

Wastewater Technology for Non-Engineers

David Dunn P.E.



- Sewage isn't scary, (although it is kind of gross).
- The Technology is complex, but not complicated.
- Your everyday experiences can help you relate.



Many Water Systems

- Drinking Water (distribution)
 - Water withdrawn for the environment and treated to standards.
 - Piped to homes and businesses for use.
- Grey Water (collection and distribution)
 - Wastewater from sinks, showers, laundry. (No toilets)
 - Used or treated and used
- Stormwater (collection)
 - Waste from roads, parking lots, roofs, and lawns; carried by rainwater.
 - Cleaned and discharged into the environment.
- Reclaimed Water (distribution)
 - Treated wastewater, receiving further treatment.
 - Used for non drinking water uses.
- Wastewater (collection)
 - Waste from homes, businesses, industries.
 - Cleaned and discharged into the environment



What is pollution?

- Material out of place.
- A material can be a "pollutant" or be "polluted"
- Examples of both:
 - Water
 - Gasoline
 - Salt
 - Oxygen



What is sewage?

- Mostly Water
 - 99.9% pure water
- Sewage is polluted Water
- Polluted with what?
 - Anything you can flush, wash off, wash out, or force through a garbage disposal.
 - Plus some less pleasant things.



Where does sewage come from?

- Toilets
 - Human Waste (#1 and #2)
 - Sick
- Sinks/showers
 - Soap, dirt, dead skin, hair, makeup, toothpaste
- Kitchen
 - Food waste
- Clothes washer
 - clothing fibers
- Less Pleasant stuff...
 - plastics, trash, spoiled food, sick, diapers.
 - Fat, Oil, Grease (FOG)
- The really bad stuff
 - Chemicals, used motor oil, antifreeze, cleaning products.
 - Drugs - legal and illegal.



What pollutants are in sewage?

- Inorganic debris
 - Sand, plastic, hair, fibers, rocks
- Organic matter
 - Carbon, Hydrogen, Oxygen, (C, H, O)
 - Nutrients (nitrogen and phosphorus) (N, P)
- Pathogens
 - Bacteria, virus, parasites.
- Toxic materials
 - ammonia, metals, pesticides, industrial chemicals



A note on measurements

- Engineers vs. scientists.
 - Specific compounds
 - Bulk measurements
- Concentration (mg/L)
- Loading (pounds or lb/day)
 - Concentration x volume = load



How do we measure Organics Matter in Sewage?

- BOD - proxy for biodegradable organics
 - Measures waste's capacity to consume oxygen (mg/L)
 - Test takes 5 days to run.
 - Does not correlate to specific compounds
- TSS - Measure of filterable solid material. (mg/L)
 - 0.45 μ m filtration.



How do we measure Pathogens in Sewage?

- Fecal Coliform
 - Used as a proxy for all other pathogens.
 - Grows bacteria colonies from a diluted sample of wastewater.
 - (CFU/100 ml) - colony forming units



How do we measure Toxic compounds in Sewage?

- Concentration of the specific toxic material.
 - mg/L = parts per million
 - μ g/L = parts per billion
 - pg/L = parts per trillion
- WET testing.





Moving Sewage: Conveyance Systems

V



No, not in buckets!

Using pipes and
pumps.



Gravity Sewers

- Stuff flows down hill.
- Sewers must maintain a uniform grade line.
- Not too steep, not too shallow.
- 0.4% for an 8-inch sewer is standard.
- Limitations to system expansion



What if your topography doesn't conform?

- Deep manholes
- Pumping systems
- Grinder pumps, or vacuum systems.
- All of these are expensive.



Pumping Systems

Warning:
Pressurized
Sewage!



