CASE STUDIES OF HIGH STRENGTH WASTEWATER

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2016 Mega-Conference in Reno, Nevada

- Joint conference between
  - NOWRA (National Onsite Wastewater Recycling Association)
  - NAWT (National Association of Wastewater Transporters)
  - FOWA (Florida Onsite Wastewater Association) and Western State Organizations
- October 26-29, 2016
- The Nugget Hotel and Resort, Reno, NV
- Call for Papers will be available soon check - nowra.org or email sheger@umn.edu

Presentation Overview

- Key design parameters
- General design solutions
- Case Studies
  - Adult care facilities
  - Rest areas

KEY DESIGN PARAMETERS

Commercial Wastewater

- Strength
  - Usually greater than residential
  - Operation based
    - Food preparation
    - Restrooms
    - Laundry
- Maybe high strength
- Maybe hard to treat

Commercial Challenges

High Strength

- Food service
- Food preperation
- Alcohol
- Dairy
- Sugar

Hard to Treat

- Cleaning chemicals
  - Sanitizers
    - Anti-bacterial
    - Quats
  - Emulsifiers
- Greases
- Dump stations
- Medicines

Quaternary Ammonia?

- Typically known as “Quats”
  - Many individual chemicals
  - Present in thousands of end-use formulations, many of which are blends of various Quats
  - Varying levels, some are worse than others
- Common uses include disinfectants, surfactants, fabric softeners & antistatic agents

More About Quats

- Compounds are very stable and hard to break, so has long lasting biocidal effect
- Certain quats will biodegrade
  - Biodegradation poor under anaerobic conditions
  - Biodegradability increases under aerobic conditions
    - 90% removal cited in literature
- Toxic/Inhibitory to Nitrifying Bacteria - in concentrations < 2 mg/l

Testing Quats

- Test strips: Hydrion, LaMotte, EM Quant
- Hach has a low range test kit for levels up to 5 ppm
- Potentiometric titration most accurate; ASTM Method D5806-95 for Quats used as disinfectants

Quat Alternatives

- In home disinfectant - Use borax: 1/2 cup in a gallon of water; deodorizes also
- Commercial sanitizing is done by either a chemical or with high temperature
  - Chlorine
  - 165 degrees F

High Strength Waste

Caused by:

- High inputs of BOD, TSS and Oil & Grease
  - Nitrogen
- Lack of dilution from low waste strength inputs (shower, laundry, etc..)
- Chemical upset of the septic tank
- Operational/maintenance issues (lack of tank pumping or missing baffles)

High Strength Waste

- Reminder that the mass of the solids is the issue
- We use concentration because we assume normal volume of sewage will be produced

High Strength Wastewater

1) Influent having
   - BOD_5 > 300 mg/L,
   - and/or TSS > 200 mg/L,
   - and/or fats, oils, and grease (FOG) > 50 mg/L entering a pretreatment component

2) Effluent from a septic tank or other pretreatment component that has:
   - BOD_5 > 170 mg/L,
   - and/or TSS > 60 mg/L,
   - and/or (FOG) > 25 mg/L and is applied to an infiltrative surface.

High Strength for Nitrogen

- No national definition
- Typically values greater then 60 mg/l are considered high strength

Biochemical Oxygen Demand (BOD)

- Amount of oxygen consumed by microbes during decomposition of organic matter
- Indicates overall organic strength of wastewater
- High BOD_5 means high levels of organics
  - CBOD – Carbonaceous Biochemical Oxygen Demand
  - NBOD – Nitrogenous Biochemical Oxygen Demand (NH_4 to NO_3)
  - UBOD- Ultimate Biochemical Oxygen Demand (Oxidize, Cell mass, Endogenous respiration)

