Fundamentals of System Design:

Key Principles, Standards & Best Practices

ONSITE WASTEWATER SUPER CONFERENCE 2025 of PENNSYLVANIA

Pennsylvania Septage Management Association

The Pennsylvania Association of SEWAGE ENFORCEMENT OFFICERS

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Penn's Trail Environmental LLC

- Septic Testing and Design
- Wastewater Treatment Design
- Act 537 Land Planning
- Septic Inspections
- Operation & Maintenance Providers
- Hydraulic Conductivity Testing
- Stormwater Infiltration Testing
- Wetlands Evaluations and Permitting
- Geologic Evaluations
- Phase I & II Environmental Site Assessments

PADEP Disclaimer:

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Fundamentals of System Design:

1. Act 537 Planning Requirements
   - New Construction vs. Repair/Replacement
2. Soil Evaluations and Associated System Criteria
3. Percolation Testing vs. Soil Loading Rates
4. Site Plans
5. Ideal Siting Locations
6. Application of System Types
7. Technologies
8. Attention to Detail
9. Field Layout Procedures
10. Questions

Act 537 Planning Requirements:

New Land Subdivision:

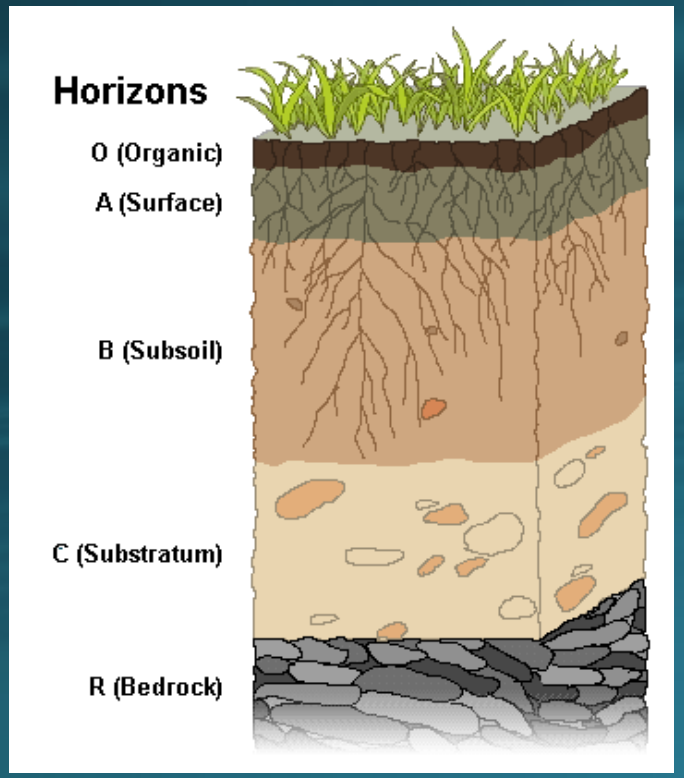
- Planning Approval Received
- Testing is complete
- General Site Suitability

Vacant Lot of Record:

- Prior to May 15, 1972:
  - No Requirement for Land Planning/Not Subject Thereto
- Between May 15, 1972 & June 10, 1989
  - No Planning Completed
    - Reconstructive Planning – Must meet GSS Criteria
    - Municipality does not require Reconstructive Planning – Must meet criteria of OAT Listing
- After June 10, 1989
  - No Planning Completed…Required
    - Must meet GSS Criteria

Soil Evaluations & Associated System Criteria:

Soil Characteristics/Limiting Factors:



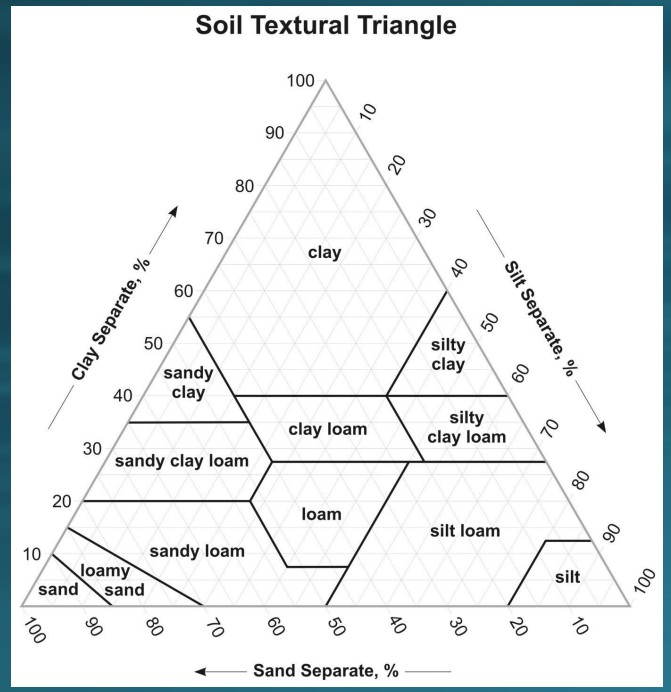
- Conventional (GSS):
  - Limiting Zone is 72 inches or greater from surface of ground
    - Subsurface Sand Filter Systems – up to 25% slopes
  - Limiting Zone is 60 inches or greater from surface of ground
    - Inground Systems – up to 25% slopes
  - Limiting Zone is less than 60 inches and greater than or equal to 20 inches from surface of ground
    - Elevated Sand Mound or Sand Trenches – up to 12% slopes
  - Seasonal High Water Table or Water is less than 20 inches and greater than or equal to 10 inches and greater than or equal to 16 inches to rock limiting zone from surface of ground
    - IRSIS – Individual Residential Spray Irrigation System – up to 25% slopes

Soil Evaluations & Associated System Criteria:

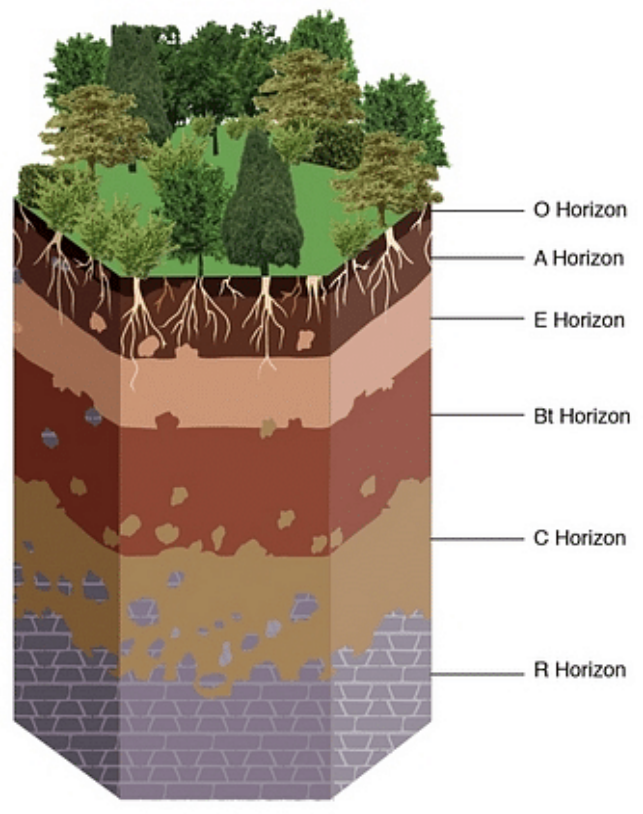
Soil Evaluations & Associated System Criteria:

Soil Characteristics/Limiting Factors:

- On-Lot Alternate Technologies (OATs):
  https://www.pa.gov/agencies/dep/programs-and-services/water/clean-water/wastewater-management/act-537-sewage-facilities-program/onlot-disposal-system/on-lot-alternate-technology-listings.html



