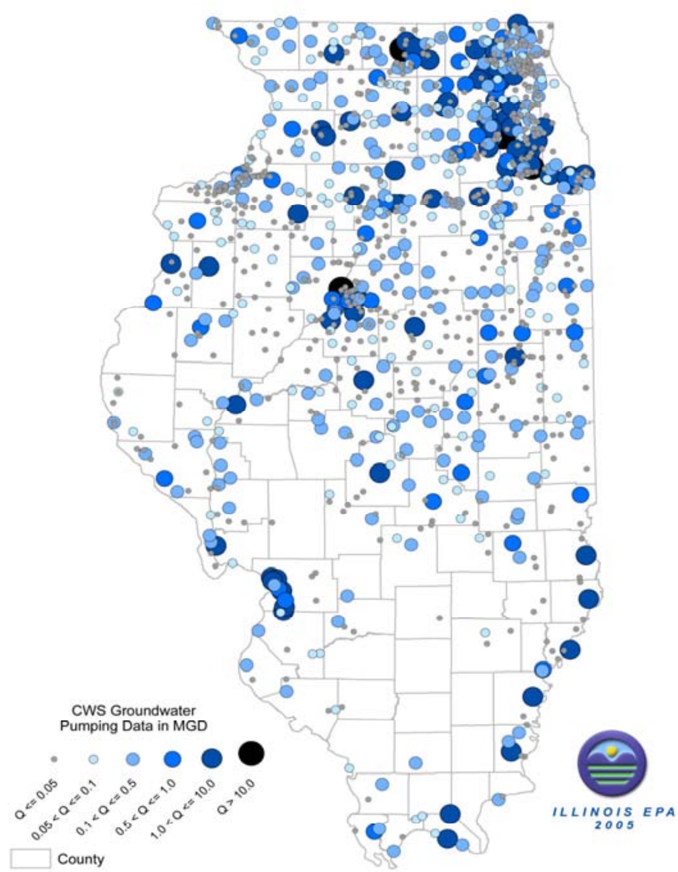


Figure C-14. Statewide CWS Pumping Rates (ISWS, 2004)



[6] Based on **USGS Circular 1344,** 2005, which can be found at http://pubs.usgs.gov/circ/1344/

the findings (Wehrmann, 2003). This report compared Year 2000 groundwater withdrawals against estimated aquifer potential yields. The comparison is presented as a ratio of groundwater use (withdrawals) to groundwater yield (i.e., potential aquifer yield) on a township basis. A high use-to-yield ratio (e.g., >0.9) suggests an area where groundwater availability problems exist or could be impending[7] (Wehrmann, 2003). For further, detail see the ISWS report at: http://www.sws.uiuc.edu/pubdoc/CR/ISWSCR2004-11.pdf.

Wehrmann (2003) pointed out that major withdrawals from sand and gravel aquifers can be seen in the Metro-East area of St. Louis and in Quincy along the Mississippi River; in the Peoria-Pekin area along the Illinois River, in the Fox River corridor in northeastern Illinois, and in the Champaign area of east-central Illinois in. Major withdrawals from the shallow bedrock aquifers can be clearly seen almost solely in northeastern Illinois in southern Cook, Kankakee and Will Counties for communities such as Crest Hill, Lockport, Manteno, New Lenox, Park Forest, and Romeoville (Wehrmann, 2003). Major withdrawals from the deep bedrock are found spread across northern Illinois, particularly in the Rockford area of north-central Illinois, the Fox River corridor, and farther south in the area of Joliet and the I-55 industrial corridor near Channahon (Wehrmann, 2003).

In addition, new comprehensive hydrogeologic analysis and demand studies in N.E. IL predict future water shortages (Meyer, Roadcap, et. al., 2009 and CMAP, 2010). For further detail see, http://chicagoareaplanning.org/watersupply and
http://www.isws.illinois.edu/iswsdocs/wsp/ppt/NEIL_RWSPG_Mar2009.pdf

Groundwater contributes to stream flow in the form of base flow in many of these river corridors. Thus, stream flows may also be impacted in areas where the ratio of use to yield is > 0.9. This is especially true in northeastern Illinois due to the following factors: Supreme Court limitations on Lake Michigan; continued population growth; and a deep aquifer condition beyond sustainable recharge. It is predicted that these factors will force an increased reliance on the use of sand and gravel and shallow bedrock aquifer resources. These shallow aquifers are in direct hydraulic connection to surface waters. Decreased base flow in the stream may have an impact on surface water quality and stream habitat.

In addition, some groundwater in Illinois is designated as “special resource.” Special Resource Groundwater is described as the groundwater contributing to highly sensitive areas such as dedicated nature preserves that supports ecologically sensitive areas such as the Parker Fen in McHenry County and the Southwest Sinkhole Karst Plain located in Monroe, St. Clair and Randolph counties.

[7] (Note: The delineation of high groundwater use to-yield areas by this method should be considered simply as a means for calling attention to areas to prioritize on a statewide basis for water resources planning and management (Wehrmann, 2003).)

C-3. Potential Causes and Potential Sources of Impairment

Potential Causes of Impairment

As previously stated, when possible, assessments of overall groundwater use support is based upon application of Illinois' GWQS (including non-degradation standards) to water quality sample measurements from the probabilistic network of CWS wells. Generally, a detection of an organic contaminant above the laboratory practical quantification limit or the detection of an inorganic constituent above the naturally occurring background level in a CWS well is considered a cause of less than full use support.

Potential Sources of Impairment

Illinois EPA used its database of potential sources that have been inventoried as part of well site surveys, hazard reviews; groundwater protection needs assessments, source water assessments, and other special field investigations to evaluate potential sources of contamination relative to CWS WHPAs. Further, the Illinois EPA utilized its Geographic Information System (GIS) to calculate land use activities proximate to the probabilistic network of CWS wells[8]. Table C-3 describes the most prevalent (common) potential sources of groundwater contamination in Illinois relative to CWS WHPAs.

[8] County by county land cover grid data for Illinois derived from Thematic Mapper (TM) Satellite data from the Landsat 4 sensor. Dates of the imagery used range from April 1991 to May, 1995.

Table C-3. Most Prevalent Potential Sources of Ground Water Contamination[9]

Contaminant Sources	Occurrence of Potential Source[10]	Contaminants[11]
AGRICULTURAL ACTIVITIES		
Agricultural chemical facilities	587	A, B, E
Animal feedlots	66	E, J, K, L
Drainage wells	3	A, B, C, D
Fertilizer applications	323	A, B, E
Irrigation practices	63	A, B, E
Pesticide applications	174	A, B, E
STORAGE AND TREATMENT ACTIVITIES		
Land Application	14	A, B, D, E, G, H, J
Material stockpiles	683	G, H
Storage tanks (above ground)	2,249	C, D
Storage tanks (underground)	2,878	C, D
Surface impoundments	236	E, G, H, J, K, L
Waste piles	231	E, G, H
Waste tailings	9	G, H, I, J
DISPOSAL ACTIVITIES		
Deep injection wells	9	A, B, C, D, E, F, G, H, I, M
Landfills	40	C, D, G, H, J
Septic systems	6,290	E, G, H, J, K, L
Shallow injection wells	9	A, B, C, D, E, F, G, H, J, K, L
OTHER		
Hazardous waste generators	-	A, B, C, D, G, H
Hazardous waste sites	97	A, B, C, D, G, H
Industrial Facilities	1,565	A, B, C, D, G, H
Material transfer operations	232	A, B, C, D, E, F, G, H
Mining and mine drainage	19	G, H, M
Pipelines and sewer lines	111	C, D, E, G, H, J, K, L
Salt storage and road salting	76	G
Salt water intrusion	-	G
Spills	9	A, B, C, D, E, G, J
Transportation of materials	164	A, B, C, D, E
Manufacturing/repair shops	1,554	C, D, G, H
Urban runoff	1,184	A, B, D, E, G, H, J, K, L
Other sources (potential routes of contamination such as drainage wells, improperly abandoned potable water wells, or sand & gravel quarries)	249	A, B, D, E, J, K, L
FACILITY TREATMENT AND RECREATION		
Former Storage Facility	113	A, B, C, D, E, G, H
Commercial Waste or Chemical Handling Facility	1,078	C, D, E, G, J
Public Utilities Facility	203	E, F, G, H, J, K, L
Waste Treatment Facility	202	E, G, H, J, K, L
Recreational facility of area	581	J, L
Agriculture Materials Storage and Sales	-	A, B, E, G, M