Pumping Systems

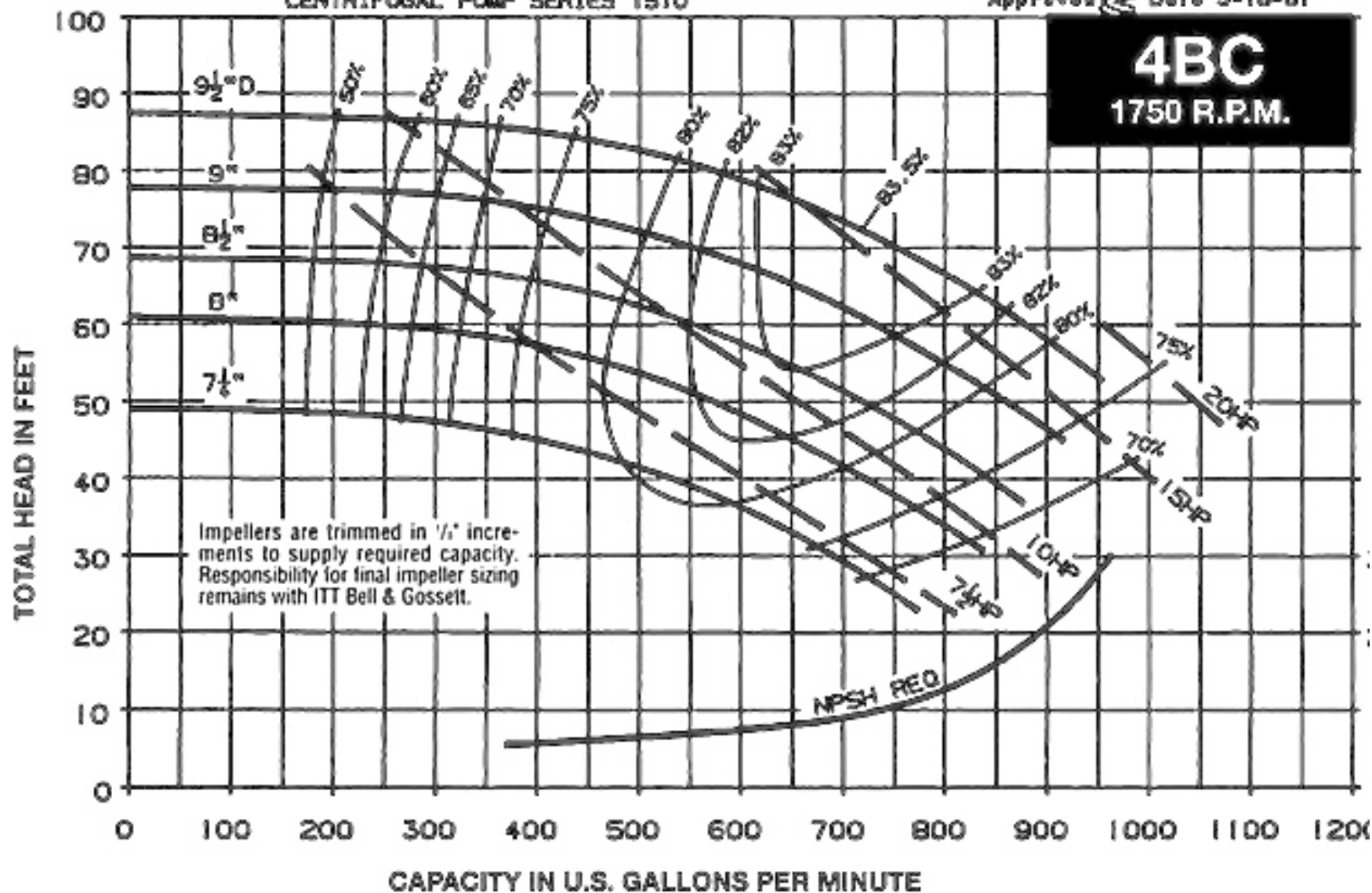
- The Pump
- The “wet” well
- The force main
- Sometimes a “dry” well
- Vaults, power, appurtenances.



Sewage Pumps

- Pressurizes sewage.
 - PSI or “Feet of head”
- Chosen for a specific flow volume, and working pressure.
- Have to operate under all possible conditions.
- Pump curves.





