# ENVSC 296: Lesson No. 9

## Part I: Drinking Water

**January 31, 2005**

**Sandy Rock**
Life Sciences Division
Bellevue Community College

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## Lesson Overview

- Three ways of looking at Water
  - Water as a vital resource
  - Water as disease reservoir
  - Water as a vehicle for disease transmission

## Overview Continued

- Drinking Water
  - Sources and supplies
    - Where does our water come from?
    - How much is there?
    - How is it used and by whom?
    - What determines its quality?
    - What are the health effects?
    - How do we prevent them?
  - Treatment

# Water

**Major Issues**

- **Water Quantity**
  - **Sources**
- **Water Usage**
  - **Pollution**
- **Water Quality**
  - **Health Effects**
  - **Treatment**

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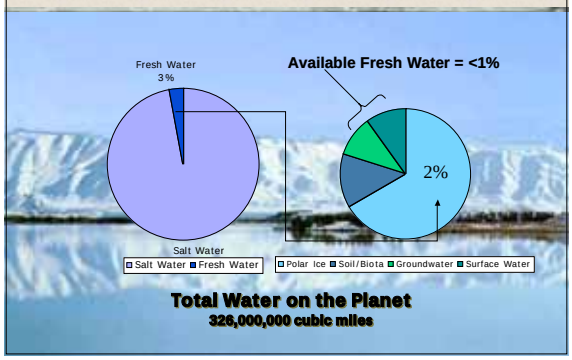
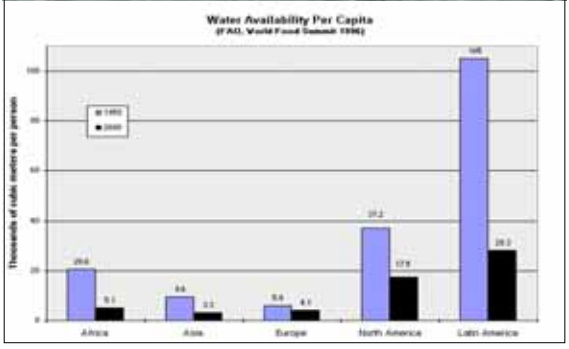
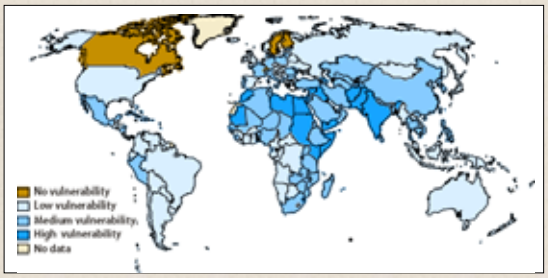
# Water Quantity




# Water Availability



## Available Water Resources

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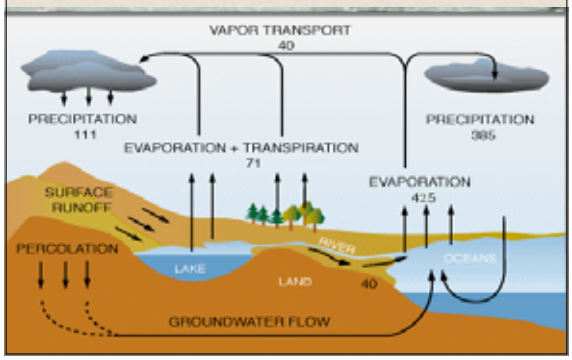
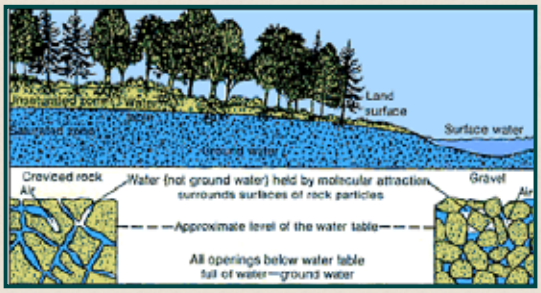
## Hydrologic Cycle




