

ENV H 440/ENV H 545

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# Water, Wastewater, and Health

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# Course Link

<http://courses.washington.edu/h2owaste/>

# Texts and References:

- NO REQUIRED TEXT
- Recommended Text
  - Water and Wastewater Technology, 5<sup>th</sup> ed. Hammer and Hammer
- Other References:
  - Manual of Environmental Microbiology, 2nd edition, ASM Press
  - Disinfection, Sterilization and Preservation, 5th edition, LWW
  - Metcalf and Eddy's Wastewater Engineering: Treatment and Reuse, McGraw-Hill
  - Water Quality and Treatment, 5th edition, AWWA
  - Any Basic Microbiology Text (e.g. Madigan, Martinko and Parker; Prescott, Harley and Klein; etc.)

# Texts and References:

- Journals:
  - Journal of Applied Microbiology
  - Letters in Applied Microbiology
  - Journal of Applied and Environmental Microbiology
  - Journal of American Water Works Association
  - Water Science and Technology
  - Water Research

# Texts and References:

- Websites

- <http://www.cdc.gov/ncidod/index.htm>
- <http://www.epa.gov/safewater/>
- <http://www.epa.gov/waterscience/>
- <http://www.doh.wa.gov/ehp/dw/>
- <http://www.doh.wa.gov/ehp/ts/waste.htm>
- <http://www.cityofseattle.net/util/RESCONS/default.htm>
- <http://dnr.metrokc.gov/wtd/rwsp/rwsp.htm>

# Class Participation

- Although class attendance is not expressly required, students will be expected to participate in classroom discussion and in-class group problem solving activities. Students will not have the opportunity to earn class participation credit for course periods during which they are absent.

# Grading Opportunities

For the sake of this class, letter and numerical grades will typically be distributed according to the university grading scale between the following standards:

- A(4.0)= Excellent and exceptional work (typically >90% of available points)
- D (1.0) = Deficient work (typically <66% of available points)
- It is expected that most students will perform at a level of ~3.5 .

# Class Rules

- Come to class, please let me know ahead of time if you can not make it.
- Arrive on time
- Turn in assignments on time
- Come to class prepared (keep up with reading)
- Be courteous (No newspapers, audible cell phones, PDAs, beepers)
- Food and drinks are welcome (but keep it quiet)
  - Exception-No food or drink in laboratory
- Refrain from unnecessary talking
- **ASK QUESTIONS**
- Try to remain awake (at least no snoring please)
- Let me know how I am doing (if I am moving too fast, not being clear, or otherwise not getting the message across, I need to know.)



# Example Topics

- Drinking Water
  - Taste and Odor Issues
  - Removal Technologies for Specific Contaminant
  - Water Security
  - Rule Promulgation
  - Risk Analysis for Specific Contaminant
  - Lake and Reservoir Management
  - Water Demand Forecasting
  - Modeling
  - Military water supply
- Wastewater
  - Biomonitoring of Receiving waters
  - Waterless Urinals
  - Treatment Technology for Specific Contaminant
  - Wastewater Microbiology
  - Pulp Mill Waste
  - Pharmaceuticals
  - Demand forecasting
  - NPDES Permitting Process
  - Military wastewater treatment

# Pop Quiz

1. Where does the water from your tap come from?
2. How is that water treated before it gets to your tap?
3. Is the water coming from your tap pure?
4. When you flush where does the waste go?
5. What treatment is provided to your wastewater before is discharged to the environment?
6. When water enters a storm drain inlet, where does that water go?
7. Is bottled water better than tap water? Why?