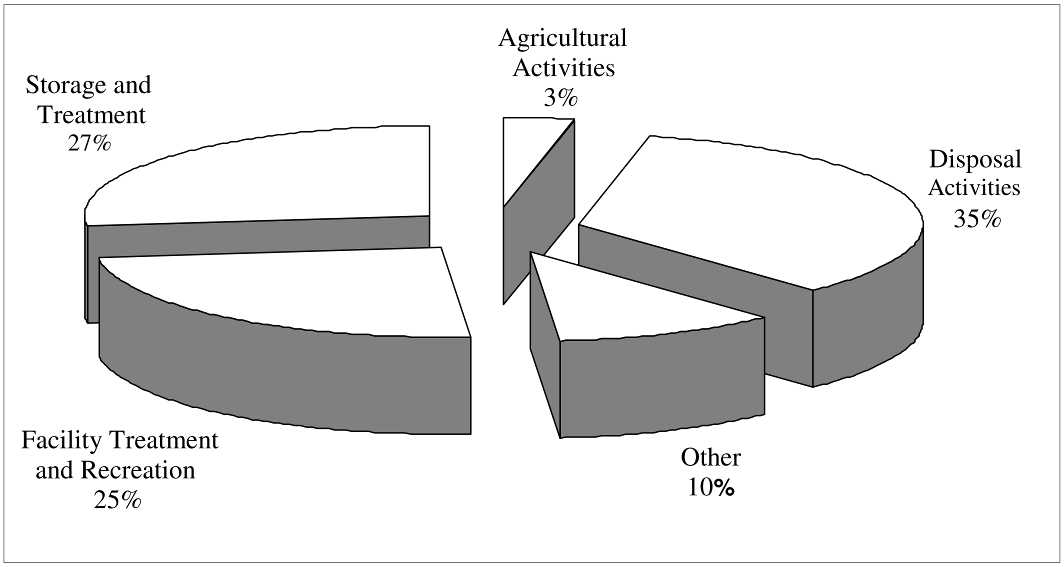
[9] The basis for the analysis provided in this table is a combination of existing monitoring data and potential source of groundwater contamination data from the completed CWS well site survey reports which Illinois EPA has conducted over the past 20 years.

[10] Occurrences are based solely on the Illinois EPA Groundwater Section's existing databases. This is only an estimate and should not be used as anything more than an approximation of potential sources of contamination to CWS wells in Illinois.

[11] Contaminants: A. Inorganic pesticides; B. Organic pesticides; C. Halogenated solvents; D. Petroleum compounds; E. Nitrate; F. Fluoride; G. Salinity/brine; H. Metals; I. Radio-nuclides; J. Bacteria; K. Protozoa; L. Viruses; and M. Other.

The Illinois EPA identified 16,354 potential sources of contamination of which 1,163 are considered threatening. Figure C-15 shows the most threatening potential contamination sources associated with CWS wells with VOC detects. The most prevalent potential source grouping was land disposal activities (2,953 sites) and the most threatening potential source grouping was chemical/petroleum processing/storage (255 sites) facilities.

Figure C-15. Most threatening potential contamination sources in community water supply wells with volatile organic compound detections



In addition, ISWS research on CWS wells in Northeastern Illinois has also determined that road salting is the most threatening potential source causing and contributing to Cl- contamination above background in Northeastern Illinois. Approximately 16% of the samples collected from CWS wells in northeastern Illinois in the 1990s had Cl^- concentrations greater than 100 mg/L, and median values were less than 10 mg/L, prior to 1960, before extensive road salting (Kelly and Wilson, 2004). The 75the quartile value of the sand and gravel CWS probabilistic network wells in N.E. IL show a 35 percent increase in concentration compared to the state wide ambient value in the CWS probabilistic network.

The current occurrence of herbicide compounds found in the pesticide sub-network of the CWS probabilistic network of wells indicates that various factors, along with current agricultural land use contribute to herbicide occurrence. It appears that many areas that were once rural agricultural land use have now been encompassed by urban land use. The USGS study of herbicide transformation and parent products determined:

> "… a strong inverse relation (-0.81) between current use of land for corn and soybean production and the current occurrence of herbicide compounds in underlying aquifers indicates that various factors, along with current agricultural land use contribute to herbicide occurrence. These factors include, among others, land-use history, ground-water age, ground-water flow patterns, geology, soil microbiology, and chemistry and persistence of the herbicide compounds (Mills and McMillan, 2004)."

C-4. Monitoring Results

IDA Dedicated Pesticide Monitoring Well Network Results

For a detailed discussion of the IDA's dedicated pesticide monitoring well network results see Illinois Integrated Water Quality Report and Section 303(d) List-2008 at: http://www.epa.state.il.us/water/tmdl/303-appendix/2008/2008-final-draft-303d.pdf.

CWS Probabilistic Monitoring Network Results

Statistics have a critical role in determining environmental impacts to groundwater quality, especially with respect to IOCs. The problem is technically interesting: given a new measurement for a well in the network, drilled in a particular aquifer, and analyzed for a particular substance, what is the probability that the measurement represents an effect of an unnatural source (Gibbons, 1995). Thus, this becomes a problem of statistical prediction. Given a collection of historical or background measurements for a substance, what limit or interval will contain the new measurement with a desired level of confidence. The wells in the CWS probabilistic network are not necessarily located in areas geographically removed from potential sources of contamination, as described above (Gibbons, 1995).

Illinois EPA is using box plots to represent a snapshot of IOC measurement results for network wells drilled in particular aquifers. As illustrated in Figure 16 a box and whisker plot provides a statistical prediction of the concentration of a substance bounded by percentiles. In other words, the box plot shows what concentration occurs between 90, 75, and 25 percent of the time for a CWS drilled in a particular aquifer. However, because the historical data set for the network may include measurement results that are due to unnatural sources, additional regional and/or site specific evaluation may be needed to determine if measurements are occurring due to natural versus unnatural sources.

Figures C-16(a-d) show the IOC results for the CWS probabilistic network wells drilled in sand and gravel, shallow bedrock, deep bedrock, and mixed aquifers. The immediate figure to the left (Figure C-15) is a key to reading the box plots that are contained in those figures.

