Sustainable Water Resources Roundtable

Urban Issues

Kent Thornton, FTN

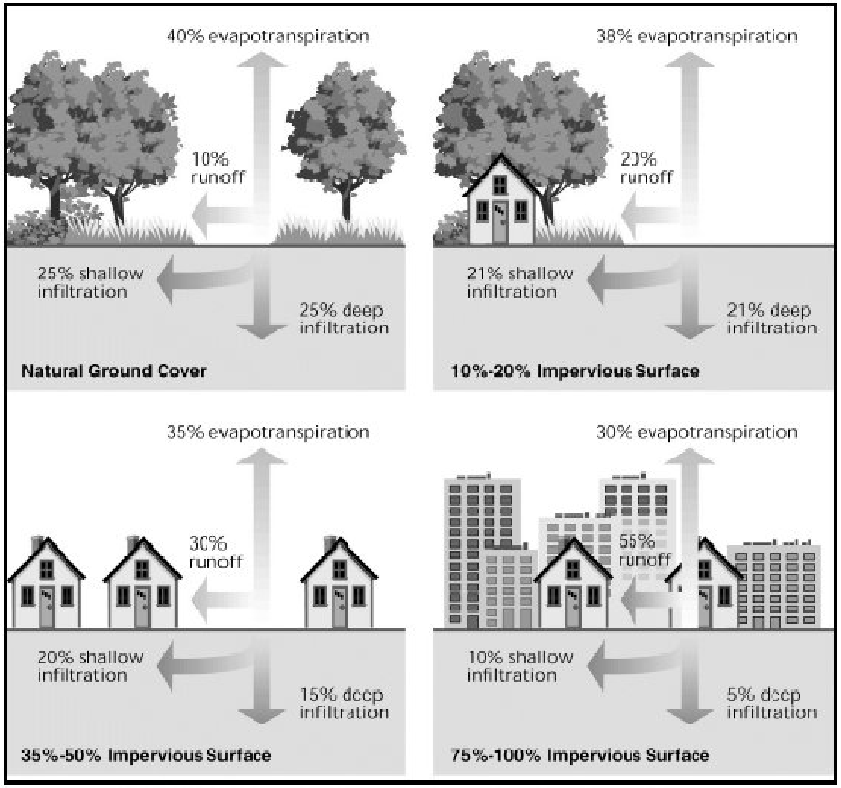
5 April 2005

Urban Issue Identification

1. WERF Project on Sustainable Water Resources Management
2. FTN Internal Discussion on Urban Issues
3. Other Engineering Firm Consultation
4. Current Issues In Arkansas

Urban Issues

- Some Are Black and White
  - —Increased population
  - —Altered land use
  - —Pervious => Impervious area
  - —Increased runoff
  - —Increased pollutant loading



Urban Issues

- Some Different Shades
  - Developers
  - Property Owners
  - Regulators
  - Utilities
  - Public
  - Civil Society Institutions

Drivers of Urban Issues

- Population Increase
  - Increased water demand
  - Increased waste water discharge
  - Increased storm water discharge
  - Increased use conflicts
  - Human health

- Population Increase
  - Increased infrastructure
    - Transportation
    - Water/wastewater
    - Electricity/Gas, etc.
  - Increased regulation
  - Increased sprawl
  - Increased demand for services

Drivers of Urban Issues

- **Altered Land Use**
  - Increased impervious area
  - Flooding
  - Heat islands
  - Altered rainfall patterns
  - Streambank erosion, instability

- **Altered Land Use**
  - Increased sedimentation
  - Increased nutrient loading
  - Increased contaminant loading
  - Decreased biotic diversity

Contributors to Urban Issues

- Lack of:
  - Planning
  - Funding
  - Implementation
  - Quantified results (e.g., BMP effect.)
  - Quantified costs and benefits
- Lack of:
  - Education
  - Conflict Resolution
  - Forums for Coop. & Collaboration
  - Political Will
  - Perspective

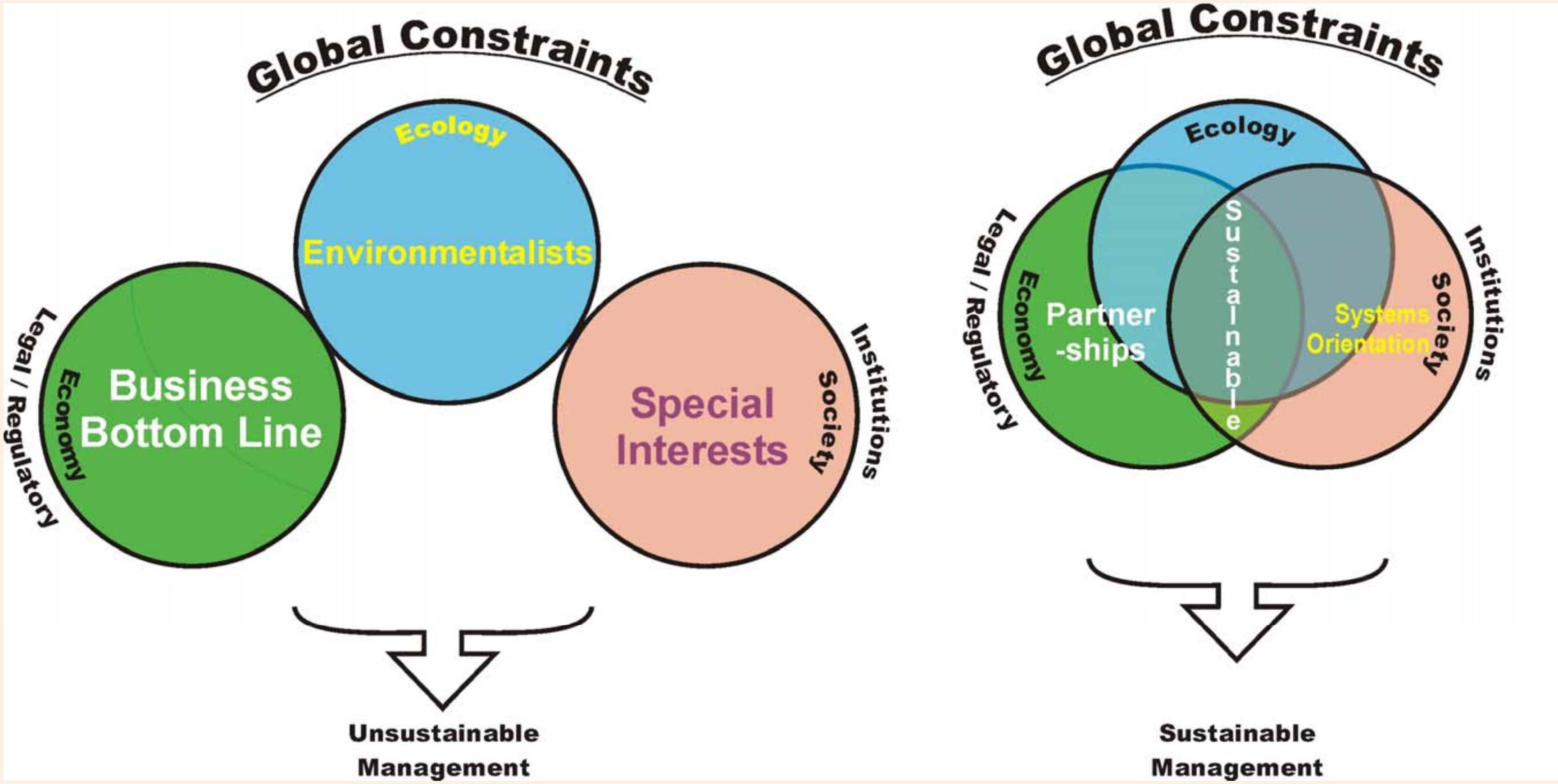
Long-Term Urban Issues

- Regional Planning/Management
- Infrastructure Replacement
- Sustaining Water Demand vs Supply Management
- Reservoir Storage Reallocation
  - Quantity
  - Cost

Long-Term Urban Issues

- Water Rights, Uses, & Conflicts
- Reuse, Recycling, and Conservation
- Integrated Water Management
- Mental Models and Social Mindscapes
- Estimating True Value and Costs of Water
- Climate Change

Primary Issue: No Integration



Integration Perspective

1. Humans part of, not apart from, environment.
2. Water essential for life; every policy, regulation, practice, law, or activity directly/indirectly affects water.
   - e.g., TEA-21, Inner City Enterprise Zones, Urban Revitalization, Brownfields all contribute to resolving water issues.
3. Every sector benefits from sustainable water

Integrated Outcomes

Sustainable Water ⇨Multiple Benefits

- **Actions:**
  - Stream Restoration
  - Economic Incentives
  - Pollutant Reduction
  - Urban Revitalization
  - Infrastructure Replace.
  - LID/ESD
  - Permeable Repavement
  - Urban Forests Mgt.
  - Energy & Water Conserv.
  - Institutional Educational Programs
- **Benefits:**
  - Restoration Industry & Jobs - Entrepreneurs
  - Efficient Q Allocation
  - Water Quality Improve.
  - Economic Develop.
  - Conflict Resolution
  - Urban Replumbing
  - Regionally Competitive
  - Water Reuse, Recycling
  - Social Amenities

Bottom Line

- Much of information needed to resolve urban water issues already exists.
- Has not been synthesized, integrated and used.
- Greatest Needs:
  - Systems Perspective
  - Integration
  - Education and Awareness
  - Adaptive Management

Achieving Sustainable Solutions

America's Pathway to Sustainable Water Utility Management

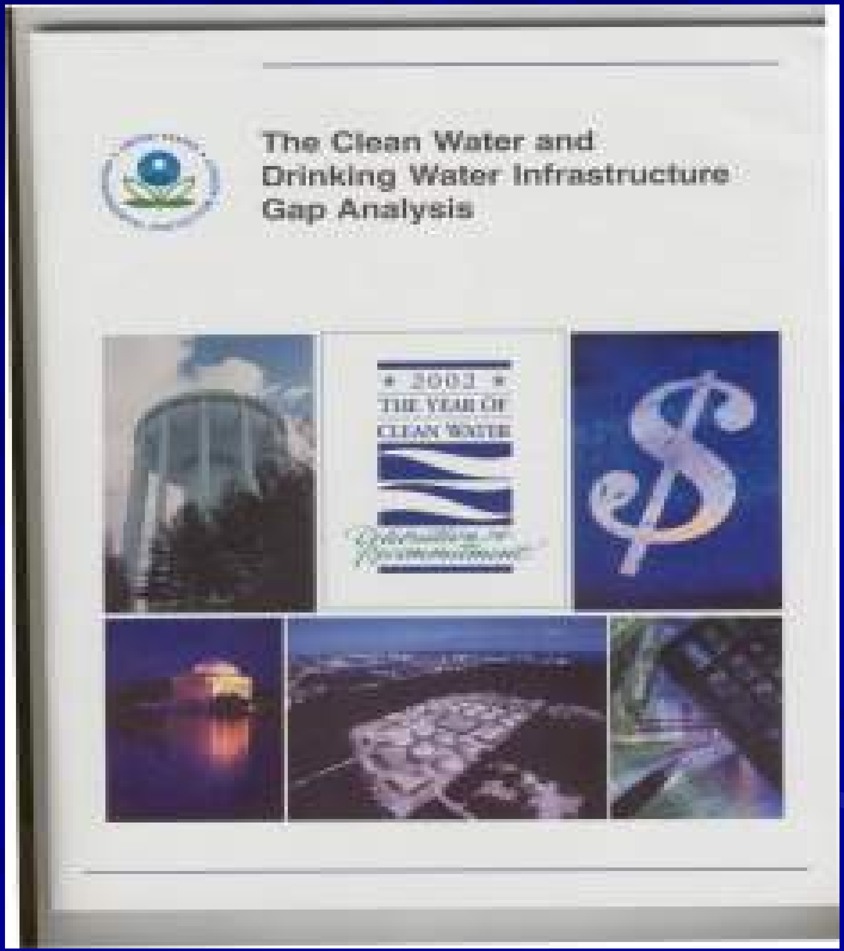
Steve Allbee
Sustainable Water Resources
Roundtable, April 5-6,2005

The Organization of This Presentation

- ❖ **Glancing in the rear-view mirror.**
- ❖ **The state of play in asset management.**
- ❖ **The sustainable systems paradigm.**

The Gap Report Released - - WEFTEC 2002

- **Purpose -- To reach a common quantitative understanding of the potential magnitude of investment needed to:**
  - **Address growing population and economic needs, and**
  - **Renew our existing aging infrastructure.**
- **The data is comparable, at order of magnitude level, with WIN & CBO reports.**



http://www.epa.gov/owm/gapreport.pdf

The Report Is Intended to Provide - - Transparent Numbers

- Estimates are made for water and wastewater, investment, cost and payments (2000-2019).
- Gap = Needs (-) Spending.
- The "gap" is not inevitable.
  - It is a starting point.
  - The impact can be somewhat mitigated.
  - Changes are needed to avoid it's implications.

The Findings For The 20 Years - - (2000-2019)

No Revenue Growth Scenario

Total Payment Gap (20 Years) (Average in Billions of Dollars)		
	Clean Water	Drinking Water
Capital	$122	$102
O&M	$148	$161
Total	$271	$263

Revenue Growth Scenario

Total Payment Gap (20 Years) (Average in Billions of Dollars)		
	Clean Water	Drinking Water
Capital	$21	$45
O&M	$10	$0
Total	$31	$45

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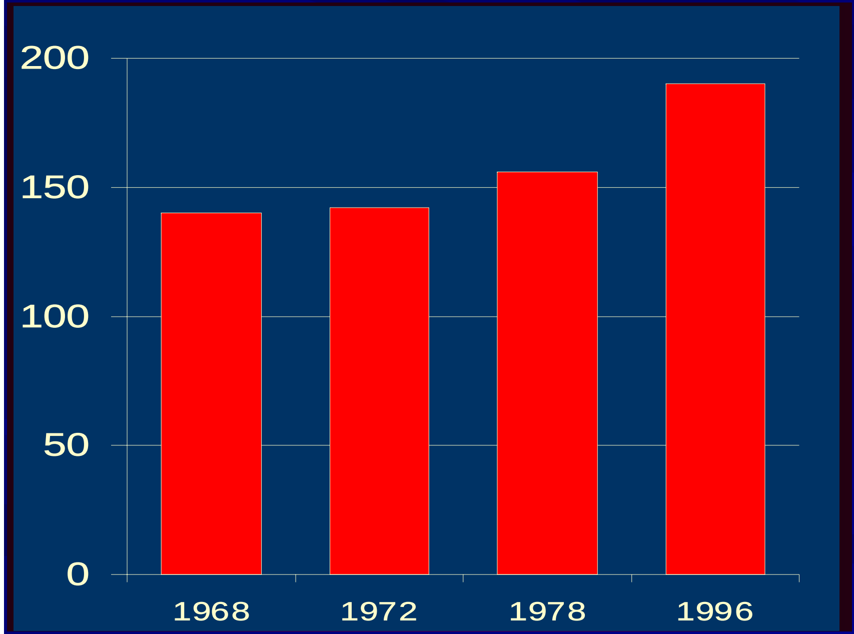
(Annual Rate of Increase - 3% Real)

The Primary Drivers of the Gap

- Another round of new investments to deal with a growing population & economy.
- For the first time, substantially adjusting financial approaches, to meet increasing demands for maintenance, repair, renewal and replacement associated with aging systems.

