Public Drinking Water Supplies

Protecting public health and meeting agricultural, industrial, and environmental water demands.

Waterscape International Group

Lecture Goals

- Provide an overview of drinking water sources, monitoring, regulation, treatment, and health considerations
- Discuss origins of water supply problems—natural and human induced
- Ways of intervening in water supply problems—such as monitoring, education, and remediation
- Few examples of water supply issues from the United States, Lithuania, and Bangladesh

Why worry about water supplies?

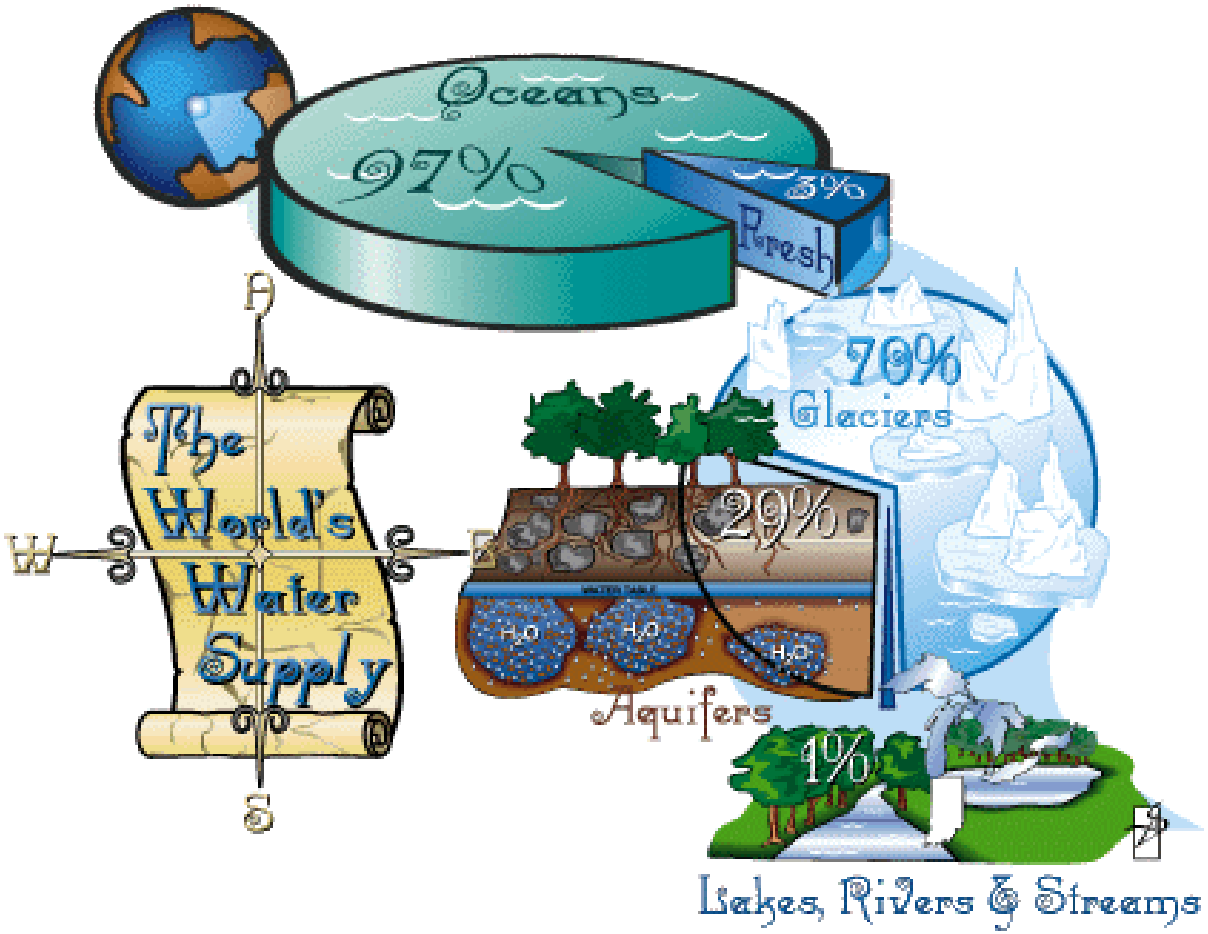
- Supports virtually everything we do: agriculture, industry, energy, and domestic needs.
- Major pathway into the body for contaminants.
- Easy to contaminate, difficult (costly) to remediate.
- Expensive to transport, necessitating local supplies for most communities.
- Different countries would respond in different ways to this question (United States, Lithuania, &Bangladesh).
- Health aspects in water are connected to many broader issues of management.

I. Introduction: Basic Info

- Where does our water come from in Berkeley?
- The Delta of the San Joaquin and Sacramento Rivers? The Ocean? The Sierras? Local well fields?