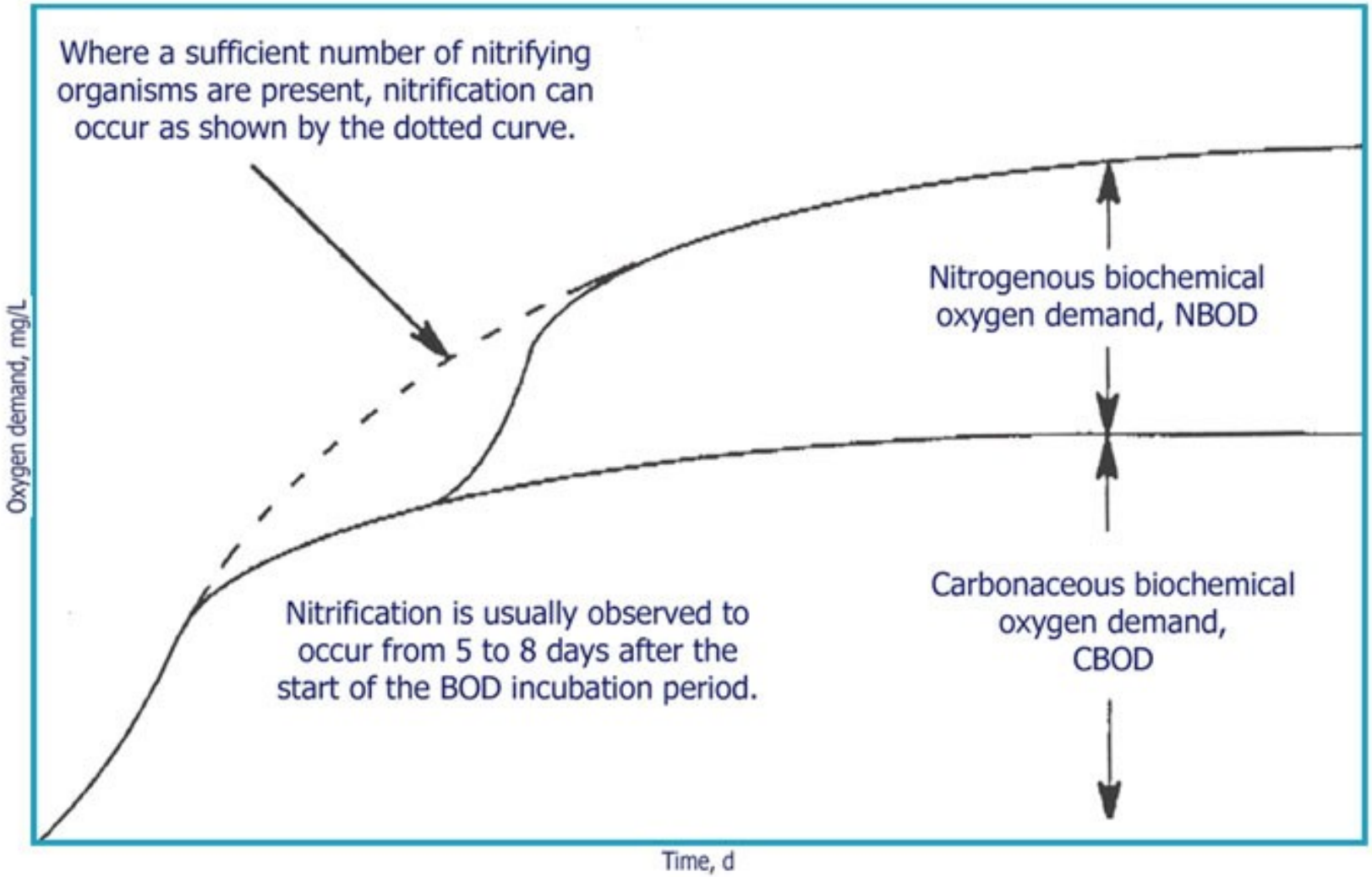


Figure 3: Carbonaceous and Nitrogenous Biochemical Oxygen Demand
Adapted from Metcalf and Eddy (1991)

Chemical Oxygen Demand (COD)

- COD is the equivalent amount of oxygen needed to break down organic matter using strong oxidizing agents
- Approximation of BOD
- Faster test than BOD
- Generally somewhat higher than BOD
- Measure of biological inhibitors – troubleshooting
- No set relationship between BOD and COD

Total Suspended Solids

- Total Suspended Solids (TSS)
  - Solids that don't pass through filter
  - Mixture of organic and inorganic particles
- Organic vs inorganic components
  - Organic can be digestible
  - Inorganic cannot be digested
- Sources
  - Organic matter (garbage disposal)
  - Toilet paper
  - Lint
  - Dirt
  - Other solids
    - Plastics
    - Feminine hygiene products

Fats, Oils, and Grease (FOG)

- Degradable
  - Animal or vegetable-based FOG
    - Kitchens
- Non-degradable
  - Petroleum-based FOG
    - Industry/automotive repair
    - Bath oils, moisturizing cream, tanning oils

A degreaser (emulsifier) will move all FOG components through a system

Fats

- Origin: Animal fats
- Examples: lard, meat fat, butter
- State: solid at room temperature
- Treatment: separate into scum, microbial degradation, non-toxic
- Requires 4 times more energy than BOD to break down
- Melting point - butter/Lard = 86 degrees F

Oils

- Origin: Vegetable or plant
- State: liquid or solid at room temperature
- Treatment: separate into scum, microbial degradation, non-toxic
- Requires 12 times more energy than BOD to break down
  - Corn oil – 12 degrees F
  - Shortening (hydrogenated vegetable oil) – 115 F

Grease

- Origin: Petroleum product
- Example: Sun tan lotion, petroleum jelly, body oils
- State: solid or liquid at room temperature
- Treatment: separate into scum, toxic to microbial activity

Range in Values for 20 Minnesota Food Related Establishments

- Sampled from septic tank outlet or pump tank
- Each sample 3 times

Parameter	Low median value mg/L	High median value mg/L
BOD_5	574	1,286
TSS	142	213
O&G	132	282

Lesikar Restaurant Study

- 28 restaurants located in Texas
- Sampled during June, July, and August 2002
- 12 samples per restaurant and 336 total observations