- Limiting Zone is 72 inches or greater from surface of ground
  - Modified Subsurface Sand Filter System (perc rates less than 3 mpi conducted between 12 and 36 inches) – up to 25% slopes
- Limiting Zone is 58 inches or greater from surface of ground
  - Shallow Placement Pressure Dosed System – maximum slope is dependent on LZ
- Limiting Zone is 48 inches or greater from surface of ground
  - At-Grade without Pre-Treatment – up to 15% slopes
- Limiting Zone is 24 inches or greater from ground surface
  - Drip Distribution without Pre-Treatment (American Manufacturing Co., Inc. PERC-RITE; JNM Technologies, Inc. SAS – up to 25% slopes



- Limiting Zone is 20 inches or greater from ground surface
  - At-Grade with Pre-Treatment (Orenco AdvanTex; EcoFlo Biofilters; PuraFlo Biofilter; Norweco HKBFR) – up to 15% slopes
  - Drip Distribution with Pre-Treatment (American Manufacturing Co., Inc. PERC-RITE; JNM Technologies, Inc. SAS – up to 25% slopes
  - Eljen Geotextile Sand Filter Systems – up to 15% slopes
  - Steep Slope Sand Mound – up to 15% slopes
- Seasonal High Water Table or Water is less than 20 inches and greater than or equal to 10 inches and greater than or equal to 16 inches to rock limiting zone from surface of ground
  - Shallow Limiting Zone At-Grade with Pre-Treatment (Orenco AdvanTex; EcoFlo Biofilters; PuraFlo Biofilter; Norweco HKBFR) – up to 15% slopes
  - PERC-RITE Drip Micromound - American Manufacturing Co., Inc. – up to 15% slopes
  - SAS Mound Drip - JNM Technologies, Inc. – up to 15% slopes
  - Eljen Geotextile Sand Filter Systems – up to 15% slopes
- Limiting Zone less than 10 inches from ground surface
  - Sundrive Biovaporator Solar Greenhouse Evapotranspiration Wastewater Disposal System – not slope dependent

Soil Evaluations & Associated System Criteria:

Percolation Testing vs. Soil Loading Rates:

- Percolation Testing:
  - Inground Trench and Bed Systems (6mpi – 90mpi)
  - Subsurface Trench and Bed Systems (3mpi – 90mpi)
  - Elevated Sand Mound and Trench Systems (3mpi – 180mpi)
  - Steep Slope Sand Mound (3 mpi – 30mpi)
  - At-Grade Systems (20”+ and 48”+ Limiting Zones) (3mpi – 180mpi)

- Soil Loading Rate:
  - Shallow Limiting Zone At-Grades (Tyler Loading Chart)
  - PERC-RITE Drip & SAS Drip Systems (OAT Listing)
  - PERC-RITE Drip Micromound & SAS Mound Systems (OAT Listing)
  - Eljen Geotextile Sand Filter Systems (Tyler Loading Chart)

- Other
  - Individual Residential Spray Irrigation Systems (§ 73.16 Table B Chart)
  - Sundrive Biovaporator Solar Greenhouse Evapotranspiration Wastewater Disposal System (OAT Listing)

Percolation Testing vs. Soil Loading Rates:

TABLE A
Minimum Aggregate Absorption Area Requirements for Treatment Tank Effluent:

	Square Feet of Aggregate Area Per Gallon Per Day	
Average Percolation Rate	*All Systems Except*	*Subsurface Sand*
Expressed as	*Elevated Sand Mounds*	*Filters and*
Minute Per Inch	*and Subsurface Sand Filters*	*Elevated Sand Mounds*
Less than 3.0[D]	Unsuitable	Unsuitable
3 - 5[C]	Unsuitable	1.50[AB]
6 - 15[C]	1.19[B]	1.50[AB]
16 - 30[C]	(Avg. Perc Rate - 15) x (0.040) + 1.19[B]	1.50[AB]
31 - 45[C]	(Avg. Perc Rate - 30) x (0.030) + 1.79[B]	(Avg. Perc Rate - 30) x (0.026) + 1.50[AB]
46 - 60[C]	(Avg. Perc Rate - 45) x (0.028) + 2.24[B]	(Avg. Perc Rate - 45) x (0.022) + 1.89[A]
61 - 90[C]	(Avg. Perc Rate - 60) x (0.023) + 2.66[A]	(Avg. Perc Rate - 60) x (0.020) + 2.22[A]
91 - 120[ACD]	Unsuitable	(Avg. Perc Rate - 90) x (0.017) + 2.82[A]
121 - 150[CD]	Unsuitable	((Avg. Perc Rate - 120) x (0.015) + 3.33) (1.05)[A]
151 - 180[CD]	Unsuitable	((Avg. Perc Rate - 150) x (0.014) + 3.78) (1.10)[A]
Greater than 181[CD]	Unsuitable	Unsuitable

A Pressure dosing required.

B One third reduction may be permitted for use of an aerobic tank.

C May be considered for experimental or alternate proposals.

D Unsuitable for subsurface sand filters.

(e) *Spray fields.* Table B shall be used in calculating the square footage of spray fields based on flows determined in Subsection (a). Table B includes allowances for garbage grinders, automatic washing machines, dishwashers and water softeners.

TABLE B

Soil Characteristics		Slope	Required Spray Field Area (Ft ^{2})	
Depth To Rock	*Depth To Water Table*		*3 Bedroom Home*	*Additional Area Per Bedroom*
16 to 20 inches	10 to 40 inches	‹=12%	40,000	10,000
		›12%	80,000	20,000
	›40 inches	‹=12%	15,000	3,750
		›12%	30,000	7,500
›20 inches	10 to 20 inches	‹=12%	20,000	5,000
		›12%	40,000	10,000
	›20 inches	‹=12%	10,000	2,500
		›12%	20,000	5,000