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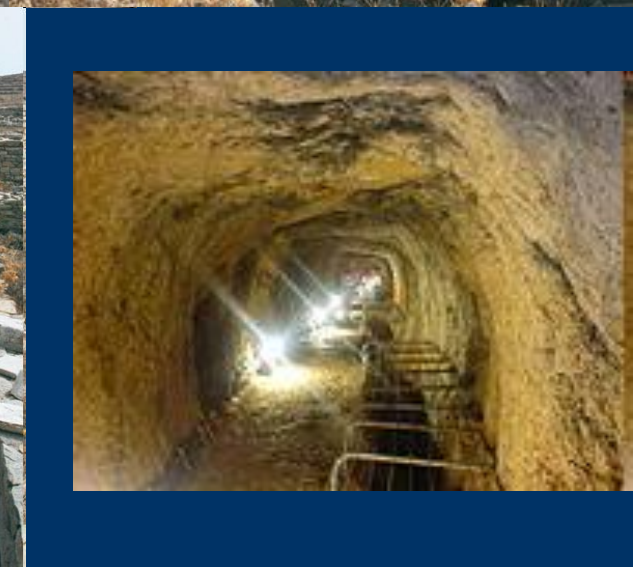
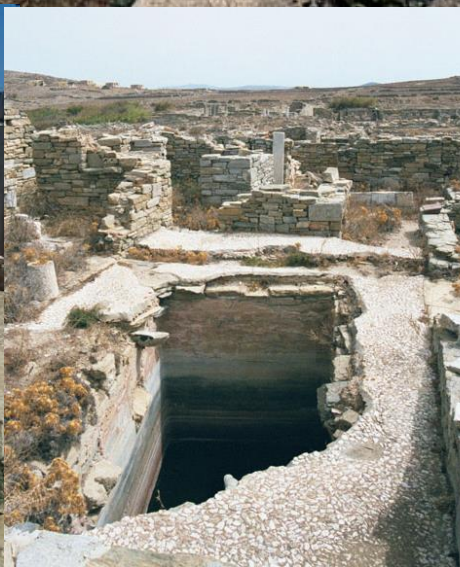
# History of Water and Wastewater Treatment

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# Ancient Water Treatment

- Ancient civilizations recognized importance of ample water quantity, water quality importance was not recognized until much later
- Initial attempts at water treatment were to improve aesthetic quality of water
- Sanskrit and Greek writings discuss water treatment methods (charcoal filtration, sunlight exposure, boiling and straining).
- Visible cloudiness (turbidity) was driving force behind early treatment
- Egyptians used alum to clarify water as early as 1500 BC
- By 1700s filtration established as effective treatment and by 1800s slow sand filtration was used regularly in Europe for surface water









- **Aqueducts first developed in Middle East**
- **First Roman-style by the Assyrians in 7<sup>th</sup> Century B.C.**
- **Impressive by any standards – dressed stone without mortar and maintaining a steady gradient of 0.4%.**
- ***400 miles of piping supplied 1st century Rome with 900 million litres of water per day.***
- ***The Roman system of water supply was not equalled anywhere until the 19th century.***

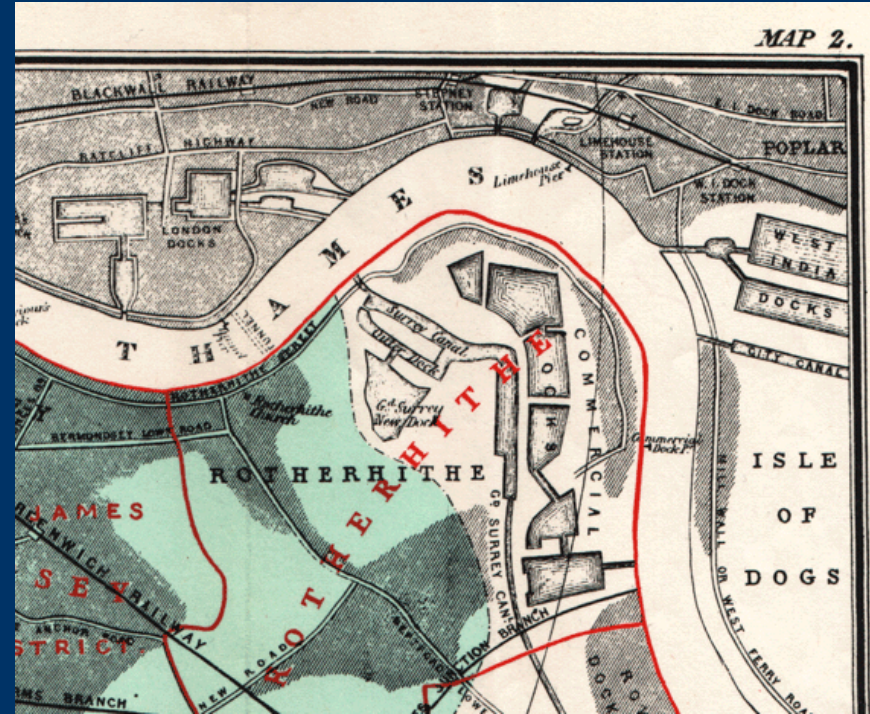
# Sir John Snow and the 1854 Map of the Broad Street Pump Outbreak