For The Last Several Decades The Focus

Serving More People (In Millions)



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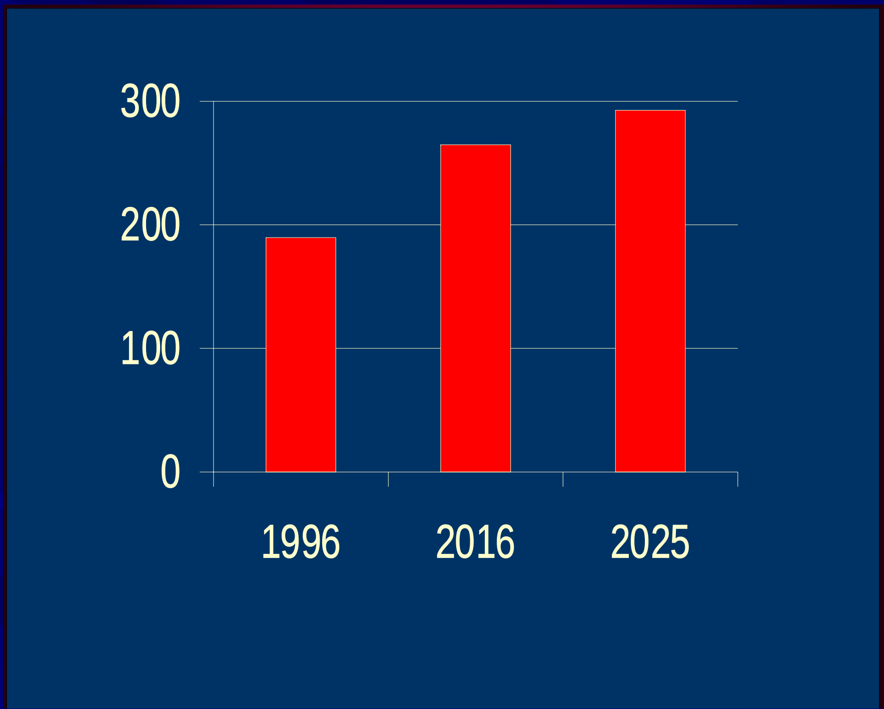
Higher levels of treatment				
	72	82	92	96
Total Plants	19,355	15,662	15,613	16,024
Less than Secondary	13.4%	19.9%	5.6%	1.1%
Secondary	48.7%	50.7%	58.2%	58.6%
More than Secondary	2.4%	17.6%	23.6%	27.6%
No Discharge	2.4%	10.2%	12.7%	12.7%

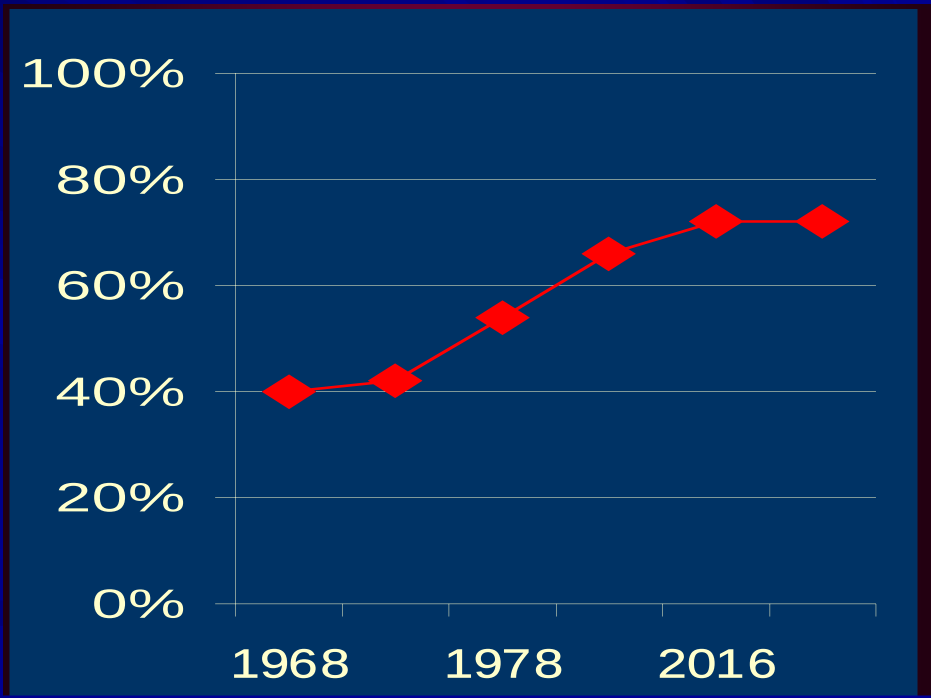
Source: USEPA, Progress in Water Quality: An Evaluation of the National Investment in Municipal Wastewater Treatment, June 2000.

The Emerging Challenge

Additional Served Population 1996 to 2025 (In Millions)



Leveling Off of BOD_U Removal Efficiencies



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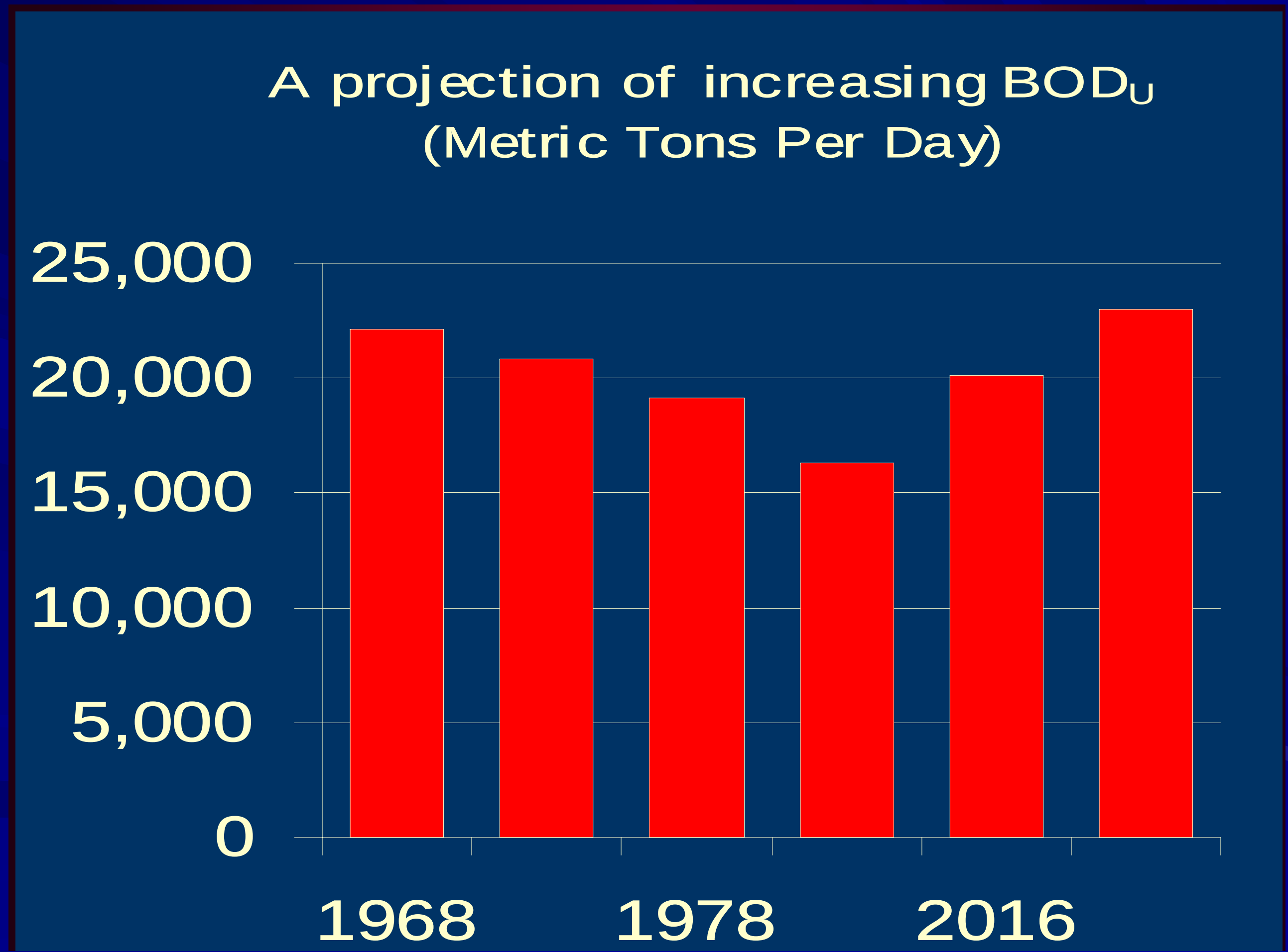
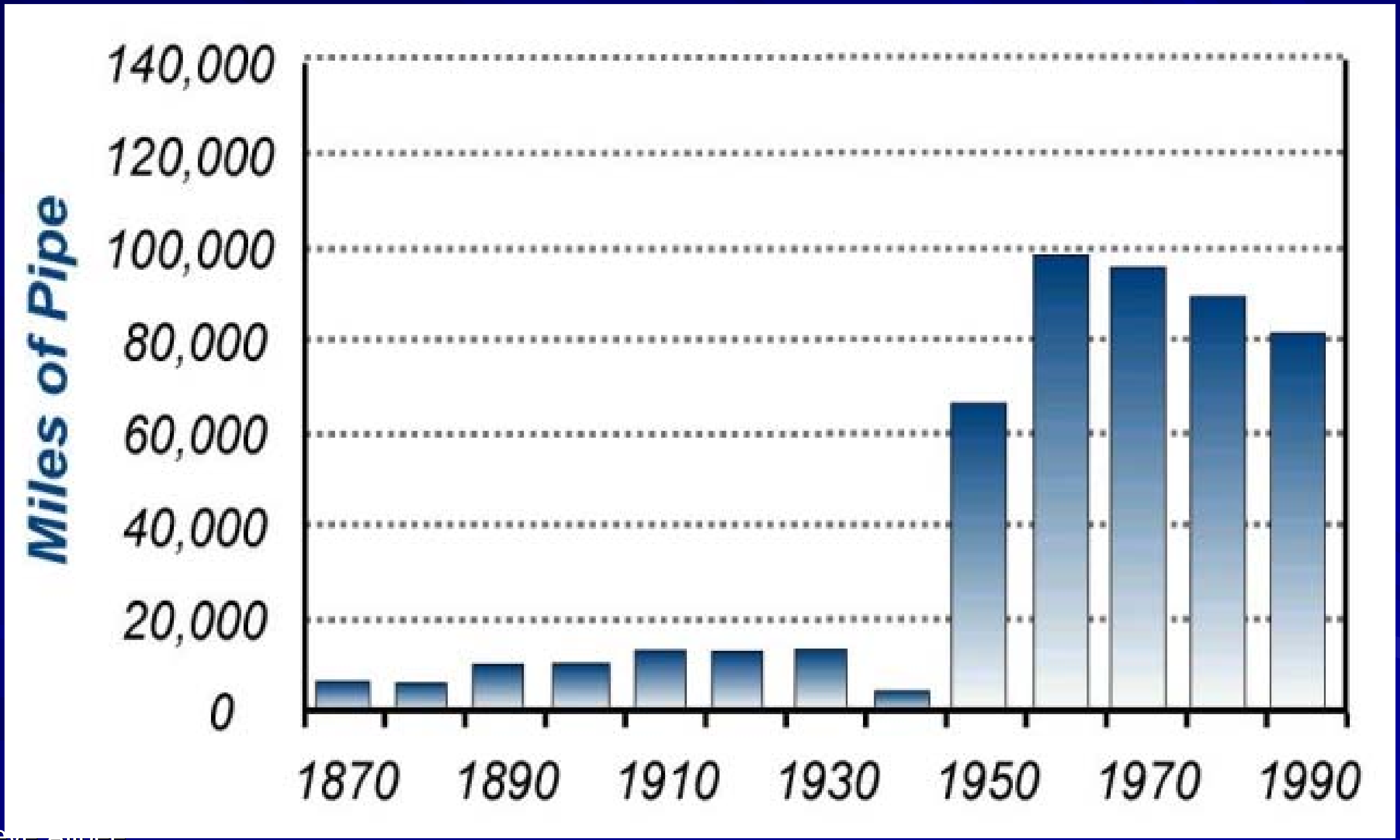
Source: USEPA, Progress in Water Quality: An Evaluation of the National Investment in Municipal Wastewater Treatment, June 2000.

The Additional Growth, Could Produce by 2016, BOD Loading to the Waters Similar to the Mid-1970s

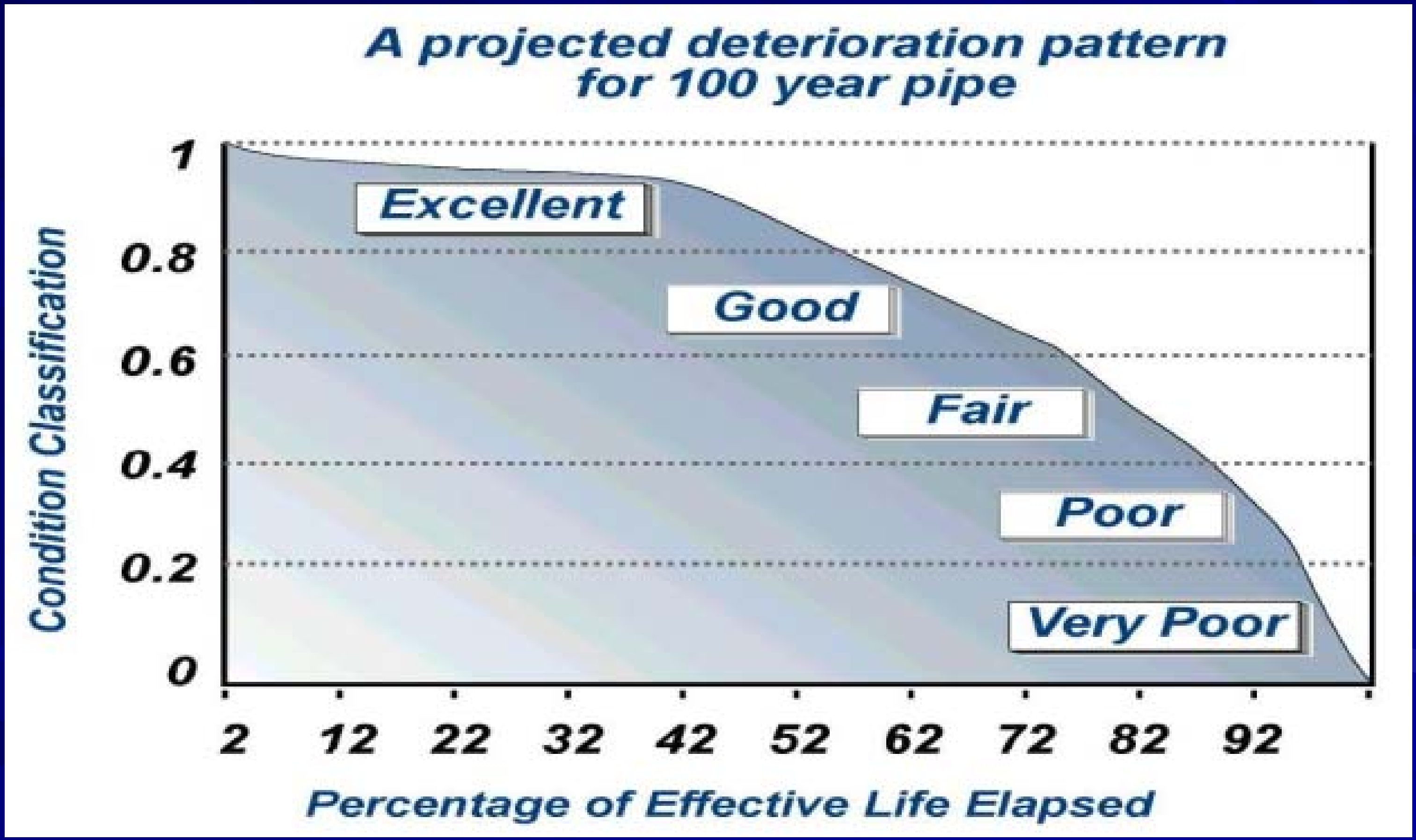
Source: USEPA, Progress in Water Quality: An Evaluation of the National Investment in Municipal Wastewater Treatment, June 2000.



