America's Ground Water Dependence:

Trends and Forecasts in a Changing Marketplace

national ground water association®

Today's Presentation

I. The hidden water resource.

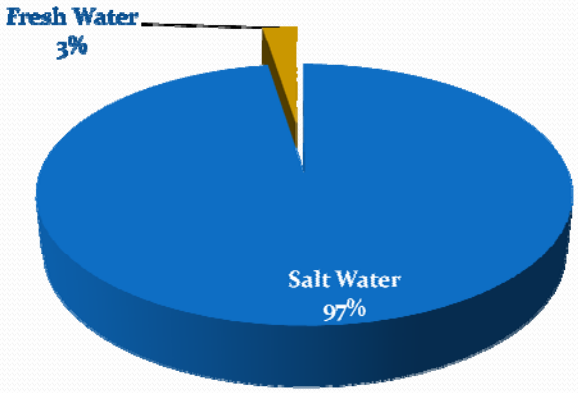
II. Why is ground water so useful?

III. Is ground water widely used?

IV. Issues affecting ground water.

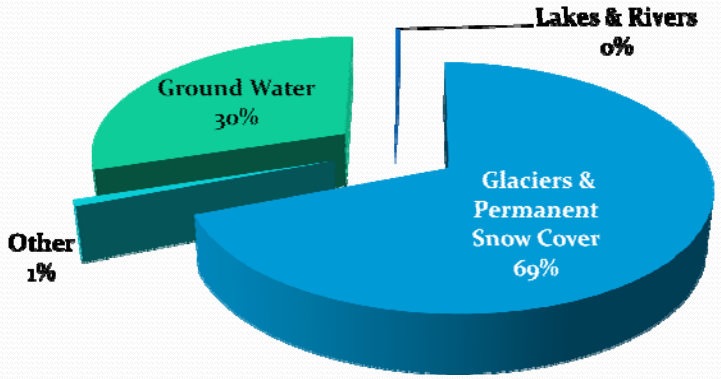
I. The Hidden Water Resource

The World's Water



Source: United Nations Educational, Scientific, and Cultural Organization

Total Global Fresh Water by Location (millions of cubic kilometers)



Source: United Nations Educational, Scientific, and Cultural Organization

408

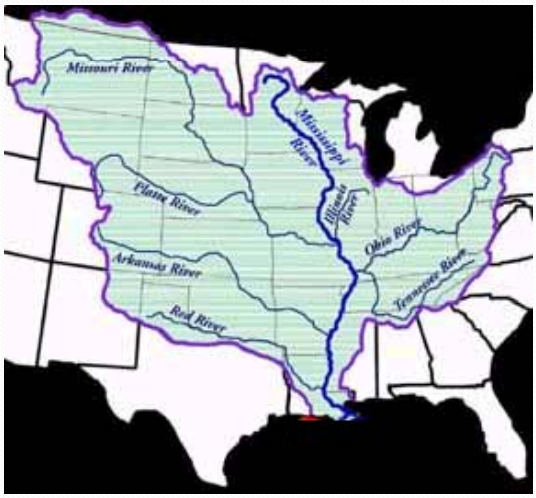
Billion Gallons / Day

U.S. Ground Water Usage

- Average Annual Ground Water Recharge
  - 1,514.0 km^3
  - 5,439 m^3/capita
- Average Annual Ground Water Withdrawals
  - 109.8 km^3
  - 432.3 m^3/capita
    - 7.3 percent of average annual recharge

Source: *World Resources: 2000-2001*

200 Years of Mississippi River Flow to the Gulf of Mexico



II. Why is ground water so useful?

Convenience

- Natural underground reservoirs
- Enormous storage capacity

Contamination Barrier

- Natural protection from contamination
- Untreated ground water usually cleaner and safer than untreated surface water

Expense

- Relatively easy and inexpensive to use
- Bring online in phases
- Low capital outlay
- Wells close to where the water is needed

Localized Stewardship

- Relatively easy to develop
- Individuals can construct, operate, and control their own supply
- Supply often on landowner's property

III. Is ground water widely used?

International Markets

UNESCO estimates that globally ground water provides about 50 percent of potable water supplies; 40 percent of self-supplied industrial water; and 20 percent of irrigated agriculture.

Ground water directly supplies about 80 percent of domestic water supply in India's rural areas; 2.8 to 3 million hand pump boreholes have been constructed there over the past 30-year period;

More than 400 million rural people in Sub-Sahara Africa are sustained by ground water and about 75 percent of improved village and small town water supplies in the region are ground water supplied. Some estimate that more than 60 percent of Algeria's population depends upon ground water, 95 percent of Libya's, 80 percent in Mauritania, and 70 percent in Nigeria.

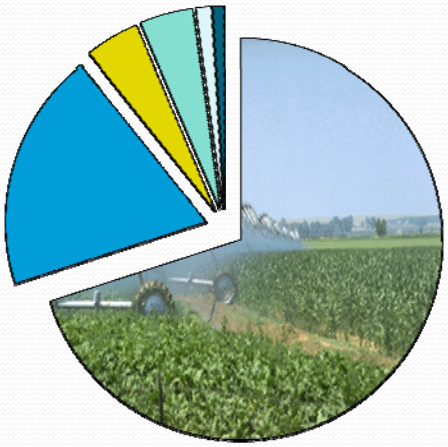
Other National Well Markets

- India -- 12.3 million
- China -- 3.4 million
- Germany -- 500,000
- S. Africa -- 500,000
- Taiwan -- 37,100
- Mongolia -- 27,000
- Ireland -- 10,000
- Botswana -- 7,500
- Costa Rica -- 5,000

83.3 Billion Gallons per Day

Public:

- 15.98 bgd
- 19% of all ground water use

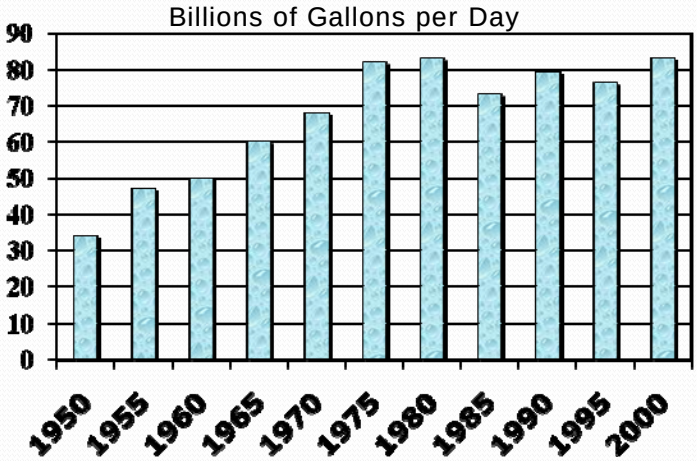


Irrigation:

- 58.04 bgd
- 70% of all ground water use

Source: U.S. Geological Survey's *Estimated Use of Water: 2000*, March 2004

Total Fresh Ground Water Withdrawals: 1950 - 2000



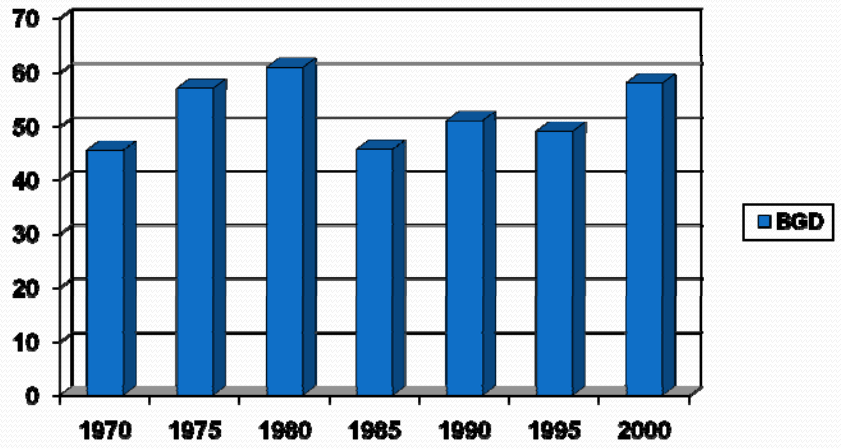
Source: U.S. Geological Survey's *Estimated Use of Water: 2000*, March 2004