Major California Water Projects

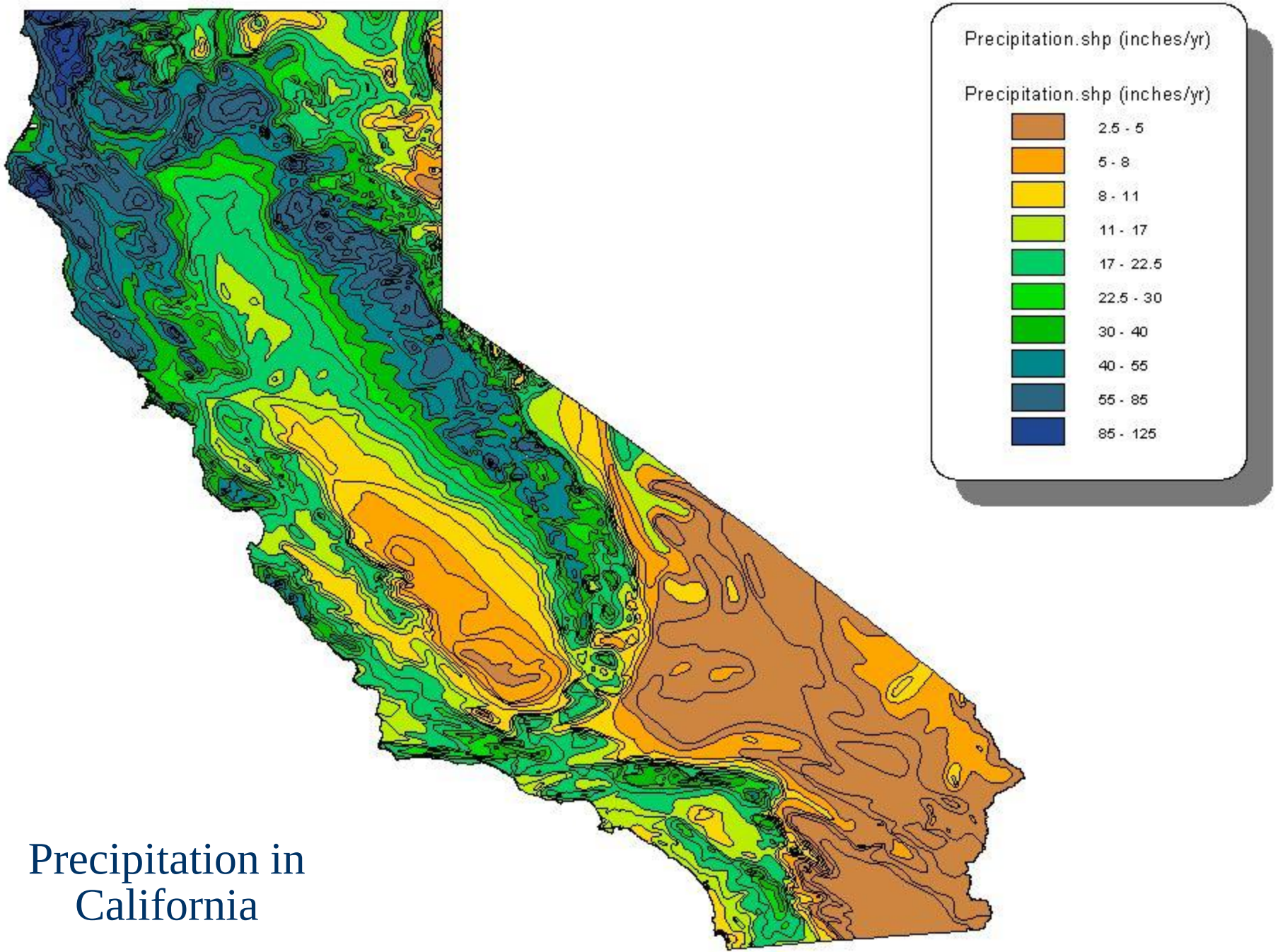
How much water is in the world?



Access to Safe Drinking Water

Region	1994 Population (millions)	Percent with Access (%)
AFRICA	707	46%
LATIN AMERICA	473	80%
ASIA & THE PACIFIC	3,122	80%
WESTERN ASIA	81	88%

- Bottom Line: About 1 billion don’t have access to clean water.
- How can we reduce this figure?