## Water Movement

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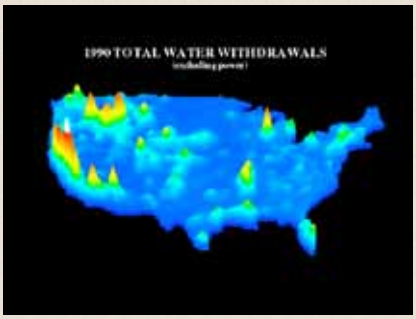
## Water Usage




Source: USGS

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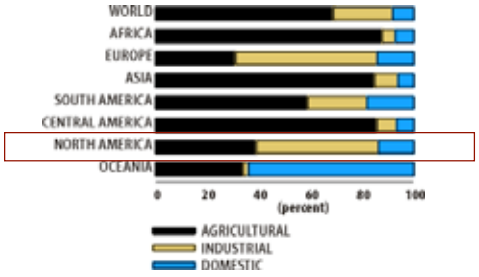
## Water Usage (Continued)




## Water Quality

- **Aesthetics**
  - Color
  - Odor
  - Taste
- **Biological** (Microorganisms)
- **Chemical** (Organic & Inorganic)
- **Physical** (Radiation Standards)

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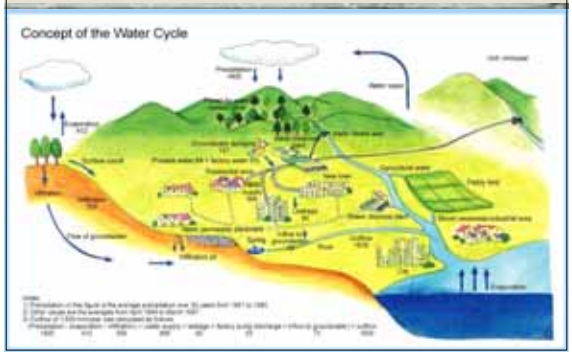
## Water Contamination




## Health Effects

- Indirect
  - Drought
  - Floods
  - Insanitary conditions
- Direct
  - Disease

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## Health Effects

- Two main transmission routes
  - Contamination of drinking water supplies
  - Water contact

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## Waterborne Disease

**Chemical Contamination**
- Agriculture
- Industry
- Transportation
- Residential

**Fecal Contamination**
- Human Wastes
- Livestock
- Wildlife

**Soil**
- Bacteria
- Minerals, etc.
- Radioactive Elements

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## Waterborne Diseases

- Acute Diarrhea
- Amebic Dysentery
- Cholera
- Cryptosporidiosis
- Giardiasis
- Infectious Hepatitis
- Legionellosis
- Shigellosis
- Typhoid Fever
- Viral Gastroenteritis
- Neurological and Systemic Poisonings

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## Causative Agents

- **Amebic Dysentery**
  - *Entamoeba histolytica*
  - **20 cysts**
- **Cholera**
  - *Vibrio cholerae*
  - **100,000,000 - 1,000,000,000 organisms**
- **Diarrheal Disease**
  - *Escherichia coli*
  - **100,000,000 organisms**

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## Causative Agents Continued

- **Giardiasis**
  - *Giardia lamblia*
  - **100 organisms**
- **Shigellosis**
  - *Shigella dysenteriae*
  - **10 - 100 organisms**
- **Typhoid Fever**
  - *Salmonella typhi*
  - **100,000 organisms**

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## Causative Agents Continued

- **Viral Gastroenteritis**
  - **Miscellaneous Viruses**
  - **1 organism**
- **Chemical Contaminants**
  - **Inorganics -- systemic toxicity**
  - **Organics -- chronic diseases**

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## Disease Transmission

- **Approximate Survival Time of Certain Pathogens in Water**
  - *Vibrio cholerae*: **3-9 days**
  - *Salmonella typhi*: **1 day - 2 months**
  - *Entamoeba histolytica*: **1 month**
  - *Shigella sp.*: **1 - 24 months**