- **Traditional/historical concern in environmental health sciences**
- **Sir John Snow: cholera in London and the Broad Street pump**
  - **A key historical event in environmental health, epidemiology, infectious disease, water hygiene, environmental engineering and GIS: he did it all!**
  - **Developed a population-based approach to track the spread of cholera in individual London boroughs.**
  - **Plotted the distribution of reported cases on a map**
  - **In one London borough the source was water polluted by sewage, which entered the Thames above the water intake.**
  - **Snow ordered the handle to be taken off the "Broad Street Pump", and locally the epidemic subsided.**
- **Explained the etiology of cholera and the mechanism of its transmission.**



# Sir John Snows Maps of the Water Plants of London



# History of Water Treatment

- In 1880s Louis Pasteur demonstrated “Germ Theory” of disease
- In late 19th and early 20th century, infectious microbes were focus of concern
- In 1908, chlorine first used as primary disinfectant in drinking water in Jersey City, NJ
- In 1914 US Public Health Service set Bacteriological standards for drinking water; expanded in 1925, 1946, and 1962.

# History of Water Treatment

- In 1960s, man-made chemicals became a focus of concern
- By 1969 only 60% of water systems delivered water meeting Public Health Service Standards
- In 1972, a study found 36 chemicals in treated water drawn from the Mississippi River
- Safe Drinking Water Act passed in 1974, with amendments in 1986 and 1996

# Public Water System

- A system for the provision to the public of water for human consumption through pipes or other constructed conveyances, if such a system has at least 15 service connections or regularly serves at least 25 individuals
- EPA regulates water quality from PWSs; does not regulate private drinking water wells

# US Water Supply

- SDWIS data for US:
  - 53,437 community water systems
  - 18,687 non-transient, non-community water systems
  - 89,192 transient, non-community water systems
  - 161,316 total public drinking water systems
  - Roughly: 9% surface water, 91% groundwater

# Washington Water Supply

- In Washington, 65% of drinking water and 25% of total water used from groundwater
- 95% of public drinking water systems from groundwater
- Additionally, 404,000 private wells serving 800,000 people in rural areas
- SDWIS data for Washington:
  - 2281 community water systems
  - 307 non-transient, non-community water systems
  - 1581 transient, non-community water systems
  - 4169 total public drinking water systems

# Ancient Sewage Treatment

- 3200 BC Scotland- First lavatory-like plumbing systems were fitted into recesses in walls of homes; had drained outlets
- 4000-2500 BC Iraq- stormwater drains in streets; some houses connected to remove waste; First use of cesspool waste disposal in homes; Clay pipe for conveyance
- 3000-2000 BC Pakistan- First centralized treatment; bar screens and cesspools; conveyance by terra cotta pipe; home bathrooms and latrines (even on second floor); vents
- 3000-100 BC Crete- Complex drainage and delivery systems; flushed latrines with water from jars; toilet in Royal Palace flushed with overhead water reservoir (first flush toilet??)
- 2000-500 BC Egypt- Complex public water works; hygiene emphasized, toilets using sand filtration to remove solids