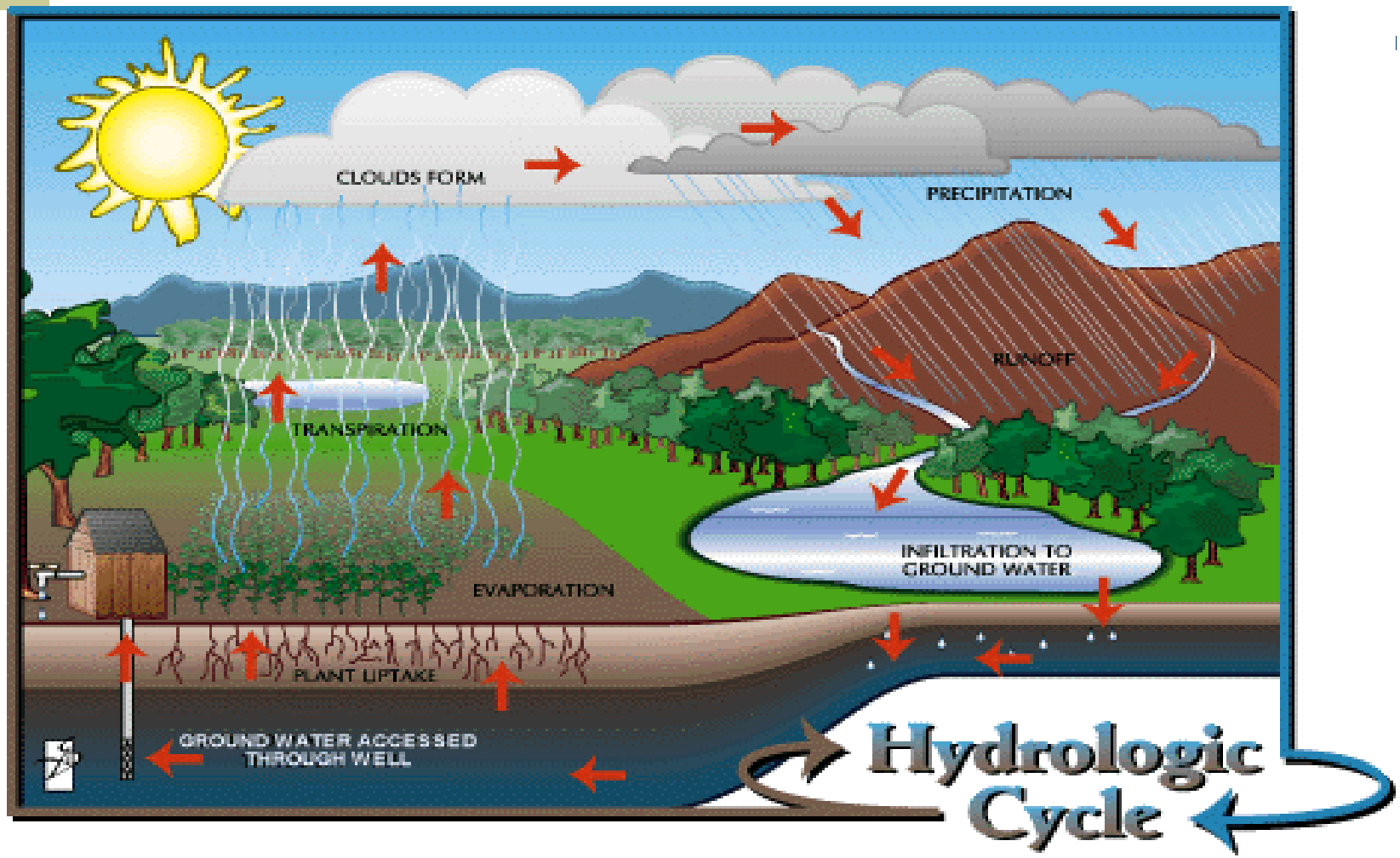
Precipitation in California

II. Water Sources and Treatment

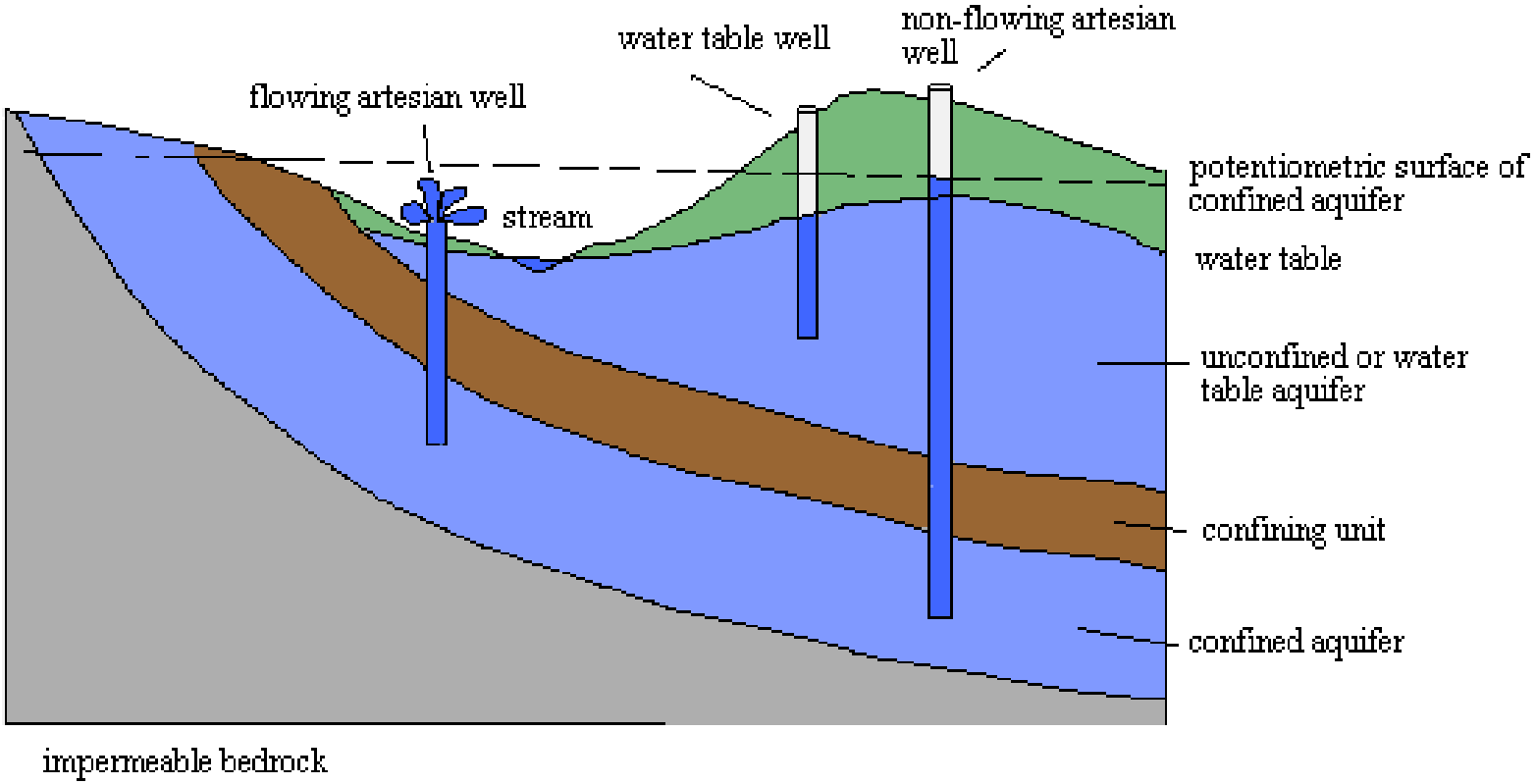
- Water Cycle
- Groundwater
- Surface water
- Treatment