Parameter	Value (mg/L)	% Data Covered
BOD_5	1523	82
TSS	664	87
FOG	197	81

MANAGING HIGH ORGANIC LOADS

Managing

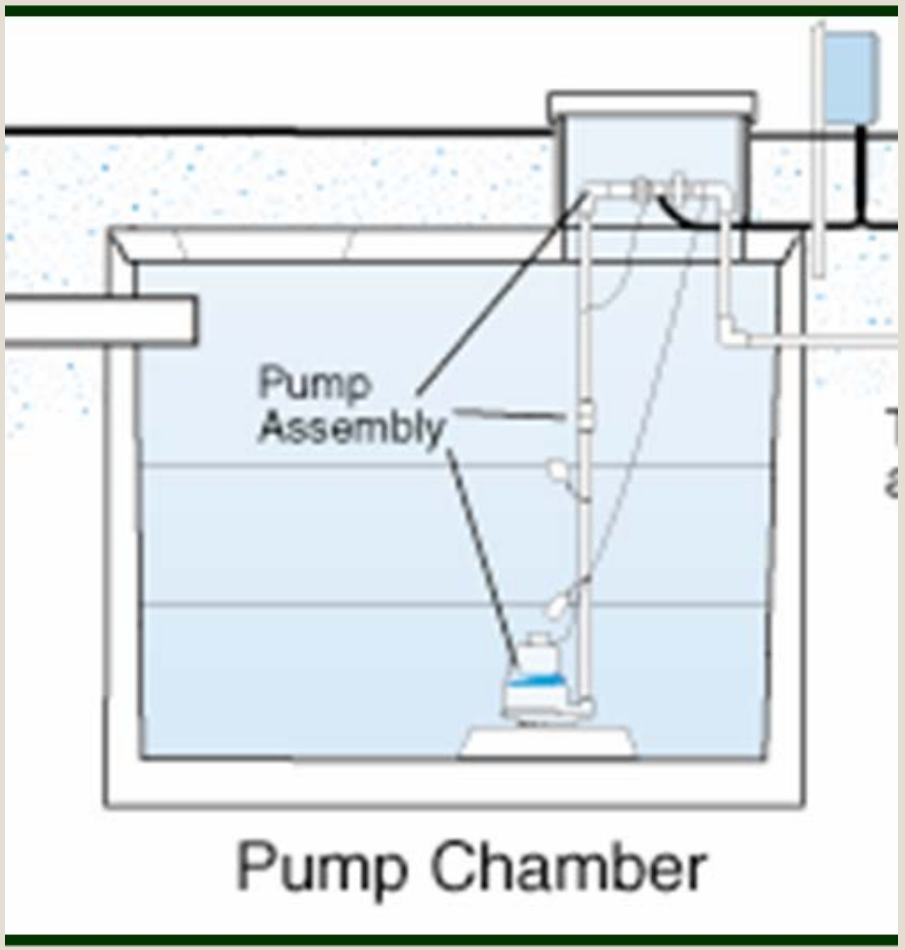
- High organic loading will cause failure
- Management considerations
  - Blackwater and graywater separation
  - Wastewater source separation
  - Advanced treatment
  - Holding tanks
  - Working with the owner

Wastewater Source Separation

- May be economically beneficial to treat a waste stream separately or pump and haul it away
  - Streams with very high chemical use that will negatively affect the treatment system
  - Floor drains, utility sinks, laboratory drains, disinfecting basins and dishwashers
  - Streams that require a long detention time

Hold & Dose

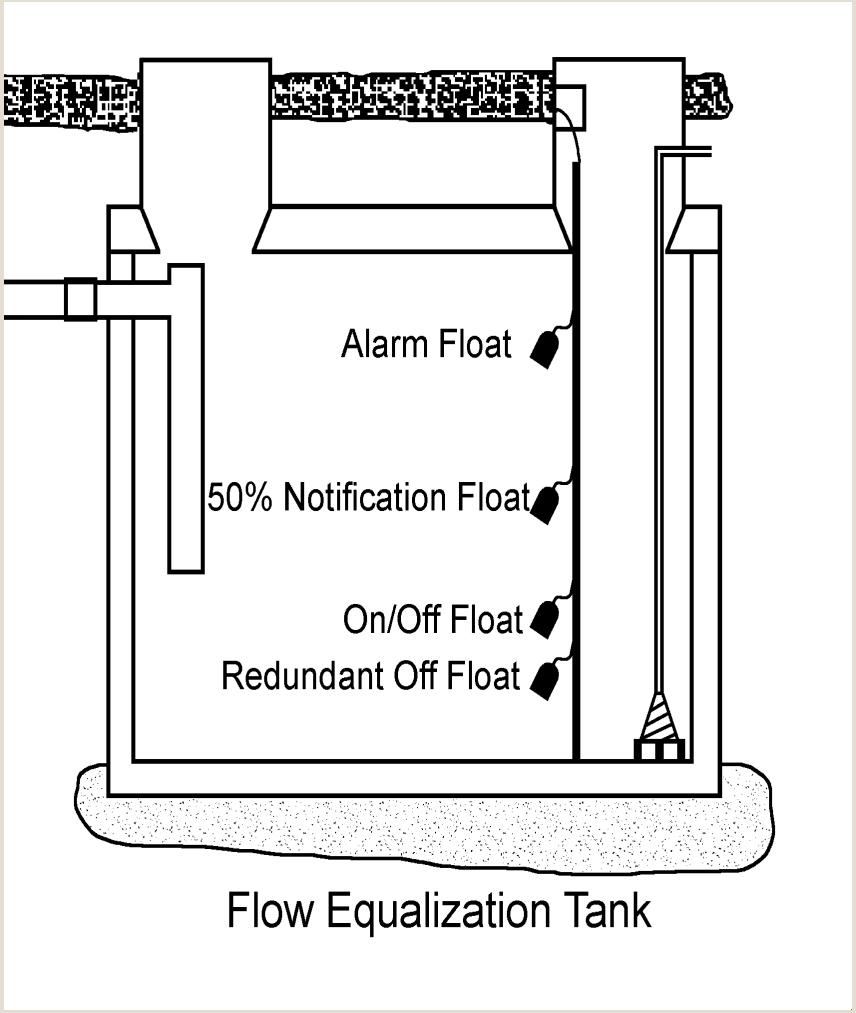
- Some chemical products must be contained in a separate tank and introduced into the system in small doses