23% increase since 1970

Top 5 States: Ground Water

Source: U.S. Geological Survey's *Estimated Use of Water: 2000*, March 2004

Ground Water for Irrigation



Source: U.S. Geological Survey, Estimates of Water Use

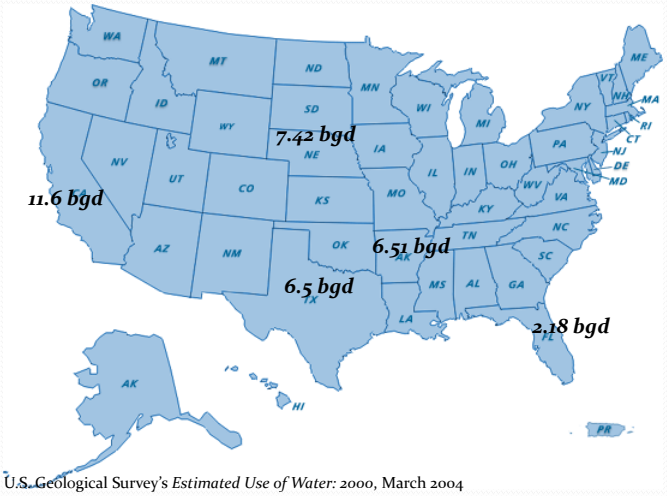
27.5% increase in ground water for irrigation since 1970

Irrigation Wells

- **1998**
  - 374,956 wells
  - 238 feet avg. well depth
  - 148 feet avg. pumping depth
  - 844 gpm avg. pump capacity
  - 32,222,665 acres irrigated by wells
  - 43,838,526 acre feet of ground water used
- **2003**
  - 379,674 wells
  - 238 feet avg. well depth
  - 158 feet avg. pumping depth
  - 819 gpm avg. pump capacity
  - 32,342,820 acres irrigated by wells
  - 43,473,978 acre feet of ground water used

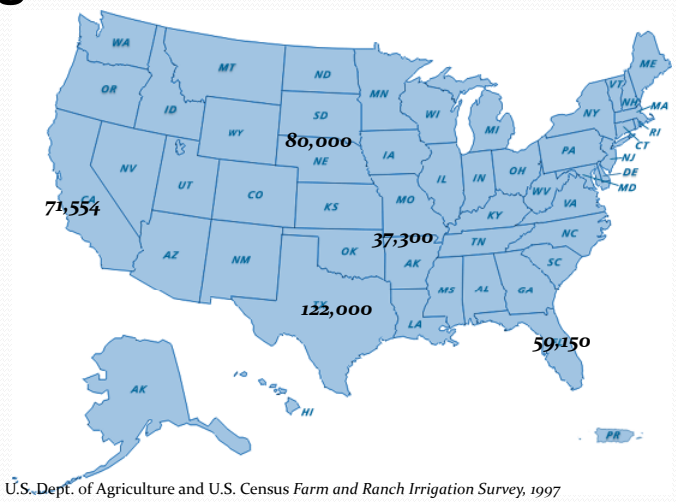
Source: U.S. Dept. of Agriculture and U.S. Census *Farm and Ranch Irrigation Survey, 2003*

Top 5 States: Ground Water Use for Irrigation



Source: U.S. Geological Survey's *Estimated Use of Water: 2000*, March 2004

Top 5 States: Ground Water for Irrigation - Wells

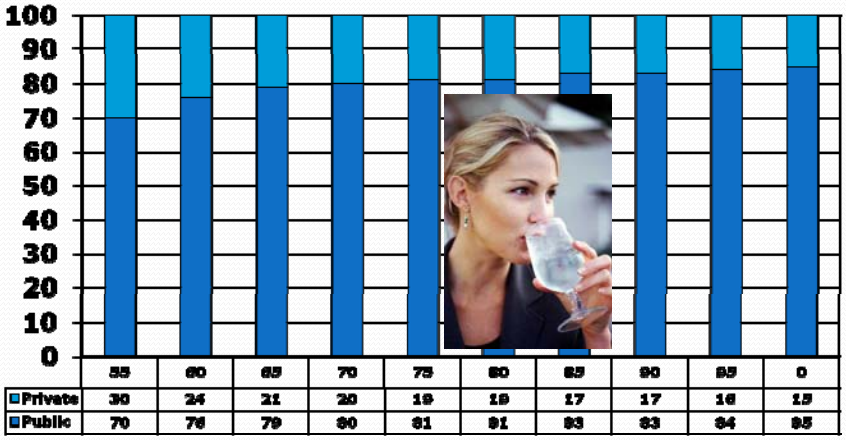


Source: U.S. Dept. of Agriculture and U.S. Census *Farm and Ranch Irrigation Survey, 1997*

Ogallala Aquifer

30% of U.S. ground water used for irrigation is pumped from the Ogallala Aquifer

U.S. Drinking Water Populations: 1955 - 2000



	55	60	65	70	75	80	85	90	95	0
Private	30	24	21	20	19	19	17	17	16	15
Public	70	76	79	80	81	81	83	83	84	85

Source: U.S. Geological Survey, U.S. EPA

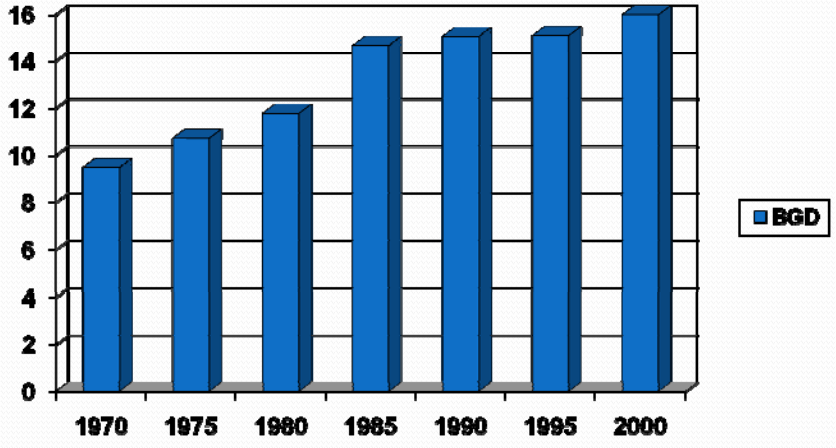
32 percent of U.S. population served by community water systems using ground water sources