- How do these vary in different countries?

Water Cycle

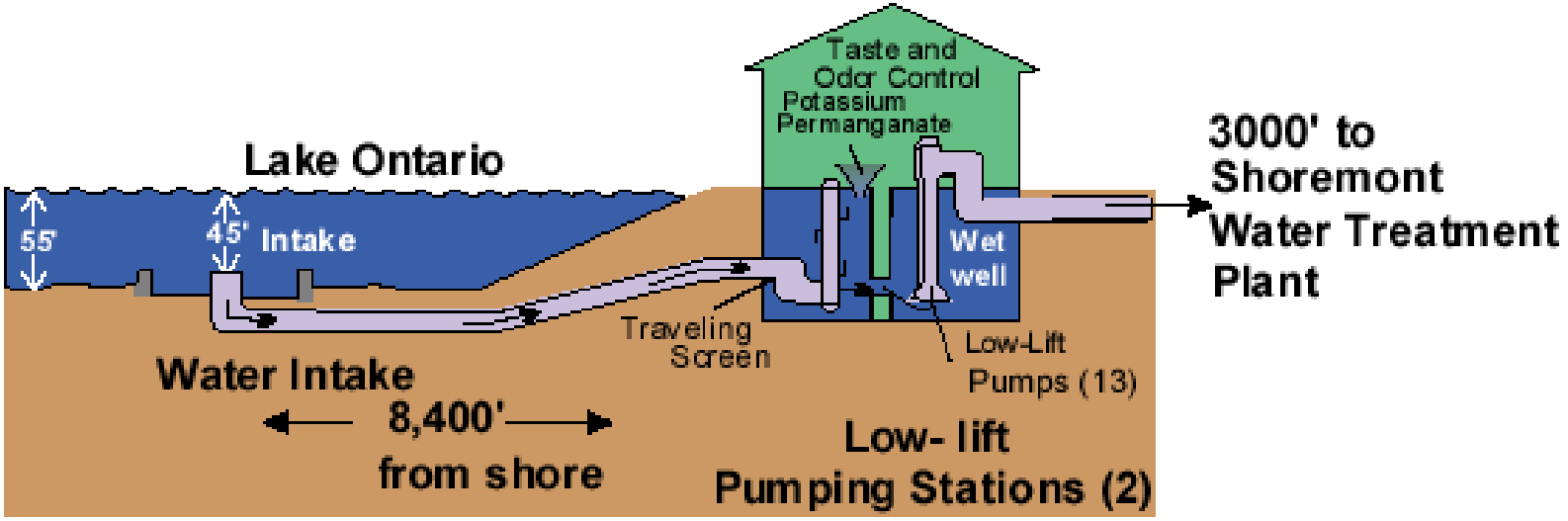

CLOUDS FORM
PRECIPITATION
RUNOFF
TRANSPIRATION
EVAPORATION
INFILTRATION TO GROUND WATER
PLANT UPTAKE
GROUND WATER ACCESSED THROUGH WELL
Hydrologic Cycle