Force Main

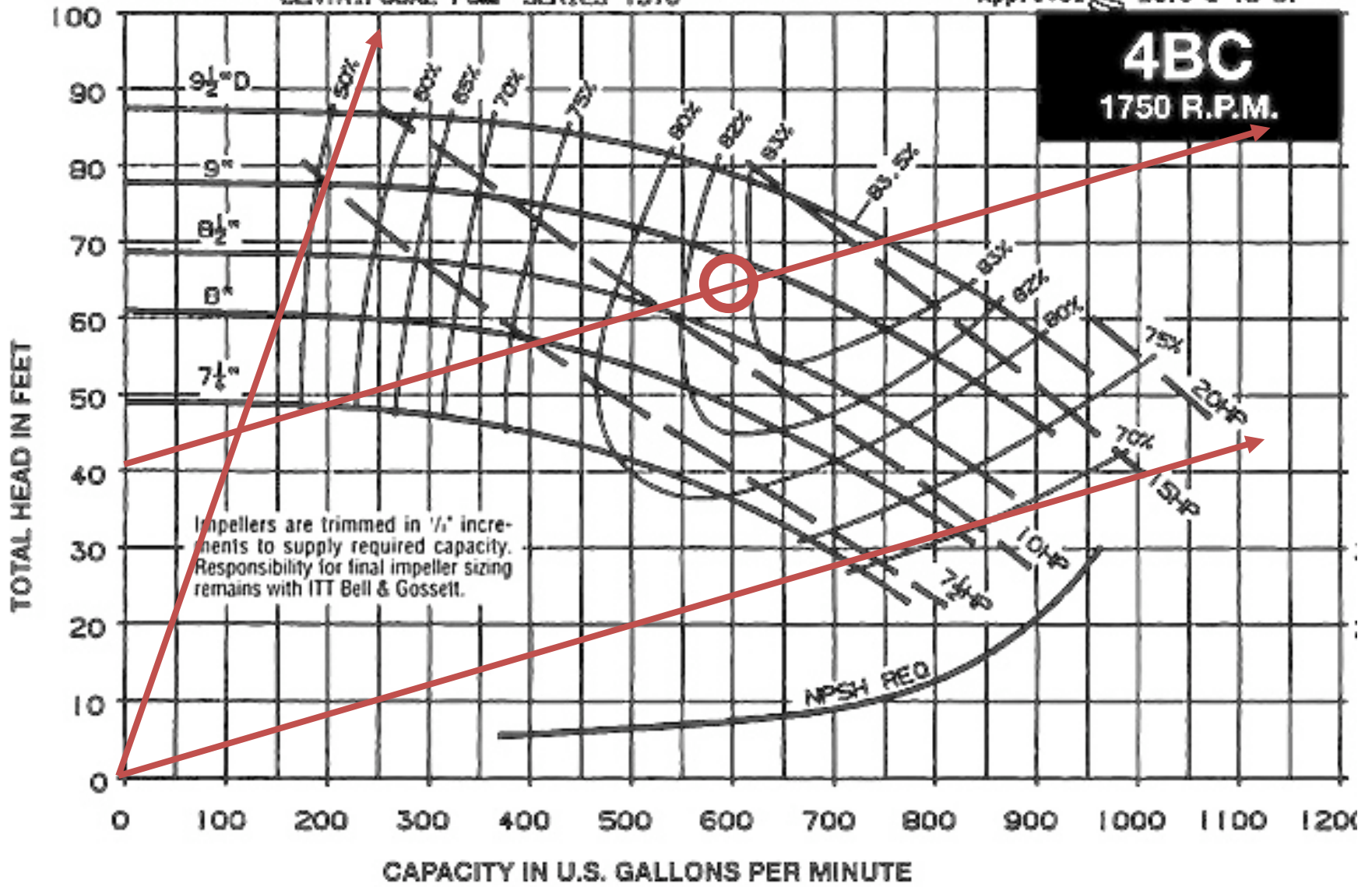
- The pipe that pumped sewage moves through.
- Length and diameter determine system curve.
- Force main storage.
 - 1 mile of 6-inch pipe holds 8,000 gallons of sewage.



CENTRIFUGAL PUMP SERIES 1510

Approved  Date 3-18-81

4BC
1750 R.P.M.



Wet Well

- The basin that fills up with sewage.
- Pumps come on when it is full
- Proper sizing prevents odors and pump wear.



When collection systems go wrong!

- Inflow
- Infiltration
- Exfiltration
- Sanitary Sewer Overflow
- Combined Sewers
- Combined Sewer Overflow







We made it to the
Treatment Plant

What do you call it?