Figure-16. A sample box plot for the following figures

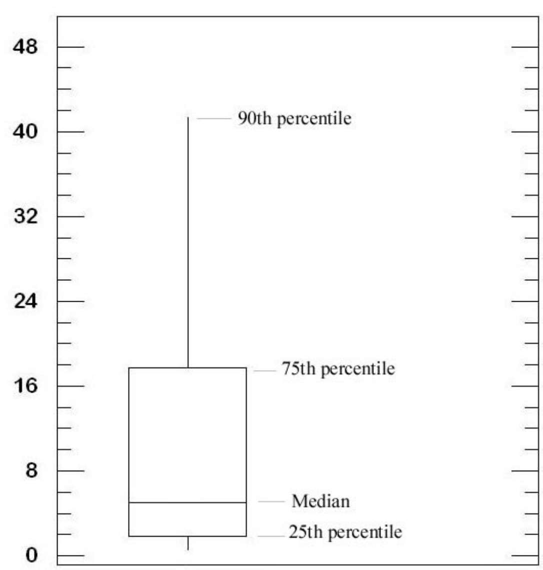


Figure C-16a. Inorganic Water Quality Data in Illinois Principal Aquifers

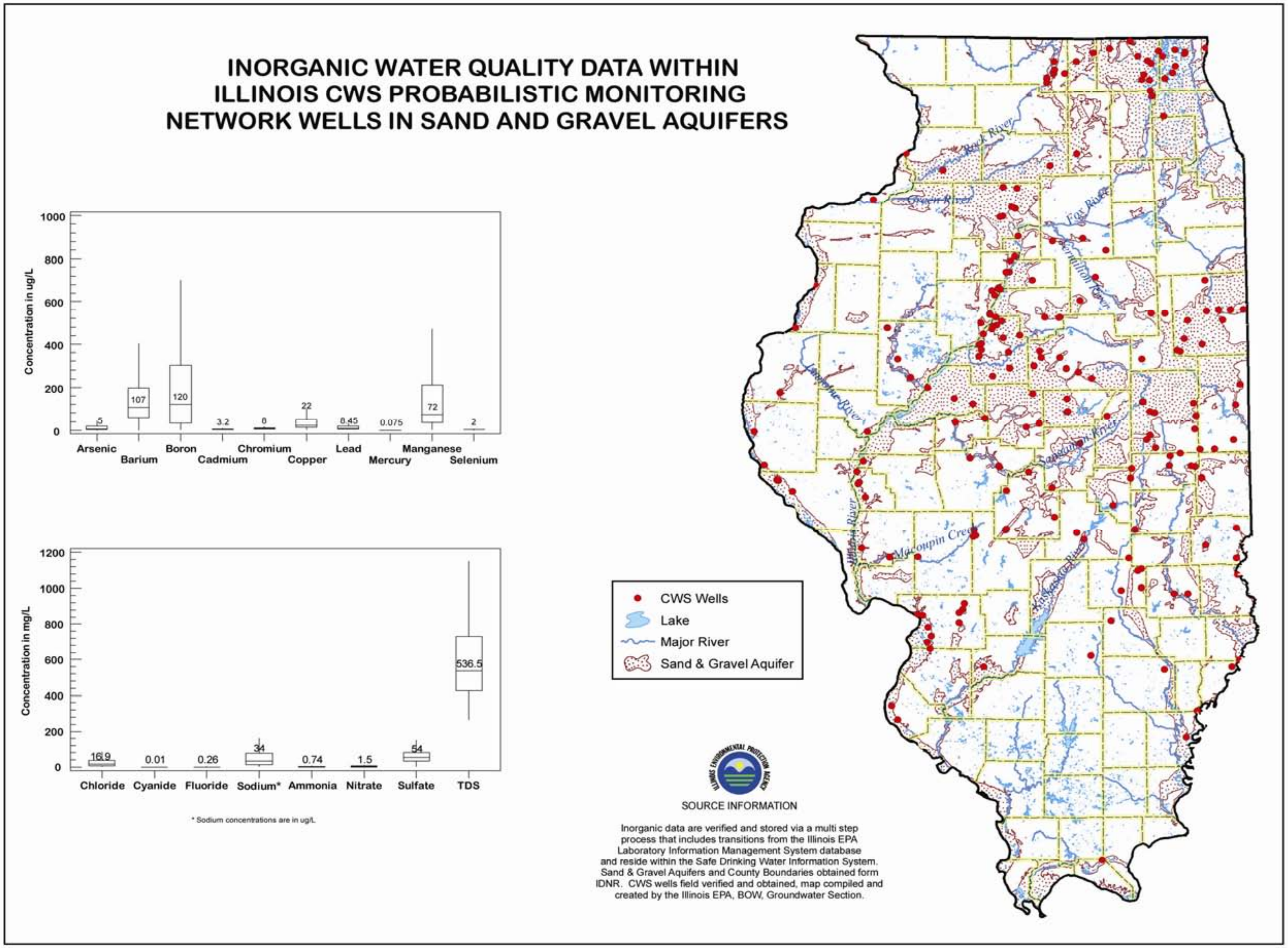


Figure C-16b. Inorganic Water Quality Data in Illinois Principal Aquifers

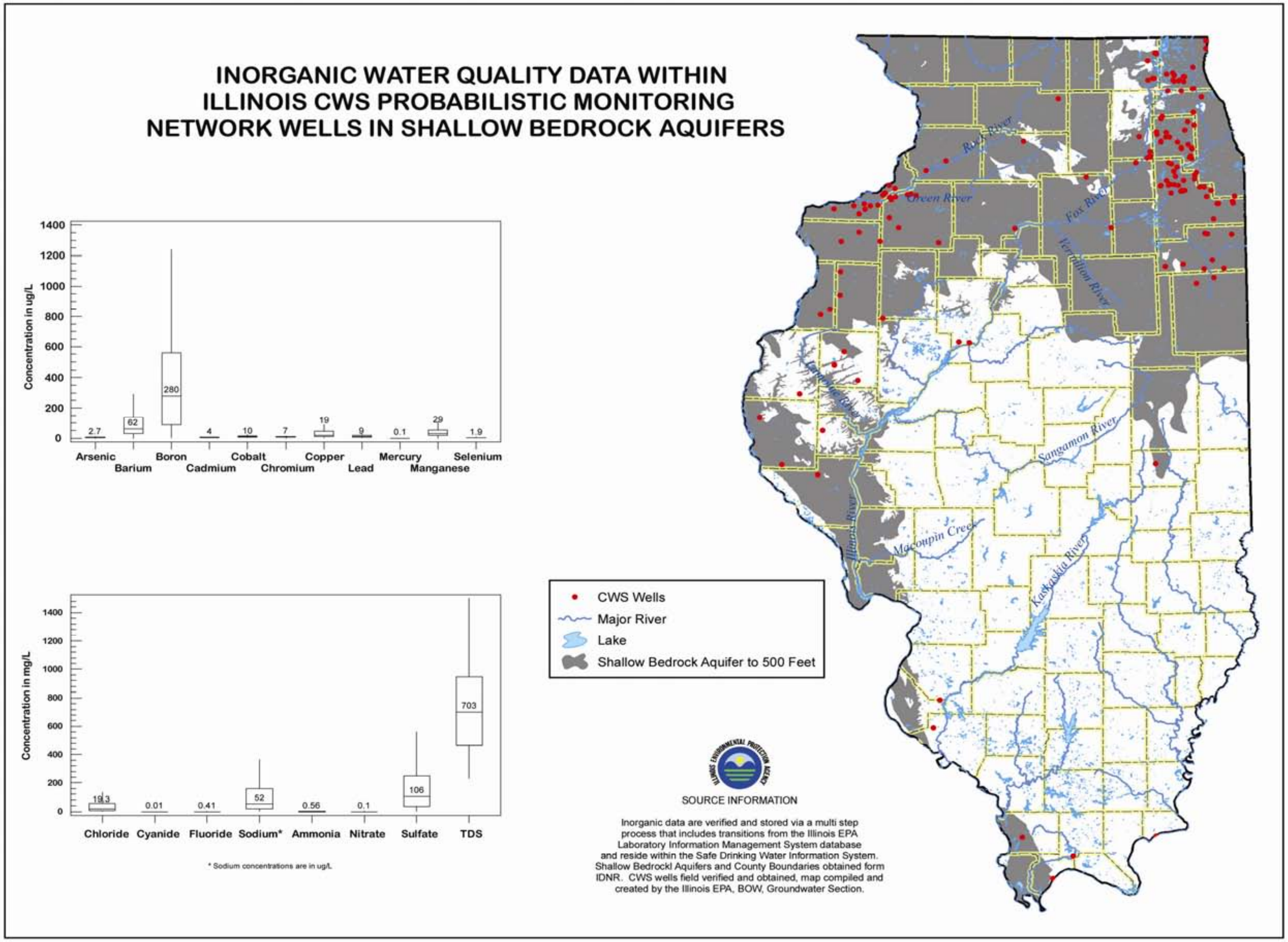
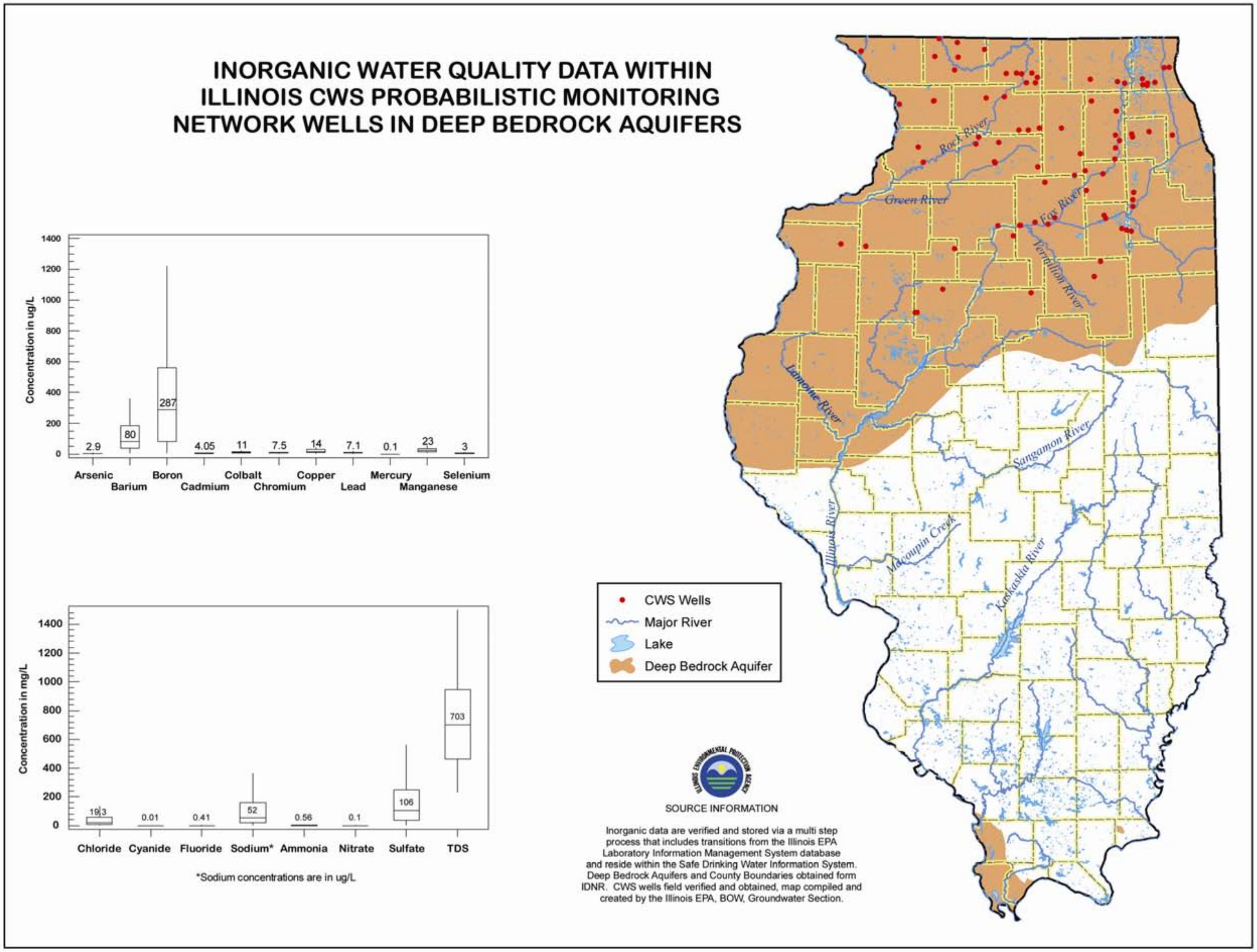