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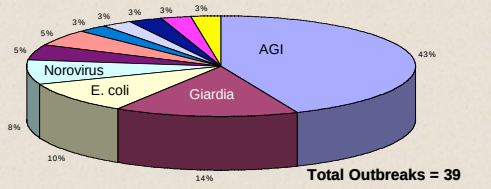
## Disease Outbreaks

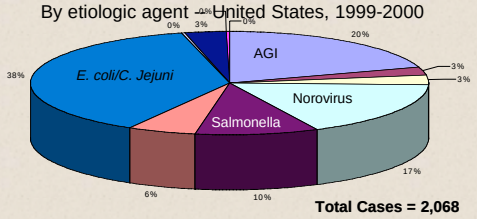
Waterborne-disease outbreaks associates with drinking water
By etiologic agent -- United States, 1999-2000




Source: US CDC, Surveillance Summary, 51(SS08), November 22, 2002

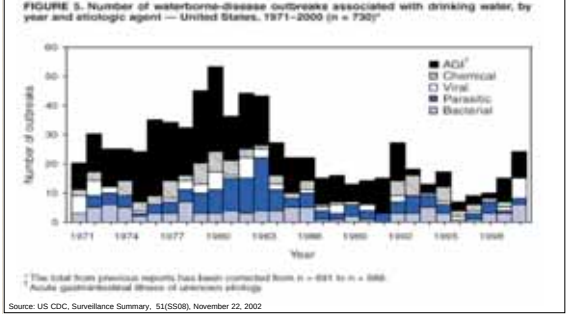
## Disease Cases

Waterborne-disease cases associates with drinking water
By etiologic agent -- United States, 1999-2000




Source: US CDC, Surveillance Summary, 51(SS08), November 22, 2002

## Reported Disease Outbreaks

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## Reported Disease Outbreaks

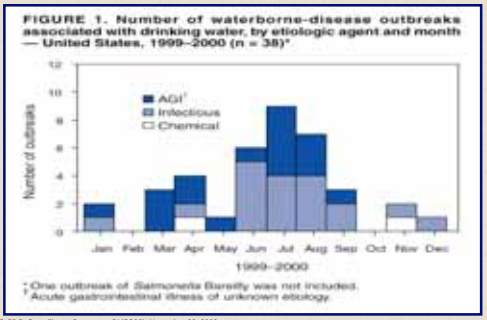
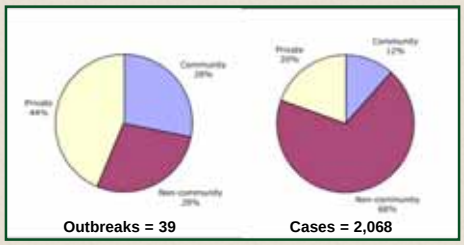



FIGURE 1. Number of waterborne-disease outbreaks associated with drinking water, by etiologic agent and month — United States, 1999–2000 (n = 38)*

* One outbreak of *Salmonella* Bareilly was not included.
† Acute gastrointestinal illness of unknown etiology.

Source: US CDC, Surveillance Summary, 51(SS08), November 22, 2002

## Waterborne Disease by System



Outbreaks = 39 Cases = 2,068

**Waterborne-disease associated with drinking water by type of water system -- United States, 1999-2000**

Source: US CDC, Surveillance Summary, 51(SS08), November 22, 2002

## Reported Disease Outbreaks

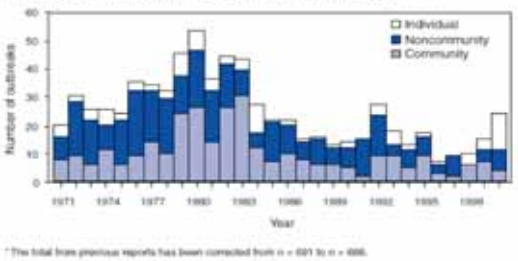
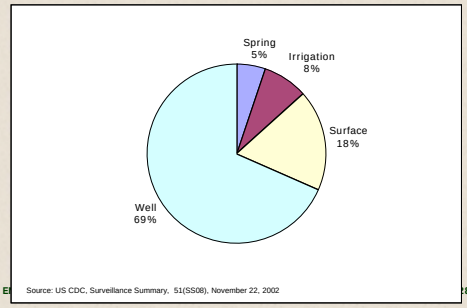