- Sewage Treatment Plant (STP)
- Wastewater Treatment Plant (WWTP)
- Publicly Owned Treatment Works (POTW)
- Water and Resource Recovery Facility (WRRF)



Basic Technologies for cleaning up sewage

- Gravity
- Bacterial growth
- Disinfection

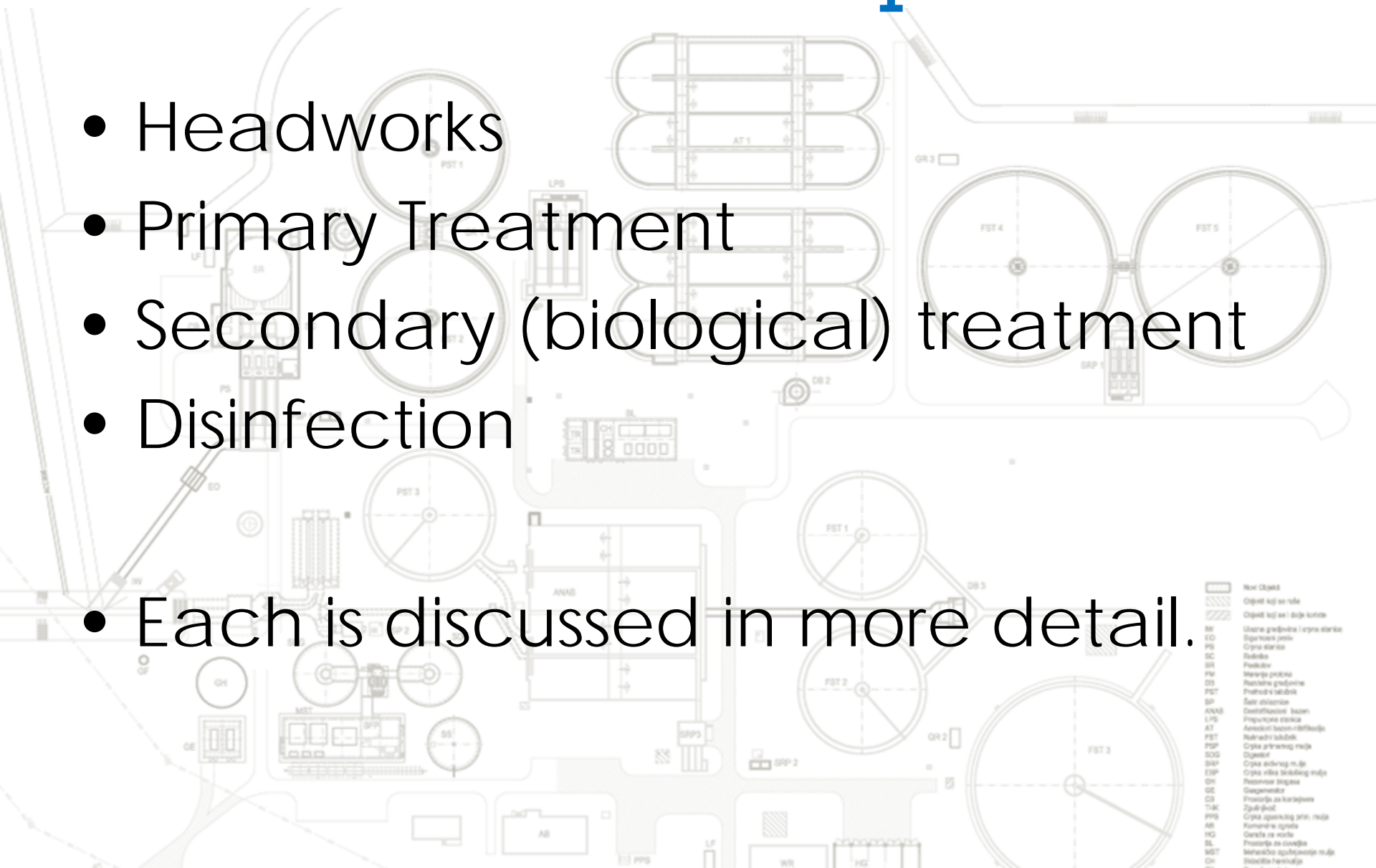


Activated Sludge!



Overview of WWTP processes

- Headworks
 - Primary Treatment
 - Secondary (biological) treatment
 - Disinfection
- Each is discussed in more detail.