Figure C-16c. Inorganic Water Quality Data in Illinois Principal Aquifers



Northeastern Illinois Chlorides

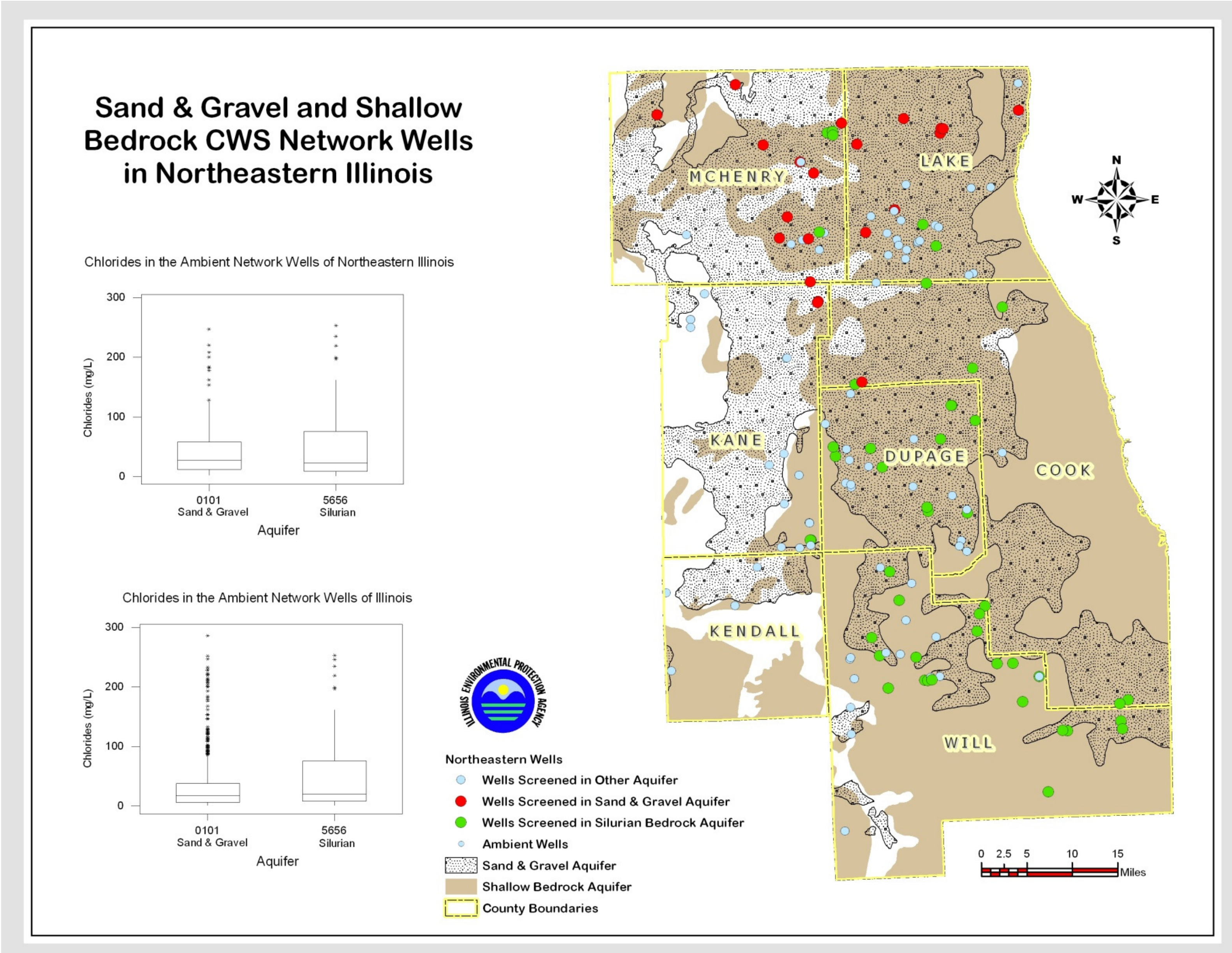
In addition to the state wide evaluation of inorganic compounds in the CWS probabilistic network presented in the maps above, Illinois EPA specifically analyzed the concentrations of chlorides in the network wells utilizing sand and gravel and shallow bedrock (i.e., Silurian Dolomite) aquifers in N.E. IL (Figure C-17). Table C-4 provides a comparison of the statistical values between the N.E. IL wells and the state wide CWS Network wells:

Table C-4. Northeastern Illinois and CWS Network Well statistics

Aquifer Type	Number of samples (N)	Mean	Median	Min	Max	Q3
Sand and Gravel State wide	1258	31.73	17.58	0.50	978.00	37.90
Sand and Gravel N.E. Ill	135	51.41	27.00	1.30	928.00	58.20
Aquifer Type	Number of samples (N)	Mean	Median	Min	Max	Q3
Silurian State wide	334	57.19	20.15	1.00	843.00	75.58
Silurian N.E. IL	282	46.75	22.00	1.00	451.00	75.58

The 75th quartile value of the sand and gravel CWS probabilistic network wells in N.E. IL show a 35 percent increase in concentration compared to the state wide ambient value in the CWS probabilistic network. In addition, as suspected there are not significant differences between network wells in the Silurian and N.E. IL since the majority of the Silurian Dolomite aquifer is in N.E. IL.

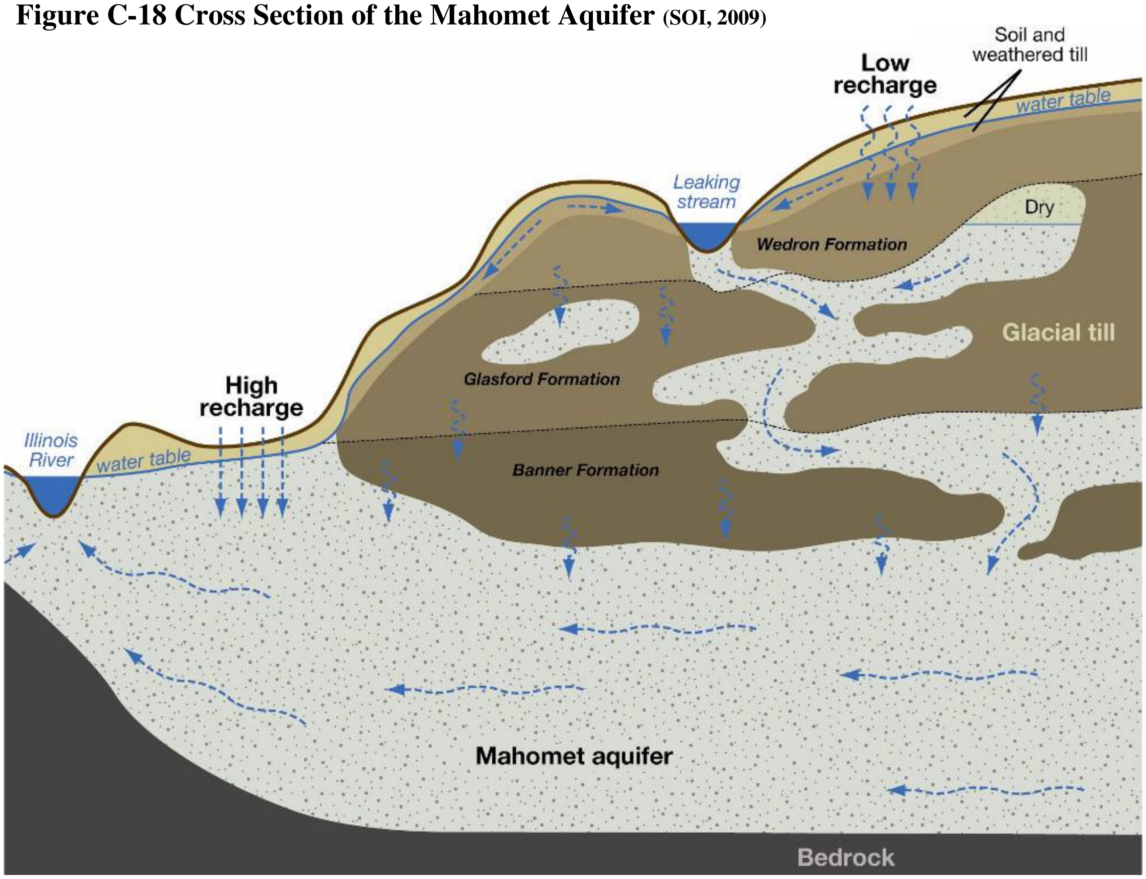
Figure C-17. Northeastern Illinois CWS Network Wells



The Mahomet Aquifer

Illinois EPA has done a focused evaluation the CWS probabilistic network wells screened in the Mahomet Aquifer. The aquifer occupies a portion of the Teays bedrock valley extending across east-central Illinois from the Indiana border near Hoopeston to the Illinois River near. The Mahomet Aquifer is comprised of various unconsolidated geologic materials as illustrated in the following conceptual model of the hydrogeology (Figure C-18)

Figure C-18 Cross Section of the Mahomet Aquifer **(SOI, 2009)**



Arsenic is a naturally occurring inorganic compound that has been the subject of numerous research projects and investigations in the Mahomet Aquifer. The concentration of arsenic in the CWS probabilistic network wells screened in different hydrogeologic units in the Mahomet-Teays Bedrock Valley are shown in the box plots in Figure C-19.