FIGURE 6. Number of waterborne-disease outbreaks associated with drinking water, by year and type of water system — United States, 1971–2000 (n = 730)*

* The total from previous reports has been corrected from n = 691 to n = 698.

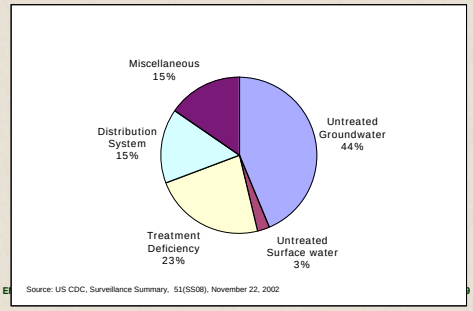
Source: US CDC, Surveillance Summary, 51(SS08), November 22, 2002

## Water Source



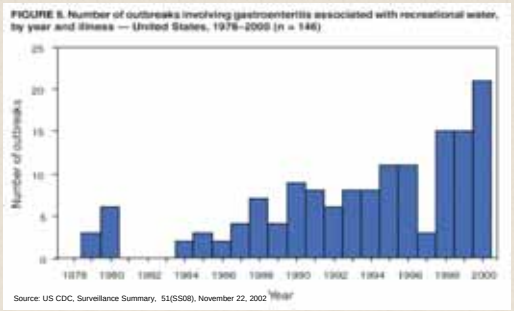

Source: US CDC, Surveillance Summary, 51(SS08), November 22, 2002

## Deficiencies



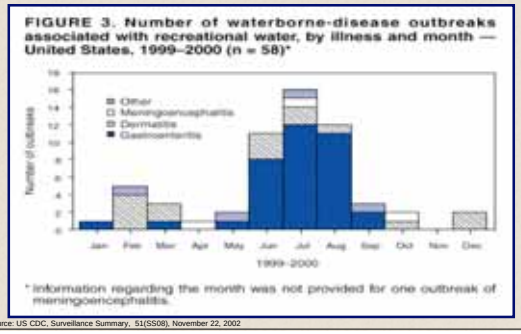

Source: US CDC, Surveillance Summary, 51(SS08), November 22, 2002

## Recreational Waters



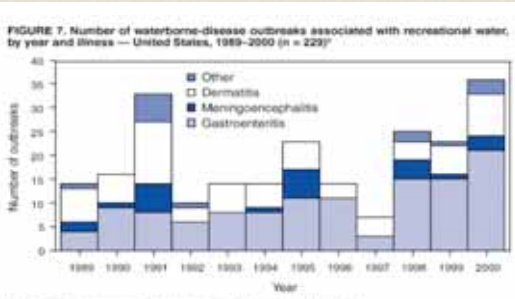

Source: US CDC, Surveillance Summary, 51(SS08), November 22, 2002

## Reported Disease Outbreaks



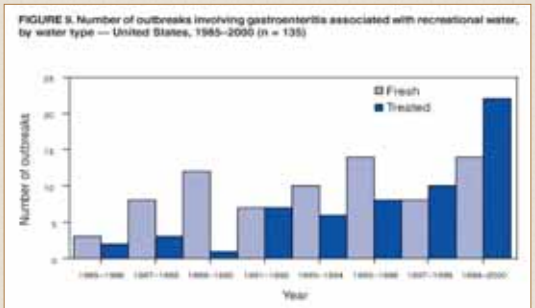

Source: US CDC, Surveillance Summary, 51(SS08), November 22, 2002

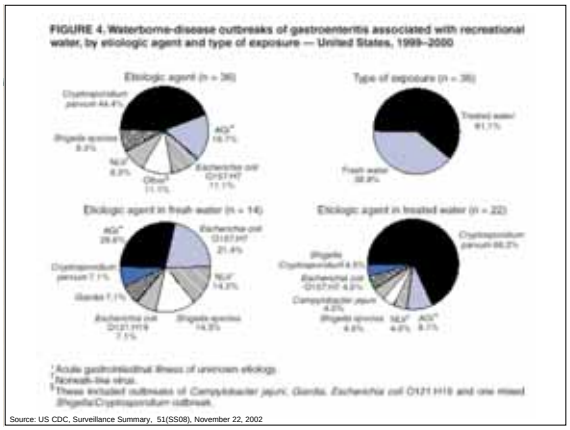
## Reported Disease Outbreaks




Source: US CDC, Surveillance Summary, 51(SS08), November 22, 2002

## Recreational Waters






## Control Strategies

- Education
  - Boil water notices
  - Public Service Announcements
- Regulatory Control
  - Clean Water Act
  - Safe Drinking Water Act
- Engineering Control
  - Treatment