Table 2
Hydraulic Linear Loading Rate Table

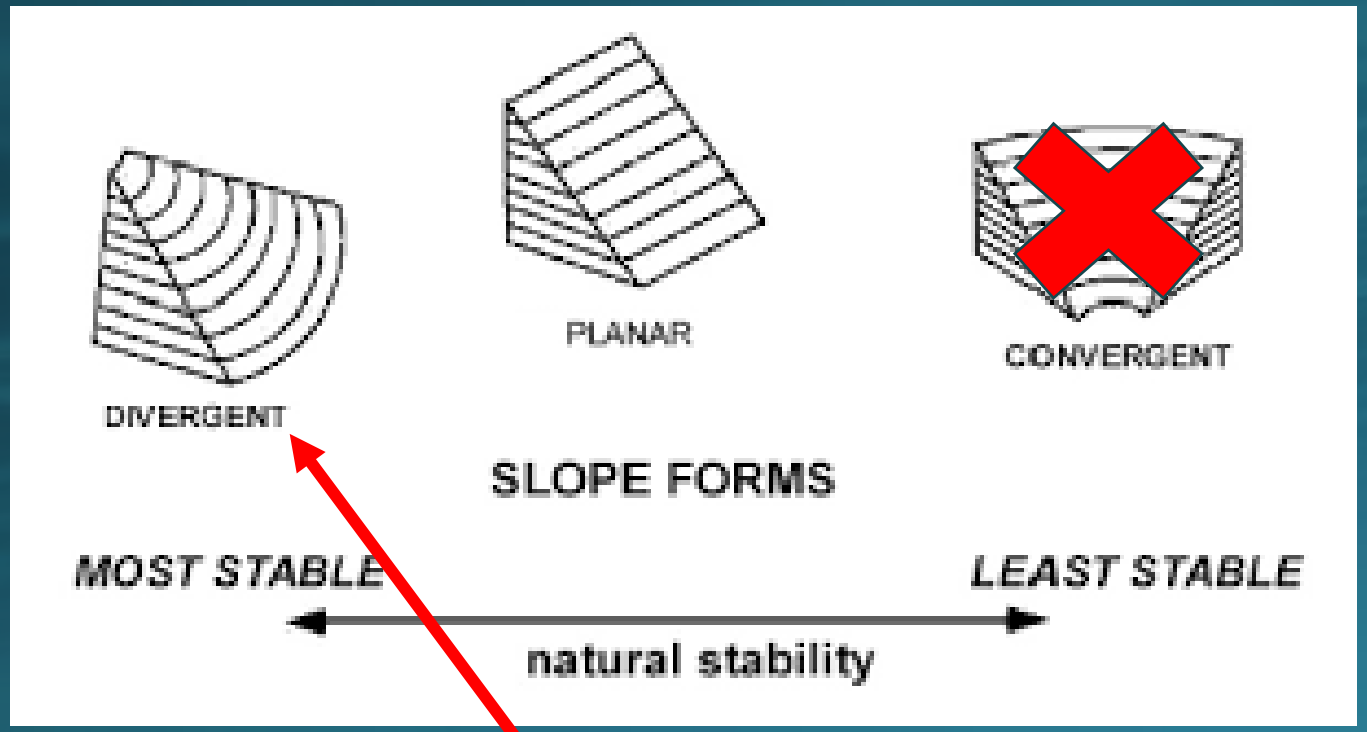
Soil Characteristics			Infiltration Loading Rate, gal/ft^2/d	Hydraulic Liner Loading Rate, gal/ft/d					
				Slope					
				0-4%		5-9%		>10%	
Texture	Structure			Infiltration Distance, Inch		Infiltration Distance, Inch		Infiltration Distance, Inch	
	Shape	Grade		10-12	12-20	10-12	12-20	10-12	12-20
COS, S, LCOS, LS	--	0SG	1.6	4.0	5.0	5.0	6.0	6.0	7.0
FS, VFS, LFS, LVFS	--	0SG	1.0	3.5	4.5	4.0	5.0	5.0	6.0
CSL, SL	--	0M	0.6	3.0	3.5	3.6	4.1	5.0	6.0
	PL	1	0.5	3.0	3.5	3.6	4.1	4.0	5.0
		2, 3							
	PR/BK /GR	1	0.7	3.5	4.5	4.0	5.0	5.0	6.0
		2, 3	1.0	3.5	4.5	4.0	5.0	5.0	6.0
FSL, VFSL	--	0M	0.5	2.0	2.3	2.4	2.7	2.7	3.2
	PL	1, 2, 3							
	PR/BK /GR	1	0.6	3.0	3.5	3.3	3.8	3.6	4.1
		2, 3	0.8	3.3	3.8	3.6	4.1	3.9	4.4
L	--	0M	0.5	2.0	2.3	2.4	2.7	2.7	3.2
	PL	1, 2, 3							
	PR/BK /GR	1	0.6	3.0	3.5	3.3	3.8	3.6	4.1
		2, 3	0.8	3.3	3.8	3.6	4.1	3.9	4.4
SIL	--	0M	0.2	2.0	2.5	2.2	2.7	2.4	2.9
	PL	1, 2, 3							
	PR/BK /GR	1	0.6	2.4	2.7	2.7	3.0	3.0	3.5
		2, 3	0.8	2.7	3.0	3.0	3.5	3.3	3.8
SCL, CL, SICL	--	0M							
	PL	1, 2, 3							
	PR/BK /GR	1	0.3	2.0	2.5	2.2	2.7	2.4	2.9
		2, 3	0.6	2.4	2.9	2.7	3.0	3.0	3.5
SC, C, SIC	--	0M							
	PL	1, 2, 3							
	PR/BK /GR	1							
		2, 3	0.3	2.0	2.5	2.2	2.7	2.4	2.9

Adapted from Tyler, 2000.
Width of Infiltration Field = Hydraulic Linear Loading Rate divided by Infiltration Hydraulic Loading Rate
Length of Infiltration Field = Peak Daily Sewage Flow Rate divided by Hydraulic Linear Loading Rate

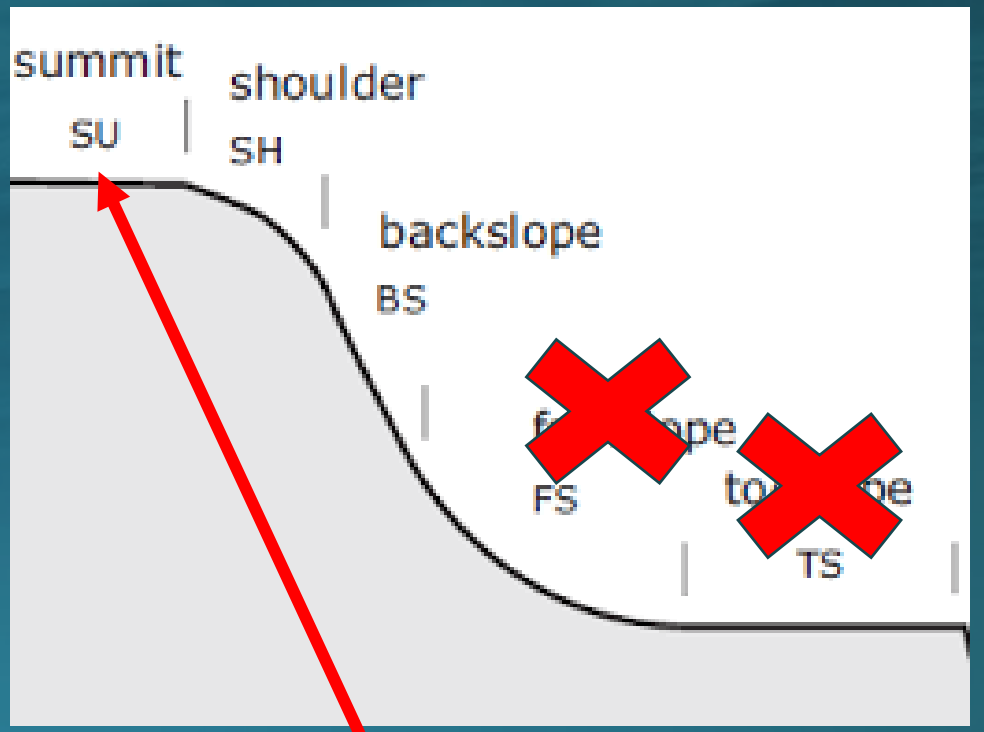
Site Plans (if you know it, show it):

- Field Data Collection Methods
  - Survey
  - GNSS /GPS Receivers
  - Tape Measure
- Scaled Plans
  - Hand Drawn
  - Computer Aided Drafting
    - AutoCAD Software
    - Carlson Software

Ideal Siting Locations:

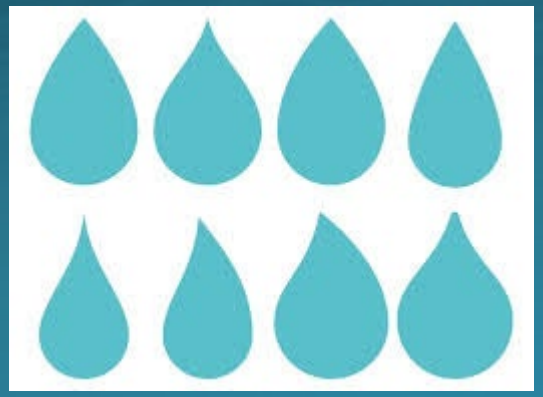


REDUCED DOWNGRADIENT
HYDRAULIC LINEAR LOAD



MINIMIZE COMPETING
SURFACE & GROUND WATER

Ideal Siting Locations (Hydraulic Linear Loading):