Groundwater

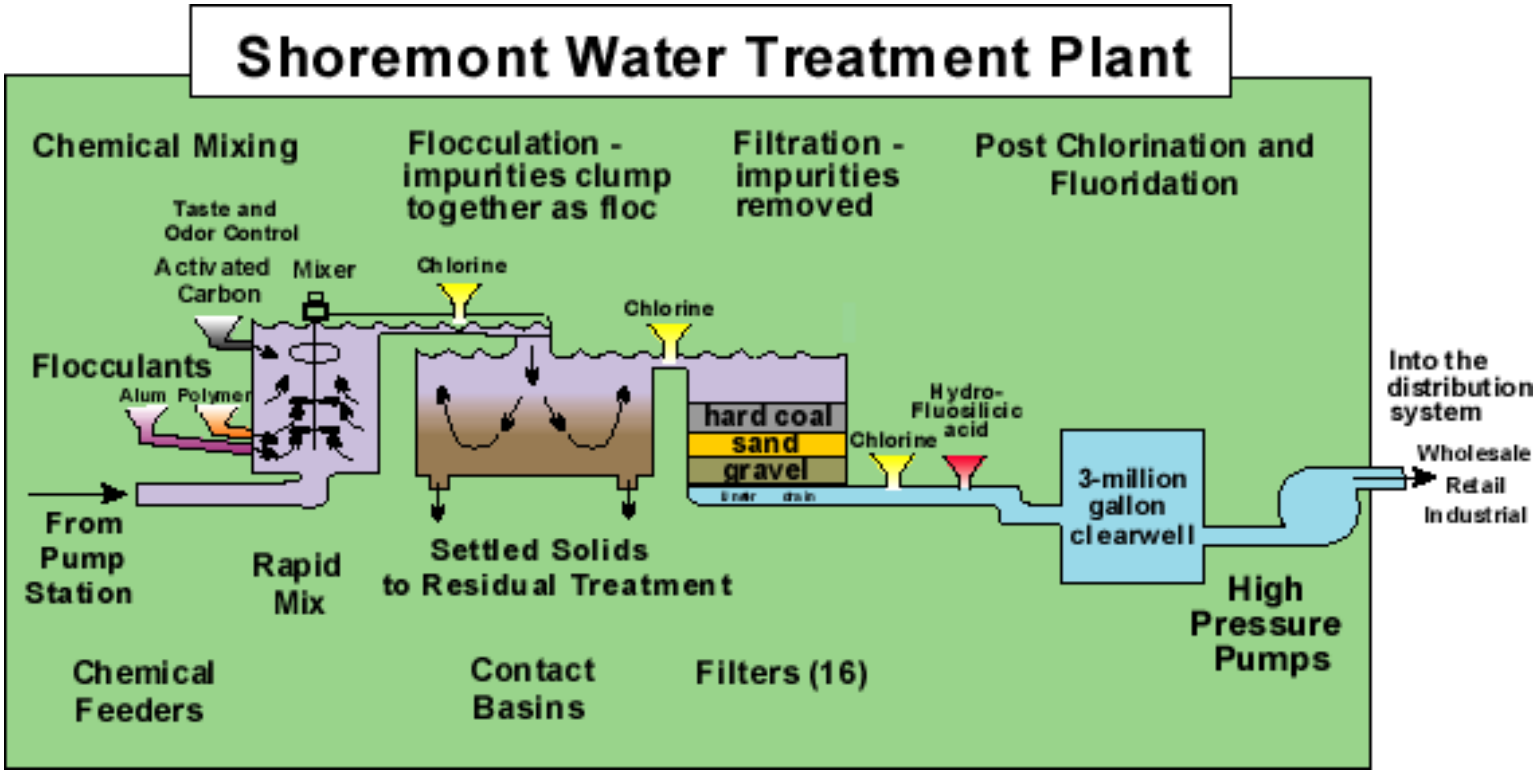


Groundwater Well

Surface Water



Treatment Plants



Water Treatment Methods

- **Flocculation/Sedimentation** Flocculation refers to water treatment processes that combine small particles into larger particles, which settle out of the water as sediment.
- **Filtration**
- **Ion Exchange** Ion exchange can be used to treat hard water. It can also be used to remove arsenic, chromium, excess fluoride, nitrates, radium, and uranium.
- **Adsorption** Organic contaminants, color, and taste- and odor-causing compounds can stick to the surface of granular or powdered activated carbon (GAC or PAC). GAC is generally more effective than PAC in removing these contaminants. Adsorption is not commonly used in public water supplies.
- **Disinfection (chlorination, ozonation)** Water is often disinfected before it enters the distribution system to ensure that dangerous microbes are killed. Chlorine, chloramines, chlorine dioxide, ozone