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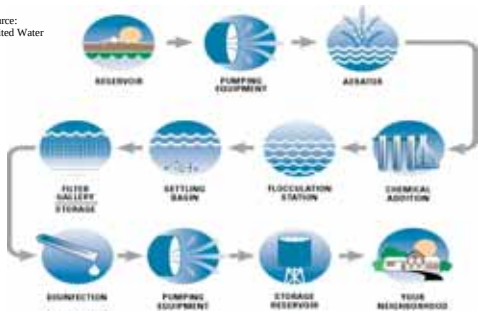
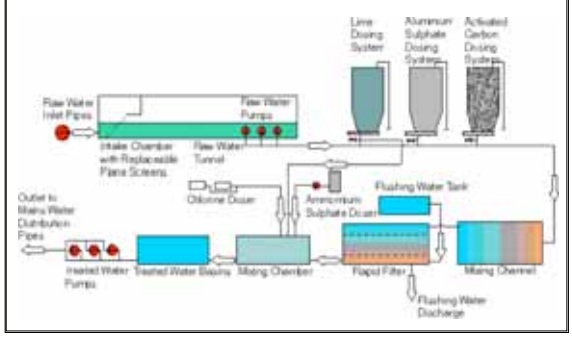
## Surface Water Treatment

Source:
United Water

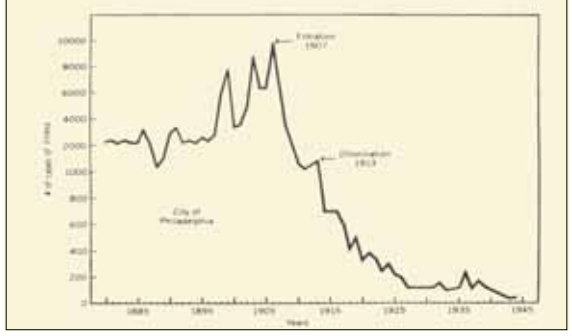


## Water Treatment Plant

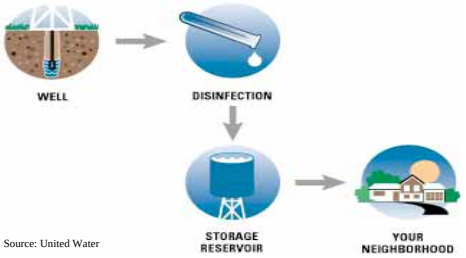

## Drinking Water Treatment




## Water Treatment



## Ground Water Treatment




Source: United Water

## Water Storage facilities

- Adequate pressure for proper delivery
- Uniform pumping rate and water supply
- Detention time for disinfection
- Reserve water to meet peak demand
- Water for fire protection
- Blending of water sources
- Backwashing

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## Distribution

## Questions



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# Part II: Wastewater

**January 31, 2005**

**Sandy Rock**
Life Sciences Division
Bellevue Community College



## Lesson Overview

- **Wastewater:**
- **What is it?**
- **Where does it come from?**
- **What are its health implications?**
- **What do we do with it?**

## Definition

- Wastewater is water which is:
  - contaminated by human use
  - and discarded

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## Definition (Continued)

- Or, said another way, wastewater is:
  - Water
  - +
  - whatever we add to it?