Gravity

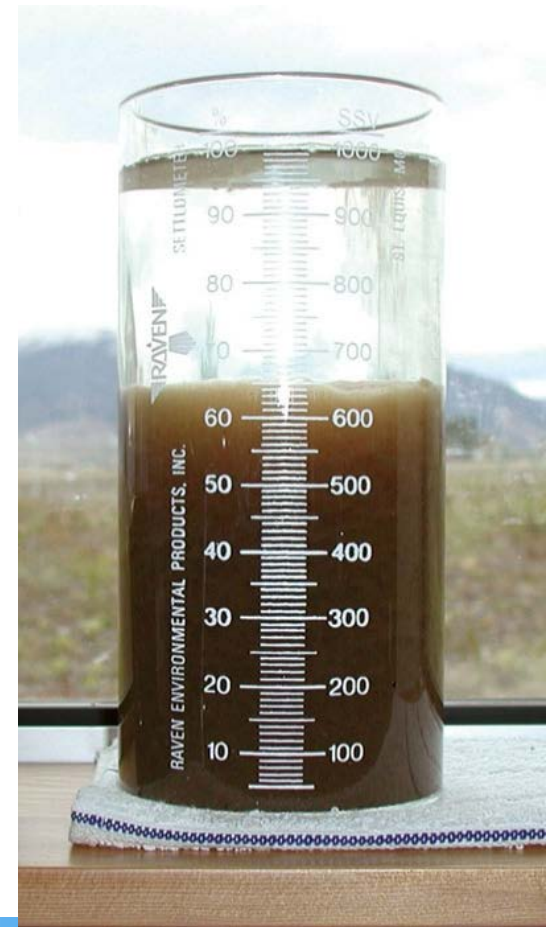
Gravity Settling

- Gravity is fantastic. it's free, no maintenance required, and zero emission.
- Stokes Law describes gravity settling:

$$v_s = \frac{2 \Delta \rho}{9 \mu} g R^2$$

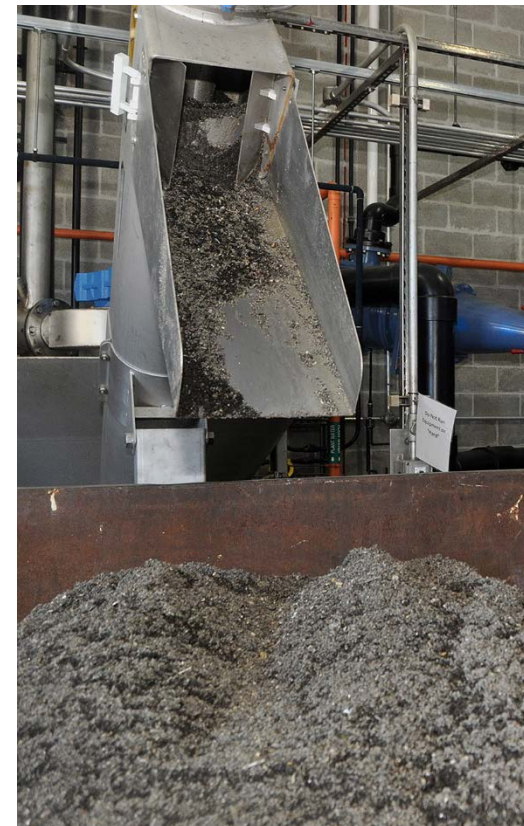
- » Settling velocity
- » density difference
- » viscosity
- » radius of particle (squared!)

- Some things won't settle
 - Very small particles
 - Dissolved materials.



The headworks

- Removes grit and inorganic debris
- Physical straining or screening
- Rapid settling (30-60 seconds)