Source: U.S. EPA, Drinking Water and Ground Water Statistics, 2003

15 percent of U.S. population served by private wells

Source: U.S. Geological Survey, 2003

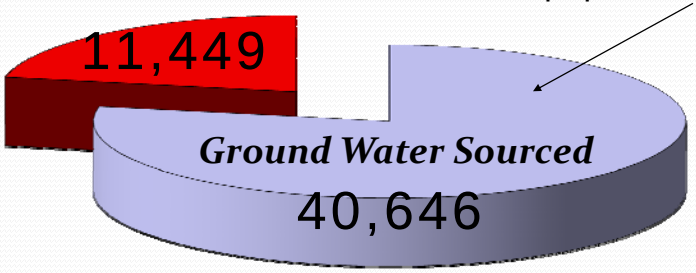
Ground Water for Public Supply



Source: U.S. Geological Survey, Estimates of Water Use

Community Water Systems: 2007

Ground water sourced systems serve 90,549,995 people or 32% of population

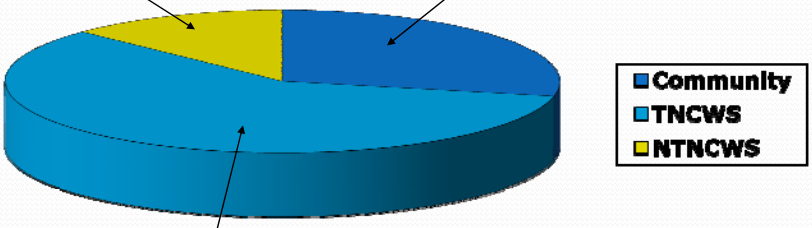


Source: U.S. EPA's *Drinking Water Factoids: 2007*, March 2008

2007 Public Water Systems Using Ground Water

18,151 serving 5.5 million people

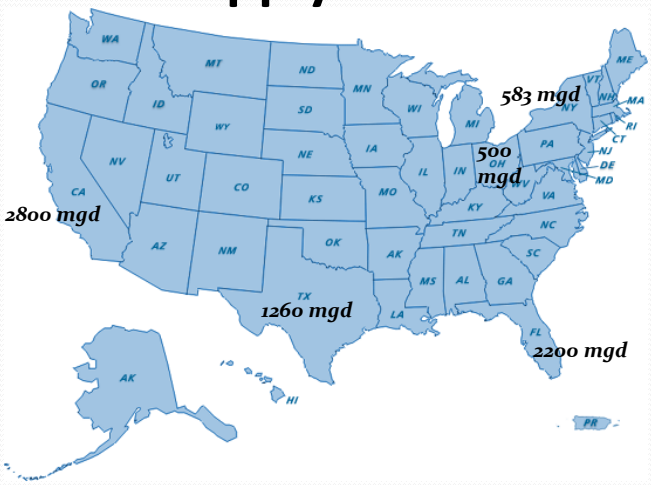
40,646serving 90.5 million people



82,851 serving 11.1million people

Source: U.S. EPA's *Drinking Water Factoids: 2007*, March 2008

Top 5 States: Ground Water Use for Public Supply



Source: U.S. Geological Survey's *Estimated Use of Water: 2000*, March 2004

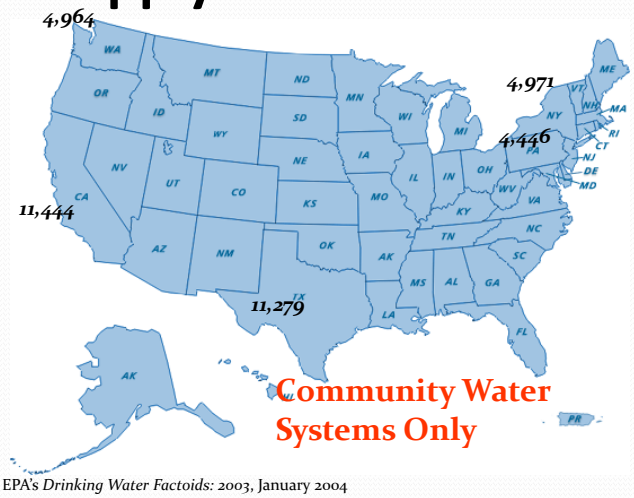
Daily Value of Ground Water Delivered by Public Systems

- 16 bgd of ground water used by public water systems
- Price per gallon of $0.0024227 (U.S. Midwest average for both surface water and ground water systems)
- Total daily value of $38.76 million
- $14.15 billion annually

Cost information from *2004 Water and Wastewater Rate Survey*, American Water Works Association and Raftelis Financial Consulting

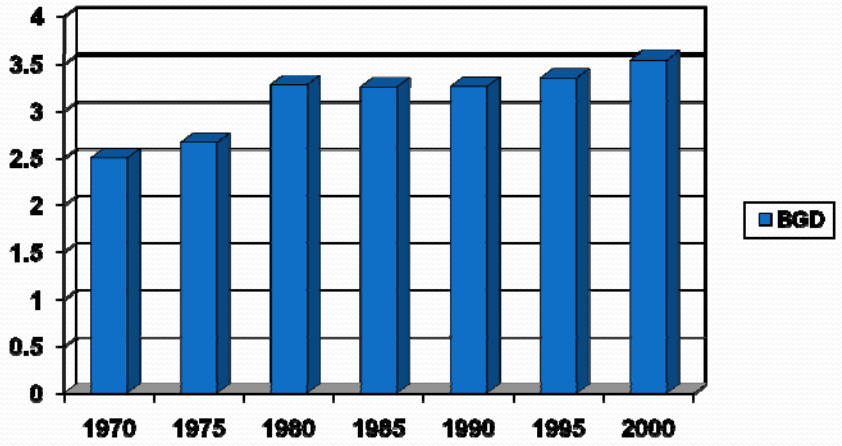
49% increase in ground water for public supply since 1970

Top 5 States: Ground Water for Public Supply - Wells



Source: U.S. EPA's *Drinking Water Factoids: 2003*, January 2004

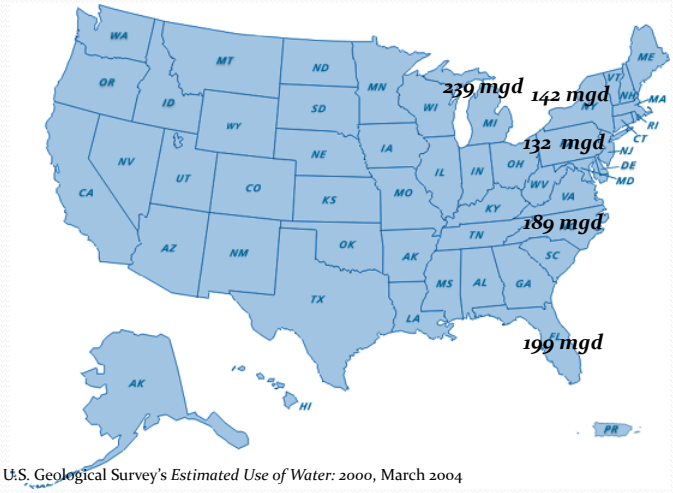
Ground Water for Private Supply



Source: U.S. Geological Survey, Estimates of Water Use

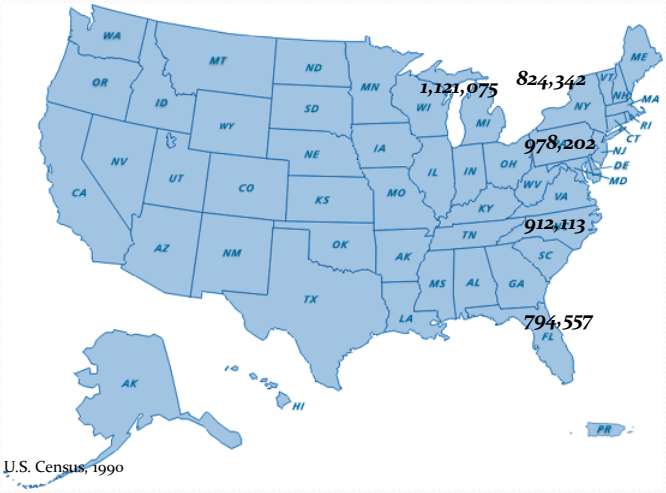
41.5% increase since 1970

Top 5 States: Ground Water Use for Domestic Supply



Source: U.S. Geological Survey's *Estimated Use of Water: 2000*, March 2004

Top 5 States: Ground Water for Domestic Supply - Wells



Source: U.S. Census, 1990

Daily Value of Ground Water Delivered by Household Well Systems

- 3.5 bgd of ground water used by public water systems
- Price per gallon of $0.0024227 (Midwest average for both surface water and ground water systems)
- Total daily value of $8.5 million
- $3.09 billion annually