# Ancient Sewage Treatment

- 300 BC – 500 AD Greece- Leaden Pipes; sewers collected stormwater and waste and conveyed to basins outside town; wastewater from basin conveyed to agricultural fields for irrigation
- 200 BC China- Latrines with running water
- 800 BC – 300 AD Rome- Public latrines, but waste still dumped into streets; first sewer constructed 800-735 BC; home sewer connections mandated in 100 AD
- Almost 4000 years for Europe to catch up to plumbing of the middle east

# History of Modern Flush Toilet

- Sewer means to the Sea
- 1000 AD – 1530AD London- Garderobes (a toilet or bank of toilets either in a private castle or public hall) used; waste deposited directly outside building
- 1530 AD London- Close stool came into fashion (chair with porcelain or metal pot underneath)
- 1596 Sir John Harrington described a flushing water closet; had venting problems\*
- Early 18th Century- nearly every residence in London had cesspit below
- 1775 Alexander Cummings first patent for flushing water closet; seals leaked sewer gas

# History of Modern Flush Toilet

- 1778 Joseph Bramah improved on Cummings design; better valve but still problems (noisy, seals dried out and still leaked)
- 1860 Henry Moule invented the earth closet; covered waste in dirt or ash to render it odorless
- 1861 Thomas Crapper opened shop; did not invent flushing toilet but did hold 9 patents improving design (pull chain system, air tight seal, venting systems)
  - “Crap” was an ancient term for rubbish or chaff
- 19th century – Large cities begin to understand that they had to reduce the amount of pollutants discharged into water to protect drinking water sources







MR. THOMAS CRAPPER.

# Early American Sewage

- Prior to early 1800s, American settlers “headed for the woods” or at best used chamber pots (term “potty”); later use of privies was developed; earth closet also used
- In the early 1800s, sewers developed in cities; primarily for stormwater, but also disposed of waste
- 1840s to 1850s few trained individuals; systems built according to common sense
- In 1875+, not one of the U.S. cities with a population of 100,000 or more used any kind of formal sewage treatment
- Between 1875 and 1925 sewage disposal moved beyond conveyance; made link between adverse health effects and disposal of sewage impacting drinking water