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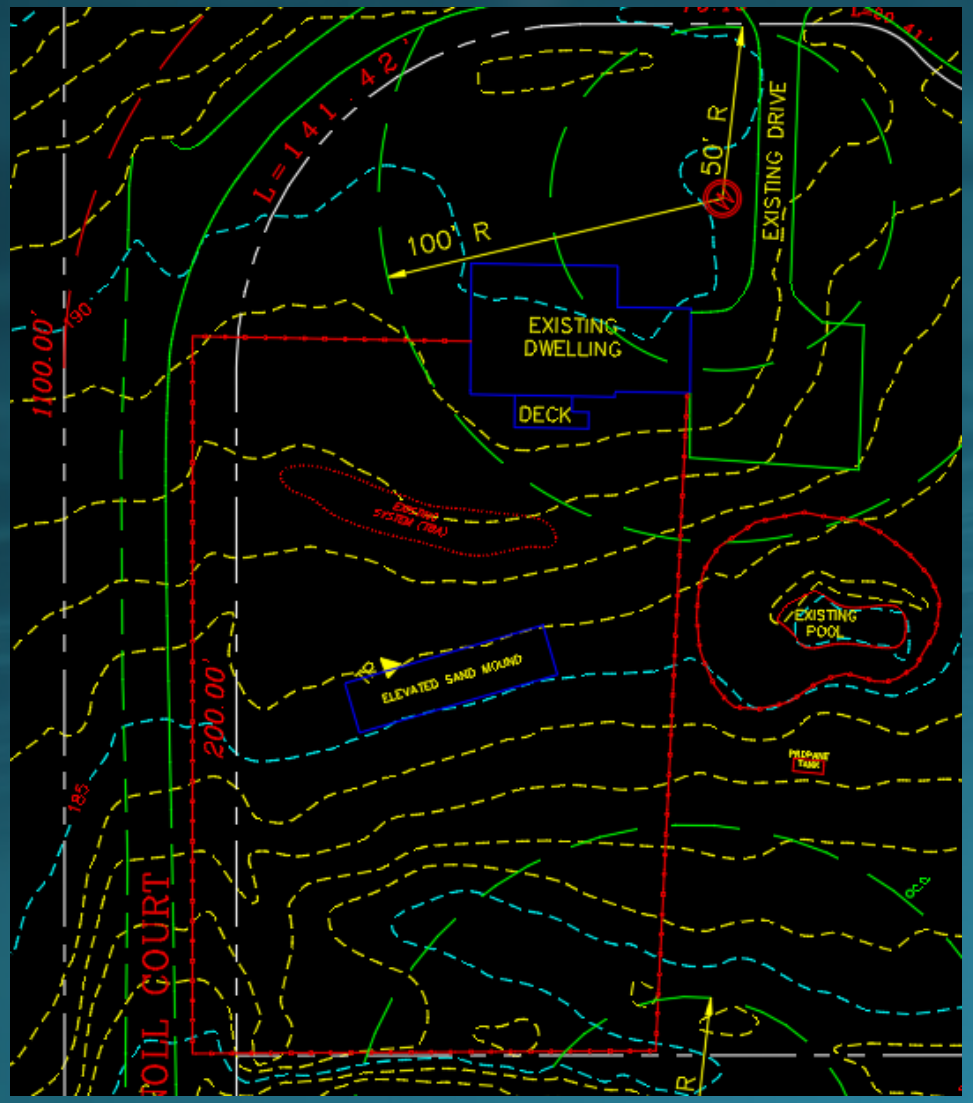
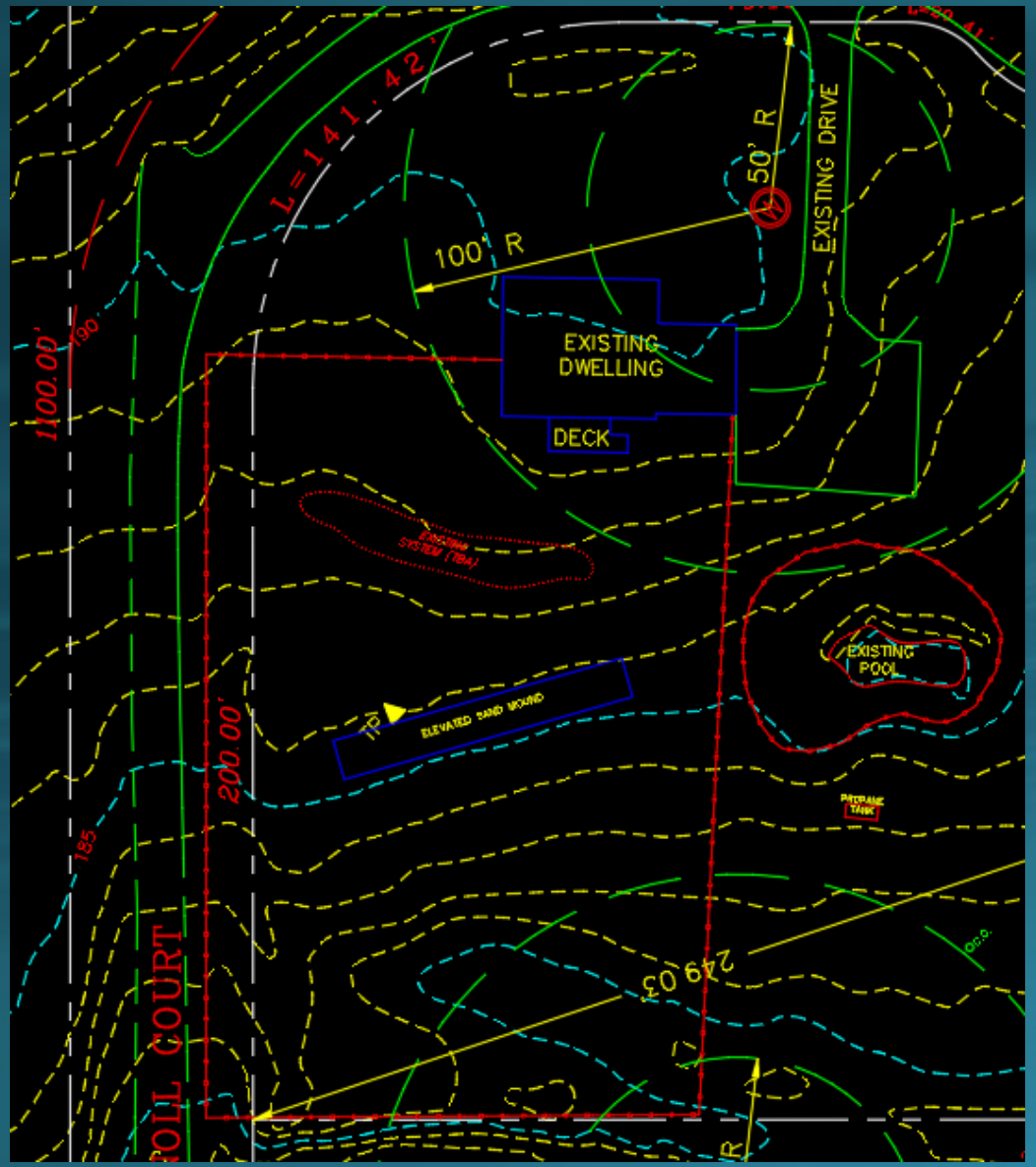


4 BEDROOM DWELLING = 500 GPD

15 X 60 FOOT ELEVATED SAND MOUND=900 SQFT

HLL = 8.33 GPD/LINEAR FOOT

Ideal Siting Locations (Hydraulic Linear Loading):