Time dosed to treatment train

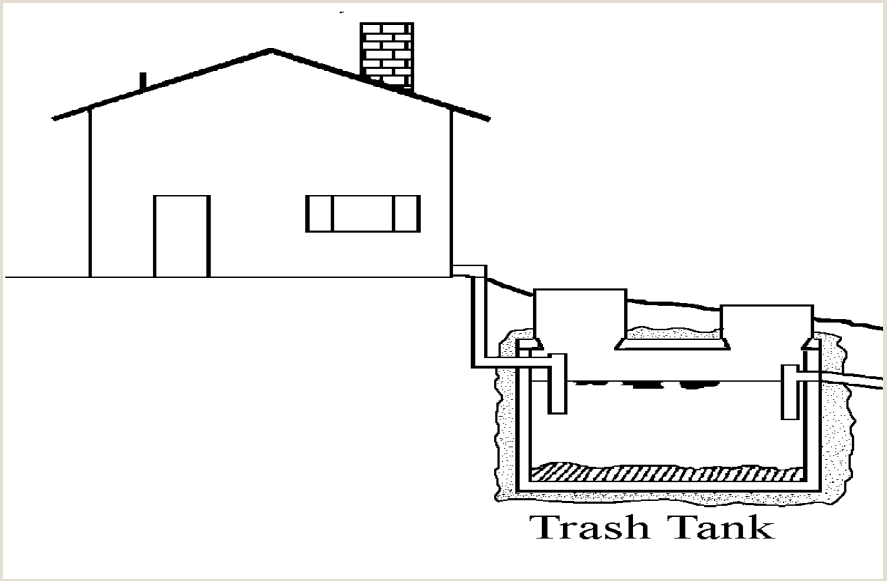
Flow Equalization Tank & Haul

- Lower the extreme surge
  - Special events
- Too costly for infrastructure needed for special event extreme flow/strength
- If the surge flows only happen a few times a year
- Pump the extra flow from surge - equalization tank



Separation of Businesses

- Strip Mall
  - Multiple stores
  - Different sources
- Initial tank for each facility
- Rental contract tied to wastewater quality & quantity



Treatment Options

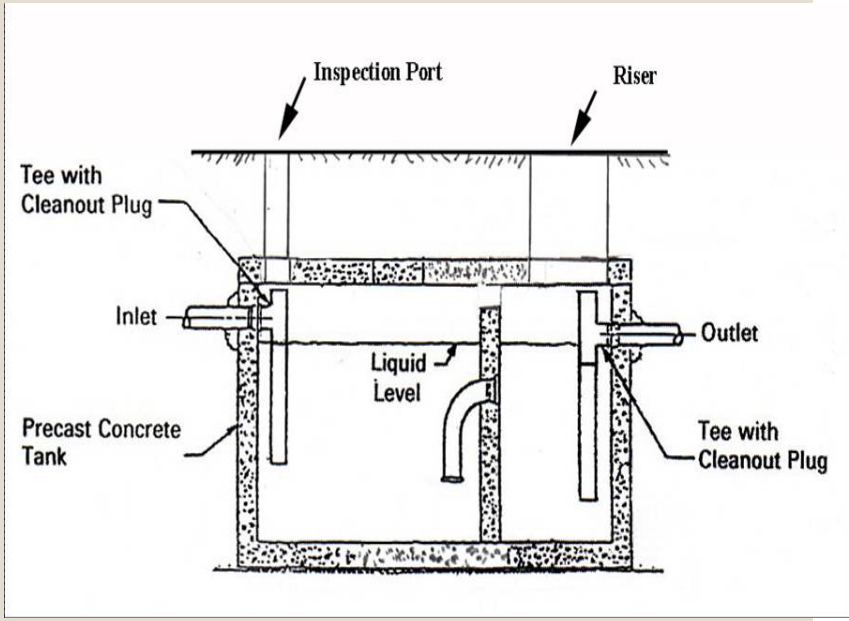
- Configuration of the system and the facility operation can be changed to influence treatment
- Start-up phase - monitor closely in first months of operation
- System is subject to the source
  - Educate users on proper procedures and how their usage is impacting the system

Fats, Oils, and Grease Management

- Best - Minimize their source
  - Use evaluation surveys
  - Find operations that can be changed or eliminated – salad bar?
- Separate waste streams
- Grease interceptor or trap
- Temperature moderation

Grease Trap

- Grease traps are often first in the treatment train
- Baffles extend lower into tank than septic tank
- Needs frequent pumping
  - Sizing dependent on pump truck capacity