# US History of Wastewater

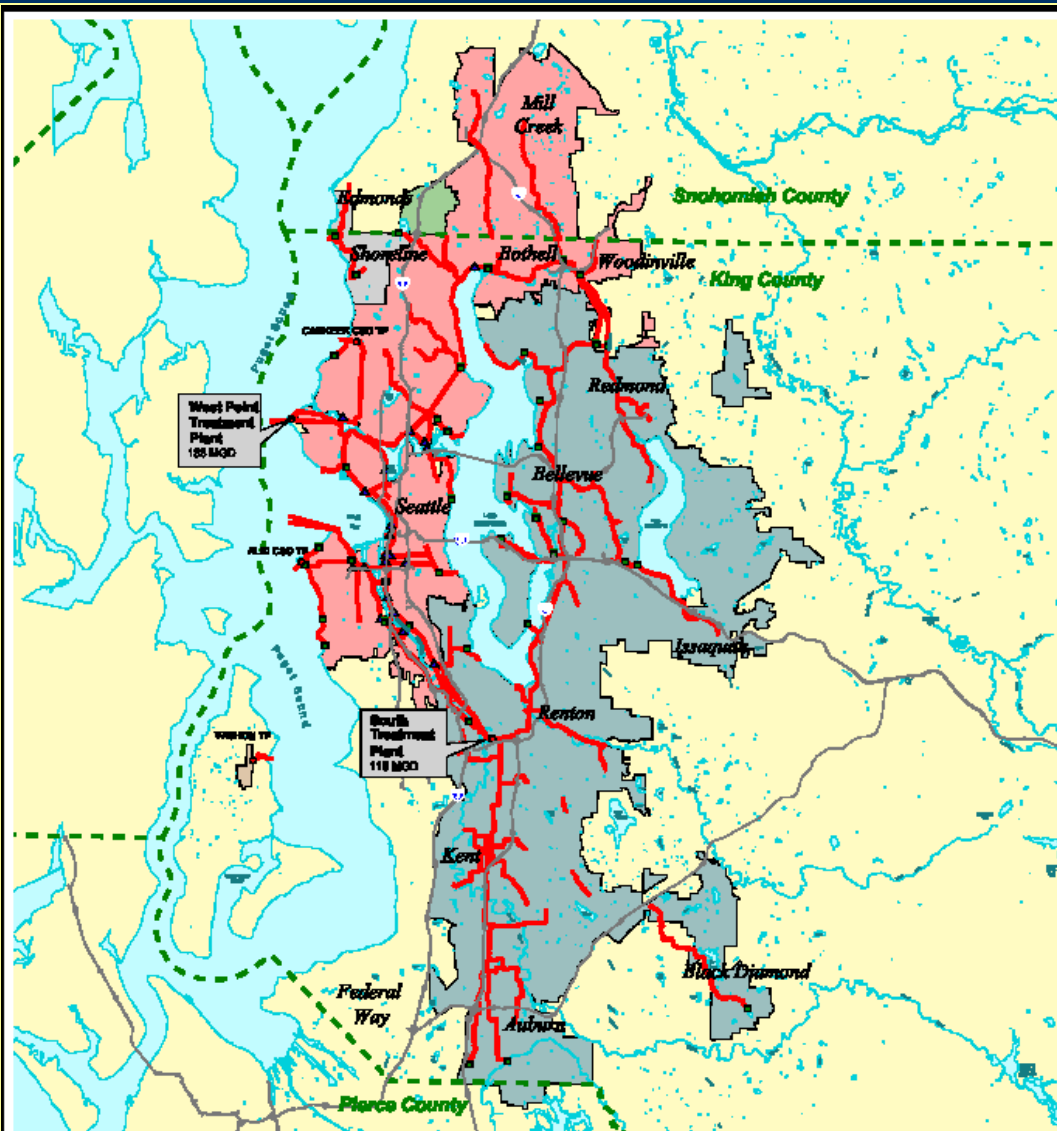
- By 1900, only 2 cities (Worcester, MA and Reading, PA) had installed treatment facilities
- 1910 US- over 25,000 miles of sewer lines
- By 1926, twenty cities had treatment plants (2/3 by settling tanks; 1/3 by activated sludge or trickling filters)
- 1968 St. Louis- 300 million gallons per day raw sewage discharged into Mississippi River
- 1972 USA- Only 1/3 of US waterways safe for drinking and fishing

# US Water Quality

- One of safest water supplies in the world
- Ranked 12<sup>th</sup> overall
  - Top 3 Finland, Canada, and New Zealand; Britain fourth
  - Belgian water worst




- Great Engineering Feats:
  - Reversal of Chicago River in 1900 to protect Lake Michigan as drinking water source, involved 28 mile channel connecting Chicago River to Des Plaines River





# King County Wastewater Treatment Service Area and Facilities

- King County Owned Treatment Plants
- Pump Stations
- ▲ Regulator Stations
- ▲ King County Conveyance Lines
- County Line
- Water Features
- KC WTD Service Area
- West Service Area
- East Service Area
- Washon Service Area
- Edmonds Service Area - Treated by KC
- KC Service Area - Treated by Edmonds

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 August 2, 2008

# Water and Wastewater History

- [www.waterhistory.org](http://www.waterhistory.org)
- [www.sewerhistory.org](http://www.sewerhistory.org)
- <http://www.theplumber.com/index.html#history>
- <http://www.epa.gov/safewater/consumer/hist.pdf>