4 BEDROOM DWELLING = 500 GPD

11 X 82 FOOT ELEVATED SAND MOUND=902 SQFT

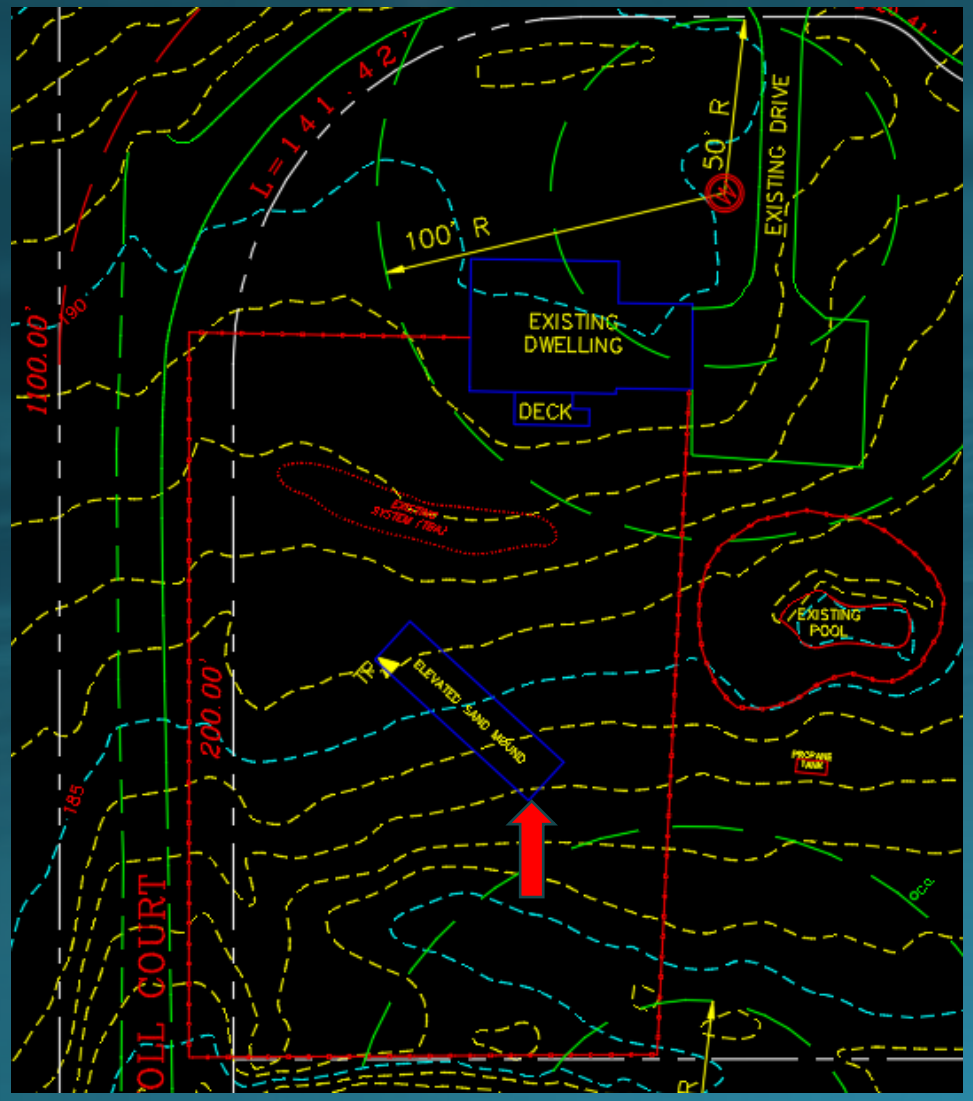
HLL = 6.09 GPD/LINEAR FOOT

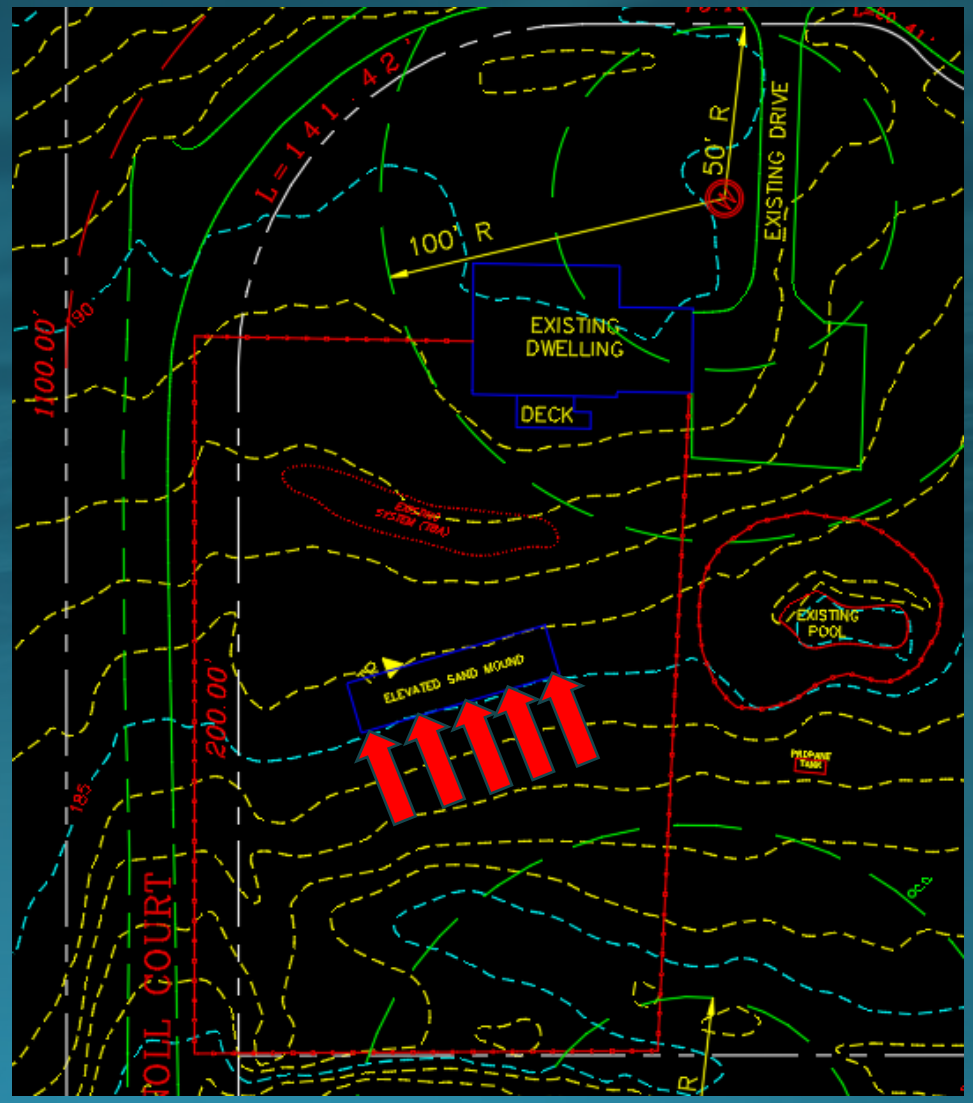
BENEFITS:

- REDUCED LOAD ON DOWNGRADIENT AREA

- REDUCED DOWNSLOPE SAND AND BERMS

Ideal Siting Locations (Hydraulic Linear Loading):





Application of System Types:

- Soil & Percolation Rates

- Site Restrictions

- Client Needs/Wants

Soil & Percolation Rates…

1. We spoke about options earlier.

2. What if the soil is suitable but the perc test isn't?

   - Use a drip instead of a mounded or subsurface system?
     - Thoughts?

   - Use a Shallow Limiting Zone Alternate Technology?
     - Thoughts?