Stereotyping

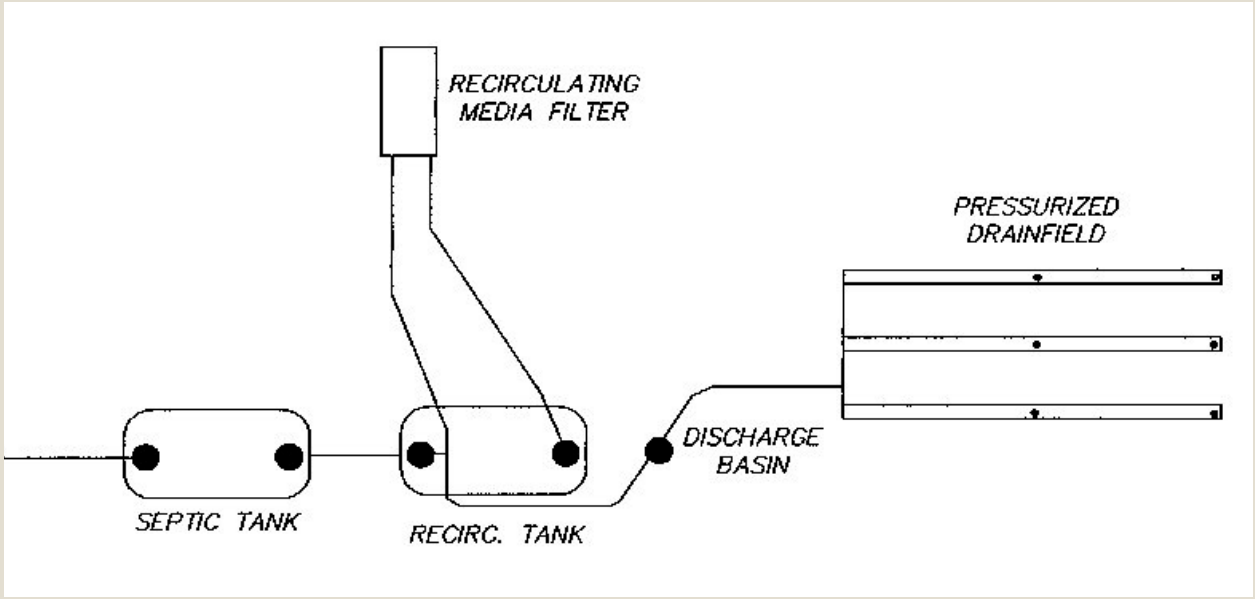
- Remember EVERY FACILITY IS UNIQUE; what works for one may not work for another
- What is a comparable facility?
- Heavily influenced by facility management
- Evaluate whether the facility is operating at assumed design values.

Recording Flow

Sampling BOD & FOG

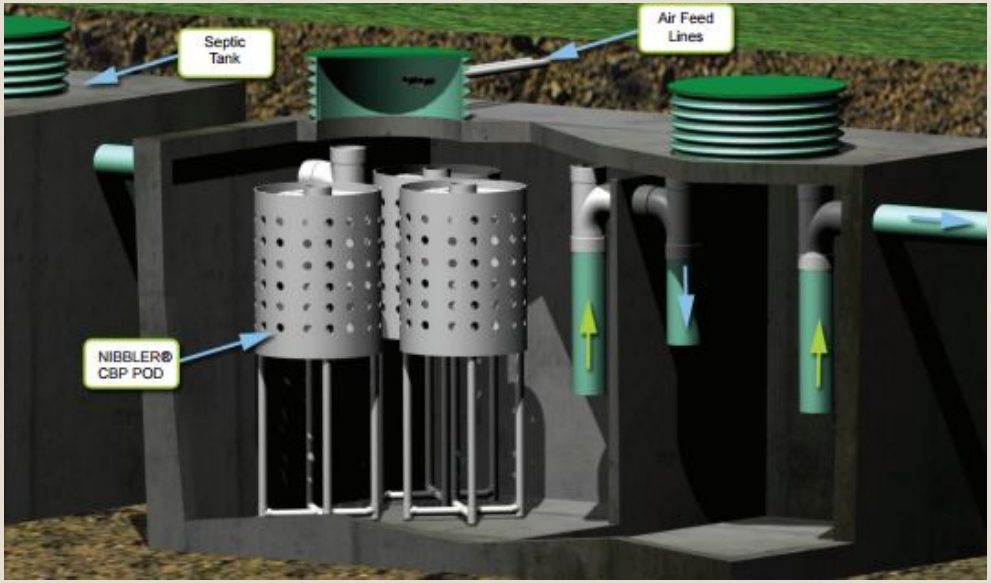
Recirculation

- Recirculation of semi-treated effluent to dilute high strength wastewater
- Denitrification
- Example - Media filters

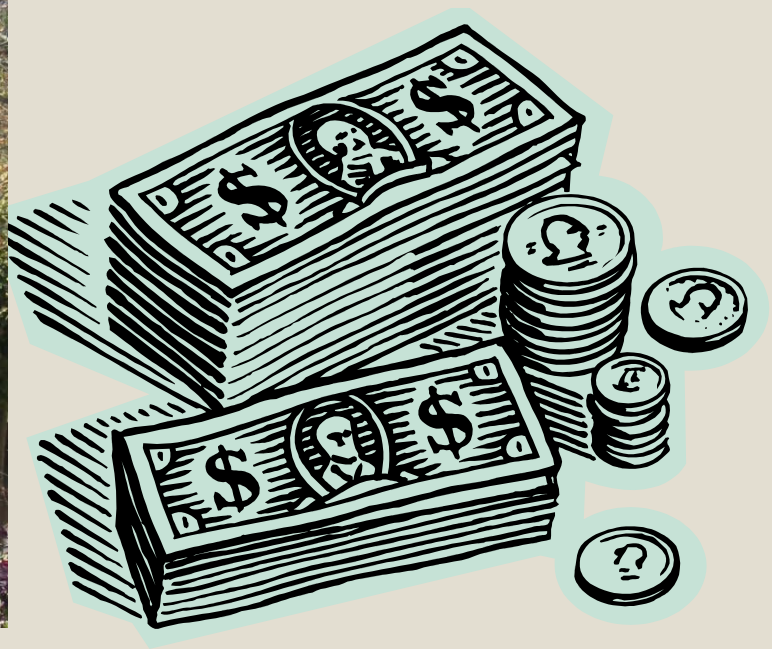


Aerobic Treatment

- Commercial units designed for high strength/commercial flows
- Typically designed in pounds of BOD removal per day
- Fats, oils and grease needs to be considered as well



Work with System Owners



- Owner education is vital
- Most effective to demonstrate the economical benefits
- Management relates directly to waste stream

Work with System Owners

- Fix leaking plumbing fixtures
- Lower water pressure
- Use automatic shut-off faucets
- Use water-saver dishwasher cycle