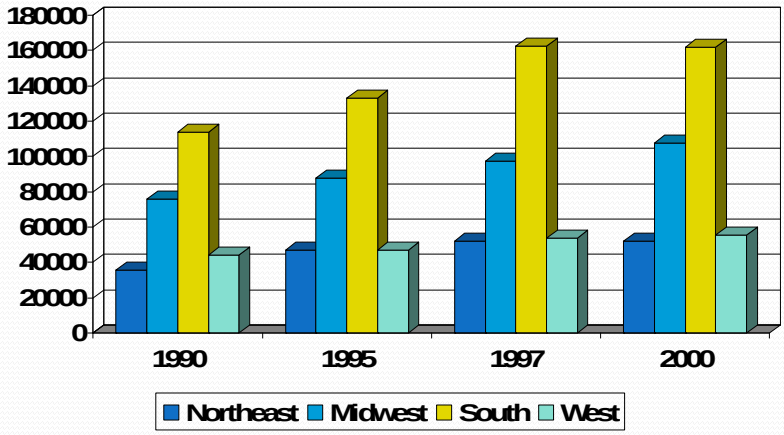
Cost information from *2004 Water and Wastewater Rate Survey*, American Water Works Association and Raftelis Financial Consulting

Ground Water Use from Private Household Wells

- 12.891 million households on drilled wells
- 917,000 seasonal households
- 11,055,000 year-round
- 9,608,000 owner
- 1,447 renter
- 15 percent of U.S. population

Source: U.S. Census

Household Wells: 1990 - 2000



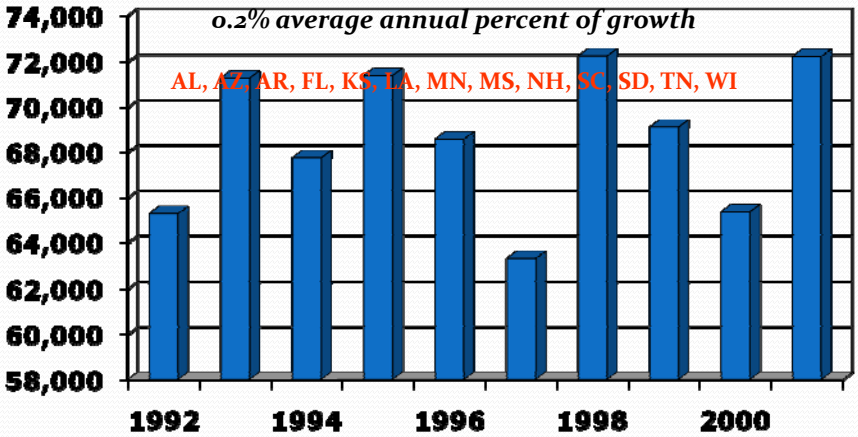
Source: *Trends in the United States Marketplace for Individually Owned Private Water Wells*, National Ground Water Research and Educational Foundation, 1999

U.S. Census: Households Served by Private Wells

1970	*1980*	*1990*
Michigan	**Michigan**	**Michigan**
737,245	934,184	1,121,075
N. Carolina	**N. Carolina**	**Penn.**
659,159	821,995	978,202
Penn.	**Penn.**	**N. Carolina**
613,197	800,292	912,113
Ohio	**Ohio**	**New York**
612,505	692,062	824,342
New York	**New York**	**Florida**
505,154	659,973	794,557

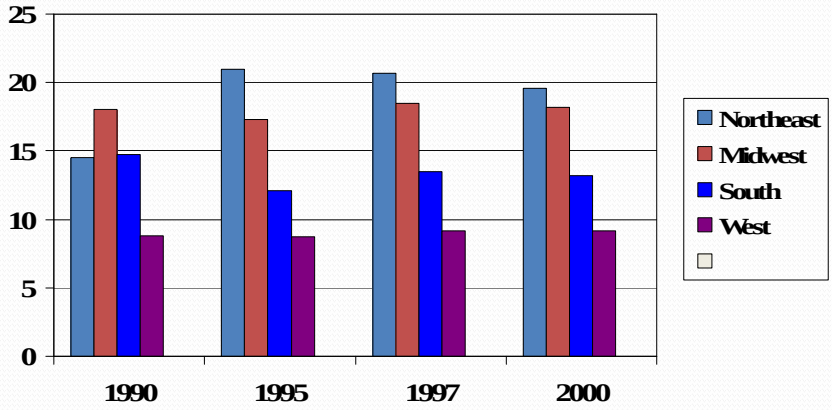
Household Wells

Same 13 states each year. Reporting lags in later years which may artificially reduce the actual construction volume illustrated.



Source: Annual NGWA Survey of Water Well Construction

Well Share of Private Housing Starts: 1990 - 2000



Source: *Trends in the United States Marketplace for Individually Owned Private Water Wells*, National Ground Water Educational Foundation, 1999

Households with Wells, by Region: 2003 & 2005

Region/Yr.	2003	2005	Value Change	% of Change
Northeast	3,072,000	3,079,000	+7,000	0.22%
Midwest	3,864,000	4,008,000	+144,000	3.73%
South	4,774,000	4,648,000	-126,000	-2.64%
West	1,387,000	1,396,000	+9,000	0.65%
NATION	**13,097,000**	**13,131,000**	**34,000**	**0.26%**

Source: American Housing Survey, 2003 & 2005, U.S. Census

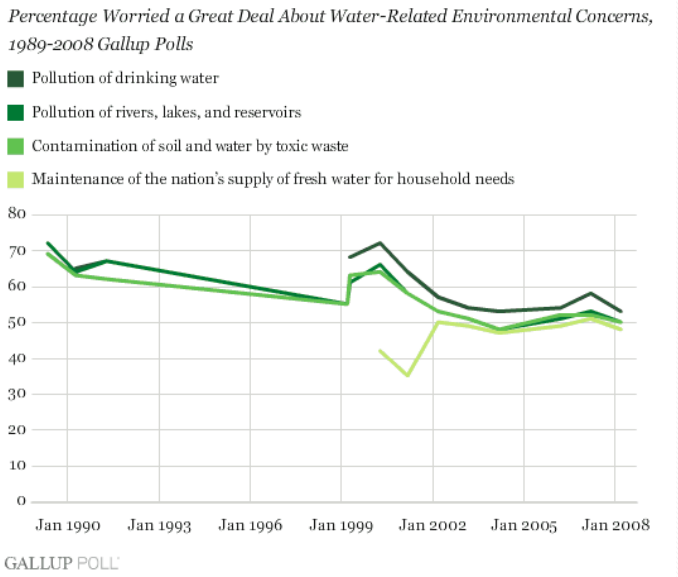
IV. Issues affecting ground water.

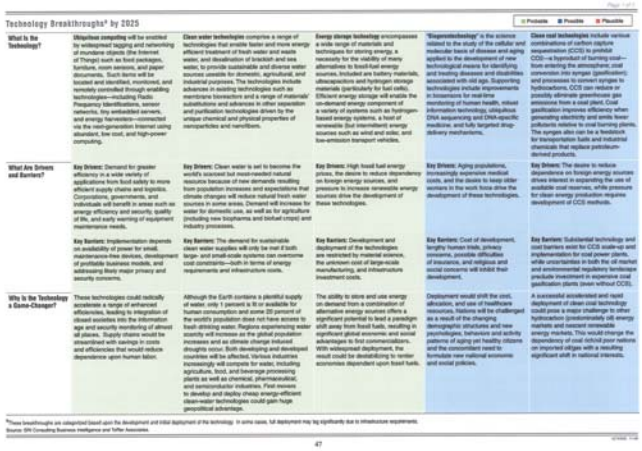
Water Themes for the 21st Century

1. Water for Food Production and Rural Development
2. Water for Cities and Urban Development
3. From Use to Management
4. From Development to Protection