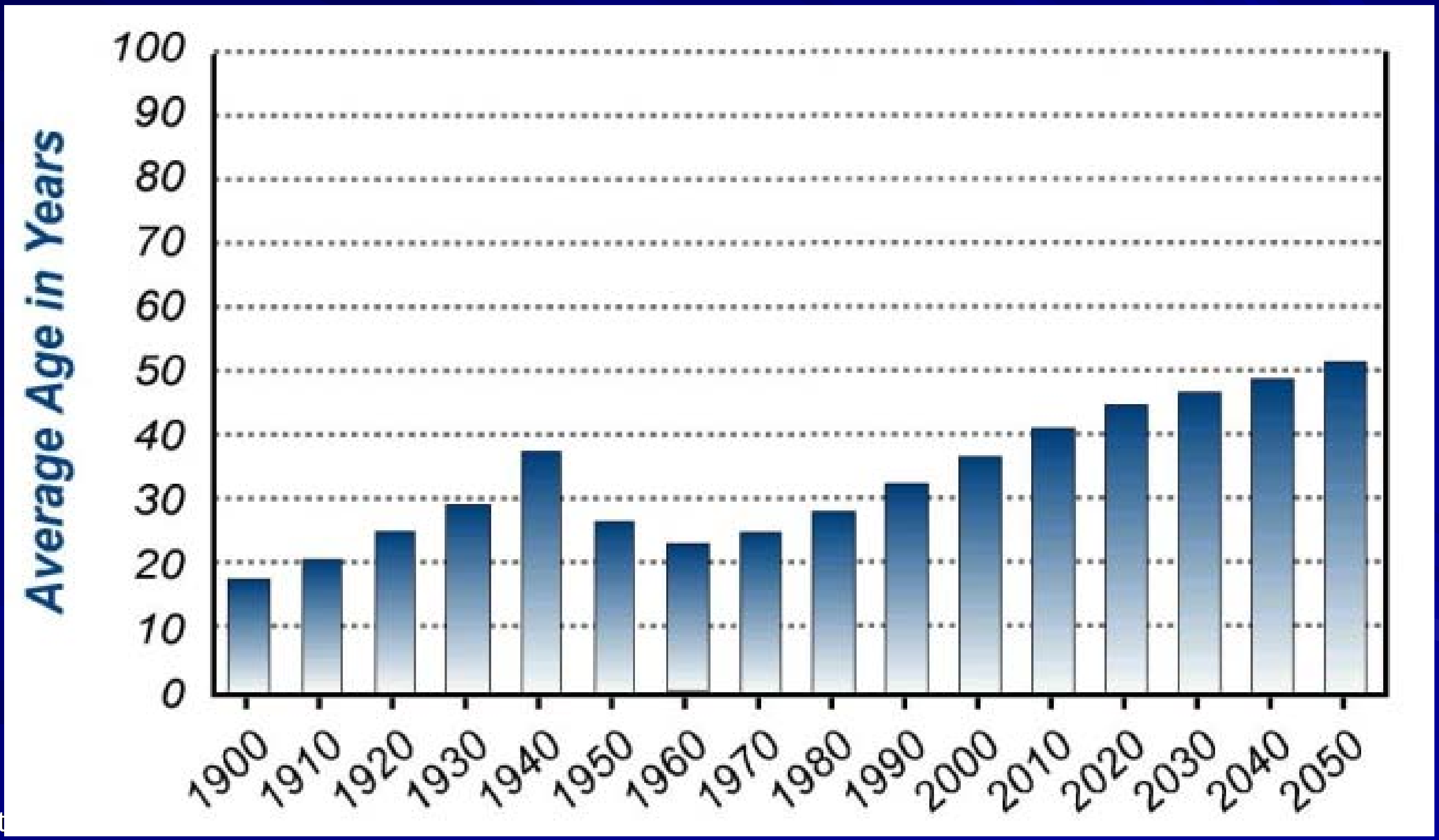
The Network Reflects the Demographics of Urbanization



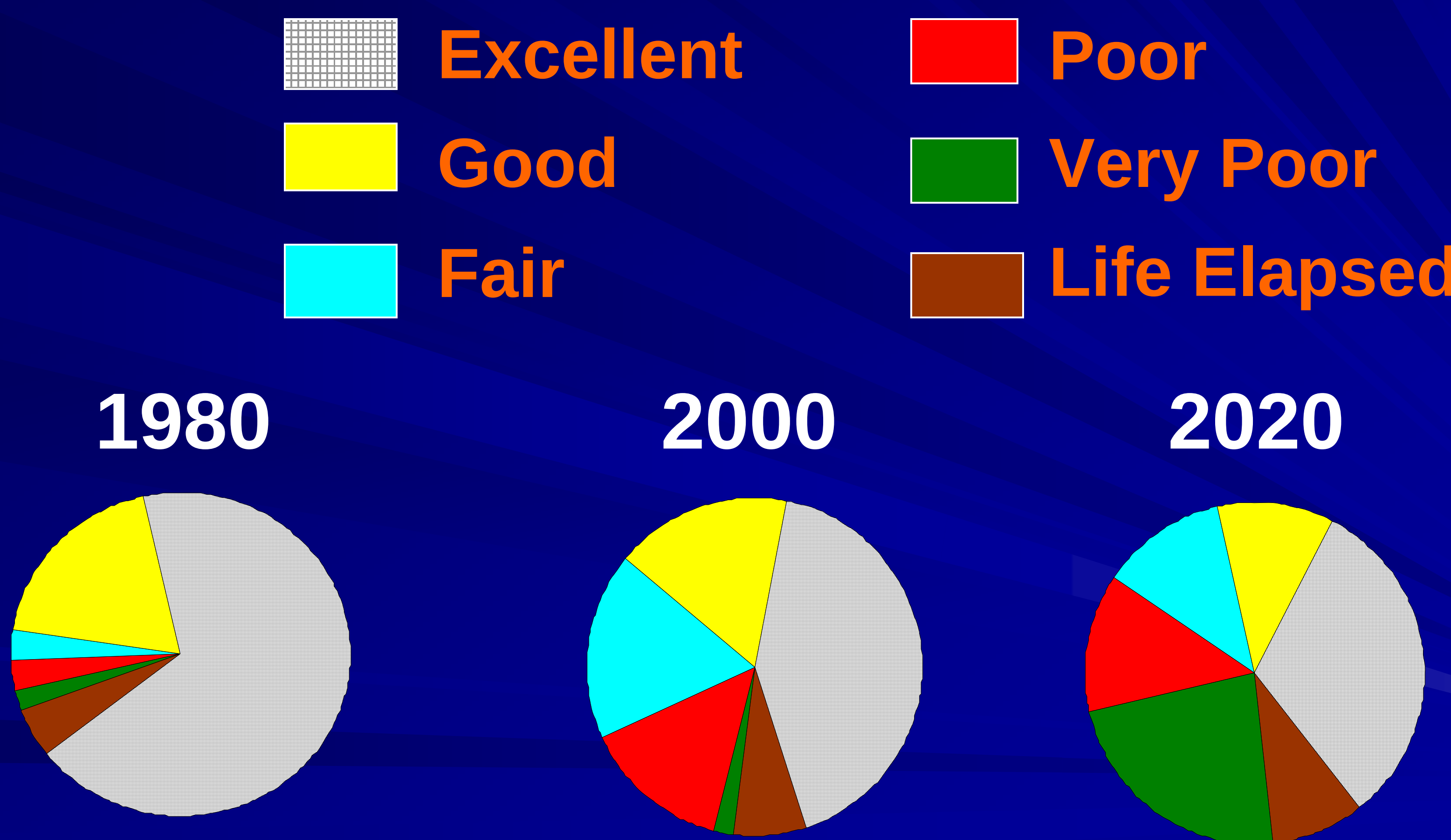
All Physical Assets Deteriorate



The Average Age of the Pipe Network Will Increase Until 2050



More Pipe in Lower Condition Levels Will Impact Costs and Performance



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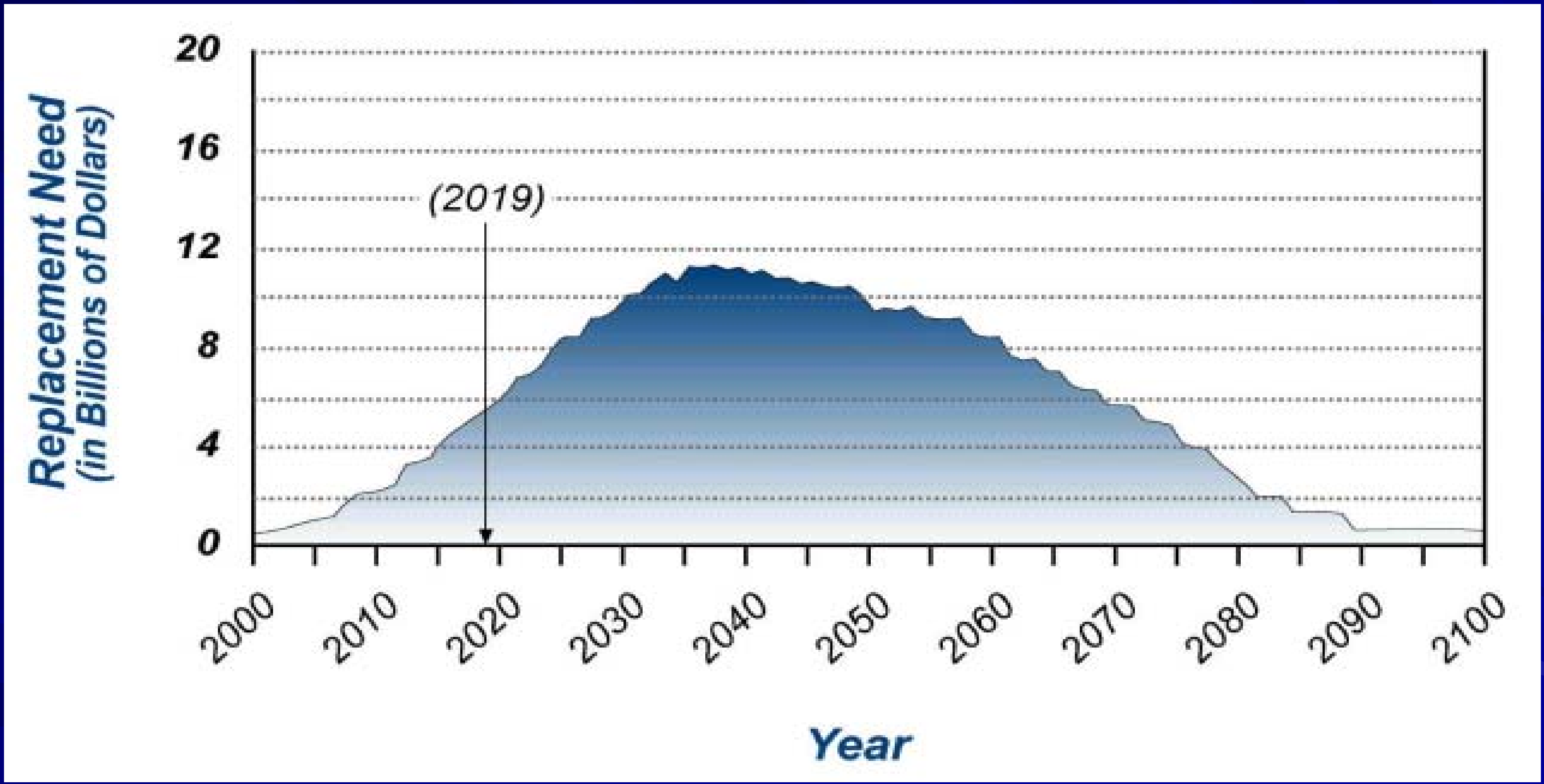
Approximately 2 - 2.5 Million Miles

Water / Wastewater: Public / Private

The Challenge Peaks After "2000 - 2019"



This Is Not A " All Broke Crisis" But, Well on the Way to a Systemic Problem

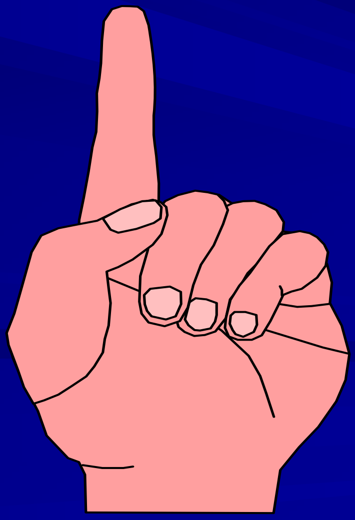
- Our systems are aging.
- The status quo will result in increased public health and environment risk.
- Failure to manage the assets based on life cycle costs will require more revenues over the long term to meet service objectives.