III. Issues of Quantity and Supply

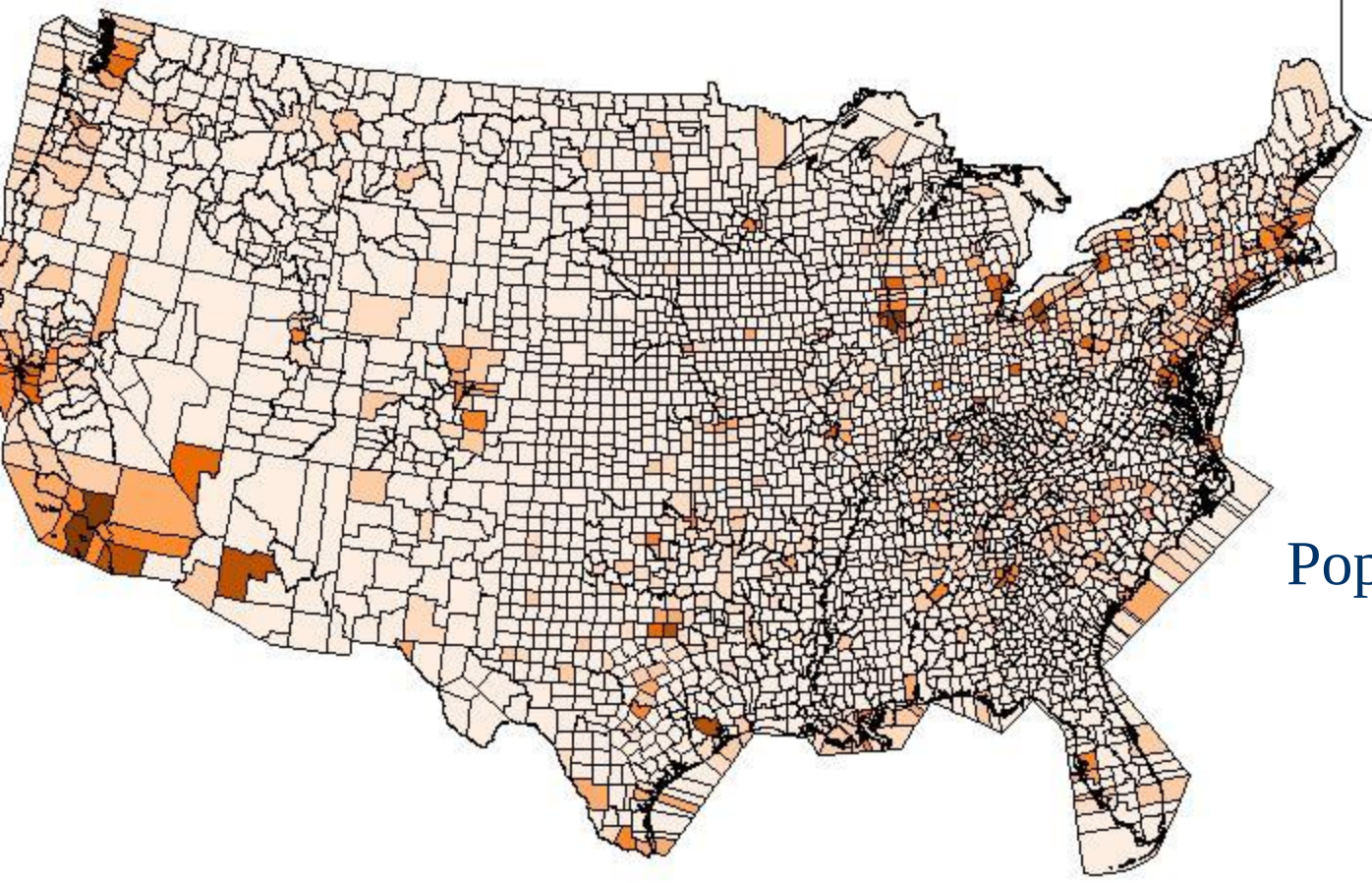
- Natural vs. artificial shortages
- Most countries have enough water
- California and several western states have created artificial shortages
- Irrigated Agriculture

Water Use in the United States

- Types of Water Uses: Agricultural, Domestic, Energy, & Environmental
- Groundwater consumption v. surface water.