Source: As identified by British Geological Survey hydrogeologist Stephen Foster

Gallup's Environmental Poll - 2008





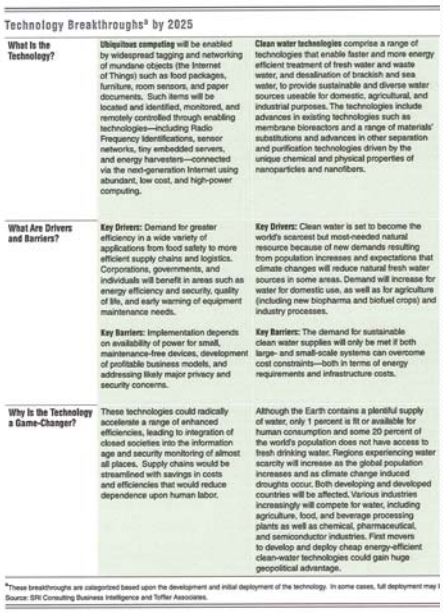
Technology Breakthroughs[a] by 2025

What Is the Technology?	**Ubiquitous computing** will be enabled by widespread tagging and networking of mundane objects (the Internet of Things) such as food packages, furniture, room sensors, and paper documents. Such items will be located and identified, monitored, and remotely controlled through enabling technologies—including Radio Frequency Identifications, sensor networks, tiny embedded servers, and energy harvesters—connected via the next-generation Internet using abundant, low cost, and high-power computing.	**Clean water technologies** comprise a range of technologies that enable faster and more energy efficient treatment of fresh water and waste water, and desalination of brackish and sea water, to provide sustainable and diverse water sources useable for domestic, agricultural, and industrial purposes. The technologies include advances in existing technologies such as membrane bioreactors and a range of materials' substitutions and advances in other separation and purification technologies driven by the unique chemical and physical properties of nanoparticles and nanofibers.	**Energy storage technology** encompasses a wide range of materials and techniques for storing energy, a necessity for the viability of many alternatives to fossil-fuel energy sources. Included are battery materials, ultracapacitors and hydrogen storage materials (particularly for fuel cells). Efficient energy storage will enable the on-demand energy component of a variety of systems such as hydrogen-based energy systems, a host of renewable (but intermittent) energy sources such as wind and solar, and low-emission transport vehicles.	**"Regenerotechnology"** is the science related to the study of the cellular and molecular basis of disease and aging applied to the development of new technological means for identifying and treating diseases and disabilities associated with old age. Supporting technologies include improvements in biosensors for real-time monitoring of human health, robust information technology, ubiquitous DNA sequencing and DNA-specific medicine, and fully targeted drug-delivery mechanisms.	**Clean coal technologies** include various combinations of carbon capture sequestration (CCS) to prohibit CO_2—a byproduct of burning coal—from entering the atmosphere; coal conversion into syngas (gasification); and processes to convert syngas to hydrocarbons. CCS can reduce or possibly eliminate greenhouse gas emissions from a coal plant. Coal gasification improves efficiency when generating electricity and emits fewer pollutants relative to coal burning plants. The syngas also can be a feedstock for transportation fuels and industrial chemicals that replace petroleum-derived products.
What Are Drivers and Barriers?	**Key Drivers:** Demand for greater efficiency in a wide variety of applications from food safety to more efficient supply chains and logistics. Corporations, governments, and individuals will benefit in areas such as energy efficiency and security, quality of life, and early warning of equipment maintenance needs.	**Key Drivers:** Clean water is set to become the world's scarcest but most-needed natural resource because of new demands resulting from population increases and expectations that climate changes will reduce natural fresh water sources in some areas. Demand will increase for water for domestic use, as well as for agriculture (including new biopharma and biofuel crops) and industry processes.	**Key Drivers:** High fossil fuel energy prices, the desire to reduce dependency on foreign energy sources, and pressure to increase renewable energy sources drive the development of these technologies.	**Key Drivers:** Aging populations, increasingly expensive medical costs, and the desire to keep older workers in the work force drive the development of these technologies.	**Key Drivers:** The desire to reduce dependence on foreign energy sources drives interest in expanding the use of available coal reserves, while pressure for clean energy production requires development of CCS methods.
	Key Barriers: Implementation depends on availability of power for small, maintenance-free devices, development of profitable business models, and addressing likely major privacy and security concerns.	**Key Barriers:** The demand for sustainable clean water supplies will only be met if both large- and small-scale systems can overcome cost constraints—both in terms of energy requirements and infrastructure costs.	**Key Barriers:** Development and deployment of the technologies are restricted by material science, the unknown cost of large-scale manufacturing, and infrastructure investment costs.	**Key Barriers:** Cost of development, lengthy human trials, privacy concerns, possible difficulties of insurance, and religious and social concerns will inhibit their development.	**Key Barriers:** Substantial technology and cost barriers exist for CCS scale-up and implementation for coal power plants, while uncertainties in both the oil market and environmental regulatory landscape preclude investment in expensive coal gasification plants (even without CCS).
Why Is the Technology a Game-Changer?	These technologies could radically accelerate a range of enhanced efficiencies, leading to integration of closed societies into the information age and security monitoring of almost all places. Supply chains would be streamlined with savings in costs and efficiencies that would reduce dependence upon human labor.	Although the Earth contains a plentiful supply of water, only 1 percent is fit or available for human consumption and some 20 percent of the world's population does not have access to fresh drinking water. Regions experiencing water scarcity will increase as the global population increases and as climate change induced droughts occur. Both developing and developed countries will be affected. Various industries increasingly will compete for water, including agriculture, food, and beverage processing plants as well as chemical, pharmaceutical, and semiconductor industries. First movers to develop and deploy cheap energy-efficient clean-water technologies could gain huge geopolitical advantage.	The ability to store and use energy on demand from a combination of alternative energy sources offers a significant potential to lead a paradigm shift away from fossil fuels, resulting in significant global economic and social advantages to first commercializers. With widespread deployment, the result could be destabilizing to rentier economies dependent upon fossil fuels.	Deployment would shift the cost, allocation, and use of healthcare resources. Nations will be challenged as a result of the changing demographic structures and new psychologies, behaviors and activity patterns of aging yet healthy citizens and the concomitant need to formulate new national economic and social policies.	A successful accelerated and rapid deployment of clean coal technology could pose a major challenge to other hydrocarbon (predominately oil) energy markets and nascent renewable energy markets. This would change the dependency of coal richlnot poor nations on imported oil/gas with a resulting significant shift in national interests.

[a]These breakthroughs are categorized based upon the development and initial deployment of the technology. In some cases, full deployment may lag significantly due to infrastructure requirements.
Source: SRI Consulting Business Intelligence and Toffler Associates.