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## Domestic Sewage

Composition:

| | |
|---|---|
| BOD | 200 - 290 mg/L |
| TSS | 200 - 290 mg/L |
| Nitrogen | 35 -100 mg/L |
| Phosphorus | 18 - 29 mg/L |
| Coliforms | $10^{10}$ - $10^{12}$ / ml |
| Fecal Coliforms | $10^{8}$ - $10^{10}$ / ml |

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## Domestic Sewage

**Sources:**

- Residential properties
- Public & commercial establishments
- Non-industrial businesses

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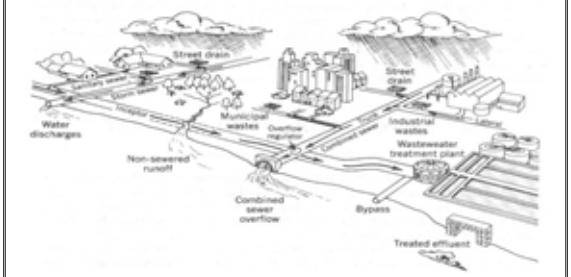
## Sources




Source: Bernarde M. *Our Precarious Habitat Fifteen Years Later*, John Wiley & Sons, 19879:487.

## Methods of Handling

- Discharge into surface waters
  - ➢ Without treatment
    - Now illegal (CWA)
  - ➢ With treatment
    - NPDES
- Surface soil disposal
- Subsurface soil discharge
- Some recycle/reuse methods

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## Treatment Methods

- Municipal Systems
  - Collection
  - Treatment
- On-site Systems

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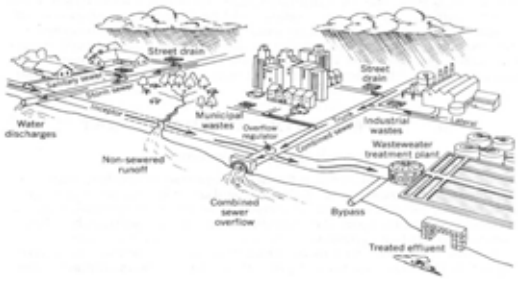
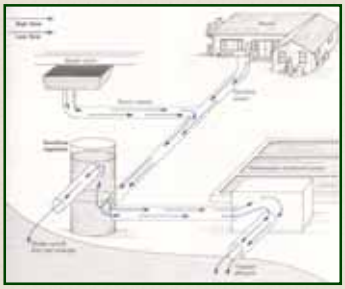
## Municipal Sewage Treatment




Source: Bernarde M. *Our Precarious Habitat Fifteen Years Later*, John Wiley & Sons, 19879:487.

## Wastewater Collection



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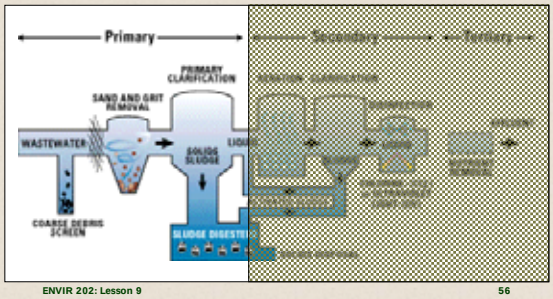
## Typical Sewage Treatment Plant