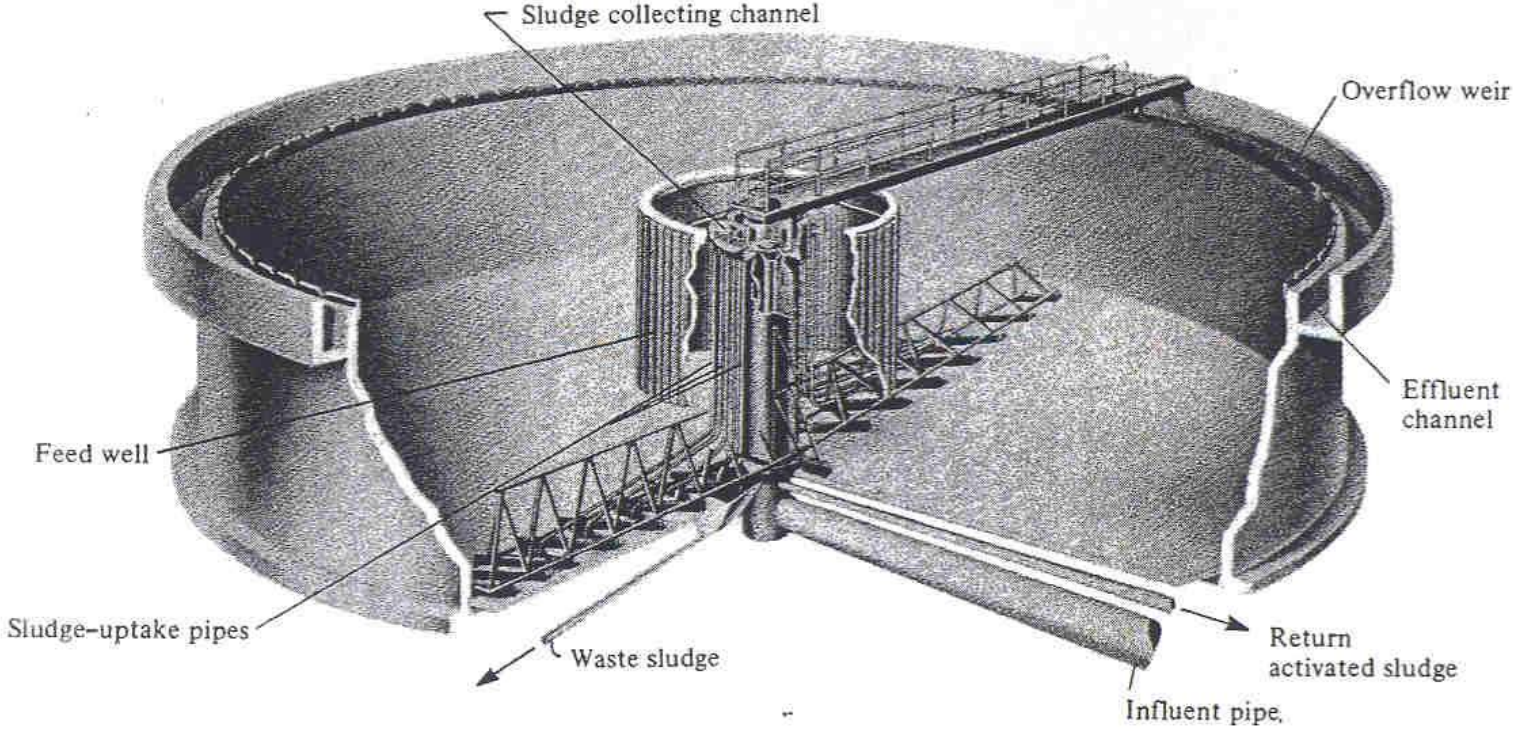


Primary Settling

- Removes "settleable" organics
- Gravity settling (1/2 - 2 hours)
- diminishing returns for longer settling time.



Settling Tank Cross Section

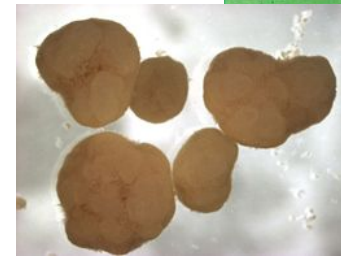
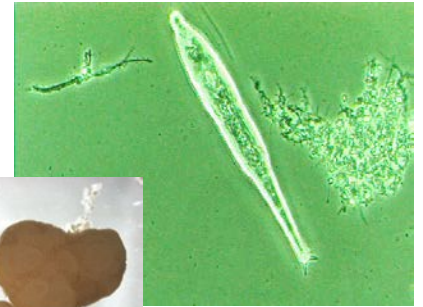




Bacterial Growth

“Activated Sludge” is an ecosystem

- By maintaining a carefully controlled environment
 - Bacterial population (crowding)
 - Available oxygen
 - Available food
 - Predator to prey ratio
 - Amount of mixing and agitation
- You can select for specific types of bacteria.
 - controlled “natural selection”
 - Bacteria acclimated to your climate and waste.