EPA Has Identified Priority Target Areas

- ❖Better management
- ❖Water efficiency
- ❖Full cost pricing
- ❖Watershed approach

EPA Is An Important, But, Not the Primary Player

The One Thing That Is Critical To Sustainability Is That Utilities Are Able to Do Their Work Expertly



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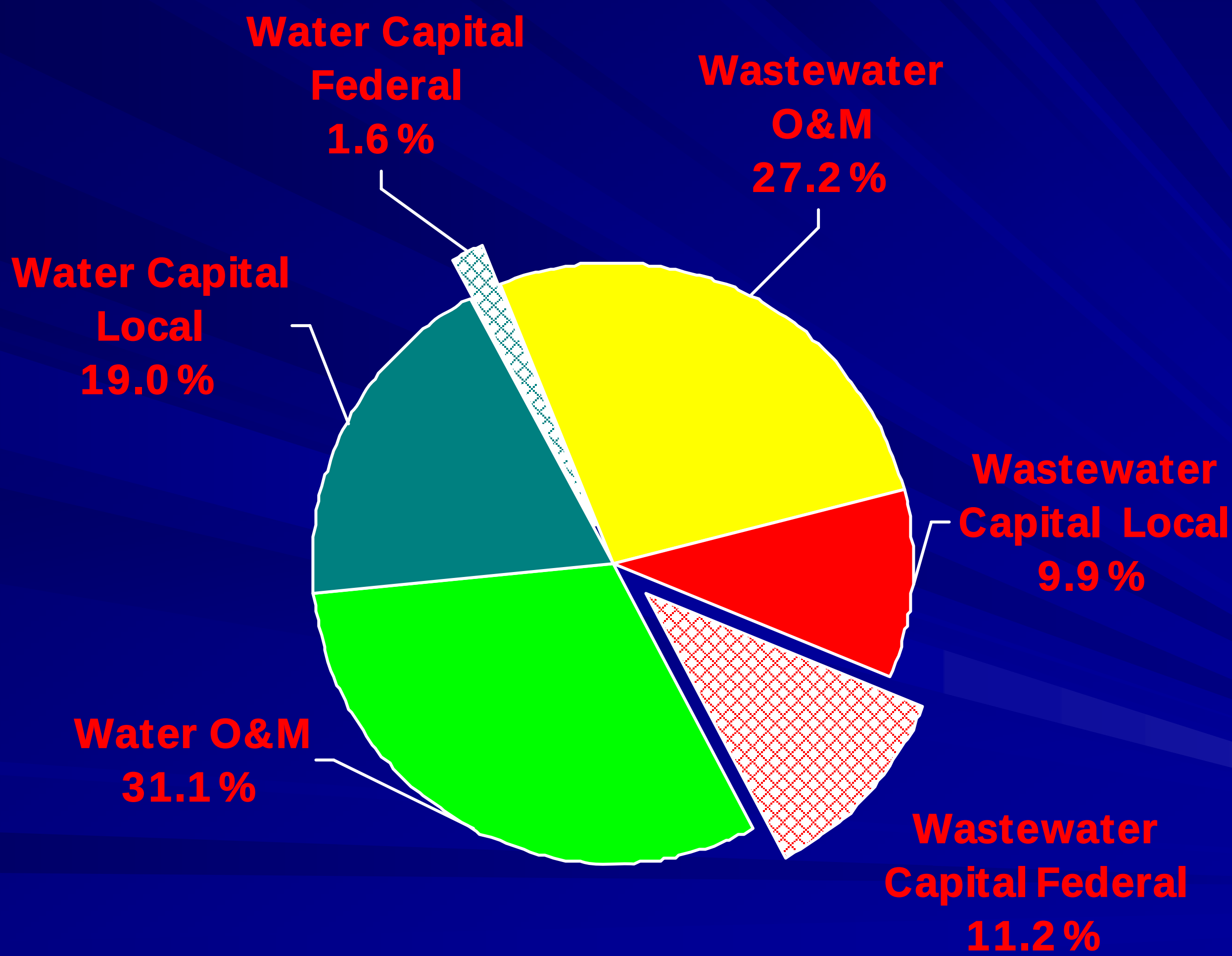
The Vast Majority of the Resources Come From Local Sources



Sources of funds from 1956 to 1994

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Sustainable Water Resources
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Bottom Line: Emergent Industry Profile

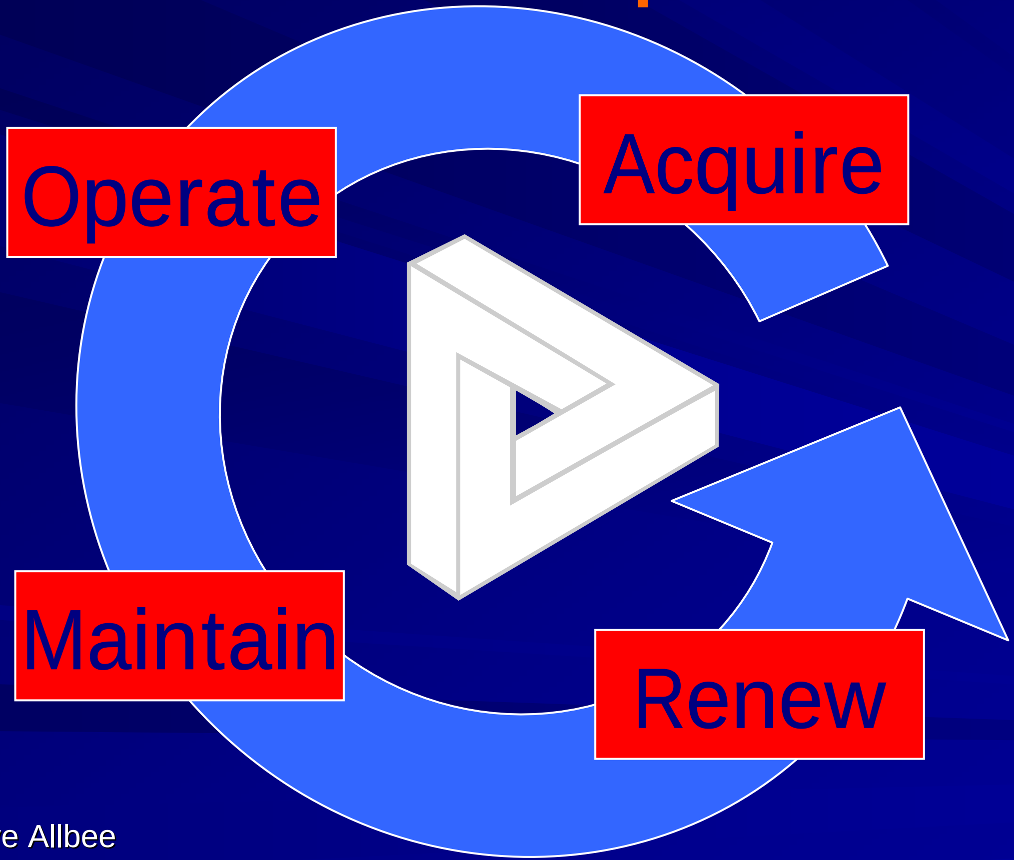
- Increasing aggregate demand – water and wastewater
- Diminishing available water resources
- Leveling of "production efficiencies"
- Increasing output restrictions
- Aging infrastructure
- ➢ ***Result: Increasingly expensive treatment options***

- Aging customer base – more and more on fixed income
- Diminishing technical labor pool running larger and more sophisticated plants and facilities
- Outflow of knowledge with retiring labor base
- Increasing resistance to rate increases
- ⦣ ***Result: Increasingly complex management environment***

Becoming Expert at Maintenance, Repair, Renewal or Replacement Is the Heart of Managing a Successful Water or Wastewater Service

Least Cost Management of the Asset Is About The Total Life Cycle Cost of Ownership

"A Dollar Spent is A Dollar Spent"



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Utilities Face Three Fundamental Management Decisions

- What are my work crews doing and where are they doing it?
- What Capital Improvements Projects (CIP) should be done and when?
- When to repair, when to renew and when to replace?

These decisions typically account for at least 80% of a utility's annual expenditures!

The Focus Of Advanced Asset Management

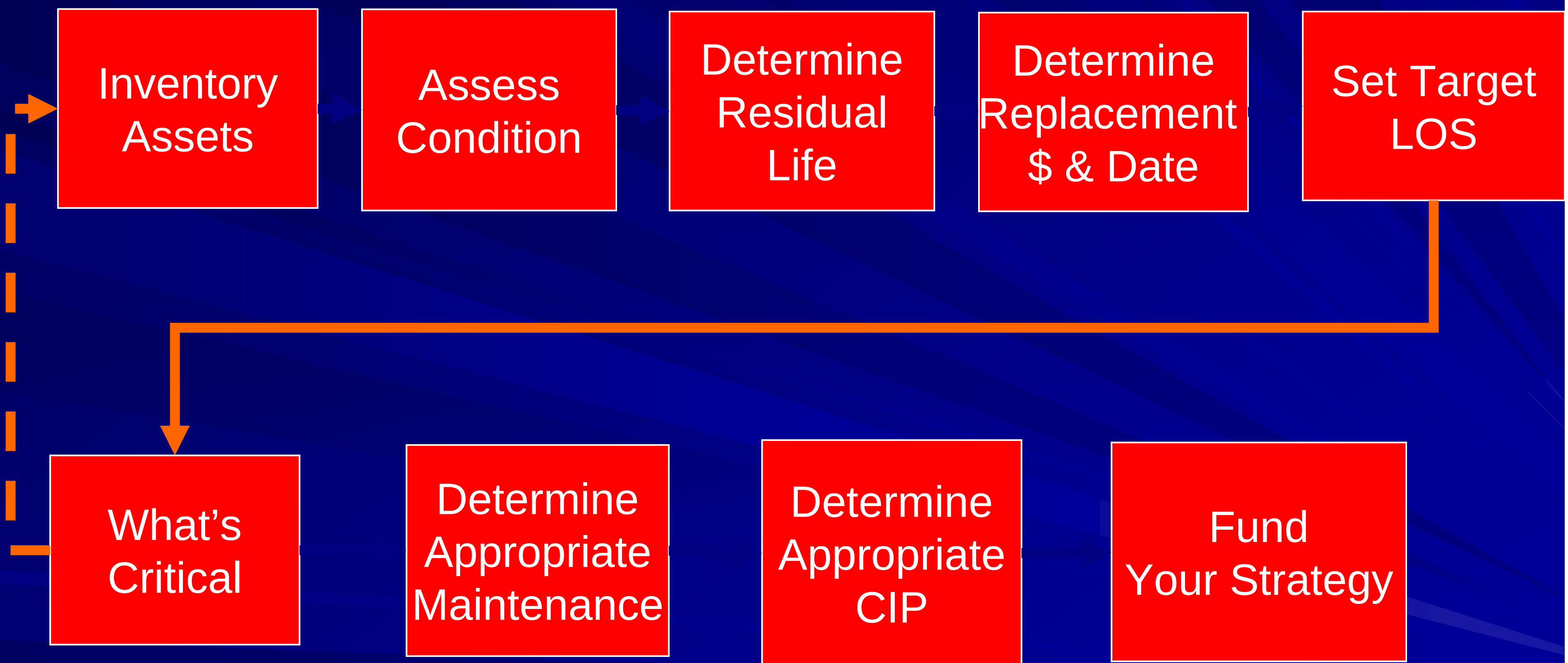
Core Questions, Process

& Life Cycle Cost

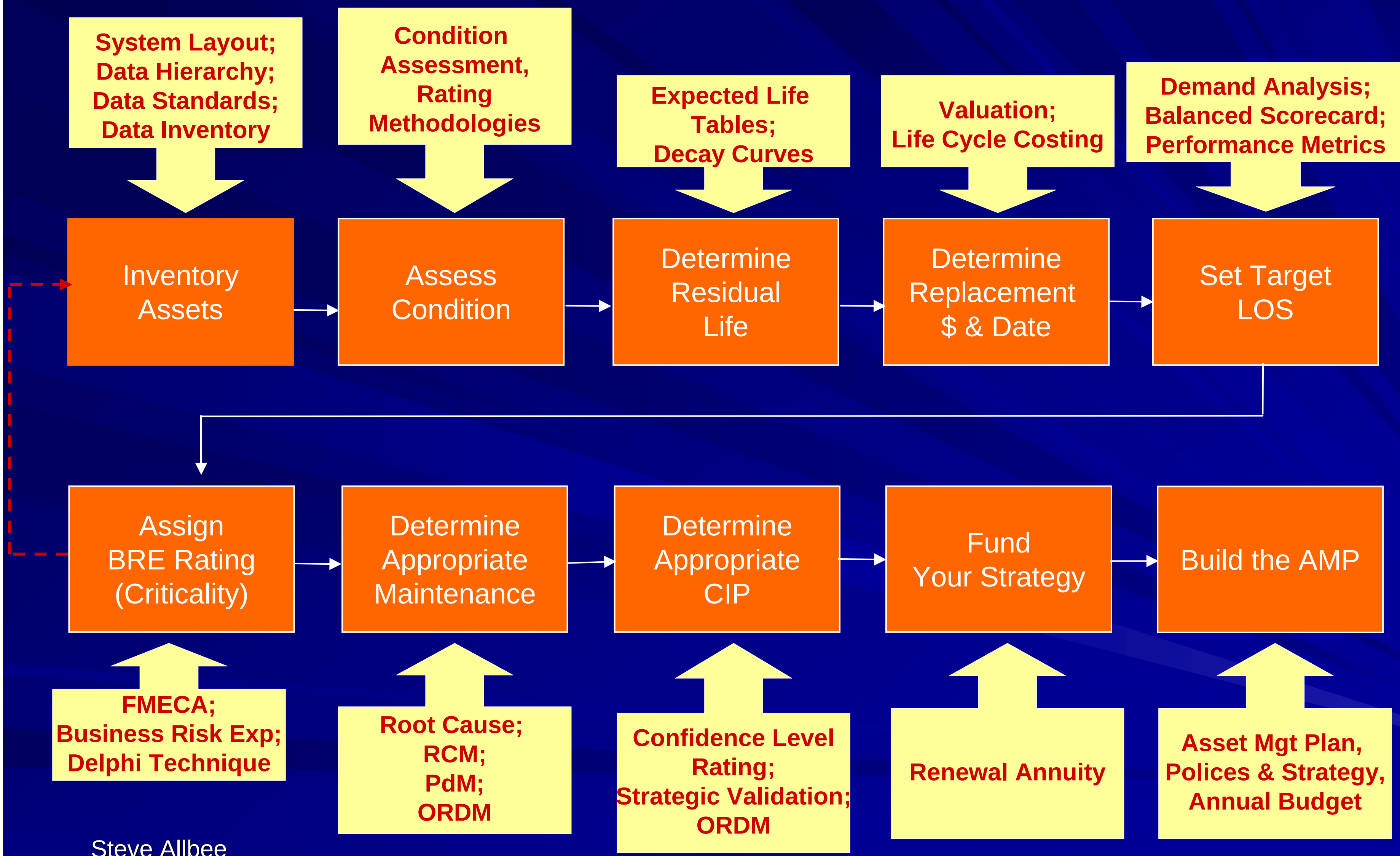
The Five Core AM Questions

Core Questions
1. What is the current state of my assets? What do I own? Where is it? What condition is it in? What is its remaining useful life? What is its economic value?
2. What is my required sustained Level Of Service? What is the demand for my services by my stakeholders? What do regulators require? What is my actual performance?
3. Given my system, which assets are critical to sustained performance? • How does it fail? How can it fail? • What is the likelihood of failure? • What does it cost to repair? • What are the consequences of failure?
4. What are my best "minimum life-cycle-cost" CIP and O&M strategies? • What alternative management options exist? • Which are most feasible?
5. Given the above, what is my best long-term funding strategy?