47

Source: National Intelligence Council's 2025 Project



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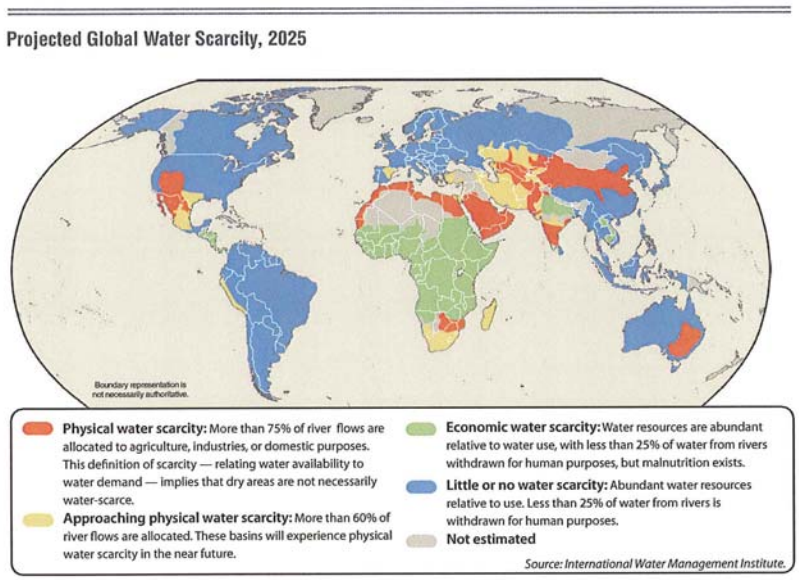
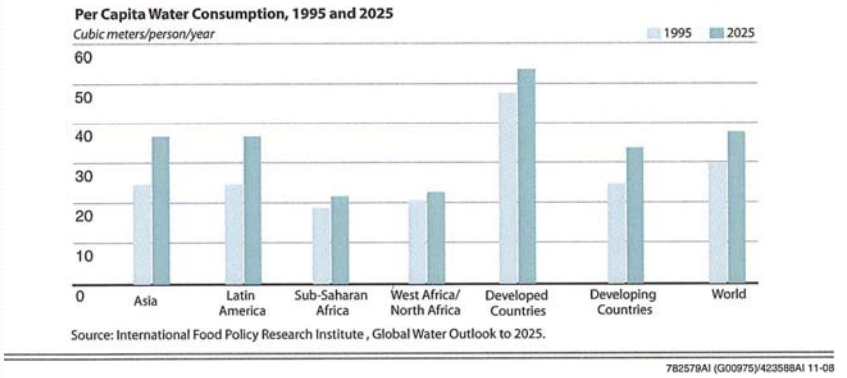
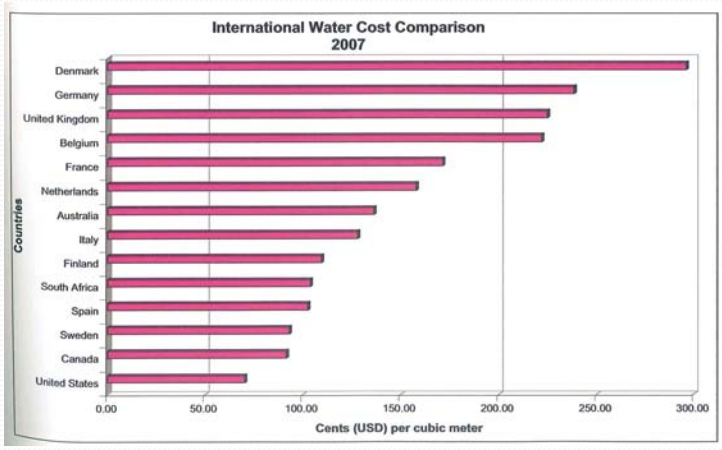


Source: National Intelligence Council's 2025 Project



Source: National Intelligence Council's 2025 Project

Global Water Prices



Source: *World Water & Environmental Engineering*, January/February 2008

Water for Food Production and Rural Development

- Significance to food production of current ground water mining in major aquifers
- Threat to food production from rising water tables and salination

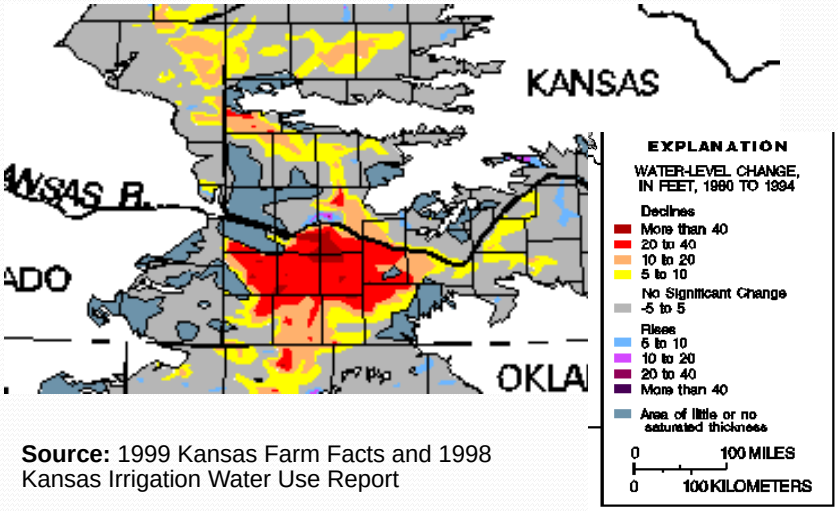
August 16, 1972

Source: http://earthshots.usgs.gov/Help-GardenCity/Help-GardenCity

August 15, 1988

Source: http://earthshots.usgs.gov/Help-GardenCity/Help-GardenCity

Ground Water Level Changes: 1980-1994



Source: 1999 Kansas Farm Facts and 1998 Kansas Irrigation Water Use Report

Value of Acre Foot of Ground Water for Irrigation in Southwest Kansas

- $90.74 in inflation adjusted 2003 dollars per acre-foot
- 2,345,353 acre-feet used for irrigated agriculture in southwest Kansas
- $212.8 billion annually without application of economic multiplier
- $425.6 billion with "reasonable" economic multiplier of 2.0

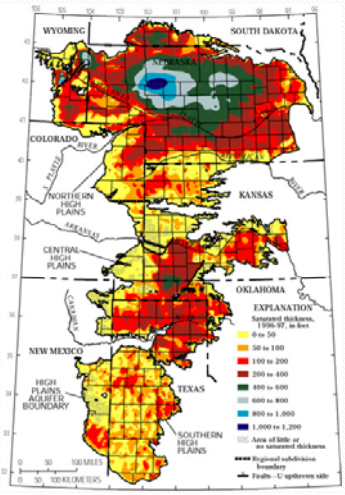
Source: *The Value of Ogallala Aquifer Water in Southwest Kansas*, Fort Hays State University, SW Kansas Groundwater Management District, 2001

"Economic forces, such as changing commodity prices or production costs are likely to induce farmers to shift marginal land in and out of production."

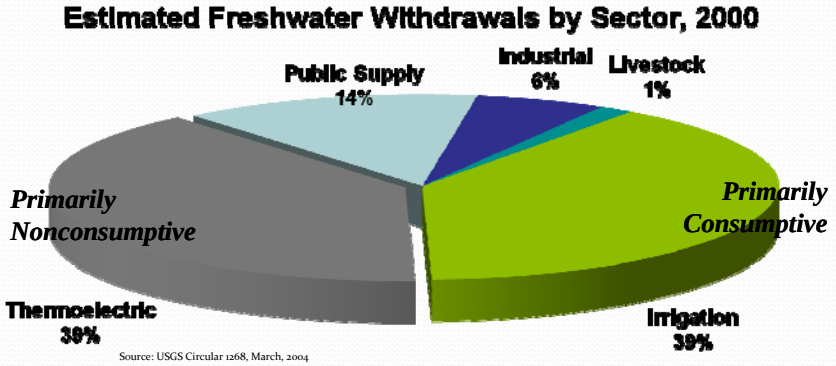
- Economic Research Service, USDA, September 2006

Corn Belt/Ethanol States

Corn Belt/Ethanol States



Energy and Agriculture Withdraw the Most Water in the U.S.



Source: USGS Circular 1268, March, 2004

Note: Hydropower uses are not included here!

Future Energy Development Will Put New Demands on Water

"Production of alternative fuels, such as synfuels from coal or hydrogen from methane, also requires water, at up to triple the requirements for water consumption in petroleum refining."

"In summary, virtually every alternative will require as much water as refineries consume now, if not substantially more. To be able to increase domestic supplies of transportation fuels will require significant water resources using current approaches and options."