Further, all of the other inorganic compounds present in the Ambient Network of CWS well screened in the respective geologic formations in the Mahomet-Teays are presented in Figures C-20(a-e).

Figure C-19 Arsenic Levels in the Mahomet Aquifer

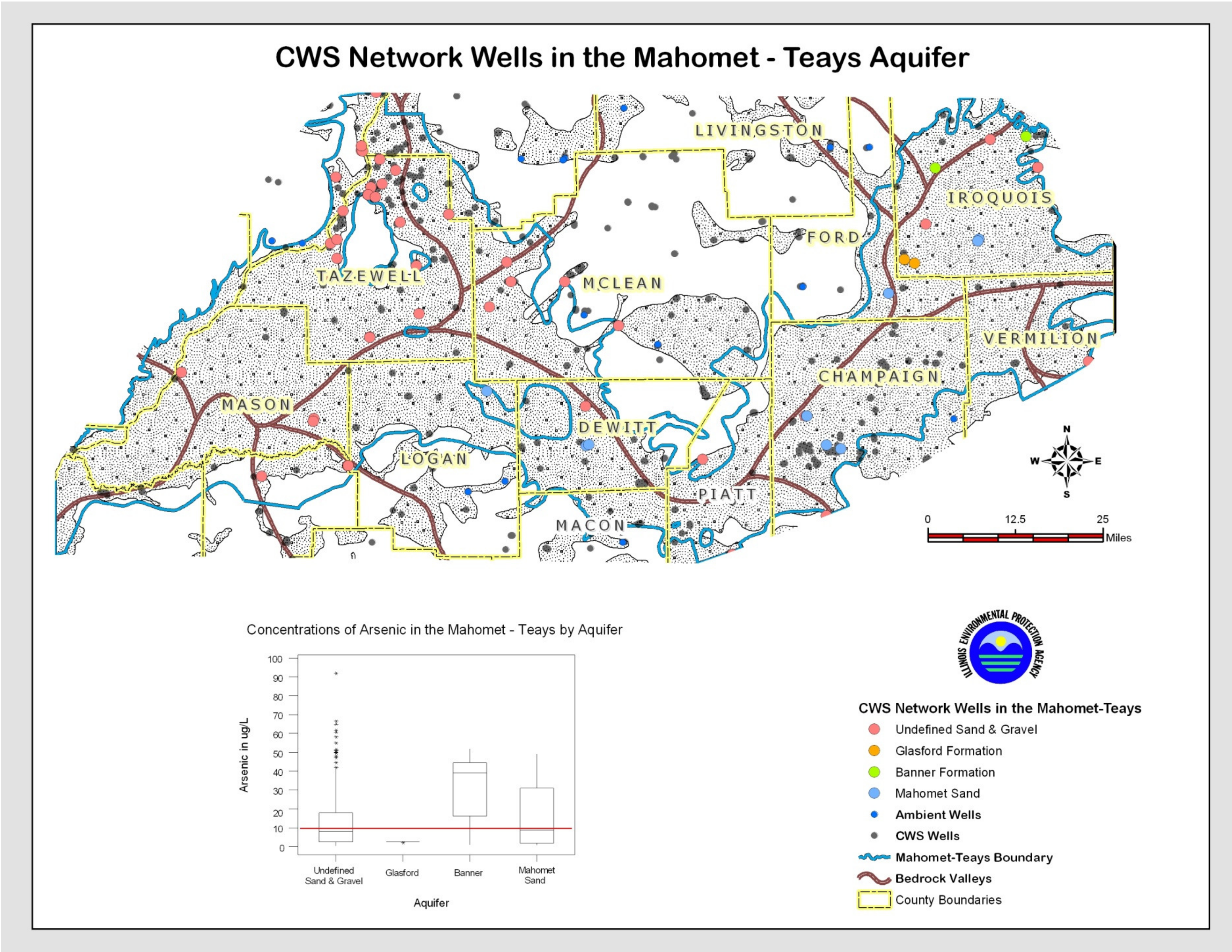


Figure C-20a Iron and TDS Levels in the formations of the Mahomet Aquifer

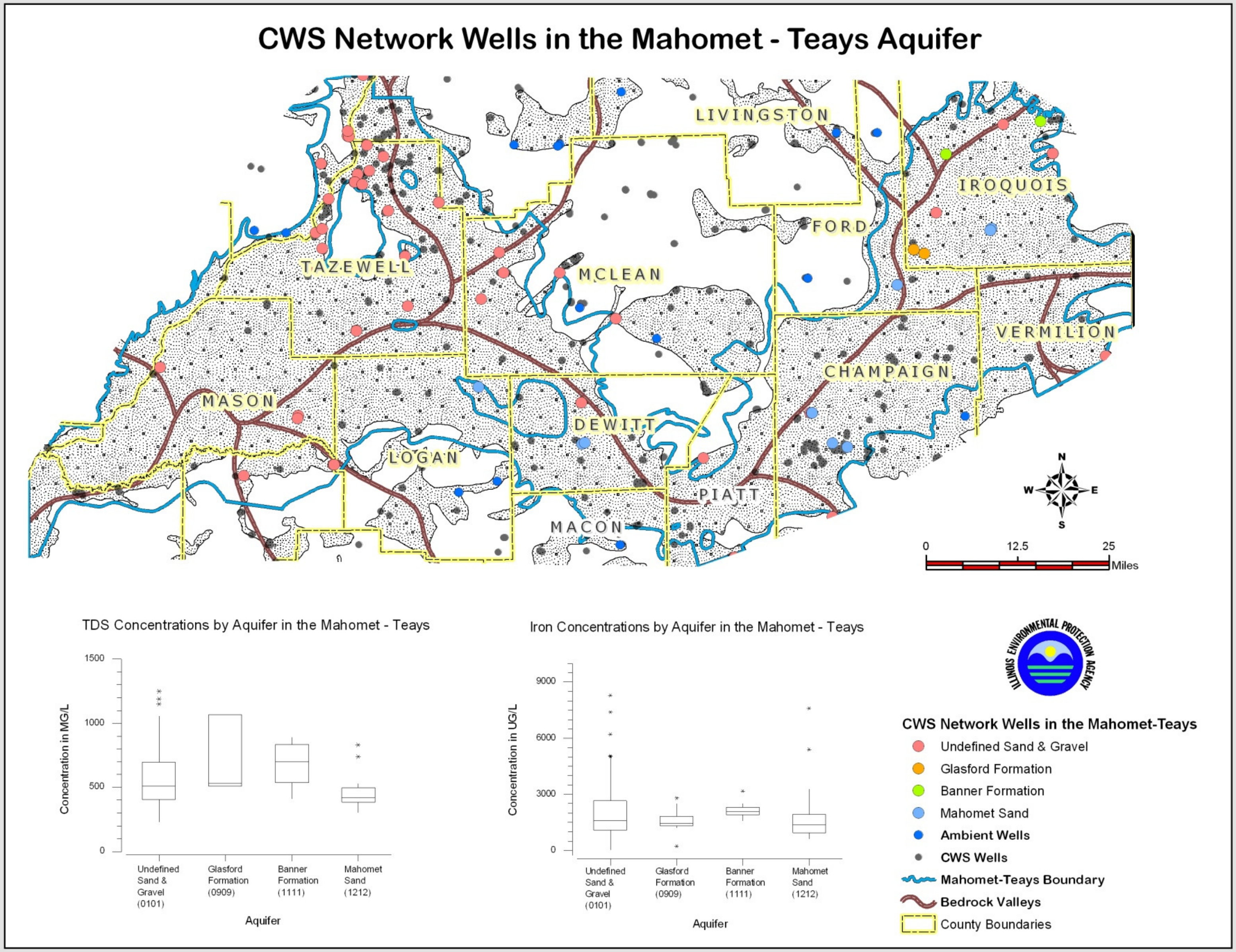


Figure C-20b IOC Levels in the Undefined Sand & Gravel of the Mahomet Aquifer