## Municipal Wastewater Treatment

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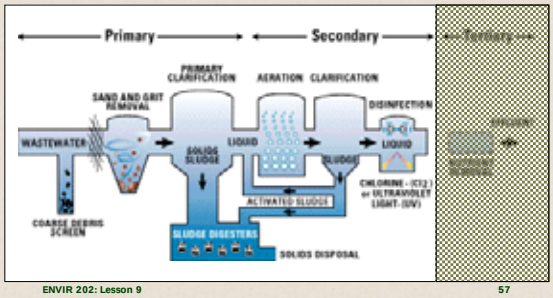
## Municipal Wastewater Treatment

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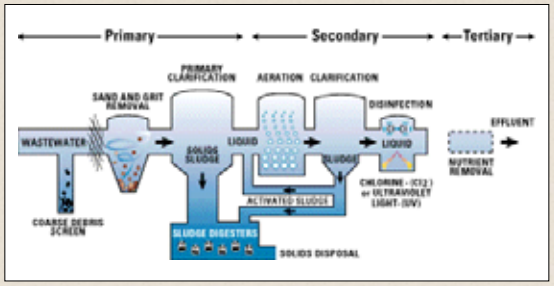
## Municipal Wastewater Treatment






## On-site Systems



## What is it?

- System designed to provide long-term treatment & disposal of sewage/wastewater
- System designed to deal primarily with residential sewage
- System designed to treat and dispose of sewage on/near generation site
- System where final disposal/dispersal is below the surface of the soil
  - INTO the soil

## Where is it used?

- Where sewer is not available
  - Suburban areas with larger lots
  - Rural areas
- Where sewer is not desirable
  - Sewer is too expensive
  - Sewer may create too high a density
  - Sewer may cause environmental concerns
- Where limited ground water is available

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## Issues & Concerns

- On-site systems used by:
  - 25% households in US (~26 million)
  - 30% households in WA (~600,000)
- 500,000 installed annually in US
- 25,000+ installed annually in Washington
- BUT, only 32% of area in US is suitable

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## Issues & Concerns

- Bad historical reputation
  - Short-term: Until sewers come
  - "Out-of-site / Out-of-mind" philosophy
  - Placed where they didn't belong
  - Many failures
  - Systems are "second rate"
- Not as convenient as sewer:
  - Can't "flush & forget,"
  - "What do you mean: I've got to be involved with my sewage"

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## Issues & Concerns

- Most of the good land is gone
- Much of remaining land is being saved for other priority uses
- Many moving from urban to rural
- There has been little or no federal assistance
  - Research
  - Grants/loans - most $$$ have been for sewers
- Lack of understanding on part of public, decision-makers, others

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## Issues & Concerns

- Land Use Issues
  - Land use & wastewater management planning done with poor assumptions
  - Sewers bring high density
  - On-site systems can't support high density
  - Industrial wastewater not suitable for on-site systems

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## Issues & Concerns

- Health concerns
  - Pathogens – bacteria, virus, protozoans
  - Chemicals – nitrogen, some organics, etc.
  - Organic material

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## Issues & Concerns


- Environmental concerns
  - Nutrients
    - nitrogen
    - phosphorus
  - Organic material
- Nuisances

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## Solutions

- Put systems where they belong
- Use systems that provide known & predictable levels of acceptable treatment
- Use systems that have long-term life expectancy
- Match site conditions & sensitivity with appropriate technology
- Practice high levels of quality control throughout system's life
- Fix problems in a timely fashion
- Educate the owners/users & others

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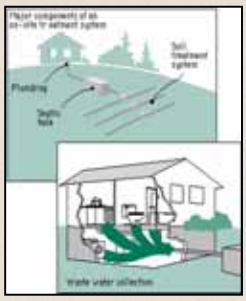
## On-site Systems



- Wastewater Collection
- Transport away from the house
- Treatment and Disposal

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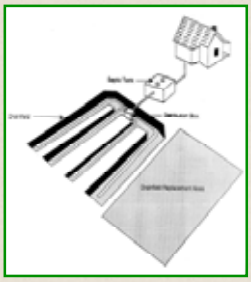
## On-site Systems

- Major Components
  - House Drain
  - Septic Tank
  - Distribution Box
  - Drain Field