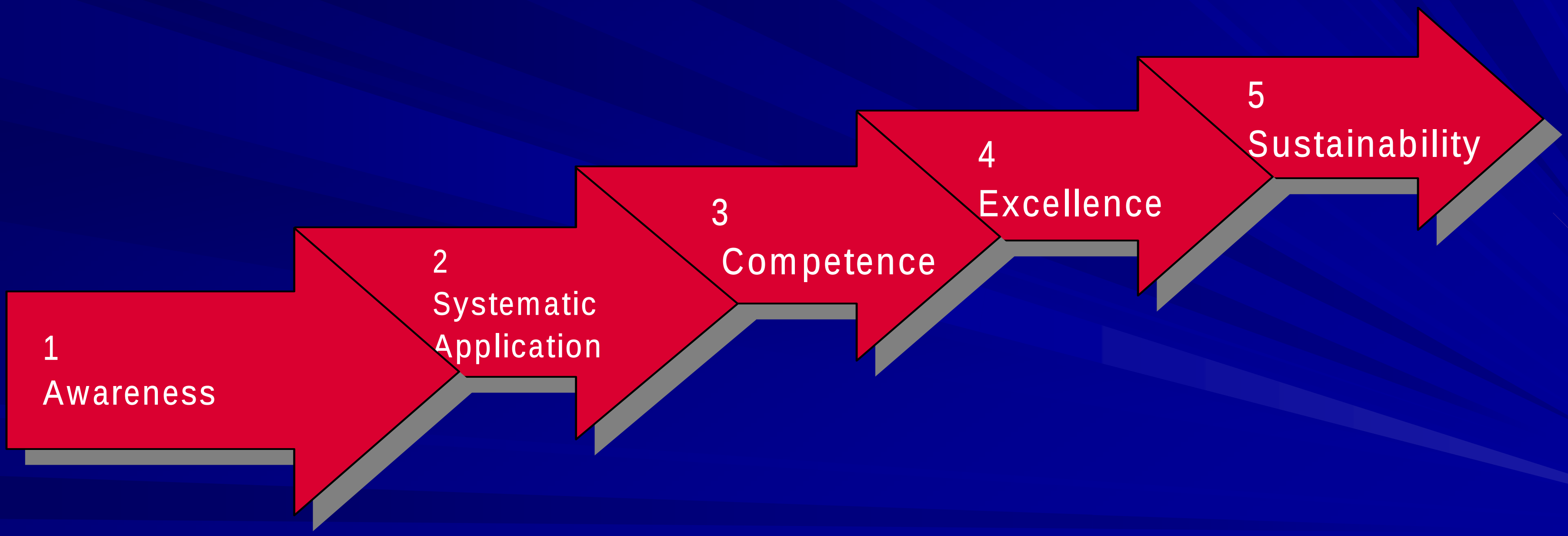
The Asset Management Program Process



Core AAM Program Process Tools



The Pathway to Success In AAM Is Through Adoption of The Framework and Structure



Time Is Required to Become Expert at the Content and Process

The Emerging Paradigm

Sustainable Management

"A Systems Approach to the Whole of What a Water Utility Does"

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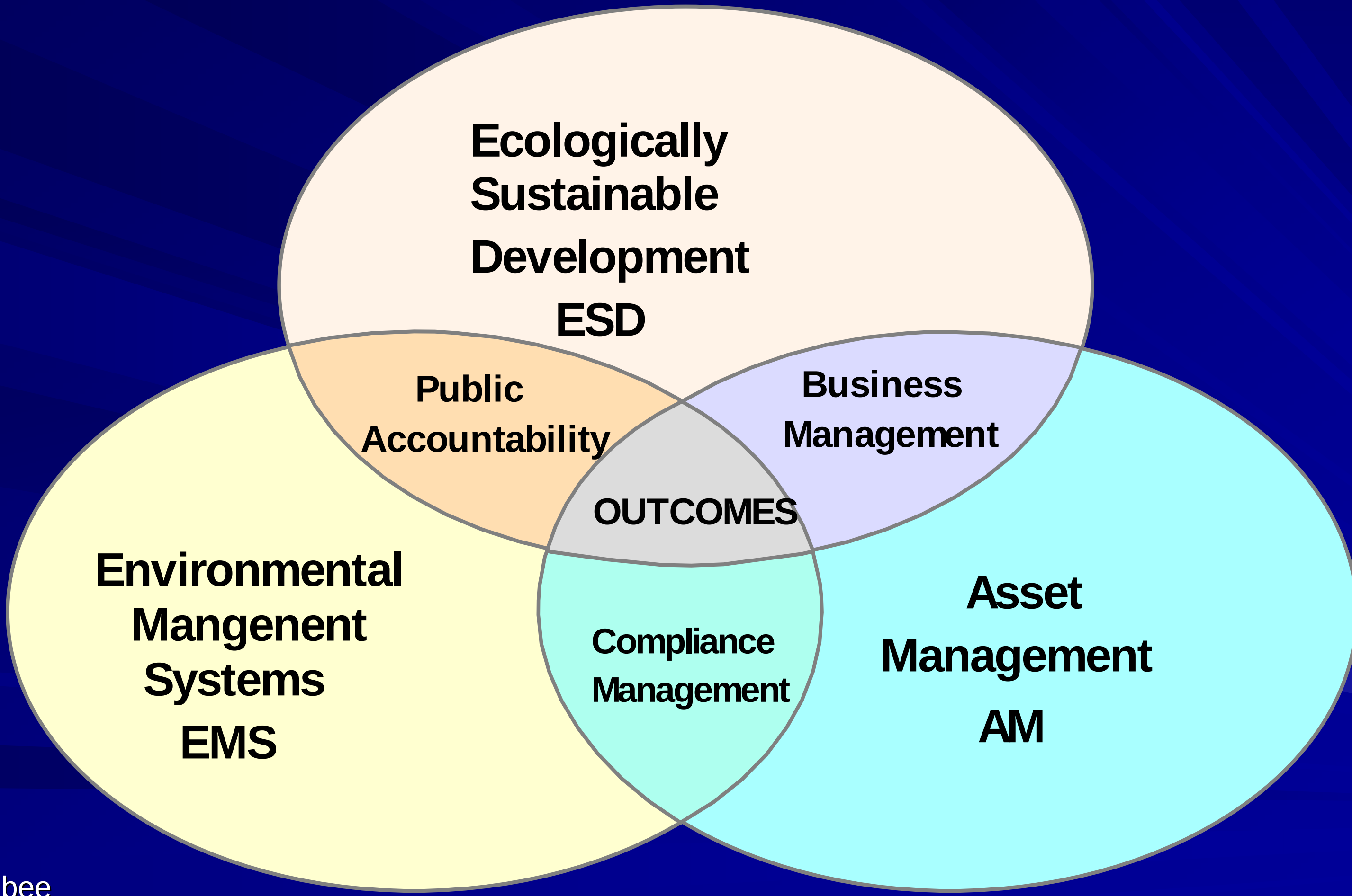
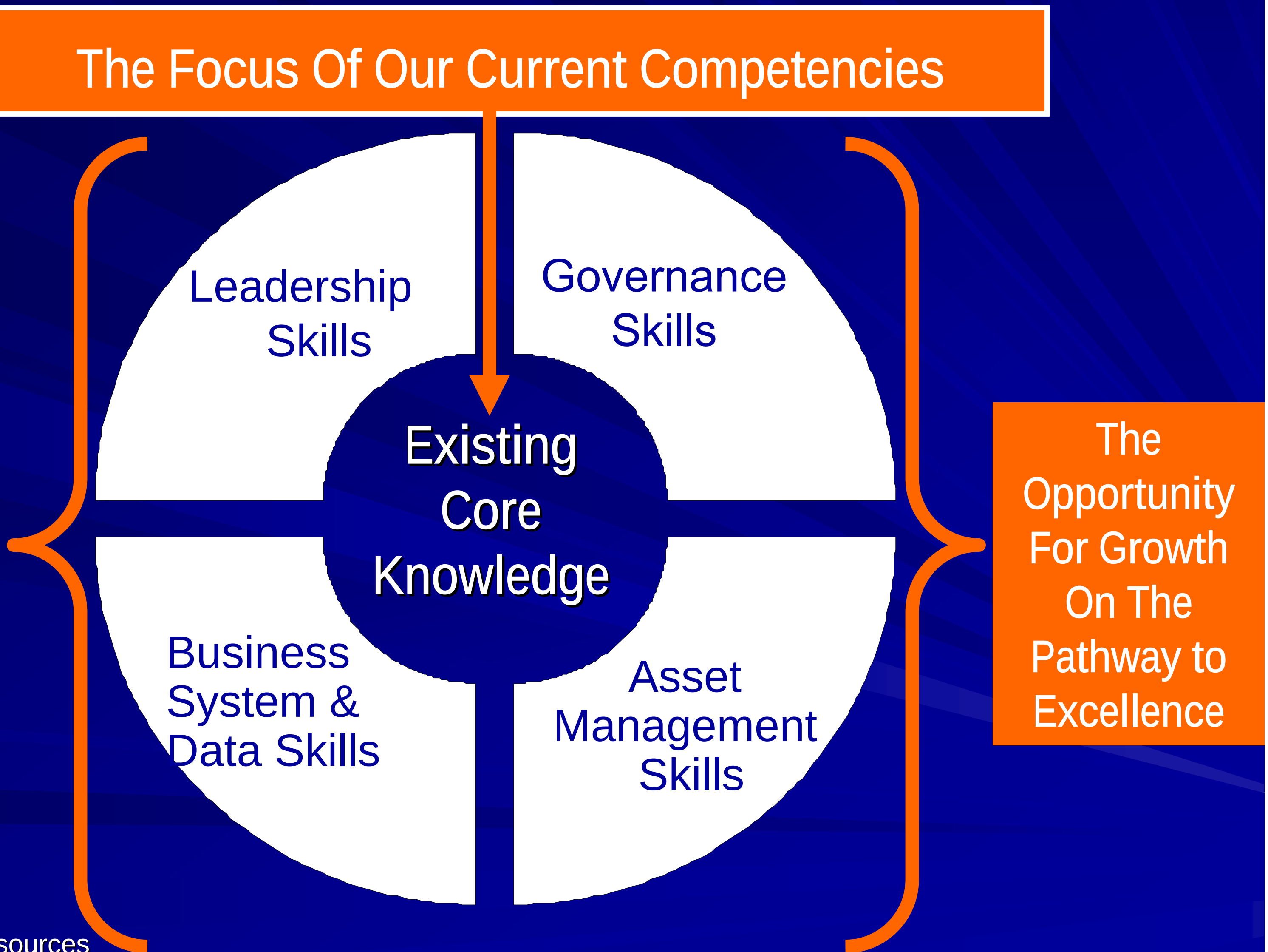
The Holistic View Of Sustainable Management Systems



Emulate The Key Characteristics of Sustainable Utilities

Additional Skills Will Be Require to Become A Sustainable Business



Have A Great Day!

Sustainable Water Resources: Drinking Water Issues

Janice Skadsen
Water Quality Manager
City of Ann Arbor

Key Issues for Drinking Water

- Quantity
- Quality
- Cost

Quantity
Ground and Surface Waters

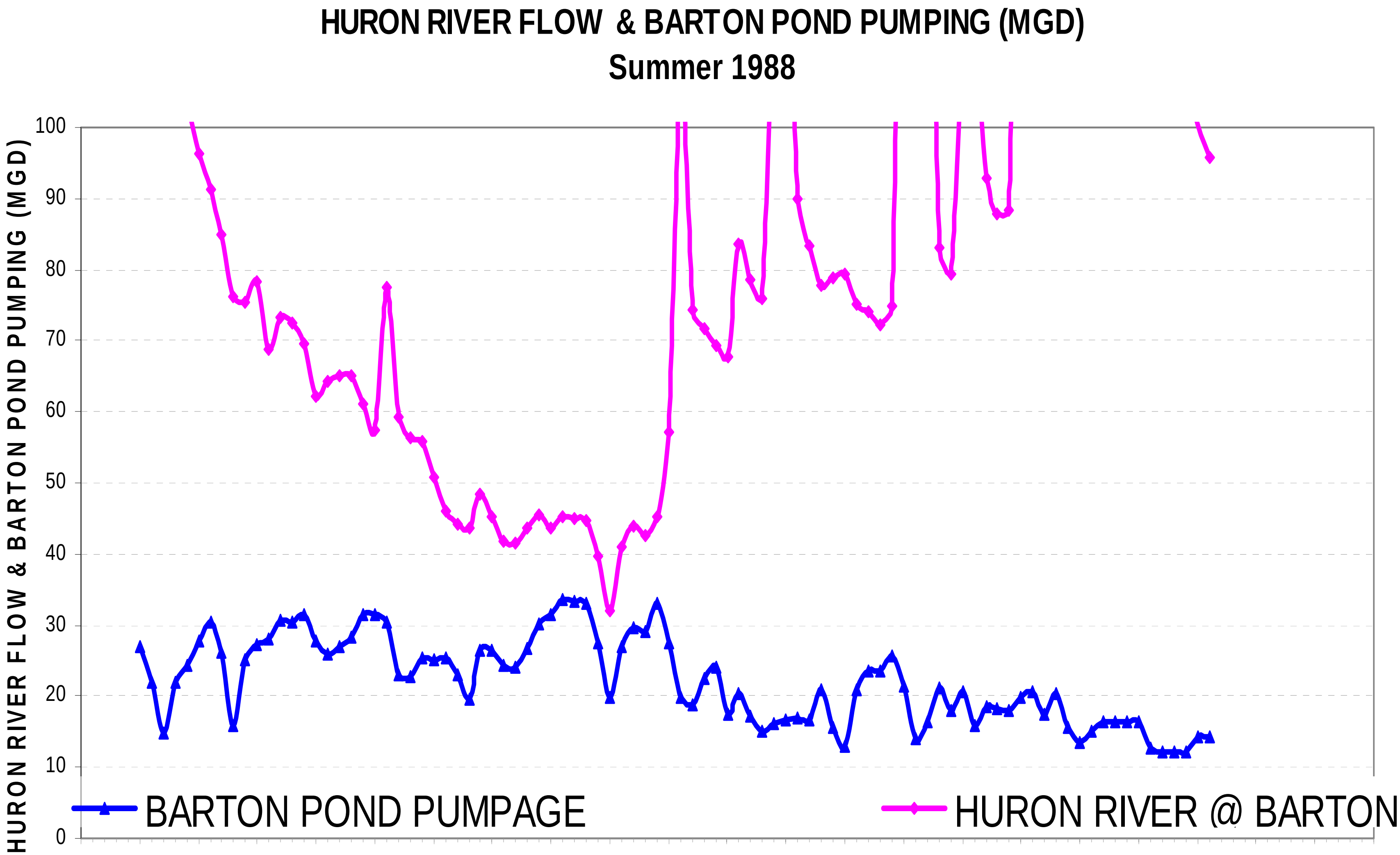
- “Great Lakes” unlimited supply
- Local impacts can limit surface and ground waters availability
- Ground and surface systems are integrally linked

Drinking Water Systems

- Over 2500 drinking water systems in Michigan rely on Groundwater
- Approximately 75 rely on surface waters

Droughts

- Decreased lake levels, river flows, water table levels impact utilities ability to withdraw sufficient water
- Droughts occur at same time as highest water demands



HURON RIVER FLOW & BARTON POND PUMPING (MGD)
Summer 1988
HURON RIVER FLOW & BARTON POND PUMPING (MGD)
100
90
80
70
60
50
40
30
20
10
0
BARTON POND PUMPAGE
HURON RIVER @ BARTON

Competition for Resources

- Multiple water users
- Run of river & pond level requirements
- Recreational usage
- Environmental needs

