Why Are We Here?

Why worry about proper wastewater treatment?

Barry Tonning
Tetra Tech
WHAT IS SEWAGE?

Used water
Where does the water come from?

- Toilet: 26.7% (18.5 gpcd)
- Clothes washer: 21.7% (15.0 gpcd)
- Bath: 1.7% (1.2 gpcd)
- Dishwasher: 1.4% (1.0 gpcd)
- Leaks: 13.7% (9.5 gpcd)
- Other domestic: 2.3% (1.6 gpcd)

Total gpcd = 69.3
Why Treat Wastewater?

Protect Public Health, the Environment, and Property Values

Contact with untreated wastewater can be hazardous to your health!
Wastewater pollutants of concern

- Bacteria and viruses, including Salmonella, Shigella, and Giardia, other protozoa, worm eggs
- Nitrogen – causes algal growth in nitrogen-limited waters; nitrate can cause “blue baby” syndrome
- Phosphorus – causes algal growth in P-limited (mostly inland fresh) waters
- Others – pharmaceuticals, cleaners, solvents, & other toxics (most of which affect treatment processes)
Got untreated sewage?

- **Salmonella**
  - Nausea, vomiting, abdominal pain, diarrhea, fever, chills, headache, muscle pain, blood in stool

- **Shigella**
  - Diarrhea often containing blood, abdominal cramps, fever

- **Giardia**
  - Parasite – symptoms include watery diarrhea, fatigue, abdominal cramps, nausea, weight loss. Can be chronic and last for years.
What Kind of Wastewater System is Bad (malfunctioning)?

- Sewage surfacing on ground – pets, wildlife can spread pathogens
- Untreated sewage discharged to ditches, surface waters, groundwater
Causes of poor sewage treatment

- Poor system design or installation
- Overloading small systems
- Heavy seasonal use
- Inadequate separation to surface or ground water
- Leaky septic tanks
- Poor system management
Wastewater 101

An Introduction to Wastewater Treatment Options
Centralized plants

- **Pros**
  - Economy of scale in high density areas
  - New plants provide good treatment
  - Served by professional operators

- **Cons**
  - Many are old and in need of upgrading
  - Some are at capacity – need expansion
  - Combined sewer overflows in places
  - Difficult to site & build in some cases
Centralized plants

- Most discharge to rivers, lakes, streams, or to the ocean
- Surface water discharges require state/federal permit (NPDES under CWA)
- New regulations forcing higher treatment levels
- Collection systems costly in low-density areas
Sewage treatment plant discharge via infrared photography
Package plants

- Serve homes, schools, rural businesses
- Discharge to ditches, creeks, lakes, etc.
- Require NPDES surface discharge permit
- Poor operation and maintenance in places
Soil-discharging systems

- **Individual systems**
  - Septic tank with gravity flow
  - Tank with pressure dosing
  - Advanced systems with dosing

- **Clustered systems**
  - Each home has a tank (usually)
  - Effluent collected via gravity, pump, or vacuum
  - Multiple options for the treatment facility
  - Dosed or gravity flow dispersal to the soil
Overview of treatment processes

- **Bacteria & other pathogens**
  - Biological death, predation, & decomposition outside host (i.e., in soil)

- **Phosphorus**
  - Some retention in tank, soil adsorption

- **Nitrogen**
  - Ammonia nitrified in treatment unit or soil; poor denitrification of nitrate w/o anaerobic step

- **Suspended solids**
  - Settling out in tank & in treatment unit sludge; filtration by soil

- **Other pollutants**
  - Aerobic soil environment helps degrade organics; treatment of other pollutants uncertain
Simple gravity-flow treatment
Septic tank & treatment processes:

Retains fats, oils, grease, & settleable solids, with some anaerobic decomposition
Effluent movement through soil
Water movement & treatment processes in the soil