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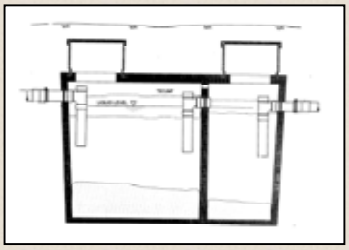
## Example

## Septic Tank

- Functions:
  - Remove solids
  - Anaerobic digestion
  - Vent back to home



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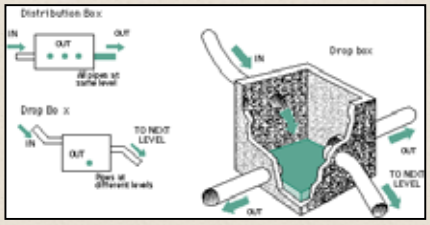
## Septic Tanks

## Distribution Boxes

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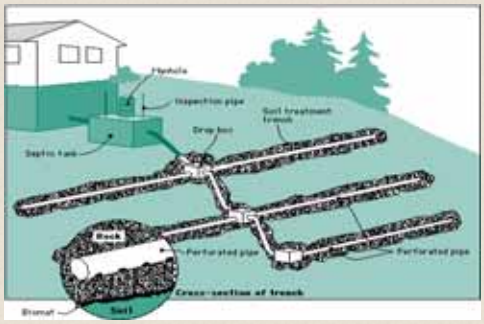
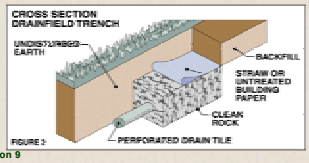
## Drainfields



## Drainfield

- Functions
  - Provide majority of treatment
  - Trench network to discharge liquid into soil
  - Provide aerobic environment
  - Remove pathogens in suitable soil below trench

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## Drainfield

## Treatment Processes

- Physical
  - Filtration
  - Adsorption to particle surfaces
  - UV disinfection – stops cell reproduction

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## Treatment Processes

- Microbiological – bacteria, fungi, yeasts
  - Aerobic, anaerobic & facultative
  - Cause chemical transformations – e.g. N

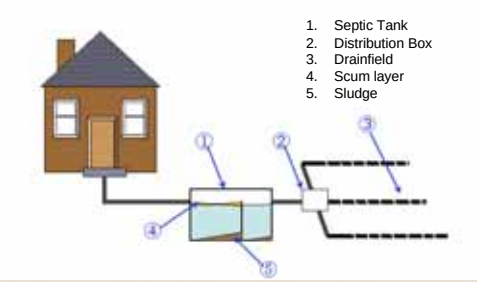

ENVIR 202: Lesson 9 79

## Treatment Processes

- Chemical
  - Ion exchange – e.g. $NH_4$
  - Chemical adsorption – e.g. $PO_4^-$
  - Oxidation - Chlorination

ENVIR 202: Lesson 9 80

## On-site System




ENVIR 202: Lesson 9 81

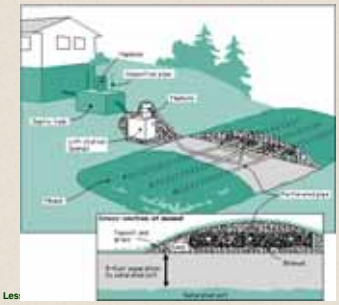
## Alternate Systems

Sand Filter

Mound System

ENVIR 202: Lesson 9 82

## Mound Systems



ENVIR 202: Les 83

## Alternate Systems

Peat Filter

Constructed wetland

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## Alternate Systems

UV Disinfection

Aerobic treatment unit

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## Summary

- Do good land use/wastewater planning
- Use appropriate technology that treats and disposes
- Assure educated/informed public
- Assure system is located, designed, installed, used, monitored & maintained properly

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## Plan & Implement Plan

## Questions

ENVIR 202: Lesson 9 88

## Next Lesson

**Vector Control**

ENVIR 202: Lesson 9 89