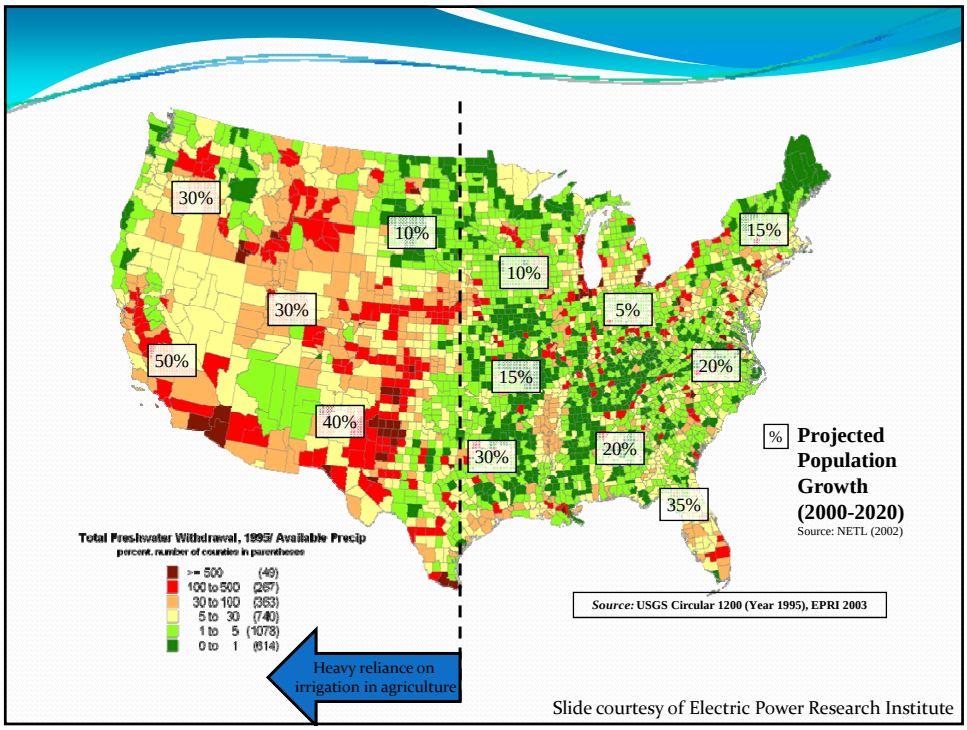
- *Energy Demands on Water Resources*, U.S. Department of Energy, December 2006

Future Energy Development Will Put New Demands on Water

- Many newer technologies will be more water intensive
- Biofuels and hydrogen economy would require significantly more water than fossil transportation fuels
- Constraints will grow for power plant siting because of water for cooling needs, advanced scrubbing, and CO_2 removal

Water for Cities and Urban Development

- Ground water and contaminant load surveys, with identification of all significant stakeholders
- Municipal planning to constrain ground water abstraction and guide sanitation schemes
- Using wastewater more effectively, either directly, or indirectly, through aquifer recharge



Slide courtesy of Electric Power Research Institute

"If they pull the water table down enough, this will be a dust bowl."

– Rancher Dean Baker

"It will completely change the economics": Dean Baker stands by a water trough on his rural Nevada ranch that used to be fed by a spring.

Vegas reaching for rural water

Pipeline plan creates fear that city will pump away agricultural livelihoods

By Jenna Ritter
USA TODAY

BATTE, Nev. — Rancher Dean Baker picks his way through greasewood and sedge to a shallow dirt depression that was once a small pond fed by a natural spring. Both have been dry for years, casualties, he says, of pumping that draws underground water to the surface to irrigate fields and water livestock.

Over a half-century, agriculture's needs have lowered the water table, Baker says, but it's nothing compared to what may be in store for this arid, sparsely populated, mine-rich desert near the Utah border.

The Southern Nevada Water Authority wants to pump vast quantities of groundwater from rural valleys. Nevada valleys and pipe it 250 miles south to Las Vegas, the nation's fastest-growing major metro area, a tourist mecca with a limited water supply strained by population and prolonged drought.

After hearings last month, a decision rests with State Engineer Tony Taylor. Water boosters as giant, in other valleys, Las Vegas officials have begun the plans to build a pipeline by 2015 and pump nearly 30 million gallons a year from 10 wells in Spring Valley alone.

At stake, ranchers say, are livelihoods and a delicate ecological balance on a landscape cursed with at most 5 inches of rain and snow a year.

"If they pull the water table down enough, this will be a dust bowl," says Baker, 68, whose family has raised cattle in Spring Valley since the 1950s. "It will completely change the economics of agric (sic) (sic). It will also change the life of the 40 local of ranchers that stay in that dusty hole."

These concerns are unfounded, the authority calls Lab, says Nevada law prohibits impairing an existing water rights, says general manager Pat Mulroy. "It's mistaken," the says. "It's misguided. It's rural vs. urban. It's fear-based. Protecting that environment will always be of tremendous importance to us."

Scarce resource

Since early settlers, water has been the West's scarcest and most valuable resource. Towns pumped water, just as ranchers fed livers ranch and streams have been dammed, drained and diverted for decades and now offer little extra supply for expanding urban centers such as Salt Lake City, El Paso, Albuquerque, Phoenix and Tucson.

Now groundwater is the target, even if as at Las Vegas case, it's cost $3 billion or more to get it and benefit one region at the expense of another.

"The $2 billion ground water plan has generated headlines from California to Washington, D.C. and historical comparisons to the massive water projects that build modern Los Angeles," says Jeff Mount, director of the Center for Watershed Sciences at the University of California, Davis. "When you look at it on a big-picture, multinational-scale write basically mining these groundwater basins at rates that can't be sustained. When the water's gone, it's gone."

Farms and ranches consume 80% of Western water supplies yet generate less than 1% of state's gross domestic product, says Ted Rothman, a history professor at the University of Nevada, Las Vegas.

"The real question isn't whether water will be transferred from rural to urban use," he says. "The debate is over the terms of the transfer. How rural communities that cede water will live on fair and valuable benefits from it."

Opponents of the water authority plan say it's one more instance of water flowing uphill toward money. Elle Los Angeles' water system, for example, drains the Owens Valley in the early 1900s. That diversion — fatal of the 1913 movie Chinatown — allowed LA. to grow but dried up a prosperous farm region.

"The parallels are stark," says Greg James, former director of the Inyo County, Calif., water department in the Owens Valley. "They're looking to build a pipeline, pump groundwater, and they're already acquiring ancillaries."

State water laws and federal environmental regulations wouldn't permit a repeat of Owens Valley, but ranchers want a guarantee that if the land settles, the pumps would be shut down. Otherwise, "by the time we see the effects of pumping, it will be too late," says Gary Ness, a Democratic commissioner in White Pine County.

The Mormon Church, based in Salt Lake City, owns water rights in Spring Valley and has asked the engineer to withhold approval until a U.S. Geological Survey study is finished next year.

The authority built a computer model to predict effects on the water table but didn't run it. When it was run by a National Park Service hydrologist, it showed a 150-foot drop over 75 years. Mulroy calls those results "hypothetical." John Bredehoeft, a hydrogeologist who testified for opponents, says "it would have been detrimental" to the authority's case.

Time is short, Mulroy says. The Las Vegas metro area — population 1.7 million, 20,000 new residents a month — uses a share of Colorado River water stored in Lake Mead for 90% of its supply. Seven years of drought have lowered the lake to half its capacity. A year like 2002, when the river ran about a quarter of normal, "would be a crisis," Mulroy says.

Reducing demand

The water authority is spending millions of dollars to entice homeowners to replace irrigated lawns with drought-tolerant plants — 70% of water consumption goes outdoors. A system captures, treats and returns water from indoor plumbing to Lake Mead.

Opponents say tougher conservation measures, including raising water rates as cities such as Aspen have done, could save as much as the authority plans to take from Spring Valley.

"That penalizes people who can't afford it," Mulroy says.

Ranchers may think Las Vegas should conserv its pennies, not that's a political non-starter in growth-swollen Nevada. At the area's current growth rate, rural groundwater is a stopgap measure at best, says Matt Vasilakis, a lawyer with the Western Environmental Law Center representing opponents.

Many people believe that if Nevada can't solve its water problems, other states are another too small to make the pipeline economical the authority will ask Congress for a bigger share from the Colorado River.

When the river's flow was diverted among seven states in 1922, Las Vegas was little more than a crossroads. Nearly a century later, 400 farmers in California's Imperial Valley still get 10 times more Colorado River water than Las Vegas does.

Las Vegas thirsts for new source of water

Las Vegas — the nation's fastest-growing metro area — wants to tap groundwater from largely agricultural counties to its north.