Site Limitations…

1. Slope limits
   - Inground Beds = 8%
   - Inground Trenches = 25% - require designer verification over 15%
   - Conventional Sand Mound = 12% with 4:1 length to width ratio over 8%
   - IRSIS = 25% Max
     - Open, grassed areas=12%
     - Forested areas=25%
     - Nonfood producing agricultural areas=4%
   - Alternate Sand Mound = 15% with 6:1 length to width ratio, perc between 3 & 30 mpi, aggregate no wider than 10 feet
   - Alternate At-Grades = 15% with 4:1 length to width ratio
   - 20”+LZ Eljen Geotextile Sand Filter = 15% with 4:1 length to width ratio over 8%
   - Drip Disposal = 25%
   - Shallow Limiting Zone At-Grades = 15%
   - Shallow LZ Eljen Geotextile Sand Filter = 15%
2. Available length on contour
3. Available Reserve Area
   - Is this the last area for a septic system?

Client Needs…

1. Is the design flow representative of the household?
2. Is there room for the dwelling to be enlarged?
3. Is the wastewater High or Higher Strength than typical?
4. Would they benefit from an Alternate System?
   - Aesthetics – Low profile or subsurface
   - Horticultural supply may benefit from a Sun-Drive Greenhouse; PTE has a client that keeps his spent peat moss as growing media for carnivorous plants.
5. Is the property for seasonal use? Which treatment?
6. Is there a water treatment system? Increased septic tank size can be helpful in dealing with backwash or discharge surges and increases retention time.
7. Installation Cost
8. Maintenance Obligations

Technology:

- Advanced pre-treatment options?

Onlot Alternate Technology Listings:

-Advantex Treatment System – Orenco System, Inc.

-Ecoflo Biofilter(s) – Premier Tech Aqua

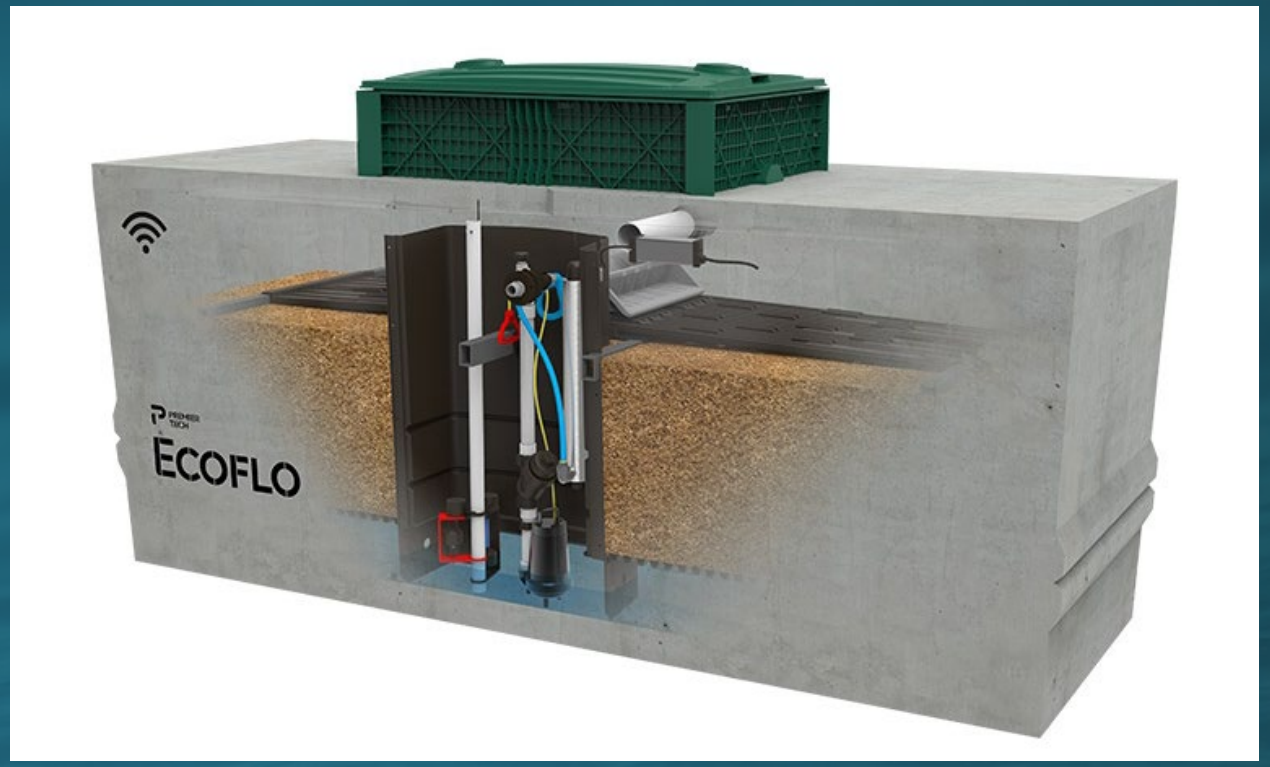
-Puraflow Peat Filter – Anua

-Singulair Hydro-Kinetic Combo (HKBFR) – Norweco, Inc.

-Benefits?

1. Installation Cost
2. Reduced footprint – Perc rate 3-60 mpi
3. Reduced Profile – Not limited by perc rate
4. Reduced Organic Load (extend system life)
5. Manageable & Monitorable

Technology:



Technology:

- Disadvantages?
  1. Installation Cost
  2. Reduced footprint – No reduction in Hydraulic Load
  3. Maintenance Costs

Cost Assessment Example: Ecoflo @ $180/year (Annual Maintenance)
+ $2500/decade (Media Replacement)
70 years to reach $30,000

-Advantex Treatment System – Two visits per year (no water softener backwash)

-Ecoflo Biofilter(s) – Annually with media replacement as necessary (10-year guarantee)

-Puraflow Peat Filter – Annually with media replacement (15 years approximately)

-Singulair Hydro-Kinetic Combo (HKBFR) – Two visits per year

Technology:

- In-situ treatment options?

Onlot Alternate Technology Listings:

-Eljen Geotextile Sand Filters – Eljen Corporation

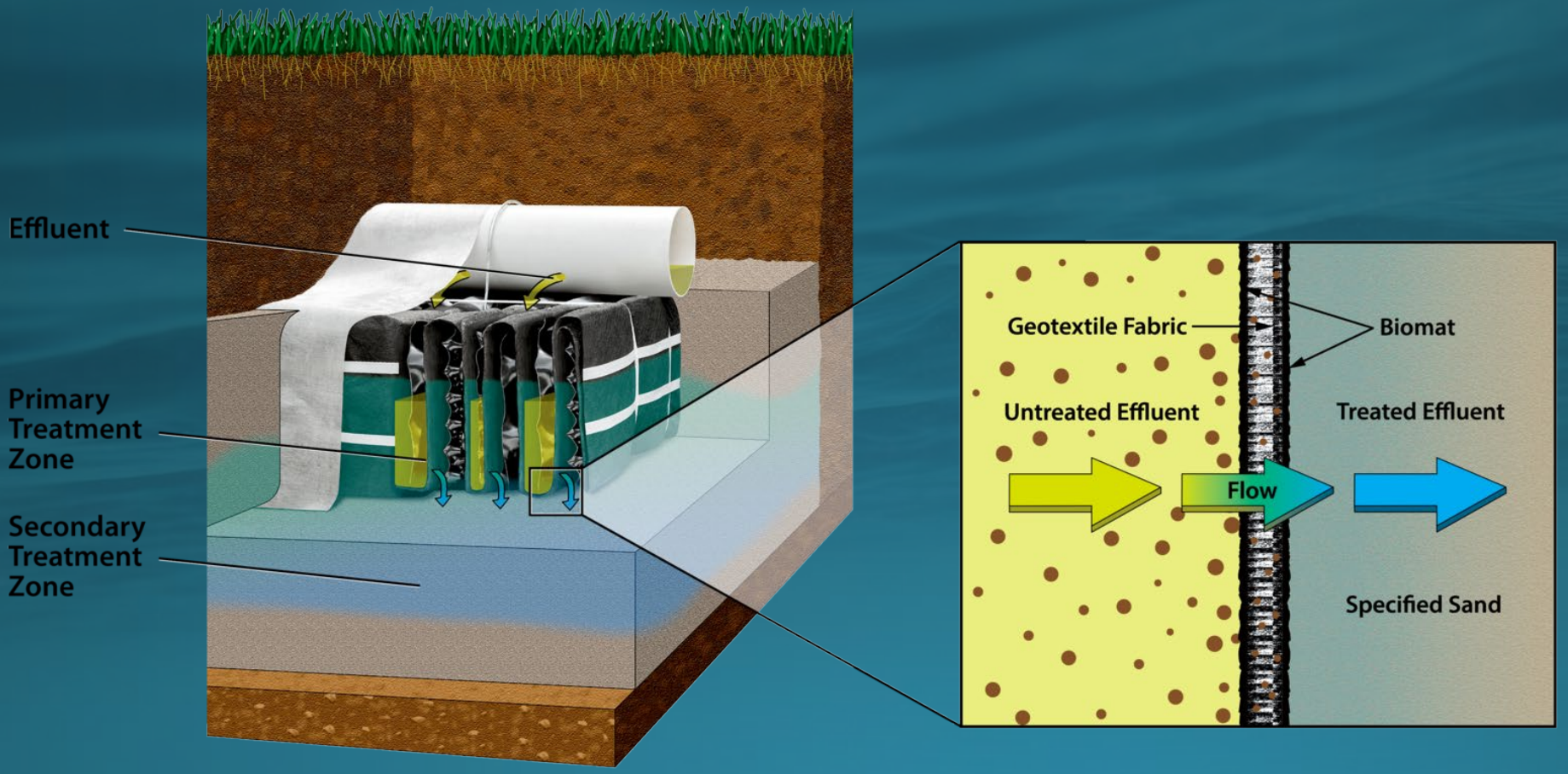
-Benefits?

1. Installation Cost
2. Reduced footprint – Perc rate 3-60 mpi
   - Reduce number of GSF Modules
3. Reduced Profile – Not limited by perc rate
4. Reduced Organic Load to soil (extend system life)
5. Time-Dosing
6. No maintenance.

- Disadvantages?

1. Reduced footprint – No reduction in Hydraulic Load
   - Reduce number of GSF Modules
2. Not accessible – no maintenance

Technology:


Effluent
Primary Treatment Zone
Secondary Treatment Zone
Geotextile Fabric
Biomat
Untreated Effluent
Treated Effluent
Flow
Specified Sand

Technology:

- Disposal options?

Onlot Alternate Technology Listings:

Drip Distribution:

1. PERC-RITE Drip System – American Manufacturing Company, Inc.
2. SAS Drip System – JNM Technologies, Inc.

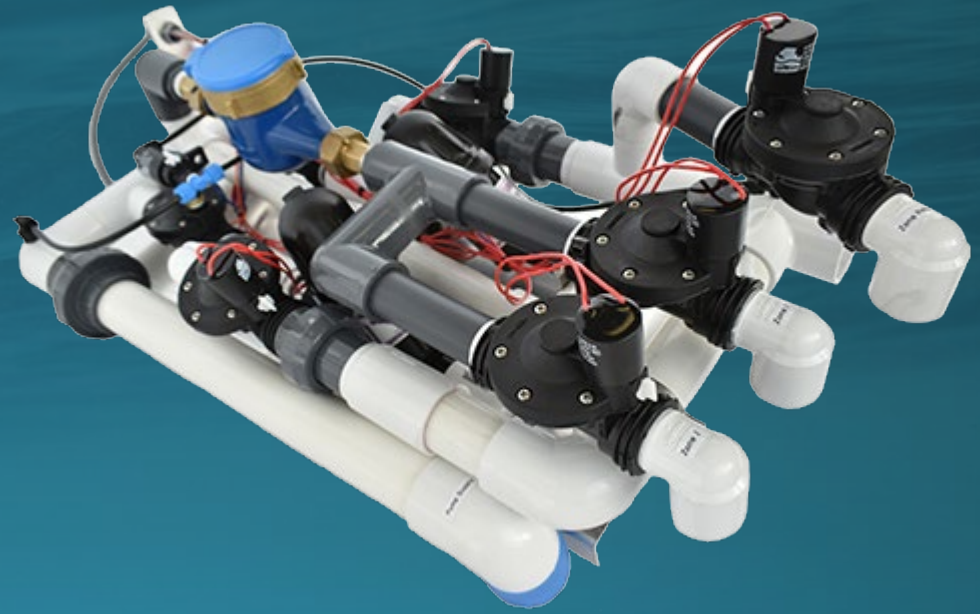
-Benefits?

1. Aesthetics
2. Micro Time-Dosing
3. Adjustable
4. Expandable
5. Manageable & Monitorable

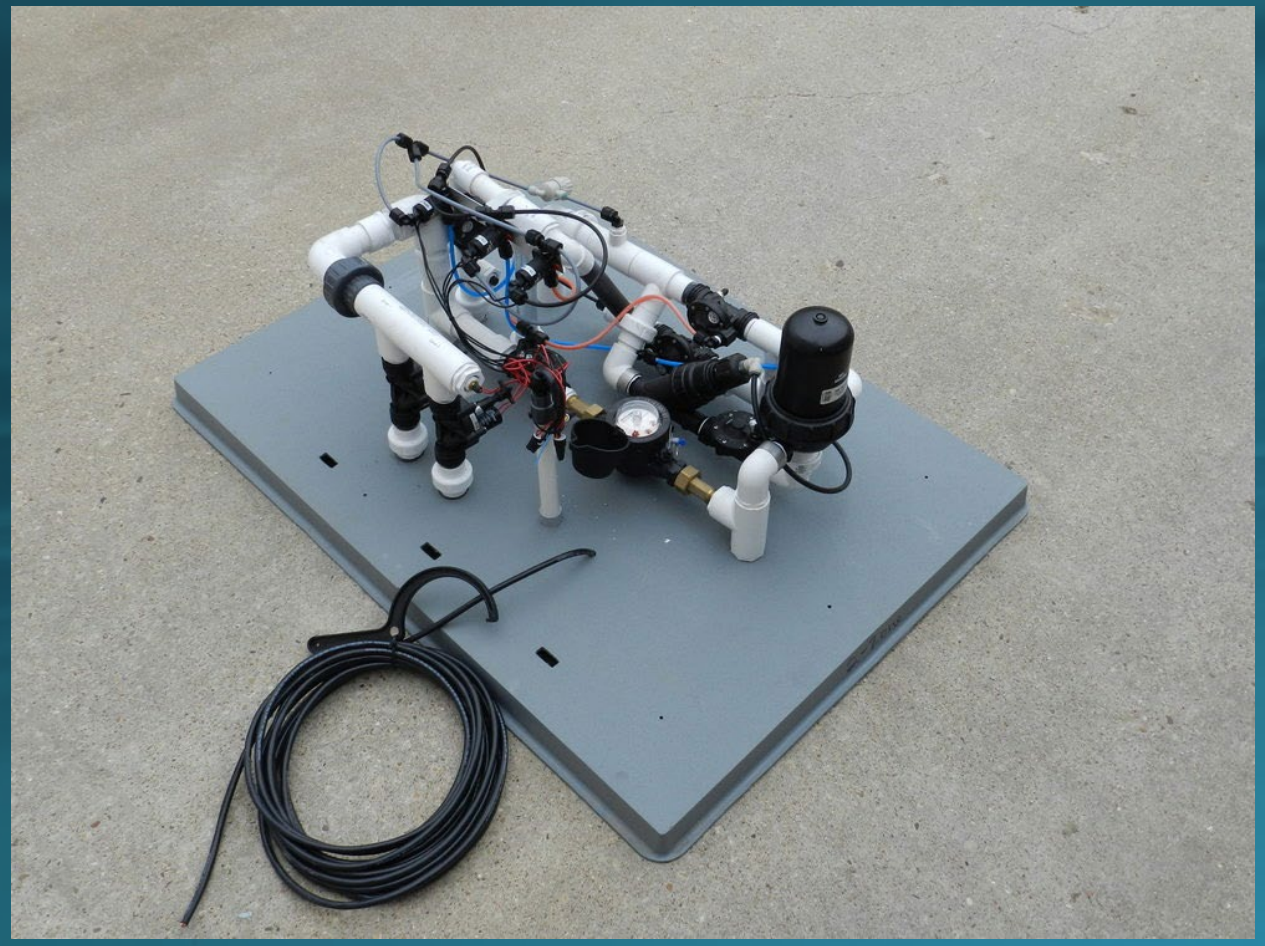
- Disadvantages?