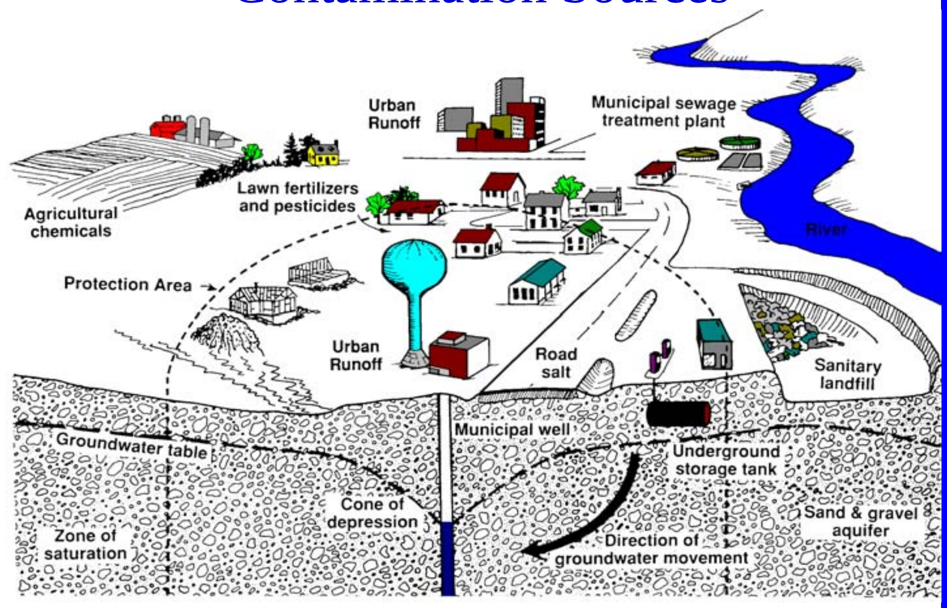
Quality

- Contamination
- Point & Non-Point Discharges
- Eutrophication
- Invasive species
- Natural constituents
- Emerging issues
- Climate change

Contamination

- Persistent
- Increased loading
- New
- New detection methods
- Lower detection limits

Contamination Sources



Point & Non-Point Discharges

- Distance between wastewater discharge and drinking water intake typically <5 miles
- Increasing population
- Manufacturing
- Changing land use

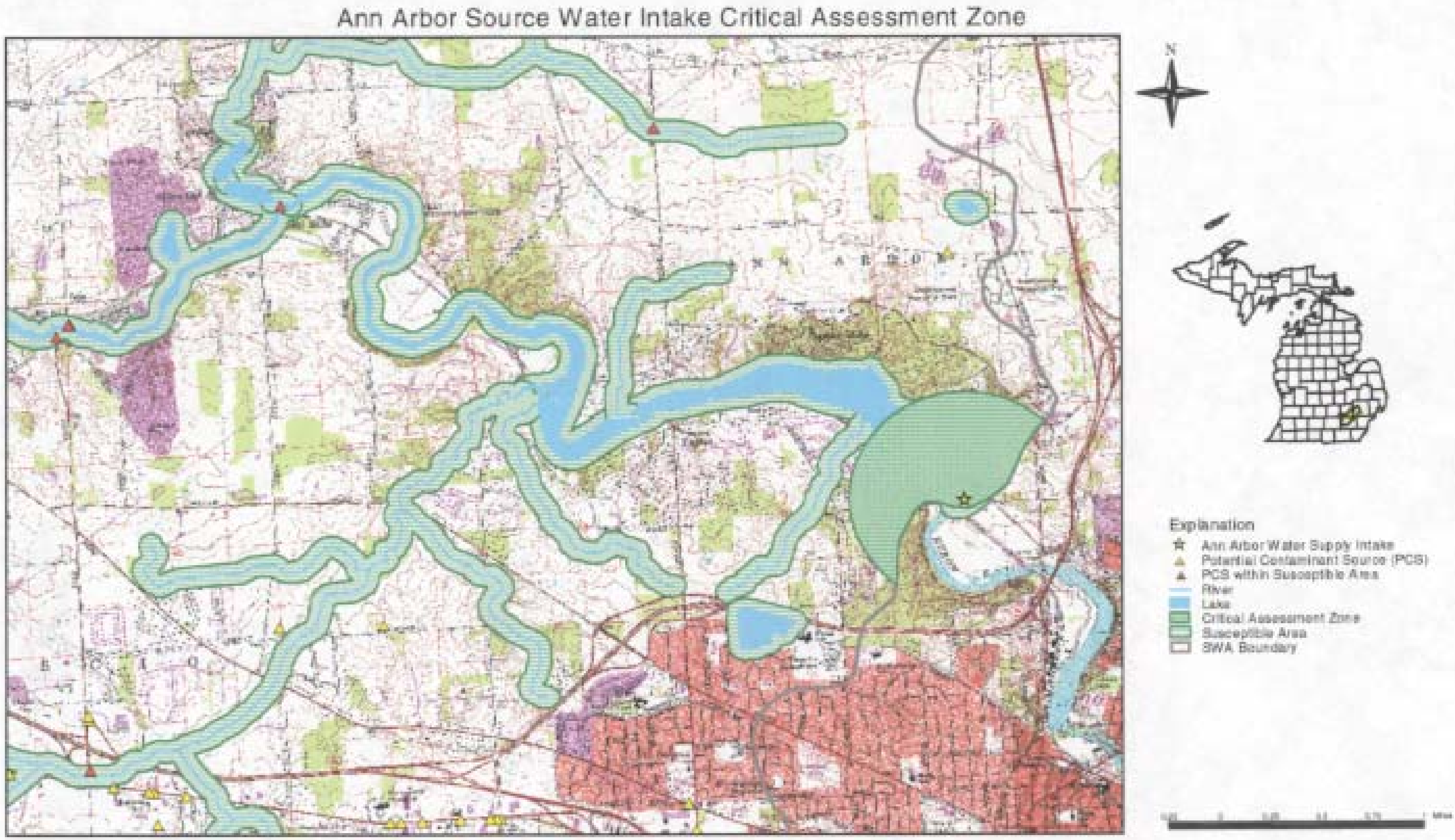


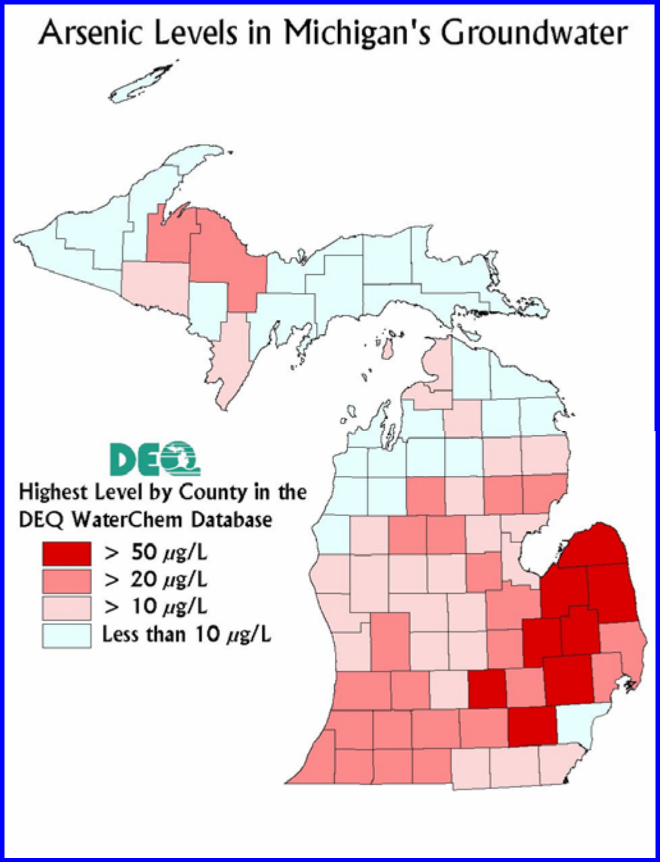
Figure 3. Critical assessment zone (CAZ) for the Ann Arbor water supply, Ann Arbor, MI.

Eutrophication

- Increasing nutrients concentrations
- Land use changes
- Increasing population

Natural Constituents

- Arsenic
- Iron
- hardness



Emerging Issues

- Pharmaceuticals
- Endocrine disruptors
- Personal care products
- Medical applications
- NDMA, perchlorate, MTBE

Study to trace new chemicals in city water

Ann Arbor gets grant to detect 'personal care' substances, such as antibiotics

latory agencies routinely monitor because they have not been an issue in the past. And no one knows what, if any, long-term effects they may have on creek health or people who come into contact with them.

WATER FROM A1

U.S. study found chemicals in 80% of sampled streams

prevalence and concentration levels of such substances in any given body of water, experts say.

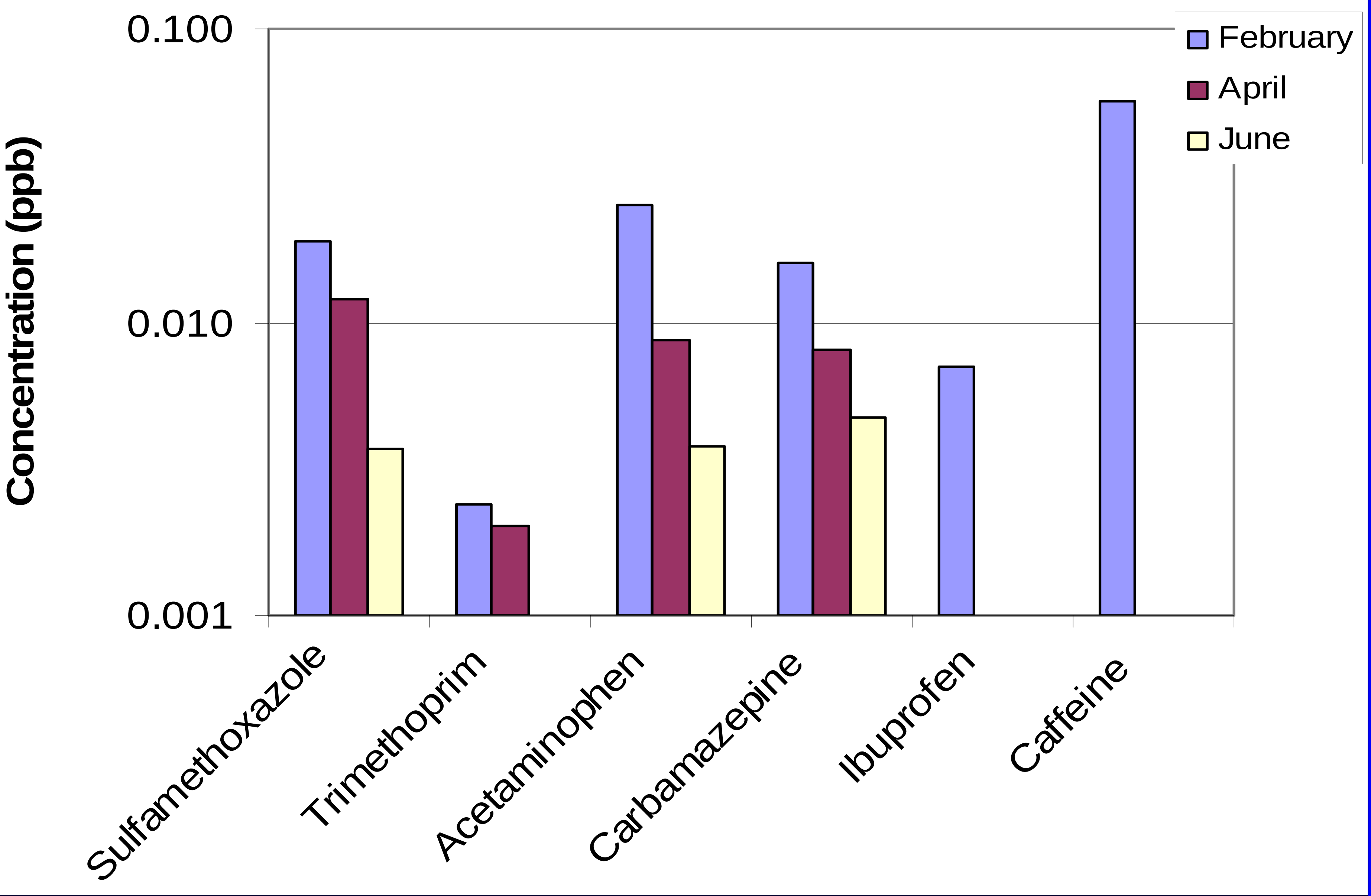
But a 1999-2000 study by the U.S. Geological Survey shows that a broad range of chemicals from residential, industrial and agricultural wastewaters often occur at low concentrations downstream of urbanized areas. The study also found they occur in waters downstream of major animal operations, like large animal farms.

Rubin, executive director of the Huron River Watershed Council.

The watershed council has been trying to educate people about disposing of medications by throwing them away instead of flushing them, Rubin said. The problem is that people worry about liability or harming others if someone else gets them out of the trash.

"As you start to look into it, it's like 'wow, of course,'" Rubin said. "The amount of antibiotics,

Huron River: PPCPs



Climate Change

- Rainfall & snowfall
- Recharge
- Storm impacts
  - Turbidity
  - Microbial degradation
  - Chemical changes

Cost

- Protection of watersheds
- Increasing costs of treatment
- Increasing regulations
- Increasing O&M costs
- Affordability essential

Aging Infrastructure

- Estimated that over $1 trillion dollars needed to repair replace decaying water/wastewater infrasturure

Research needs: quantity

- Interrelationship between ground and surface waters
- Impacts of climate change
- Water conservation
  - Methods for the Midwest
  - Public acceptance
- Impacts of land use
- Protection of water resources
  - Communication
  - Commitment
  - Priority
  - Effectiveness

Research needs: quality

- Disconnect between point/nonpoint sources versus drinking water supply
- Nutrient reduction
- New contaminants
- Health effects of contaminants
- Spill detection and response
- Source tracking

Conclusions

- Quantity and quality are critical for the production of drinking water
- The more reliable the quantity and the higher quality of the source, the better the quantity and quality of the drinking water
- Goal is to protect public health
- Cost: must be affordable

Risks in Urban Water Management:
Current and Future Water Needs

Peter Adriaens, Ph.D.
Environmental and Water Resources Engineering and Natural Resources and Environment