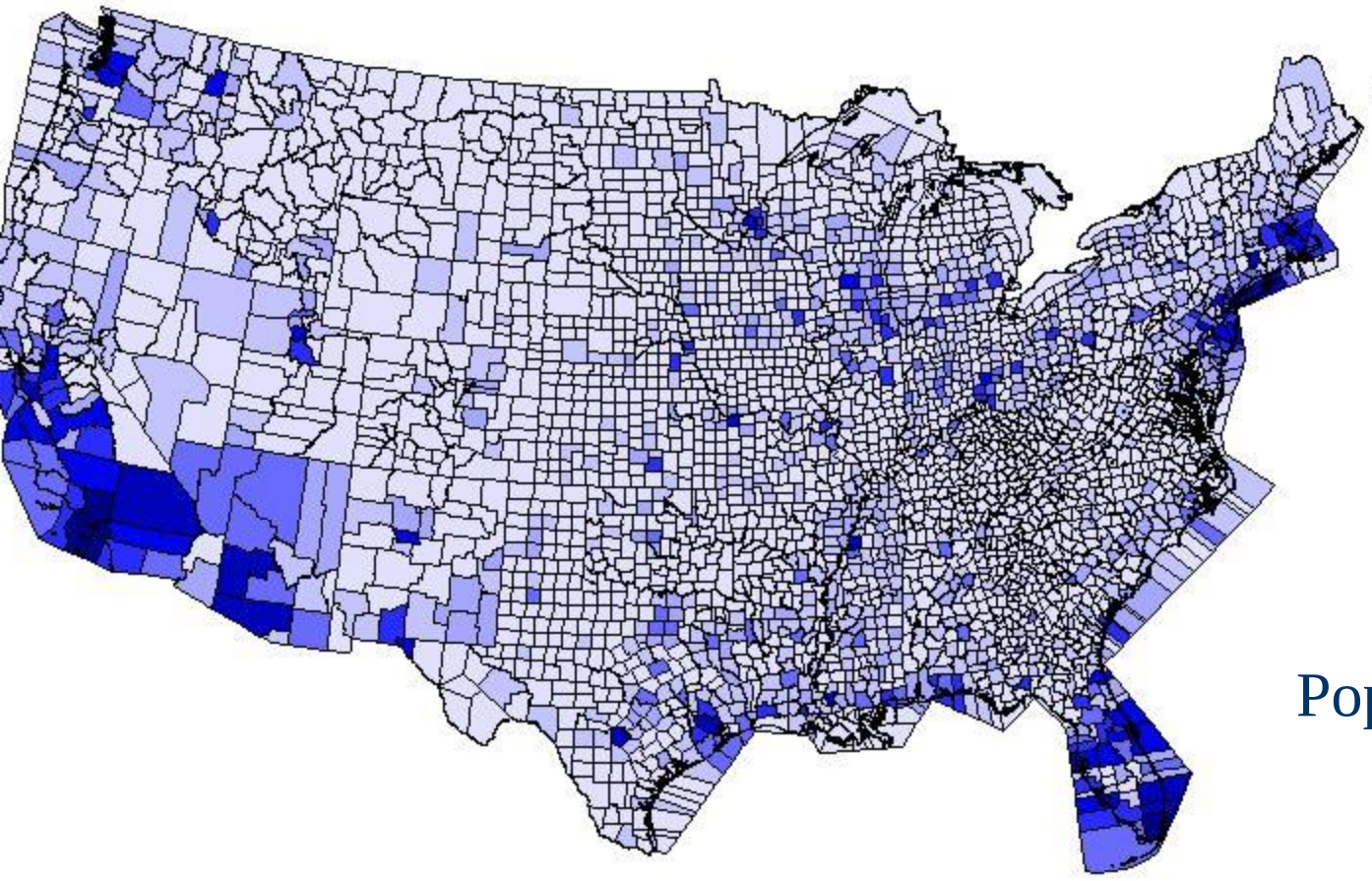
- United States of America 1995 469.00 km^3 (1,688 m^3/person/yr)
- Bangladesh 1987 22.50 km^3 (175 m^3/person/yr)
- Lithuania 1995 0.25 km^3 (68 m^3/person/yr)
- California in 1990:
  Domestic: 6.6 MAF
  Irrigation: 32 MAF
  Indust/Mining: 0.7 MAF
  Thermo-electric: .3 MAF
  Total: 40 MAF

Population Server by Surface Water ('000) in 1995



Population Served by Surface Water

Population Served by Ground Water ('000) in 1995



Population Served by Groundwater

IV. Origins of "Contamination"

- **Contaminant:** Any physical, chemical, biological, or radiological substance or matter that has an adverse effect on air, water, or soil.

- Naturally occurring
- Point-source (end-of-pipe)
- Non-point source (agricultural, land use)

V. Major Water Quality Indicators

- Microorganisms, Disinfectants & Disinfection Byproducts, Inorganic Chemicals, Organic Chemicals, & Radionuclides
- Regulated in U.S. by the Safe Drinking Water Act and state laws
- Overview: Origin, Mitigation, Treatment, Health Effects

Safe Drinking Water Act

- Originally passed in 1974 and regulates 170,000 public water systems in U.S.
- Standards and Treatment Requirements
- Expanded in 1996 in the areas of sole source water supplies, protection and prevention, and public information.

Microorganisms

- Example indicators:

Total Coliforms (including fecal coliform and *E. Coli*)	zero	5.0%4	Used as an indicator that other potentially harmful bacteria may be present5	Coliforms are naturally present in the environment; fecal coliforms and E. coli come from human and animal fecal waste.
Turbidity	n/a	TT3	Turbidity is a measure of the cloudiness of water. It is used to indicate water quality and filtration effectiveness (e.g., whether disease-causing organisms are present). Higher turbidity levels are often associated with higher levels of disease-causing microorganisms such as viruses, parasites and some bacteria.	Soil runoff

Disinfectants & Disinfection Byproducts

- Example Indicators
- TTHM is a major concern for Contra Costa Water Agency

Chlorine (as Cl_2)	as of 01/01/02: MRDLG=41	as of 01/01/02: MRDL=4.01	Eye/nose irritation; stomach discomfort	Water additive used to control microbes
Total Trihalomethanes (TTHMs)	none7 --- as of 01/01/02: n/a6	0.1 --- as of 01/01/02: 0.08	Liver, kidney or central nervous system problems; increased risk of cancer	Byproduct of drinking water disinfection

Inorganic Chemicals

- Arsenic is caused usually by exploiting aquifers of marine origin (Coast Ranges)
- Nitrate is a major problem for shallow wells in agricultural areas.