Work with System Owners

- Scrape plates into garbage, not the sink
- Install drain covers and sink baskets/strainers
- Avoid use of a garbage disposal
- Avoid using slop sinks to dispose of liquid food items

Work with System Owners

- Avoid use of harsh detergents: hand washing & automatic
- Hand washing – disinfection process
- Isolate harsh flows

CASE STUDY: ADULT CARE FACILITIES

Background

- 6 foster homes owned by same individual had reported various issues with their septic system operation and performance, including:
  - surface discharge of wastewater and
  - premature system failure
- The systems evaluated are conventional systems with septic tanks followed by in-ground soil treatment areas or mound systems
- Septic tanks pumped annually

Example Faclity

Permanent Residents:	**4**
Ave. Onsite Staff:	**2**
Bedrooms:	**4**
Bathrooms:	**2**

Methods

- *Water Usage* - staff who work in the facilities collected daily water meter readings for April–August 2013
- *Onsite Practices and Behaviors*
  - Staff provided feedback and assisted in completing a survey
  - Provided inventories for each site listing all pharmaceuticals and personal care products used in the facilities

Wastewater analysis

- Samples obtained from outlet baffle of septic tank or pump tank
- Analyzed for:
  - Dissolved oxygen (DO), temperature and pH
  - 5 day biochemical oxygen demand (BOD5)
  - Total Kjeldahl nitrogen (TKN)
  - Total phosphorous (TP)
  - Total suspended soils (TSS)
  - Heterotrophic Plate Count (HPC)
  - Surfactants - Methylene Blue Active Substances – (MBAS)
  - Contaminants of Emerging Concern (CEC)

Results – Water usage

Site	Flow, gpd		
	Mean Ave. Recorded	70% of Design	Design
A. Maple View	321 ± 13	525	750
B. Shady Lane	462 ± 6	420	600
C. Woods	326 ± 22	420	600
D. Jocelyn	630 ± 19	525	750
E. Upland	521 ± 6	840	600/1200
F. Meadows	491 ± 23	525	750

Results – water usage

- Flow was higher than the ideal operating maximum (70%) at 2 sites (3 if you take into account system that was expanded)
- None of the sites exceeded the maximum design flow (on average)
- **Recommendations:**
  - **Laundry**
    - All sites use top-loading washers.
    - 1 to 12 loads in a single day
    - Convert to front-loading laundry machines
    - Limit bleach usage
  - **Bathing, Washing, and Toilet Use**
    - None of the homes had low-flow showerheads or toilets
    - Convert to:
      - low-flow showerheads (<2.0 gal per minute, gpm),
      - sink faucets/fixtures (0.5–1.5 gpm), and
      - toilets (<1.6 gal per flush)

Results - cleaning products

- Soap and detergents are often a significant part of maintaining a clean and hygienic home
- These cleaning products, however, can often stress septic systems when overused or disposed of improperly
- **Personal Care Products -** It would be prudent to reassess all cleaning products and personal care products
- Opting to use perfume- and dye-free alternatives will help cut down on unnecessary chemicals in wastewater

Results – soaps and detergents

- Several antibacterial soap products and disinfectants are listed in the site inventories
- Some may be necessary (antibacterial denture cleaning tabs) while others (hand soaps and dish detergents) are not*
- Replacing these products with non-antibacterial alternatives should reduce stress to the microbial communities and will not affect hygiene
- Not all troublesome products are labeled as antibacterial. Mouthwash and toothpaste brands with triclosan as an active ingredient should be avoided

* Aiello, et al., 2007

Results – disposable wipes

- During several site visits, non-biodegradable products were observed in the pretreatment tanks at 3 sites
- Recommendation – Remove from facilities and remind staff as well as guests wipes, personal wet-cloths, and moist towelettes are not suitable for septic systems
  - These should be disposed of with solid waste

BOD_5 data

Site	BOD_5, mg/L		
	Mean	Min.	Max.
A. Maple View	143 ± 31.0	80.8	166
B. Shady Lane	129 ± 12.4	110	147
C. Woods	193 ± 34.2	159	235
D. Jocelyn	144 ± 41.5	93.4	195
E. Upland	182 ± 49.9	119	244
F. Meadows	132 ± 64.9	48.7	191
G. Control Site	64 ± 30.7	38.6	114

TSS data and analysis

Site	TSS, mg/L		
	Mean Ave.	Min.	Max.
A. Maple View	46.5 ± 2.7	44.1	51.0
B. Shady Lane	38.9 ± 16.9	20.5	67.4
C. Woods	39.6 ± 8.7	28.2	54.5
D. Jocelyn	48.6 ± 10.5	36.7	65.3
E. Upland	51.1 ± 18.7	31.9	84.7
F. Meadows	24.7 ± 6.3	17.5	32.0
G. Control Site	40.3 ± 24.4	17.3	71.8

- All sites had TSS concentrations within the standard range*
- Lint filters and effluent screens recommended

* CIDWT Glossary, 2009

Methylene Blue Active Substances

- MBAS are a group of anionic surfactants accounting for as much as 63% of synthetic surfactant production worldwide*
- Detergents, cleaners, and soaps
- Surfactants do not typically pose a risk to groundwater, unless under saturated conditions, because of a strong tendency for soil sorption*