- House
- Septic tank
- Dispersal system
- Evapotranspiration
- Percolation
- No restrictive horizon
- Restrictive horizon
- Ground water mound/perched water table
- Bedrock or impermeable soil layer
- Gallop
- Seep
- Runoff to lakes and streams

To wells, springs, ➔ Ground water ➔ ➔ and base flow
soil based on soil properties, groundwater depth and gradient, and flow rate from treatment system
Soil properties:
Most important treatment system component for septic tank systems!
Treatment in the soil

- Unsaturated soil maintains **oxygen transfer** needed for organic decomposition
- Also maintains effluent **flow rate** through the soil, for maximum soil contact
Pathogen treatment in soil

Flow through soil

Attached to particles
Soil treatment of septic tank effluent at varying soil depths

<table>
<thead>
<tr>
<th>Pollutant Parameter</th>
<th>Tank Effluent</th>
<th>Avg. after 24” soil filtration</th>
<th>Avg. after 48” soil filtration</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOD (mg/l)</td>
<td>93.5</td>
<td>&lt;1</td>
<td>&lt;1</td>
</tr>
<tr>
<td>NO$_3$-N (mg/l)</td>
<td>0.04</td>
<td>21.6</td>
<td>13.0 – 29.0</td>
</tr>
<tr>
<td>TP (mg/l)</td>
<td>8.6</td>
<td>0.4</td>
<td>0.18 – 1.8</td>
</tr>
<tr>
<td>F. Coli (log #)</td>
<td>4.57</td>
<td>No detect</td>
<td>No detect</td>
</tr>
<tr>
<td>F. Strep (log #)</td>
<td>3.6</td>
<td>No detect</td>
<td>No detect</td>
</tr>
</tbody>
</table>
Soil properties to consider

- Depth – unsaturated soil depth
- Horizons – layers with similar properties
- Texture – sand/clay/silt mix (permeability)
- Structure – granular, angular, platy, etc.
- Color – indicates minerals, redox, etc.
- Consistence – cohesion / plasticity
- Restrictive horizons – penetration resistance
- Others – organic content, P adsorb potential, etc.
Soil treatment design challenges

- Poorly drained or compacted soil
- High groundwater table
- Nitrate & phosphorus loading
- Steep slopes
- Large rocks
- Rapid flow

Figure 3. Native Soil

A healthy vibrant soil structure teeming with micro and macro organisms. The presence of abundant organic material allows the soil to hold and retain water, and bind and degrade pollutants.
Conventional drainfield trench
Gravelless wastewater infiltration options
Beyond the “box & rocks” systems

- Package & site-built units provide additional treatment for septic tank effluent
  - Usually requires tank for primary treatment
  - Can discharge to soil or surface waters (with NPDES permit)

- Treatment processes include:
  - Suspended growth biological treatment, followed by settling tank & disinfection (if discharging to surface waters)
  - Fixed film biological treatment, followed by filtration & drip irrigation to soil
  - Includes use of various media, such as sand, gravel, peat, textile, tire chips, etc.

- All treatment systems require professional management!
High groundwater? Raise the infiltration area with a mound.
Mounds with other types of “media” instead of sand
Lots of technology options . . .