1. Installation Cost
2. Maintenance

PERC-RITE Drip:



SAS Drip:



Technology:

- Disposal options continued:

Onlot Alternate Technology Listings:

Leaching Chambers – Infiltrator Systems, Inc.

- Benefits?

1. Installation access
2. Reduced footprint – Perc rate 3-60 mpi

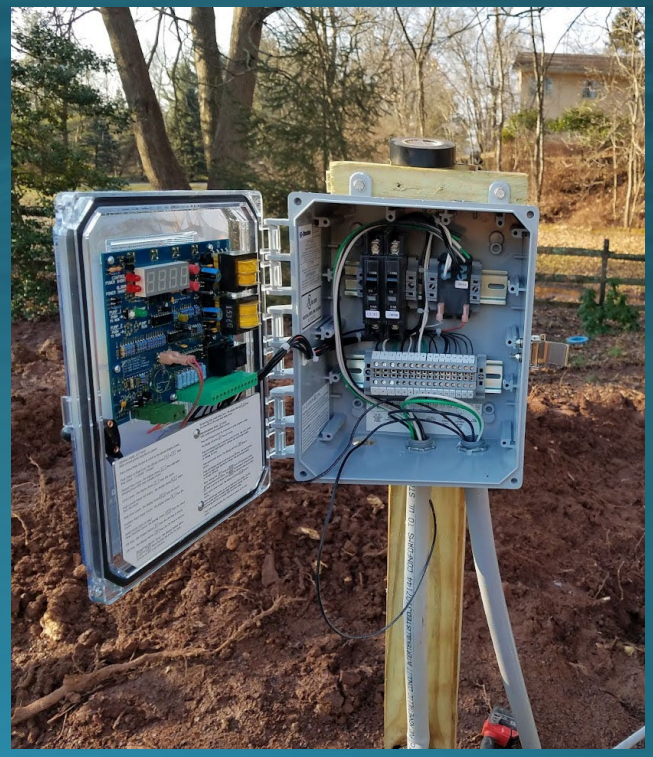
- Disadvantages?

1. Reduced footprint – No reduction in Hydraulic Load

Leaching Chambers:

Other Components:

- Pumps - just because it qualifies for gravity doesn't mean it has to be!!
- Flout – great alternative to a siphon
- Elapsed Time Meter
- Cycle Counter
- Water Meter
- Telemetry
- Time-Dosing
- Effluent Filters
  - Educate the property owner
  - Consider a high water alarm



Attention to detail…

1. Risers – Inform the client of the benefits of risers and access to tankage.
   - Options; concrete or poly
2. Effluent filters – Inform the client of the benefits of an effluent filter. Make sure they are aware of the maintenance requirements. Suggest a high-water alarm.

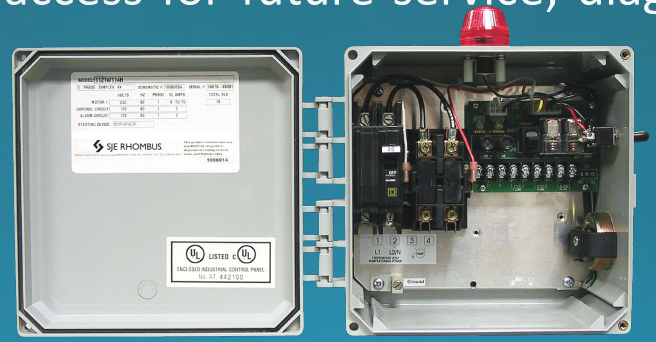
Polylok PL-625

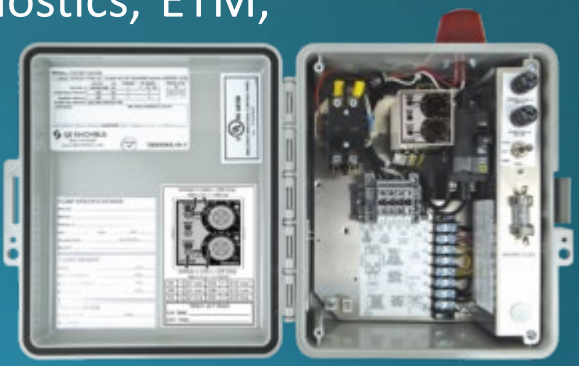
Polylok SmartFilter Control Switch & Alarm

3. Conduit – Don't run wire without it!
4. Control Panels vs. Alarm Boxes – access for future service; diagnostics, ETM, Cycle Counter, etc.

SJE RHOMBUS

-TANK ALERT AB
-MODEL 112
-MODEL TD





Attention to detail (continued)…

5. Public water or generator? Consider a solar alarm backup

SJE Rhombus-Xpert Alert WiFi

SJE Rhombus-Tank Alert Solar

6. Seasonal use/intermittent occupancy/rental? WiFi Alarm or other telemetry

7. Use a pump! No matter how you slice it, a pressurized system provides better distribution.

8. If gravity must be used….add an access riser to the distribution box or better yet, use a small tank as a distribution box. Tank adds retention time, promotes further settling/reduces carry-over, deeper excavation provides better foundation and better access.

9. Add Air Release Valves to Schedule 40 lateral end cleanouts and house in a valve box to grade. Creates faster pressurization times and draws fresh air into the system.

Attention to detail (continued)…

10. Anchor your valve boxes!! Use rebar to anchor valve boxes/observation ports.
11. Add observation ports.
12. Upsize your drip valve boxes.
13. Insulate valve boxes & manifolds.
14. Stormwater diversion/curtain drains
15. Ball valves on delivery lines are great. Are they the right valve? Consider a globe valve for throttling.
16. Avoid cellular and foam core PVC. Solid core PVC is best. Make sure you are using pressure rated fittings.
17. Pay attention to final grading. Is the system integrated into the landscape as best is possible? Can you even mow those berms???
18. Use mulch/seed mats to control erosion and promote grass growth. Maybe even use sod.

How does this benefit the SEO?

- An educated consumer is the best kind
- Builds your reputation
- Maintenance is a REVENUE GENERATOR!!

Field Layout Procedures…

1. Mounds

2. Drip Disposal

3. Shallow Limiting Zone Systems

Questions???

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PENN'S TRAIL Environmental, LLC

PASEO The Pennsylvania Association of SEWAGE ENFORCEMENT OFFICERS

MOWPA MARYLAND ONSITE WASTEWATER PROFESSIONALS ASSOCIATION

Pennsylvania Septage Management Association — Environmental Responsibility, Integrity, Ethics, Regulatory Compliance — Founded 1986

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