Lincoln County, population: 4,000; County seat: Pioche (700)

White Pine County, Population: 10,000; County seat: Ely (1,000)

Clark County, Population: 1.7 million; County seat: Las Vegas (570,610)

Path of proposed pipeline

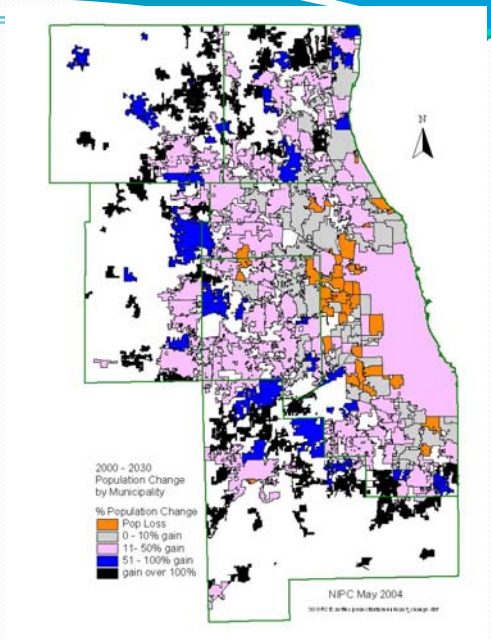
Source: Southern Nevada Water Authority, Nevada Department of Conservation & Natural Resources

By Mike Stanton, USA TODAY

USA TODAY, THURSDAY, OCTOBER 19, 2006 · 5A

"The $2 billion ground water plan has generated headlines from California to Washington, D.C. and historical comparisons to the massive water projects that build modern Los Angeles."

– *Las Vegas Sun*, September 10, 2006


N
2000 - 2030
Population Change
by Municipality
% Population Change
Pop Loss
0 - 10% gain
11- 50% gain
51 - 100% gain
gain over 100%
NIPC May 2004

"The network of reservoirs, pipes, and treatment facilities are the lifeblood of our communities. Only tap water delivers public health protection, fire protection, support for the economy, and the overall quality of life we enjoy."
- Jack Hoffbuhr,
American Water Works Association

The American Society of Civil Engineers has given the pipes and other parts of the U.S. water system a D-minus.

$34.4 billion

95% of America's community water systems need to spend now to comply with SDWA regulations and related obligations

$745 billion to $1 trillion

U.S. water and waste water infrastructure repair and replacement needs over next 20 years

$300 billion

Costs to replace aging centralized water distribution system pipes alone over the next 20 years, according to the American Water Works Association

"The challenges and costs of maintaining an adequate water supply in areas of high need and low resources – collecting it, storing it, treating it, and delivering it – all relate to the ultimate requirement – paying for it. …cities and counties face a Catch-22 situation – either raise taxes to pay for maintaining the water supply or grow development to increase the tax base by increasing the number of taxpayers (which will, of course, increase the demand for water, as well."

Source: *Public Works*, 1998

"Although the benefits of consolidation are potentially large, water supply systems remain almost uniquely unconsolidated among all local and municipal services."
- *Journal AWWA*, September 2006

From Use to Management

- Lack of awareness of the consequences of excessive exploitation and hence inadequate consensus for action
- Definition of ground water abstraction rights, and thereby mobilization of stakeholder participation

From Use to Management

- Uncertainty of resource evaluation due to inadequate monitoring of aquifer behavior
- Undervaluation of ground water, leading to economically inefficient allocation and use, and under-investment in water conservation and resource management

From Use to Management

- Transformation of government organizations to enable them to facilitate the management process
- Raising political and public awareness of the need for sustainable management
- Development and application of ground water resource decision-support systems

From Use to Management

- Assignment and consolidation of ground water rights, and introducing realistic abstraction charges
- Stimulation of stakeholder participation through the formation of aquifer-use associations

From Use to Management

- Breaking the paradigm that aquifer recharge is fixed, rather than variable with climatic cycles/changes and with modifications to surface water engineering and irrigated agriculture
- Recognition of the interaction/interdependence between ground water and surface water

From Development to Protection

- Growing volume and complexity of contaminant loads as a result of inadequate handling, disposal, and reuse of waste water
- Widespread diffuse contaminant load due to leaching of agrochemicals and derivatives

From Development to Protection

- Identifying areas where aquifers are vulnerable to pollution due to insufficient intrinsic pollutant attenuation capacity, especially in the capture areas of major ground water supply sources
- Controlling the subsurface contaminant load in such areas by appropriate land use controls

From Development to Protection

- A more integrated approach to the management of ground water and waste water in urban areas

U.S. EPA says that at the current rate, 36 states will face water shortages by 2013.

From where will more water come?

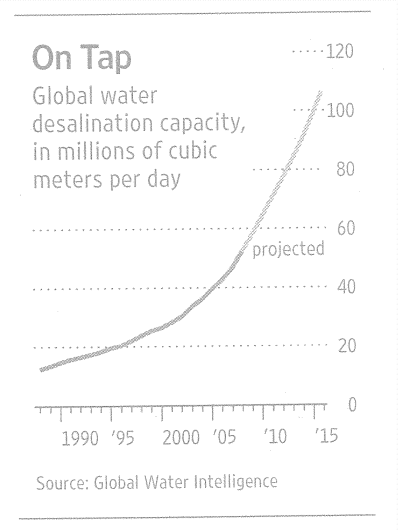
- No shortage of water, shortage of good water management.
- Too many people living in places where there isn't enough water.

From where will more water come?

- Desalination
- Conjunctive use of ground water and surface water
- Better agricultural irrigation practices
- Water conservation devices
- Less water usage in industrial processes
- Reuse

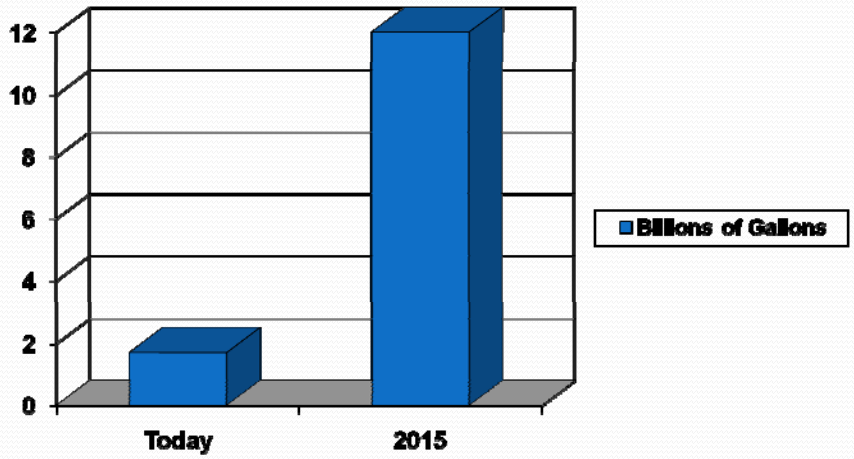
"In many cases, depending on scale, ASR [aquifer storage and recovery] is more cost-effective than building above-ground reservoirs."
- John Wodraska, *Journal AWWA*, May 2006

Desalination



Graphic: *Wall Street Journal*, March 11, 2008

Water Reuse Projection



Source: R.J. Wimmer, *UltraPure Water* 2004 conference

By 2010

- Water and waste water prices will continue to increase
- Will stabilize between 1 and 1.5% of median annual U.S. household income – about 2x the current prices
- Water desalination will approach raw water transport and treatment prices by 2010, making water availability virtually unlimited within 1,000 vertical feet of the world's oceans

By 2050

- Water prices will be better rationalized to water quality, quantity, and specific end-uses
- Less engineering of water projects and more value engineering of water for specific applications

Additional NGWA Resources

- *U.S. Ground Water Industry Market Backgrounder*, 2002, NGWA Press
- *Trends in the United States Marketplace for Individually Owned Private Water Wells*, 1999, National Ground Water Research and Educational Foundation
- *2003 Water Well Contractor Survey*, 2003, NGWA Press

Additional NGWA Resources

- Spreadsheet summaries of:
  - U.S. water well contractor business statistics
  - Ground water use by state and demand
  - Irrigation use of ground water and wells
  - Public water systems using ground water
  - Pump and drilling machine production
- 800-551-7379
- www.ngwa.org
- kmccray@ngwa.org

Thank you for this opportunity to be of service.

national ground water association