Hubbard, 2002, Reneau and Pettry, 1975, Weil-Shafran *et al.*, 2006

MBABS & septic systems

Concentration (mg/L MBAS)	Potential Effects (Hernández Leal et al., 2011, and Weil-Shafran et al., 2006)
≥1.0	Risk of long-term accumulation of surfactants in soil, leading to decreased hydraulic conductivity and increased water repellence
10	Inhibition of hydrolysis, leading to greater accumulation of solids in anaerobic sewage treatment systems
30	Direct degradation of soil structure and decrease in hydraulic conductivity

MBAS results (1 sampling event)

Site	Anionic Surfactants (MBAS), mg/L
A. Maple View	2.0
B. Shady Lane	0.76
C. Woods	3.8
D. Jocelyn	8.6
E. Upland	1.5
F. Meadows	3.4
G. Control Site	2.7

- 6/7 sites showed concentrations above the recommended 1.0 mg/L for soil treatment

Contaminants of Emerging Concern (CECs)

- According to the EPA, chemicals are being discovered in water and wastewater that previously had not been detected or are being detected at levels that may be significantly different than expected
- These are often referred to as “contaminants of emerging concern” (CECs), because the risk to human health and the environment associated with their presence, frequency of occurrence, or source may not be known

CECs

- Pharmaceuticals and personal care products (PPCPs)
- Rare earth metals, radioactive isotopes, and other unusual elements
- Pesticides, including insecticides, herbicides, and fungicides
- Hormones, steroids, and endocrine-disrupting compounds
- Genetic material, such as RNA or DNA (including antibiotic resistance genes)

- Various CECs were found at each of the sites
- This reflects the medical nature of the foster care homes and supports the notion that foster care homes have fundamentally different wastewater characteristics than average residential wastewater
- There are likely many other compounds present beyond the 26 included in this study

CEC units results

- Nanograms/liter
- 1 part per trillion
- 1 ng/l Analogy – 1 oz. in 7.5 billion gallons of water

Compound	Common Name(s)	Description	Results, ng/L			
			C Woods	D Jocelyn	E Upland	F Meadows
Trimethoprim	Proloprim Monotrim Triprim	Antibiotic—Used for urinary tract infections	50.2	63.5	33.0	<5
Antidepressants and Mood Stabilizers						
Bupropion	Wellbutrin Budeprion	Rx Drug—Antidepressant or smoking cess. aid	62.1	255.7	102.4	937.9
Lamotrigine	Lamictal	Rx Drug—Anticonvulsant and mood stabilizer	106.7	80.7	0.151	158.4
Venlafaxine	Effexor	Rx Drug—Antidepressant; treats depression and anxiety	7,818	<0.001	59,087	3946
Gemfibrozil	Lopid Jezil Gen-Fibro	Rx Drug—Treats high triglyceride and cholesterol levels	<0.005	<0.005	91,162	323

Compound	Common Name(s)	Description	Results, ng/L			
			C Woods	D Jocelyn	E Upland	F Meadows
Beta Blockers						
Atenolol	Tenormin	Rx Drug—Treats high blood pressure and angina (chest pain)	<5	<5	471.9	<5
Metoprolol	Lopressor Toprol-xl	Rx Drug —Treats cardiovascular diseases, especially hypertension	<1	1728	1385	3752
Propranolol	Ciplar Inderal Deralin	Rx Drug—Treats hypertension, anxiety, and panic	<1	<1	23.8	<1
Pesticides						
Atrazine	Atazinax Weedex A	Common Herbicide	<2	94.5	<2	<2
Diuron (DCMU)	Di-on Karmex	Common Herbicide	408.2	<5	<5	<5
Fluridone	Sonar Alligare	Herbicide	<5	93.9	<5	<5

Compound	Common Name(s)	Description	Results, ng/L			
			C Woods	D Jocelyn	E Upland	F Meadows
Caffeine		Stimulant	1363.1	347.5	247.6	448.3
Cotinine		Stimulant—Alkaloid found in tobacco and derived from nicotine	2.44	0.25	1.28	1.73
Sucralose	Splenda	Food Additive— artificial sweetener	122.4	96.6	29.2	258.7
Acetaminophen	Tylenol	OTC Drug—Pain reliever and a fever reducer	581.7	23.7	28.7	714.3
DEET		Chemical—Most common active ingredient in insect repellents	74.8	29.1	12.5	26.0
Diphenhydramine	Benadryl Unisom NyQuil	OTC Drug—Antihistamine; treats allergies and cold/flu symptoms	2022	1258	1078	1260

Additional recommendation

- Some of the existing systems are not up to basic standards
- Effluent screens and alarms should be added
- New systems or those being upgraded should time dosing and incorporate secondary treatment prior to soil treatment to mediate:
  - flow,
  - waste strength, and
  - CECs

CASE STUDY
MINNESOTA DEPARTMENT OF TRANSPORTATION (MNDOT) REST STOP EVALUATION

Research background

- MnDOT owns and operates 52 septic systems serving the rest stops, truck garages and scales across Minnesota
- Little information exists or has been evaluated regarding
  - Flows
  - Waste strength
  - Chemical usage
- Many systems are 30+ years old
- Majority only have pretreatment in a septic tank
- Difficult site conditions
  - Compaction, fill soils, setbacks, etc

Field data gathered - facility

- Toilets, gallons per flush
- Sinks, manual or automatic
- Water conditioning devices, discharge location
- Water treatment
- Water foundations
- Chemicals outside of 3M supplied by central administration
- Flows recorded daily by manager from flow meter

Field data gathered – septic system

- Pumping frequency
- Problems/issues
- Tanks: Type, depth, capacity, sludge, scum, pH., dissolved oxygen, temperature
- Pump operation
- From pretreatment unit
  - Septic/pump tank
  - A few advanced treatment unit
    - Aerobic treatment units
    - Advantex
  - BOD, COD, TSS, nitrogen, phosphorous
  - Fecal coliform and chemicals at select sites