Contents

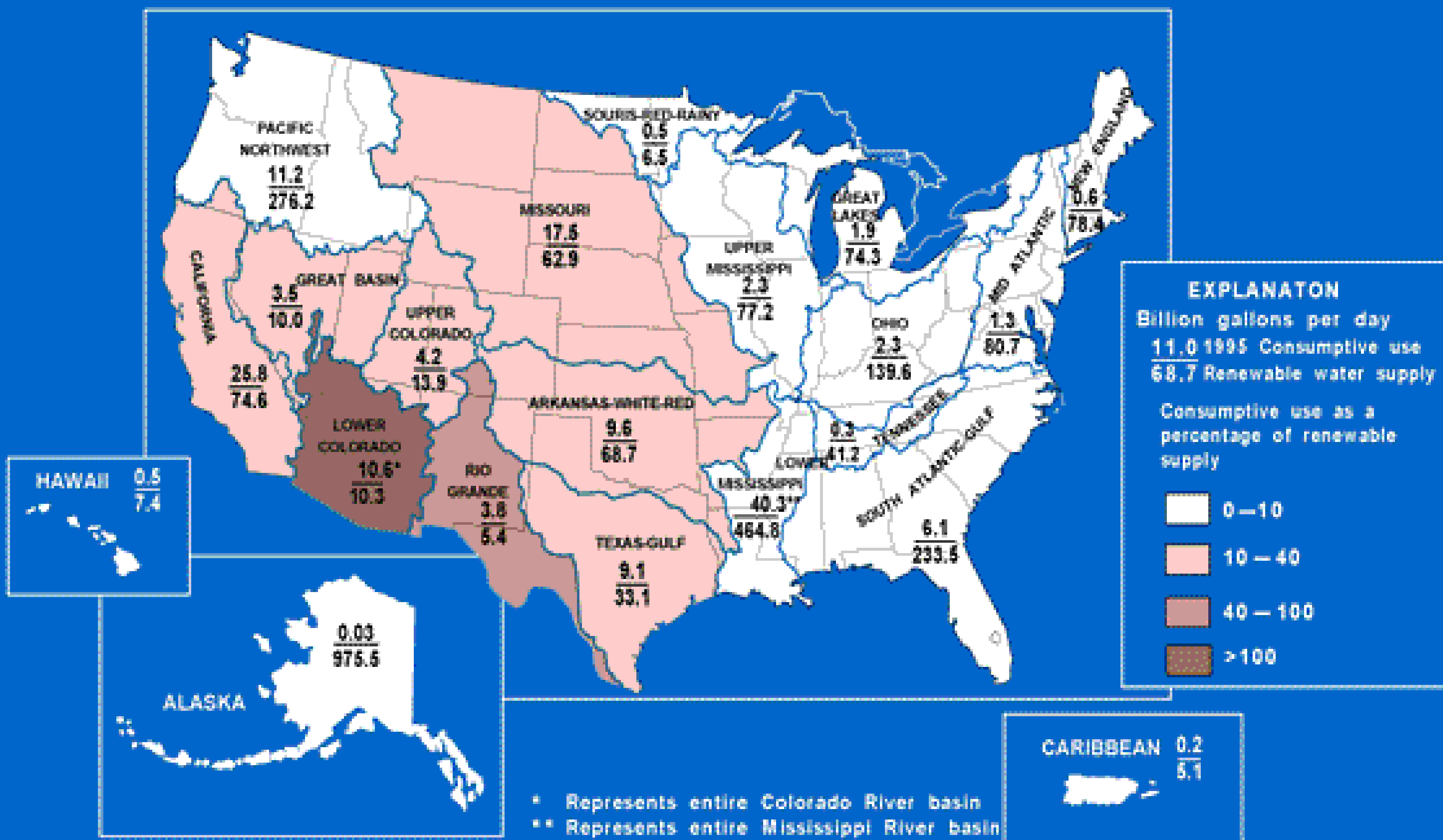
- Framing the question: “Urban water risk and risk management in 21st century”
- Challenges I: Infrastructure report card
- Challenges II: Waterborne diseases
- Challenges III: Emerging contaminants
- Challenges IV: Vulnerability of water supply systems
- Conclusions

Urban Water Challenges: 20th vs 21st century

- Acute problems
- Short-term impacts
- Technical probability certain
- High cost/benefit ratio
- Public perception of risk clear

- Chronic problems
- Long-term benefits?
- Technical probability uncertain
- Cost/benefit ratio uncertain
- Public perception of risk unclear

CONSUMPTIVE USE AND RENEWABLE WATER SUPPLY, BY WATER-RESOURCES REGION



USGS

Society no longer has the luxury of using water only once.

Levine and Asano, ES&T, June 2004

Urban Use: Stretching the water supply through recycling

The introduction of wastewater into drinking water aquifers and surface water has become an important element in water resource planning to stretch a scarce resource

The potential health and ecological effects of exposure to recycled water are not well understood

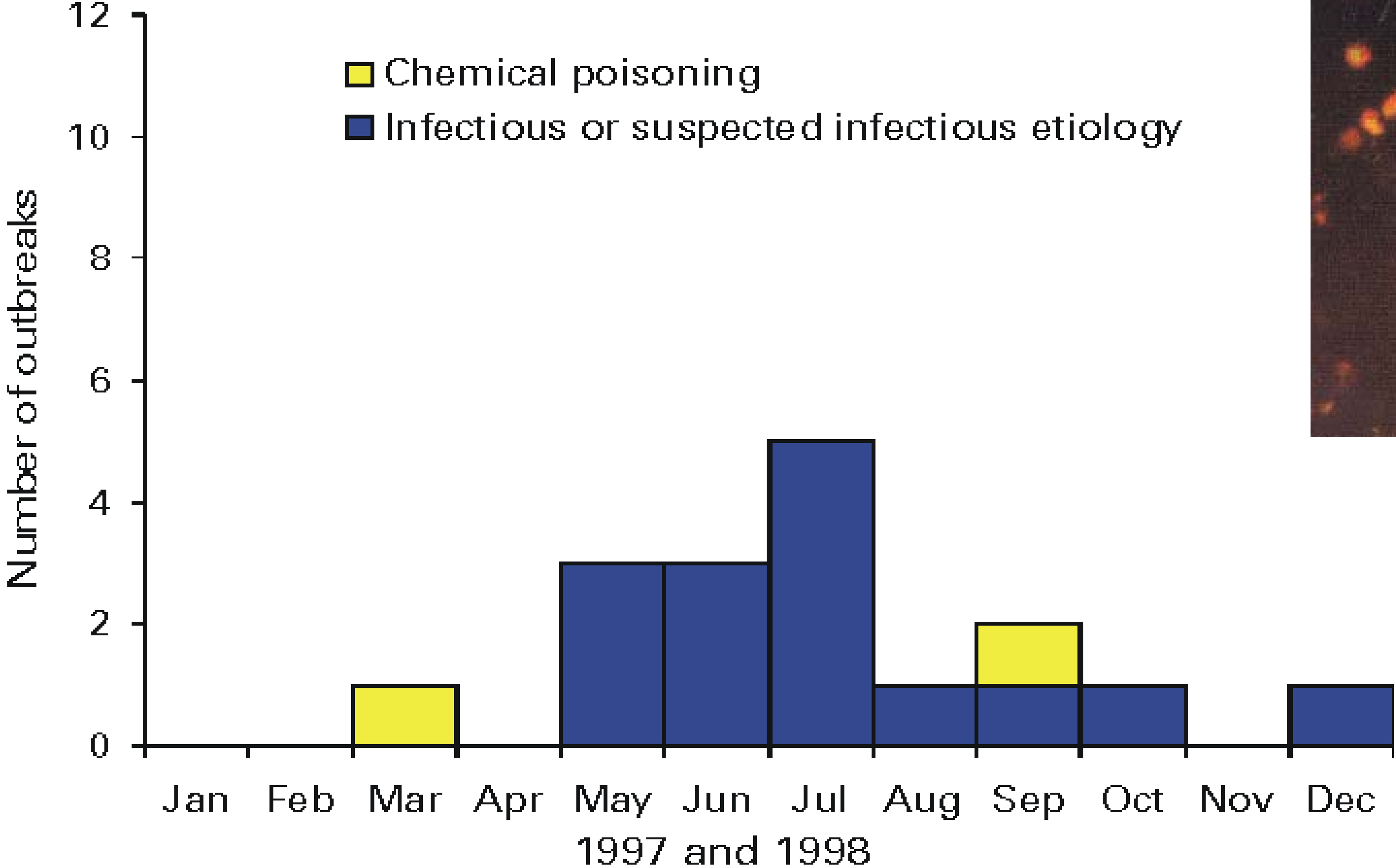
Urban Water Challenges: I. Water-Borne Diseases

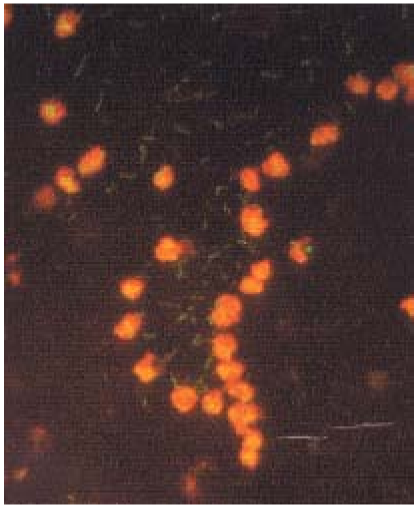
- Widespread contamination of surface waters and shallow wells by multiple pathogens (e.g. *Giardia* or *Cryptosporidium* in 5-50% of well and springs)
- From 6-40% of gastrointestinal illness is water related
- Need for disinfection complicates picture due to emerging evidence of disinfection by-products
- Limited effectiveness of disinfection to control most common pathogens
- Re-emerging pathogens and antibiotics
- Transfer of molecular detection methods for target pathogens and their infectivity from the research laboratory to the field

Major Infectious Agents in Contaminated Drinking Water

Organism	Disease	Primary sources
Bacteria		
Campylobacter	Gastroenteritis	Human feces
Enteropathogenic *E. coli*	Gastroenteritis	Human feces
Salmonella (1700 spp.)	Typhoid fever/salmonellosis	Human/animal feces
Shigella (4 spp.)	Bacillary dysentery	Human feces
Vibrio cholerae	Cholera	Human feces
Yersinia enterocolitica	Gastroenteritis	Human/animal feces
Legionella pneumonophila	Acute respiratory illness	Thermally enriched waters
Viruses		
Adenovirus	Upper respiratory and gastrointestinal illness	Human feces
Enteroviruses (71 types)	Aseptic meningitis poliomyeltis	Human feces
Hepatitis A	Infectious hepatitis	Human feces
Norwalk virus	Gastroenteritis	Human feces
Reovirus	Mild upper respiratory and gastrointestinal illness	Human/animal feces
Rotavirus	Gastroenteritis	Human feces
Coxsackie virus	Aseptic meningitis	Human feces
Protozoans		
Balantidium coli	Balantidiasis (dysentery)	Human feces
Cryptosporidium entamoeba histolytica	Amoebic dysentery	Human feces
Giardia lamblia	Giardiasis (gastroenteritis)	Human feces

Waterborne Disease Outbreaks Associated with Drinking Water (n=17)





Disease Outbreaks: Etiology and Type of Water System

	Type of water system*							
	Community		Noncommunity		Individual		Total	
Etiologic agent	Outbreaks	Cases	Outbreaks	Cases	Outbreaks	Cases	Outbreaks	Cases
AGI†	1	10	3	148	1	5	5	163
Copper	2	37	0	0	0	0	2	37
Cryptosporidium parvum	1	1,400	0	0	1	32	2	1,432
Escherichia coli O157:H7	1	157	1	4	1	3	3	164
Giardia intestinalis	2	57	1	100	1	2	4	159
Shigella sonnei	1	83	0	0	0	0	1	83
Total (%)	**8** (47.1%)	**1,744** (85.6%)	**5** (29.4%)	**252** (12.4%)	**4** (23.5%)	**42** (2.1%)	**17** (100.0%)	**2,038** (100.0%)

*Community and noncommunity water systems are public water systems that serve ≥15 service connections or an average of ≥25 residents for ≥60 days/year. A community water system serves year-round residents of a community, subdivision, or mobile home park with ≥15 service connections or an average of ≥25 residents. A noncommunity water system can be nontransient or transient. Nontransient systems serve ≥25 of the same persons for >6 months of the year (e.g., factories or schools), whereas transient systems do not (e.g., restaurants, highway rest stations, or parks). Individual water systems are small systems not owned or operated by a water utility that serve <15 connections or <25 persons.

†Acute gastrointestinal illness of unknown etiology.

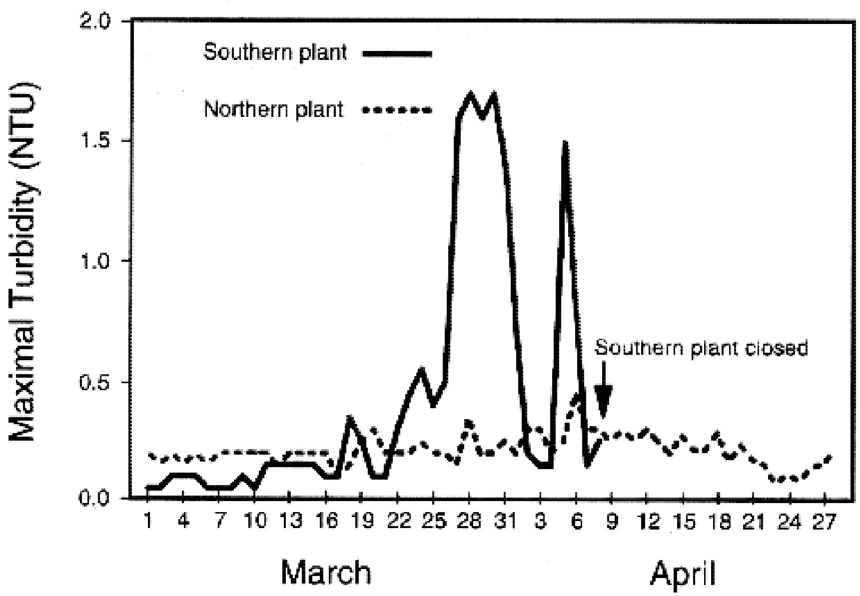
Type of Deficiency

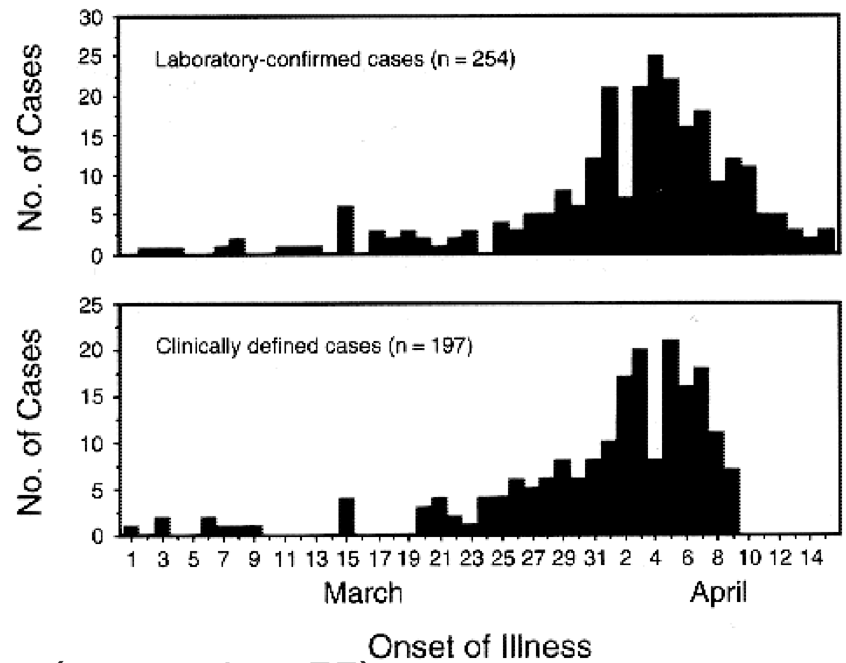
	Type of water system*							
	Community		Noncommunity		Individual		Total	
Type of deficiency†	Outbreaks	(%)	Outbreaks	(%)	Outbreaks	(%)	Outbreaks	(%)
Untreated surface water	0	(0.0)	0	(0.0)	0	(0.0)	0	(0.0)
Untreated groundwater	2	(25.0)	0	(0.0)	2	(50.0)	4	(23.5)
Inadequate treatment	3	(37.5)	3	(60.0)	1	(25.0)	7	(41.2)
Distribution system	3	(37.5)	2	(40.0)	0	(0.0)	5	(29.4)
Miscellaneous or unknown	0	(0.0)	0	(0.0)	1	(25.0)	1	(5.9)
Total	**8**	**(100.0)**	**5**	**(100.0)**	**4**	**(100.0)**	**17**	**(100.0)**

*Community and noncommunity water systems are public water systems that serve ≥15 service connections or an average of ≥25 residents for ≥60 days/year. A community water system serves year-round residents of a community, subdivision, or mobile home park with ≥15 service connections or an average of ≥25 residents. A noncommunity water system can be nontransient or transient. Nontransient systems serve ≥25 of the same persons for >6 months of the year (e.g., factories or schools), whereas transient systems do not (e.g., restaurants, highway rest stations, or parks). Individual water systems are small systems not owned or operated by a water utility that serve <15 connections or <25 persons.