Effluent Pumping

Textile Filter

Intermittent Sand Filter

Recirculating Sand Filter
Some other treatment approaches

1. Physical filtering
2. Aerobic breakdown at plant roots
3. Anaerobic breakdown in media

**Constructed wetland**

**Peat filter**

**Aerobic treatment unit (suspended growth type)**
## Treatment system effectiveness

<table>
<thead>
<tr>
<th>Pollutant Parameter</th>
<th>Septic Tank Effluent</th>
<th>Aerobic Treatment Unit</th>
<th>Sand Filter Treatment</th>
<th>Foam or Textile Unit</th>
<th>Removal Rate: 3-5’ Soil</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOD (mg/l)</td>
<td>140-200</td>
<td>5-50</td>
<td>2-15</td>
<td>5-15</td>
<td>&gt;90%</td>
</tr>
<tr>
<td>TN (mg/l)</td>
<td>40-100</td>
<td>25-60</td>
<td>10-50</td>
<td>30-60</td>
<td>10-20%</td>
</tr>
<tr>
<td>TP (mg/l)</td>
<td>5-15</td>
<td>4-10</td>
<td>&lt;1-10</td>
<td>5-15</td>
<td>0-100%</td>
</tr>
<tr>
<td>Bacteria</td>
<td>$10^6$-$10^8$</td>
<td>$10^3$-$10^4$</td>
<td>$10^1$-$10^3$</td>
<td>$10^1$-$10^3$</td>
<td>&gt;99.99%</td>
</tr>
</tbody>
</table>
Drip irrigation: new technology from the agricultural sector

- Drip lines high in the soil profile enhance treatment
- Good for sites with high water tables
- Can be used on sloping sites with trees, etc.

Source: University of Minnesota Extension
Drip Irrigation

- Disperses treated water (soil used only to polish)
- Spreads flow out over entire lateral field (pressure distribution)
- Spreads flow out over time (time dosed)
Installing drip irrigation tubing for effluent dispersal into the soil
Clustered treatment systems

- **Existing development**
  - Can serve dense areas with small lots
  - Improves treatment levels considerably
  - Increases groundwater recharge

- **New development**
  - Advanced treatment for sites with poor soils, steep slopes, high groundwater
  - Very friendly to smart growth & low-impact development
  - Promotes clustering of homes & businesses, preservation of woodlands & open space
Cluster system basic layout
A small-diameter collection system is made up of interceptor tanks, service lines, and small-diameter collection mains. The interceptor tanks, similar to septic tanks and located upstream of each connection, remove grease and settleable solids from the raw wastewater. The settled wastewater is discharged from each tank first into the service laterals and then into the gravity collector mains. The mains transport the effluent to a treatment facility or connection with a conventional collection system. Other names for small-diameter collection systems include variable-grade effluent sewer (VGES), septic tank effluent gravity (STEG), and small bore collection.
A vacuum collection system is composed of holding tanks, collection mains, and a central collection station. Wastewater from each home flows by gravity to a holding tank. Generally, when 10-15 gallons of wastewater accumulate in the tank, a vacuum interface valve opens, allowing the wastewater to be drawn into the main pipe leading to the central collection station. When wastewater in the central collection station reaches a certain volume, it is transferred by pump to a treatment plant or conventional collection system.
Grinder pump collection system

**Pressure collection** is a small-diameter pressurized pipeline, buried below the frost line, following the land contour. Normally, either a grinder pump or septic tank effluent pump (STEP) is used to discharge the wastewater to the pressure main whereby it is conveyed to a central treatment facility. A grinder pump is a small pump located in a tank/vault outside the house that grinds the solids in the wastewater into a slurry and after a predetermined level has been reached in the tank, then discharges the slurry to a pressure sewer. The STEP system uses a septic tank to remove the solids, grit, grease, etc., with the pump conveying the effluent to a centralized collection system.
Large Pump/Holding Tank
30,000 gallons per day treatment plant
Ultraviolet disinfection unit, for wastewater re-use (irrigation, etc.)
Subsurface effluent dispersal

- Meadow or prairie (open space) land
- Park land (with disinfection)
- Forest land
- Landscaped areas
- Lawn irrigation
- Re-use (with disinfection)
Managing onsite/clustered systems

- Management for existing systems
  - Assess surface & groundwater quality
  - Assess treatment systems & risks
  - Find & fix problems

- New systems
  - Planning
  - Design
  - O&M
General management approach

- Management intensity is tied to risk
  - Sensitivity of receiving water
  - Complexity of treatment systems
- Management entity is necessary!
  - Sanitation district or etc.
  - Maintenance contract
  - Operating permits
  - 3rd party ownership