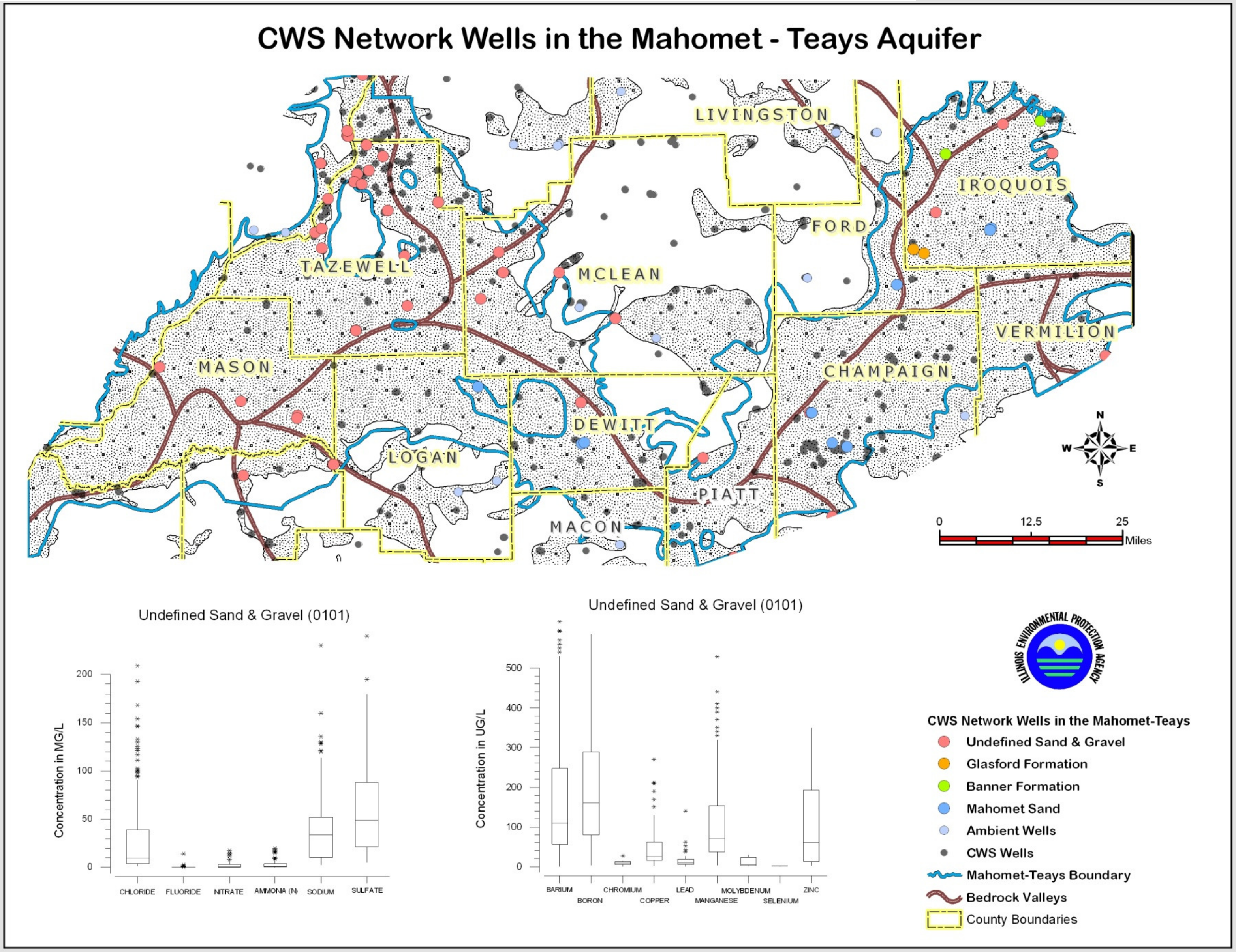


Figure C-20c IOC Levels in the Glasford Formation of the Mahomet Aquifer

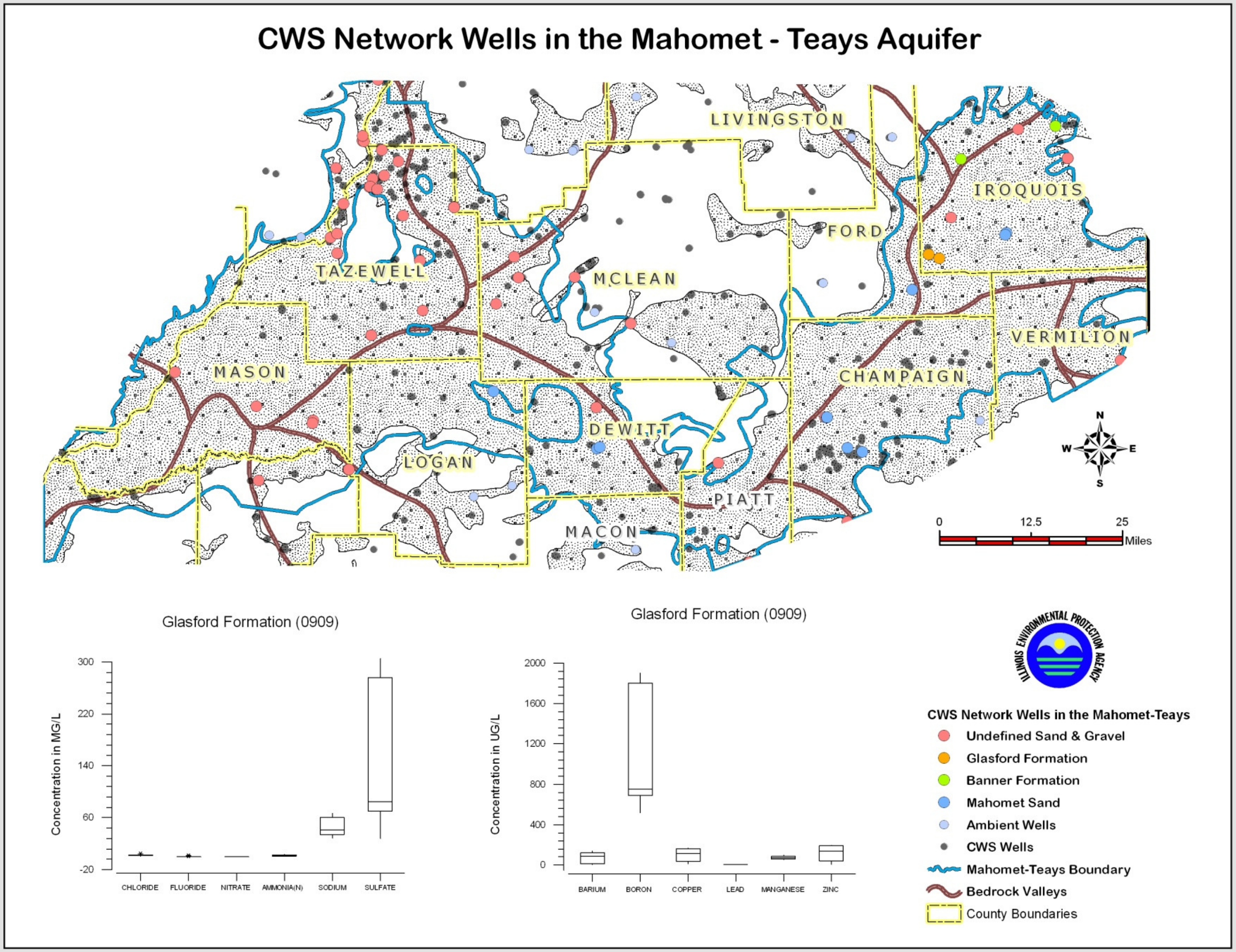


Figure C-20d IOC Levels in the Banner Formation of the Mahomet Aquifer

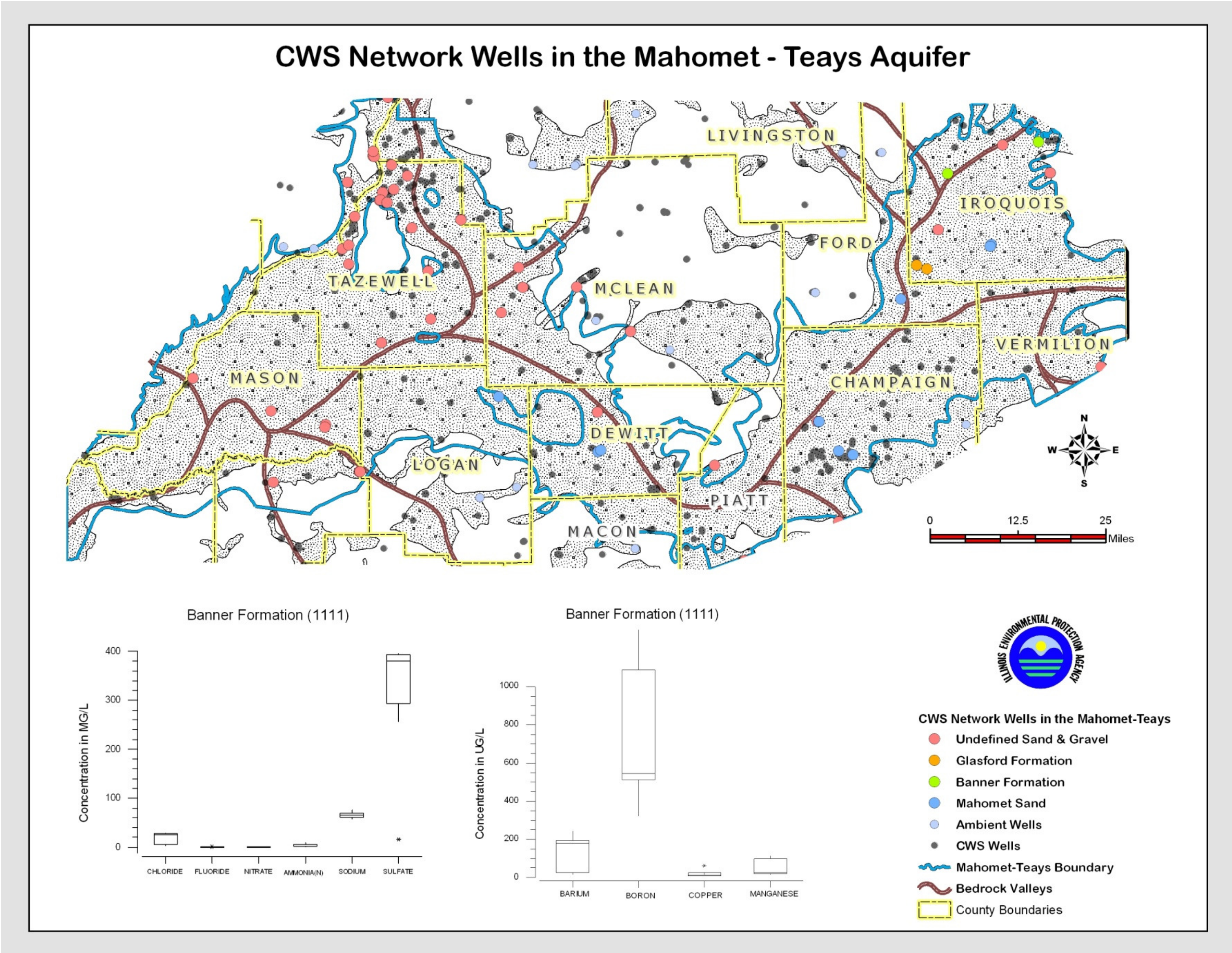
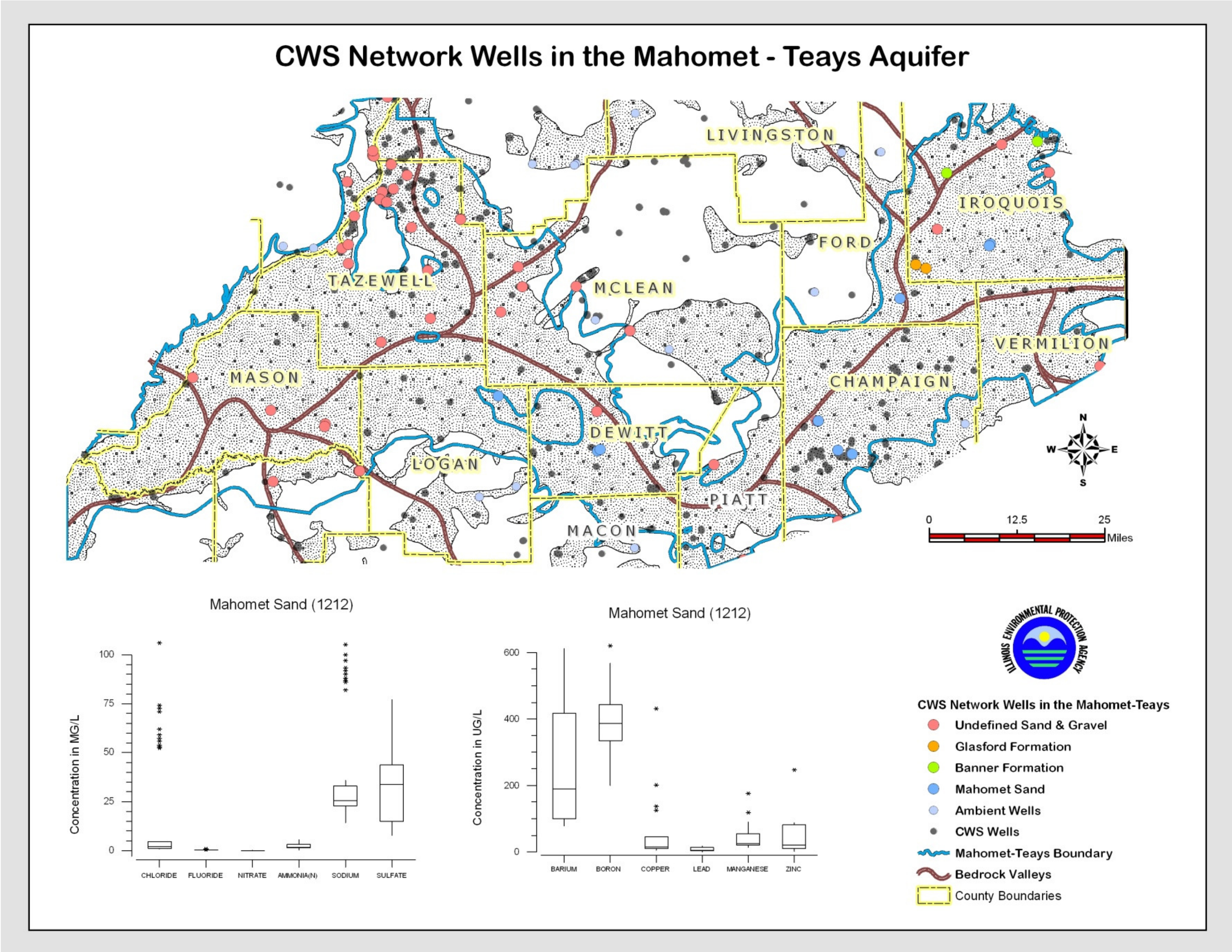


Figure C-20e IOC Levels in the Mahomet Sand of the Mahomet Aquifer

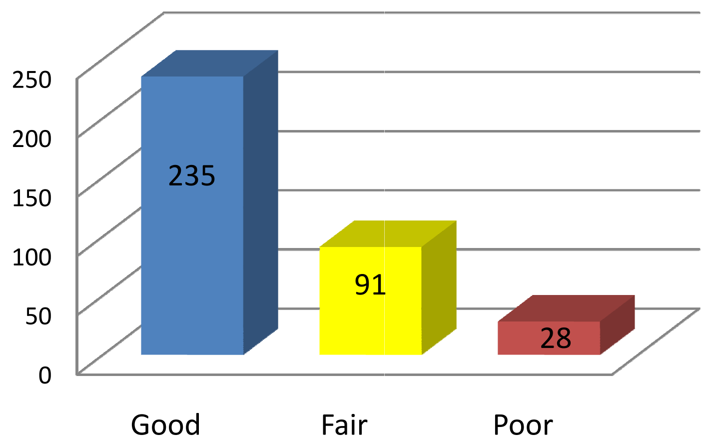


The Illinois EPA included the data on nitrate above from the CWS Ambient Network wells screened in the Glasford Formation and the data on nitrate and sulfate above from the CWS Ambient Network wells screened in the Banner Formation but the number of these sample sets may not be statistically representative.

C-5. Use Support Evaluation

Figure C-21 and C-22 summarize use support in the State of Illinois as determined by measurements in the probabilistic network of CWS wells. The results show that of the 354 CWS probabilistic network wells:

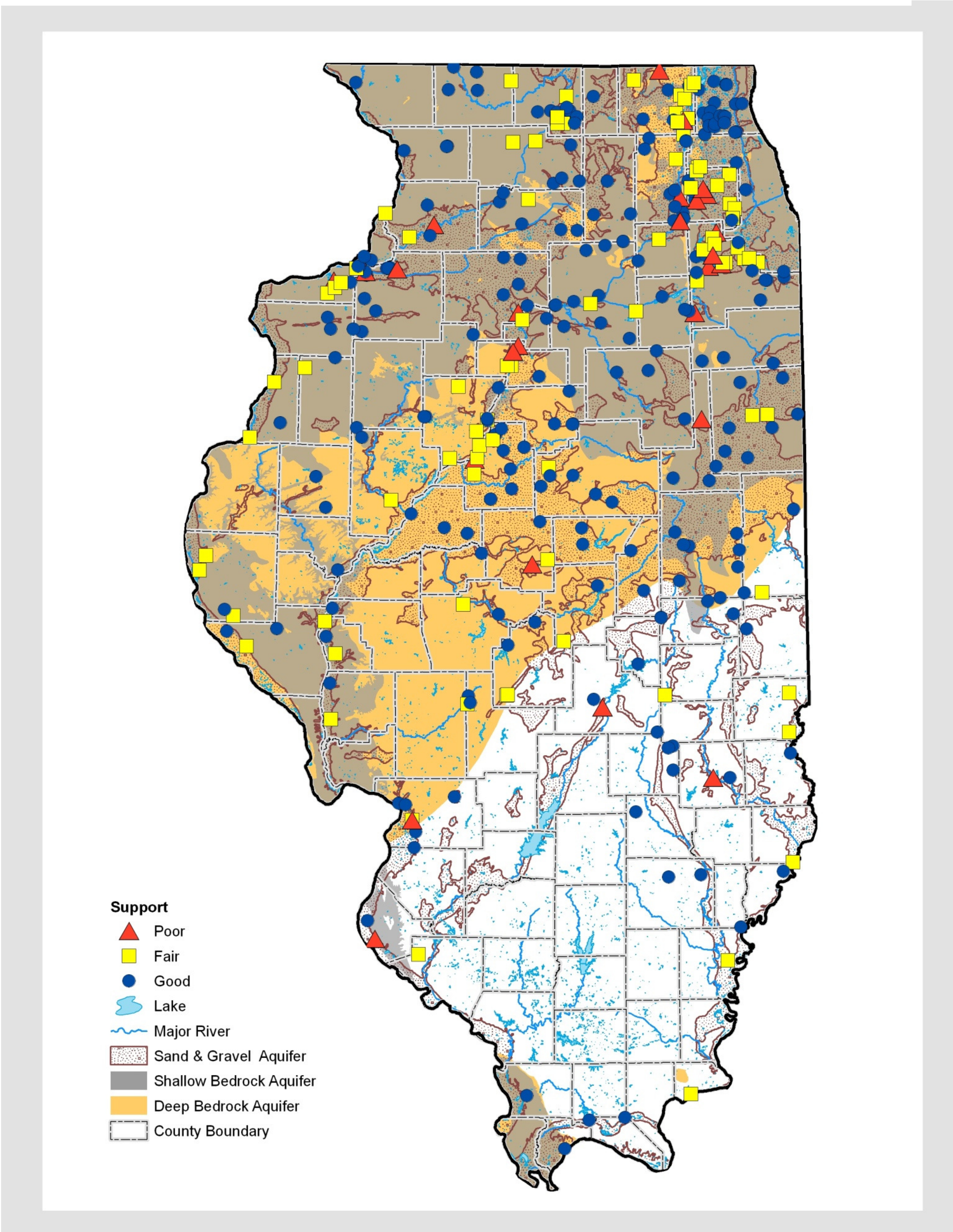
n CWS Network Wells



- **28 (8 percent (%))** were determined to be Not Supporting ("poor") due to the elevated levels of nitrate and VOCs that include trichloroethylene and tetrachloroethylene. All of these wells draw their water from shallow sand & gravel aquifers, except for one, which is using a deep well from the Cambrian/Ordovician bedrock aquifer in the northern part of the state);
- **90 (25%)** were determined to be Not Supporting ("fair") due to statistically significant increases chloride (Cl-) above background, detections of VOCs, nitrate (total nitrogen) greater than 3 mg/l, but have not exceeded the health-based Groundwater Quality Standards (GWQS); and
- **236 (67 %)** were determined to be Fully Supporting ("good"), which show no detections of any of the above analytes.

Trend analyses for VOC's also shows that there continues to be a significant increase in the number of CWS wells with VOC detections, despite the fact that the number of CWS analyzed for VOC's over the same time period declined, and the detection limit remained constant. The 75the quartile value of the sand and gravel CWS probabilistic network wells in N.E. IL show a 35 percent increase in concentration of chlorides compared to the state wide ambient value in the CWS probabilistic network screened in sand and gravel aquifers.

Figure C-22. Use Support for the CWS Ambient Network Wells within Illinois' Principal Aquifers

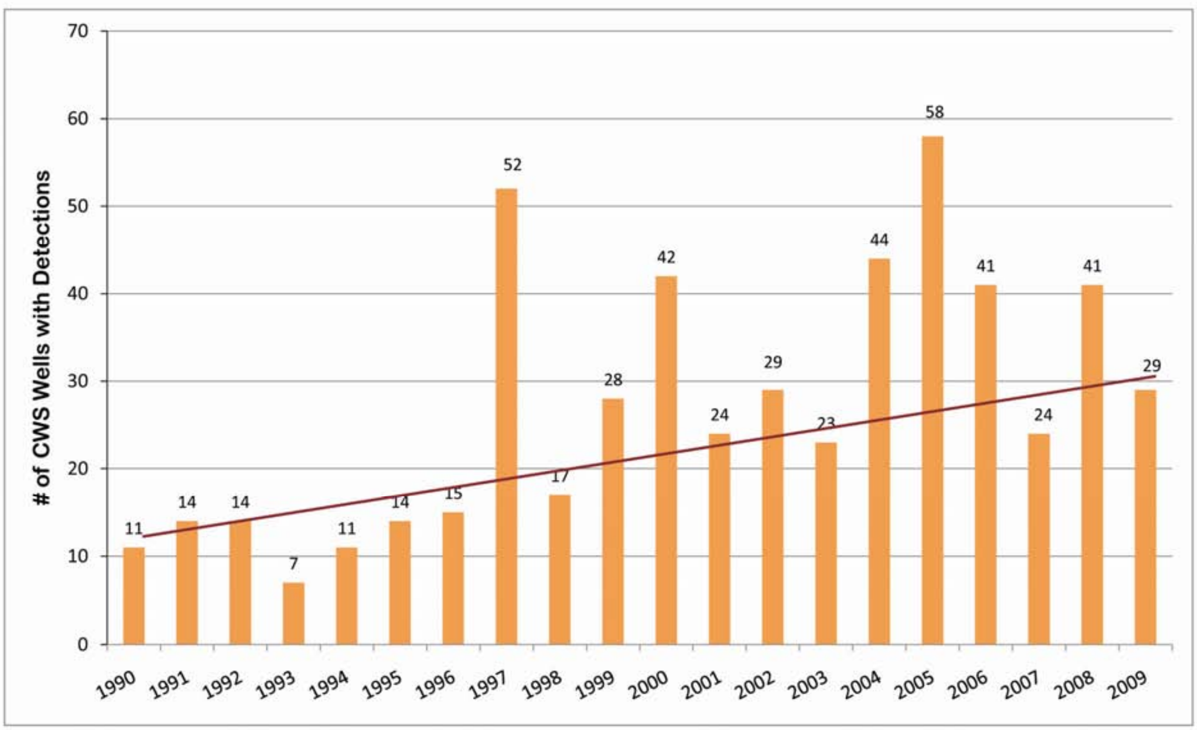


C-6. Potential Causes of Impairment

VOCs in CWS Wells

As previously stated, when possible, assessments of groundwater overall use support is based upon Illinois' GWQS within the probabilistic network of CWS wells. Generally, a detection of an organic contaminant above the laboratory practical quantification limit or the detection of an inorganic constituent above the naturally occurring background level in a CWS well is considered a cause of less than full use support. Detections of VOCs in CWS wells on a statewide basis have fluctuated since 1990 showing the lowest concentration of wells with detections in the early nineties (During the mid-nineties VOC detections exceeded the GWQS a total of five times. However, the findings of the first long term trend analysis conducted for all of the CWS wells (not just the fixed station network wells) monitored for VOC results. The entire data set (1990 to the present) was analyzed and the results are shown in Figure C-23.

Figure C-23. Long-term VOC trend from the full data set



VOCs analyses of data collected from 1990 to the present shows a statistically significant increasing trend of CWS wells with VOC detections per year. The causal data also show total xylenes and 1,1,1- trichloroethane as the top ranked VOCs detected

Chlorides in CWS Wells

The 75the quartile value of the sand and gravel CWS probabilistic network wells in N.E. IL show a 35 percent increase in concentration of chlorides compared to the state wide ambient value in the CWS probabilistic network screened in sand and gravel aquifers. Further, ISWS research determined that: approximately 16% of the samples collected from CWS wells in northeastern Illinois in the 1990s had Cl- concentrations greater than 100 mg/L; median values were less than 10 mg/L prior to 1960, before extensive road salting (Kelly and Wilson, 2004).

Groundwater Degradation

Illinois groundwater resources are being degraded. Degradation occurs based on the potential or actual diminishment of the beneficial use of the resource. When contaminant levels are detected (caused or allowed) or predicted (threat) to be above concentrations that cannot be removed via ordinary treatment techniques, applied by the owner of a private drinking water system well, potential or actual diminishment occurs. At a minimum private well treatment techniques consist of chlorination of the raw source water prior to drinking. This groundwater degradation is exacerbated due to the predicted shortages of drinking water sources in the N. E. IL.

It should be noted that groundwater that is consumed via a CWS has to be treated before it is delivered to the users. This treatment often includes methods for removing various contaminants, including the ones previously mentioned in this section. For more information of waters that are being consumed from CWSs, the public can contact their local CWS or the applicable *Consumer Confidence Report* at http://epadata.epa.state.il.us/water/bowccr/ccrselect.aspx

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