†1=untreated surface water; 2=untreated groundwater; 3=treatment deficiency (e.g., temporary interruption of disinfection, chronically inadequate disinfection, and inadequate or no filtration); 4=distribution system deficiency (e.g., cross-connection, contamination of water mains during construction or repair, and contamination of a storage facility); and 5=unknown or miscellaneous deficiency (e.g., contaminated bottled

Cryptosporidium Outbreak: Milwaukee Public Water Supply





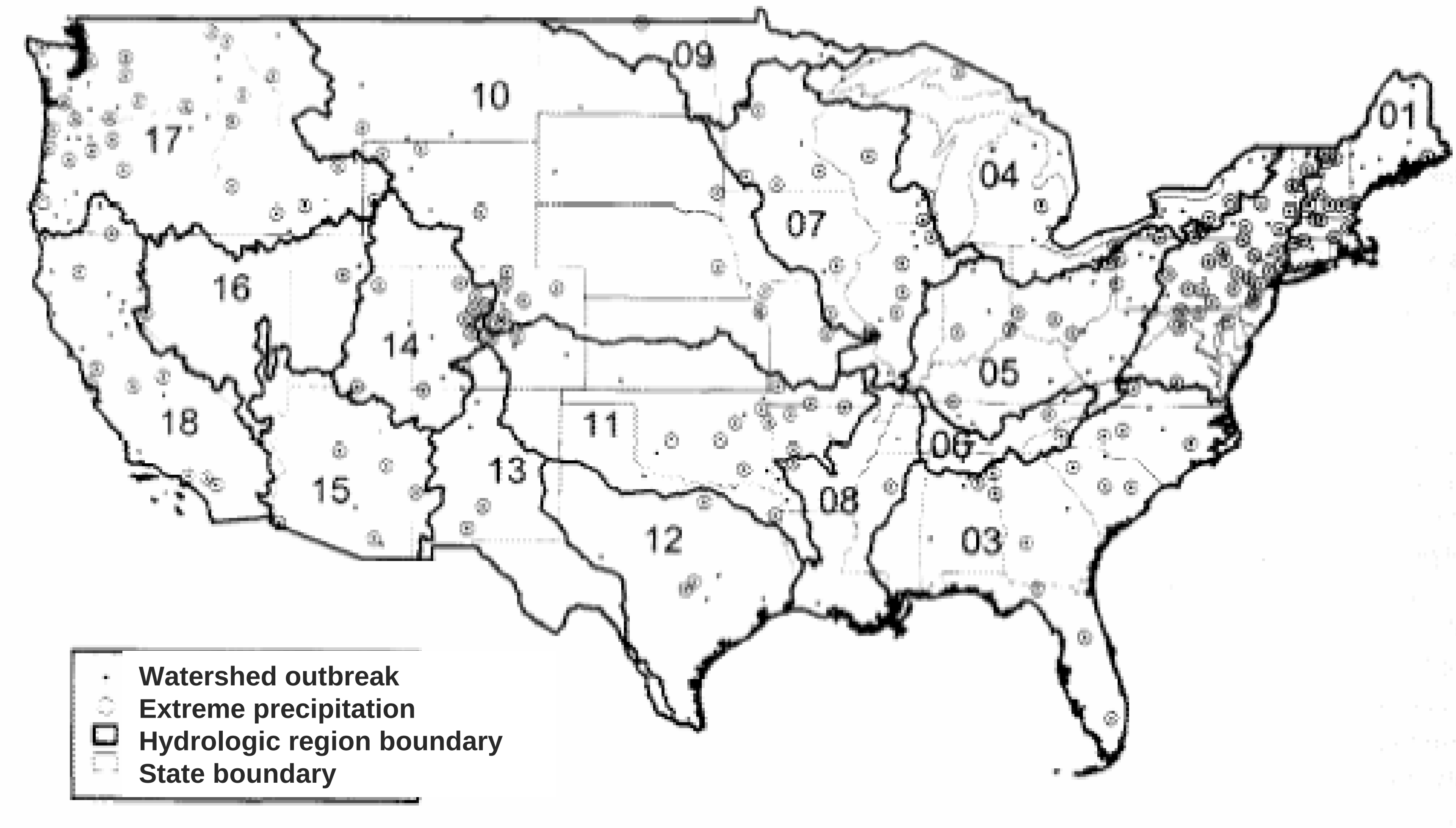
- The median duration of illness was 9 days (range, 1 to 55).
- Among 285 people surveyed who had laboratory-confirmed cryptosporidiosis, the clinical manifestations included watery diarrhea (93 %), abdominal cramps (84 %), fever (57 %), and vomiting (48 %).
- Estimated 403,000 people had watery diarrhea attributable to this outbreak.

Mac Kenzie et al., NEJM (1994)

Impacts of Global Warming

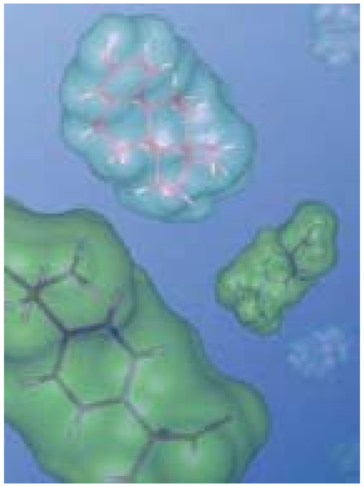
- Increased algal blooms in inland systems (odor, taste, biotoxins)
- Higher microbial and nutrient loadings
- Increased heavy rains and flooding associated with waterborne disease outbreaks
- Increased urban water consumption (irrigation, lawn watering, drinking water, etc…)

Waterborne Disease Outbreaks and Extreme Precipitation Events

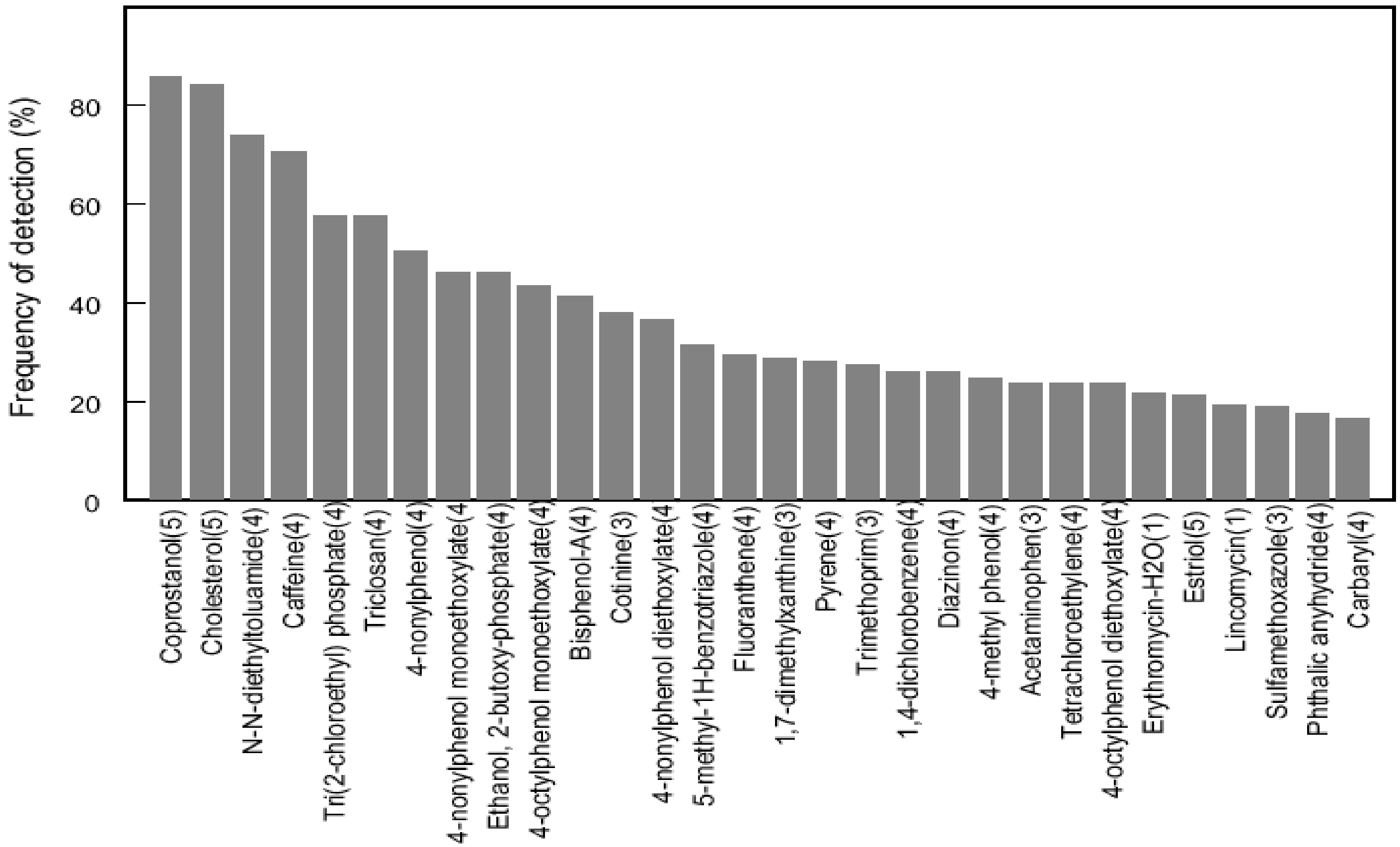


Urban Water Challenges: II. Emerging Contaminants

- Although pharmaceuticals and industrial chemicals have dramatically improved quality of life worldwide, the presence of residual materials and byproducts in reclaimed water has introduced new challenges to the engineering community.
- As new types of chemicals are introduced into the waste stream, the water reclamation community finds itself fighting an elusive battle to address new and emerging contaminants of concern.
- Currently, a gap exists between what analytical methodology can detect and the composition of reclaimed water, particularly with respect to analytes that could pose uncertain and potentially long-term health risks.



Most Frequently Detected 'Emerging Contaminants' in the Nation's Streams



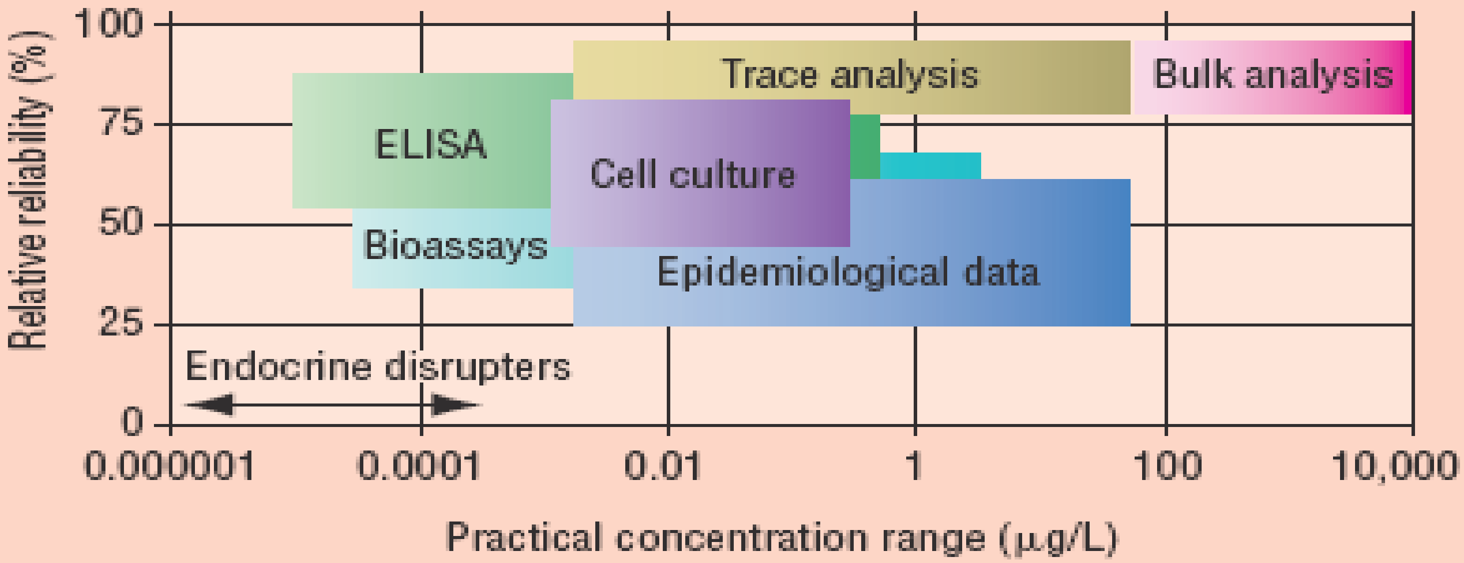
Based on 139 streams in 30 states:

Hormones, personal care products, pharmaceuticals, antibiotics, flame retardants, insect repellants...

Analytical Challenges for Sensing/Monitoring Networks

Analytical methods for trace organic compounds and endocrine disrupters

Various chemical and biological assays can detect trace organic compounds in water, but each method's detection limits and reliability differ. In lieu of exhaustive chemical monitoring, enzyme-linked immunosorbent assays (ELISAs) and in vivo and in vitro bioassays can detect the low-level effective ranges required to detect endocrine disrupters.



Urban Water Challenges: III. Vulnerability of Water Supply Systems

- Infrastructure
  - ASCE Report card (March 2005): E
  - Need to invest $151 bn. over next two decades to maintain water infrastructure and ensure safe and healthy community water supplies
  - Need to increase current wastewater infrastructure investment by $19 bn. per year

Water Infrastructure Threats

- Chlorine tolerance of biological weapons agents considered water threats:
  - Anthrax – spores resistant
  - Brucellosis – unknown
  - C. perfringens – resistant
  - Tularemia – inactivated (1 ppm, 5 min)
  - Shigellosis – inactivated (0.05 ppm, 10 min.)
  - Cholera – ‘Easily killed’
  - Plague – unknown
  - Botulinum toxins – inactivated (6 ppm, 20 min)
  - T-2 mycotoxin – resistant
  - ….
- Need for water infrastructure ‘hardening’ (access, monitoring, etc…

Contaminant Propagation in Water Systems

- Water distribution systems are far flung and made up of different hydraulic elements
- Complex contaminant dispersion
- Near impossible source tracking
- Simulation North Penn Water Authority: complete dispersion after 24 hrs; disappearance after 34 hrs.

Conclusions

- The state of public water infrastructure is inadequate to even meet current needs; future needs include hardening of public water infrastructure
- Land-use pressures will challenge watershed sharing
- Short-circuiting of water cycle results in increased recycling of water, exhibiting health implications
- Needs for increased monitoring for emerging target pathogens
- Balance disinfection needs and DBP exposure
- Needs for methodology to monitor emerging contaminants and biology