Arsenic	none7	0.05	Skin damage; circulatory system problems; increased risk of cancer	Erosion of natural deposits; runoff from glass & electronics production wastes
Lead	zero	TT8; Action Level=0.015	Infants and children: Delays in physical or mental development.Adults: Kidney problems; high blood pressure	Corrosion of household plumbing systems; erosion of natural deposits
Nitrate (measured as Nitrogen)	10	10	"Blue baby syndrome" in infants under six months - life threatening without immediate medical attention.Symptoms: Infant looks blue and has shortness of breath.	Runoff from fertilizer use; leaching from septic tanks, sewage; erosion of natural deposits

Organic Chemicals

- Include pesticides, degreasing agents, petroleum byproducts.

Benzene	zero	0.005	Anemia; decrease in blood platelets; increased risk of cancer	Discharge from factories; leaching from gas storage tanks and landfills
Polychlorinated biphenyls (PCBs)	zero	0.0005	Skin changes; thymus gland problems; immune deficiencies; reproductive or nervous system difficulties; increased risk of cancer	Runoff from landfils; discharge of waste chemicals
Toxaphene	zero	0.003	Kidney, liver, or thyroid problems; increased risk of cancer	Runoff/leaching from insecticide used on cotton and cattle
1,1,1-Trichloroethane	0.2	0.2	Liver, nervous system, or circulatory problems	Discharge from metal degreasing sites and other factories

Radionuclides

- Mostly from natural deposits.

Uranium	as of 12/08/03: zero	as of 12/08/03: 30 ug/L	Increased risk of cancer, kidney toxicity	Erosion of natural deposits

VI. Approaches to mitigating contamination & managing supply

- Monitoring & Planning
- Source water protection (WHPP, CWA, DWSAPP)
- Education (BMPs, RTK)
- Treatment & Remediation
- Examples of these approaches, pros and cons of each

Monitoring & Planning

- Water quality, quantity, and use information should be collected continuously using EPA or other specific guidelines (GIS).
- Threats to water supplies should be assessed regularly (EPA doesn't require frequent monitoring of all possible contaminants).
- Data standardization and collaboration among government agencies should be a priority.
- Plan for chemical spills, droughts, and other disasters.

Source Water Protection

- Source water protection programs protect watersheds or groundwater basins that serve as water sources.
- Methods of protection include: land use regulations (zoning, chemical handling restrictions, required best management practices for certain industries).
- The Clean Water Act's regulation of industries that discharge into surface water/groundwater (NPDES) might also be considered this type of program

Education

- Education is vital for private well owners and the public.
- Active education programs that teach Best Management Practices to farms, gas stations, dry cleaners, and others (e.g. motor oil).
- Public involvement is critical to justify increased water costs to protect quality (e.g. Vilniaus vandenys).

Treatment & Remediation

- A certain amount of treatment will usually be necessary for microbiological contaminants, however cleanup costs for organic chemicals can be quite high. Hence, prevention is better, but it requires spending money up front.
- Many countries of world do not have the financial resources for extensive treatment and remediation.

Role of Regulation

- Water as a common pool resource, a source and sink
- Regulation will likely be required to promote these programs.
- Types of regulations: monitoring, planning, reporting, standards, handling, wellhead, watershed.

VIII. Case Study

- Bangladesh
- Economic levels, education and other factors impact the ability of countries to protect drinking water supplies

Arsenic in Bangladesh

- 20% of the countries wells affected
- 900,000 of the country's four million tubewells were sunk with UNICEF assistance
- Estimated that the number of people exposed to arsenic concentrations above 0.05 mg/l is 28-35 million (more than 0.01 mg/l is 46-57 million) (BGS, 2000)
- Long-term exposure to arsenic via drinking-water causes cancer of the skin, lungs, urinary bladder, and kidney, as well as other skin changes such as pigmentation changes and thickening.
- Government was slow to respond
- Needed steps: identify safe wells, techniques for reducing exposure, purification and other water sources
- http://www.unicef.org/arsenic/

IX. Concluding Remarks

- Owens Lake
- Mono Lake Story: A potentially similar fate
- In 1941, the Los Angeles Department of Water and Power began diverting Mono Lake's tributary streams 350 miles south to meet the growing water demands of Los Angeles. Deprived of its freshwater sources, the volume of Mono Lake halved, while its salinity doubled.
- 1979 Case Filed
- In 1983, the California Supreme Court ruled that, in granting DWP's licenses to divert water from Mono Basin streams, the Water Board's predecessor had erred by failing to take into account protection of Mono Lake's public trust values -- "the purity of the air, the scenic views of the lake and its shore, the use of the lake for nesting and feeding birds...."
- Mono Lake Basin Water Right Decision 1631.

References

- http://www.worldwater.org/
- http://www.who.int/water_sanitation_health/
- http://www.epa.gov/safewater/
- ATSDR