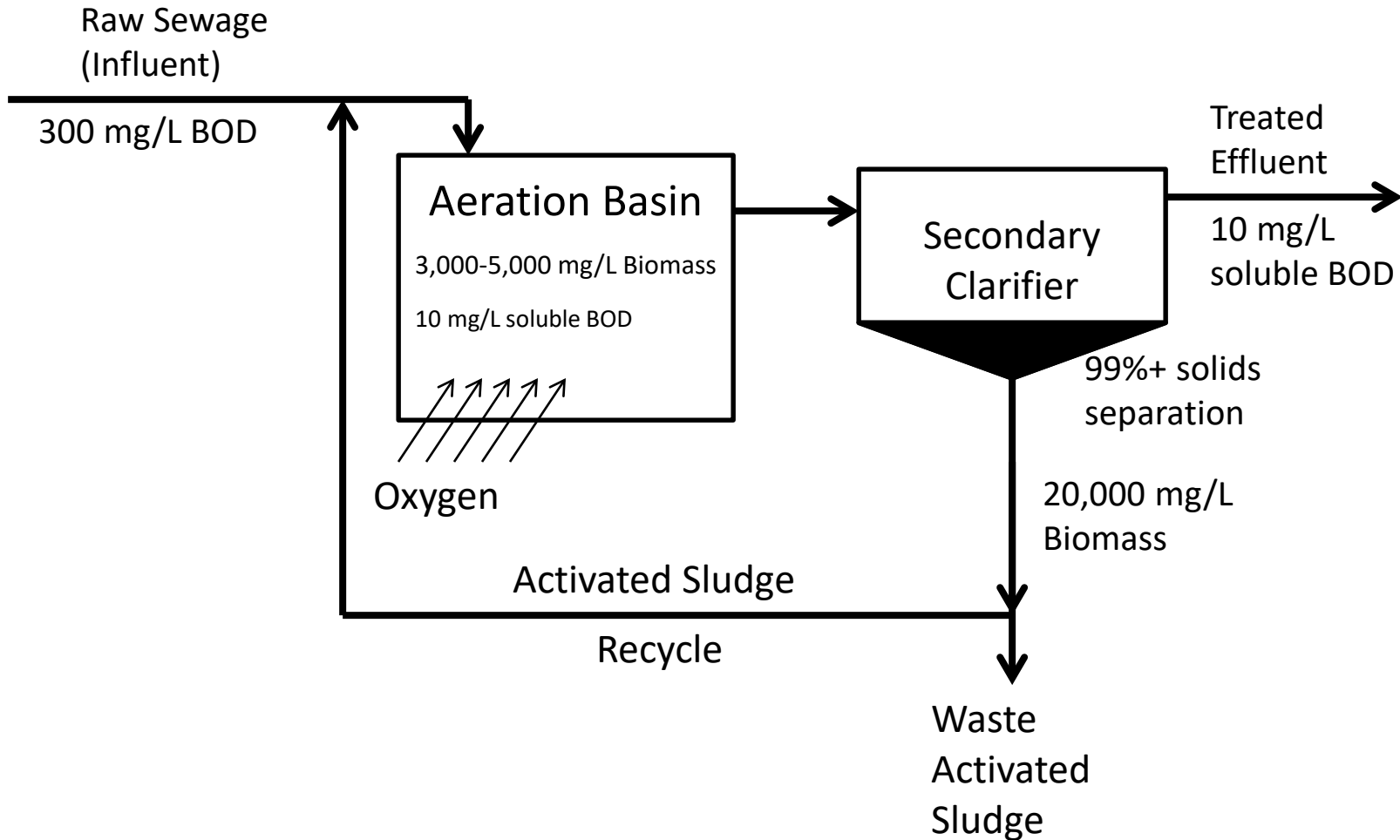


Bacteria can be selected to:

- Settle very well.



Activated Sludge



A word about membranes (and other ways to separate mixtures)

- Membranes
 - Micro to nano scale pore size
 - High efficiency
 - Very compact
 - Energy intensive
 - Maintenance intensive
- Fixed Film
 - Growing the biology on surfaces
 - On pellets that settle fast
 - On surfaces that stay in the aeration basin
- Lagoons
 - Extremely long settling times
 - Liquid retention time ≈ 28 days
- Septic Systems
 - Settling happens first.
 - Anaerobic bacteria treat solids in septic tank.
 - Soil used to filter out pathogens and for additional treatment.