Field data gathered – septic system continued

- Distribution method: gravity, siphon, pump
- Confirm size of system
- Measure amount of ponding
- Vegetation issues
- Soil
  - Separation to limiting condition
  - Texture/structure - sizing

Field data outcomes

- Use information gathered along with additional information to
  - Prioritizing upgrades based on risk factors
    - Systems surfacing
    - Systems not protecting groundwater
    - Higher flows increase risk/weight
    - Age
    - Effluent quality
  - Provide design and management recommendations
  - Provide improved design standards

Treatment Levels

Treatment Level	Maximum BOD_5/TSS (mg/L)	Number of Systems
A/B	<25/30	3
C	<170/60	30
HSW	>170/60	17
HSW+	>500/100	2

Nitrogen Data

- 14 systems had nitrogen concentrations over 120 mg/L
- 24 exceeded 60 mg/l
- 73% of the systems have elevated nitrogen levels compared to typical domestic wastewater
- Due to the preponderance of blackwater versus graywater

Organically Overloaded?

- Due to conservative designs:
  - six systems were undersized based on organic loading
  - Nine of the 52 systems had septic tanks less than the current requirements
    - 3 days of hydraulic retention time

Results - Vertical separation

- Distance from bottom of media to limiting soil condition

Amount of Separation (ft)	Number of Systems
>3	11
1-3	12
<1	29

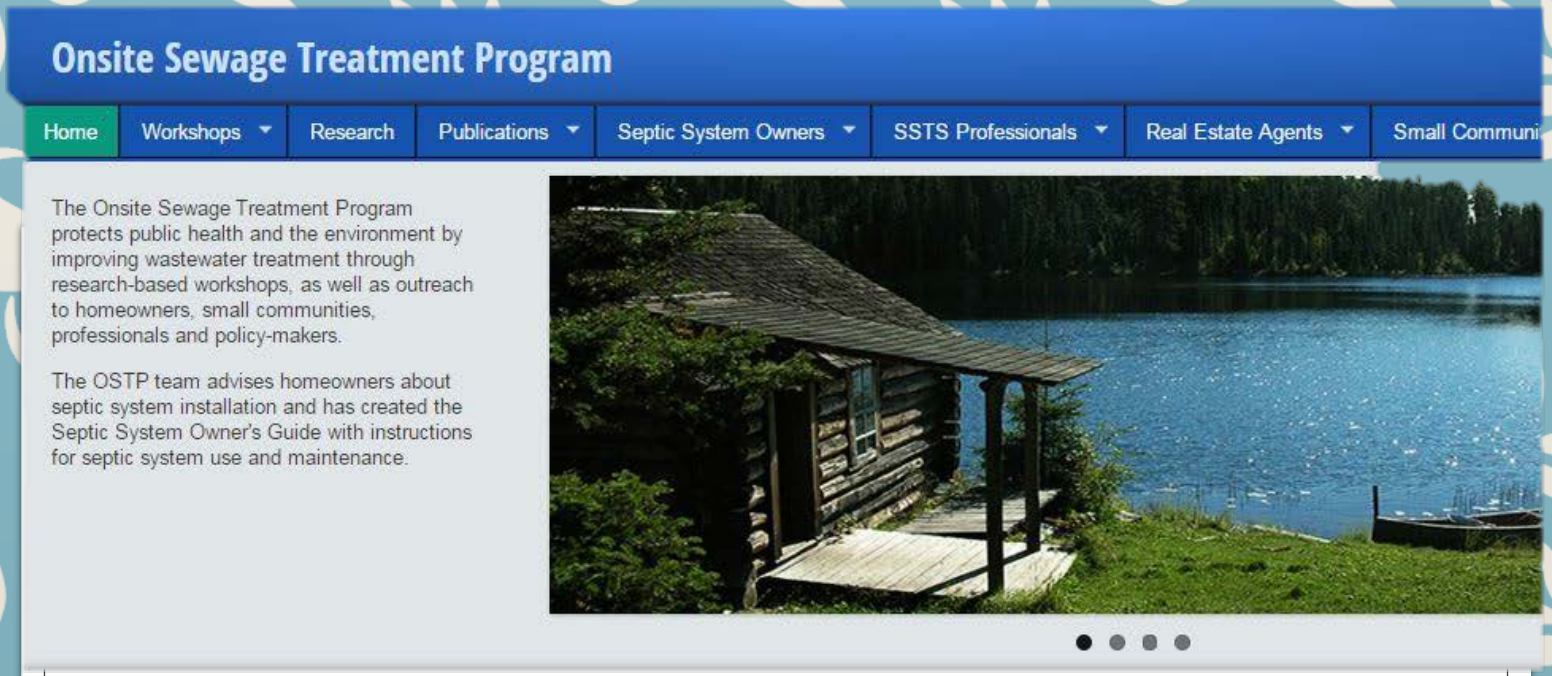
  - 16 systems with evidence of surfacing
  - ~300% of required size based on hydraulics

Maintenance

- Thirty-three of the systems either had:
  - no pumping data on last pumping
  - were in need of maintenance at the time of our assessment
- For the systems with no data the interval had been greater than three years which is the minimum time frame allowed by MN Rules even for small residential systems

More In-Depth Research Underway

- 2 sites selected
- Evaluating contaminant fate and transport
- Groundwater mounding



STUDY REPORTS: SEPTIC.UMN.EDU