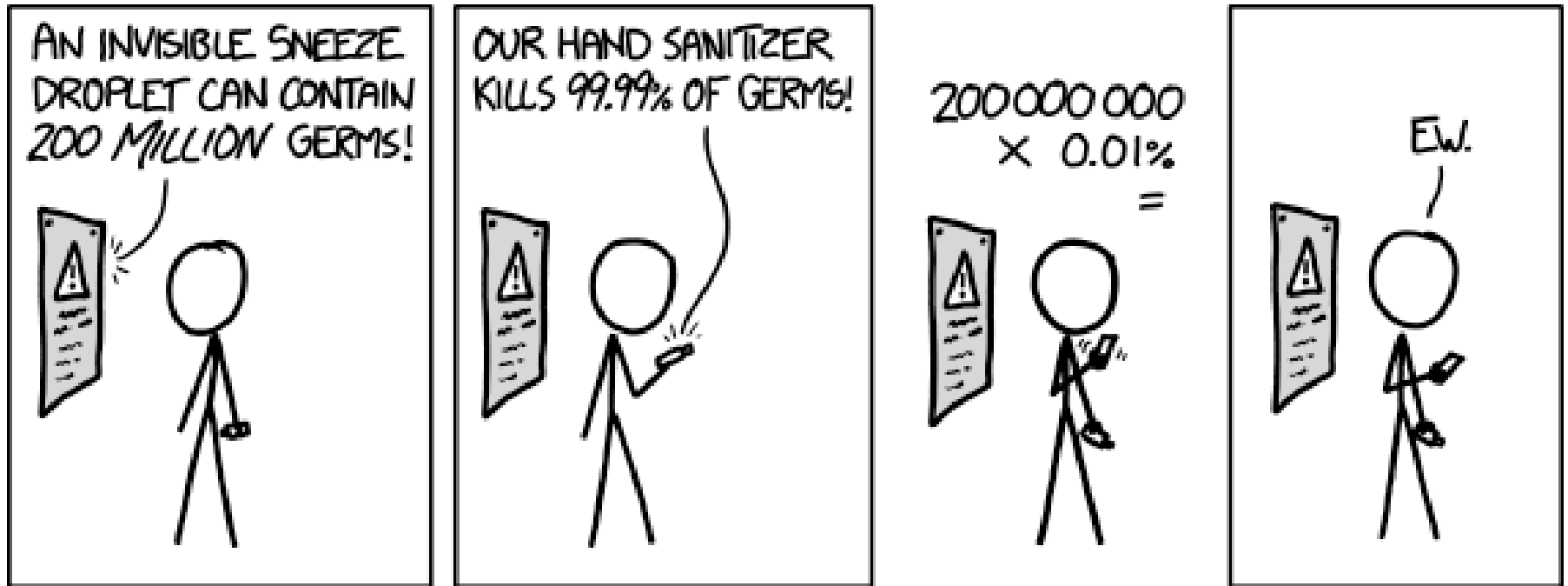






Disinfection

Disinfection is not Sterilization



Disinfection

Chemical or Radiation?

- Chemical disinfection
 - Bleach is common, either Cl_2 (g), or concentrated liquid bleach
 - O_3 , Br_2 , or I_2 are sometimes used.
 - Physically attacks cell wall, breaks down lipid bi-layer, leads to cell death.
- UV radiation
 - exposure to UV radiation ($\lambda=250\text{-}270$ nm) (UV-C)
 - Mercury vapor lamps
 - Attacks DNA bonds



Challenges with Chemical Disinfection

- Worker Safety
- Safe Storage of gas
- Residual chemical in effluent
- Possible need for de-chlorination



Challenges with UV Disinfection

- Worker Safety
- Only works in clear effluent.
- Interferences:
 - Cloudy, turbidity
 - Particles or pin floc
 - Iron, Alluminum



Wastewater 101

- Gravity Sewers
- Pumping Systems
- Gravity Settling
- Bacterial growth
- Disinfection



**Any last
questions?**

Contact Information

David Dunn

david.dunn@ecy.wa.gov

360/407-6503

