Onsite Wastewater Treatment Utilizing Packed Bed Filter Technology

MHOA Annual Conference 2026

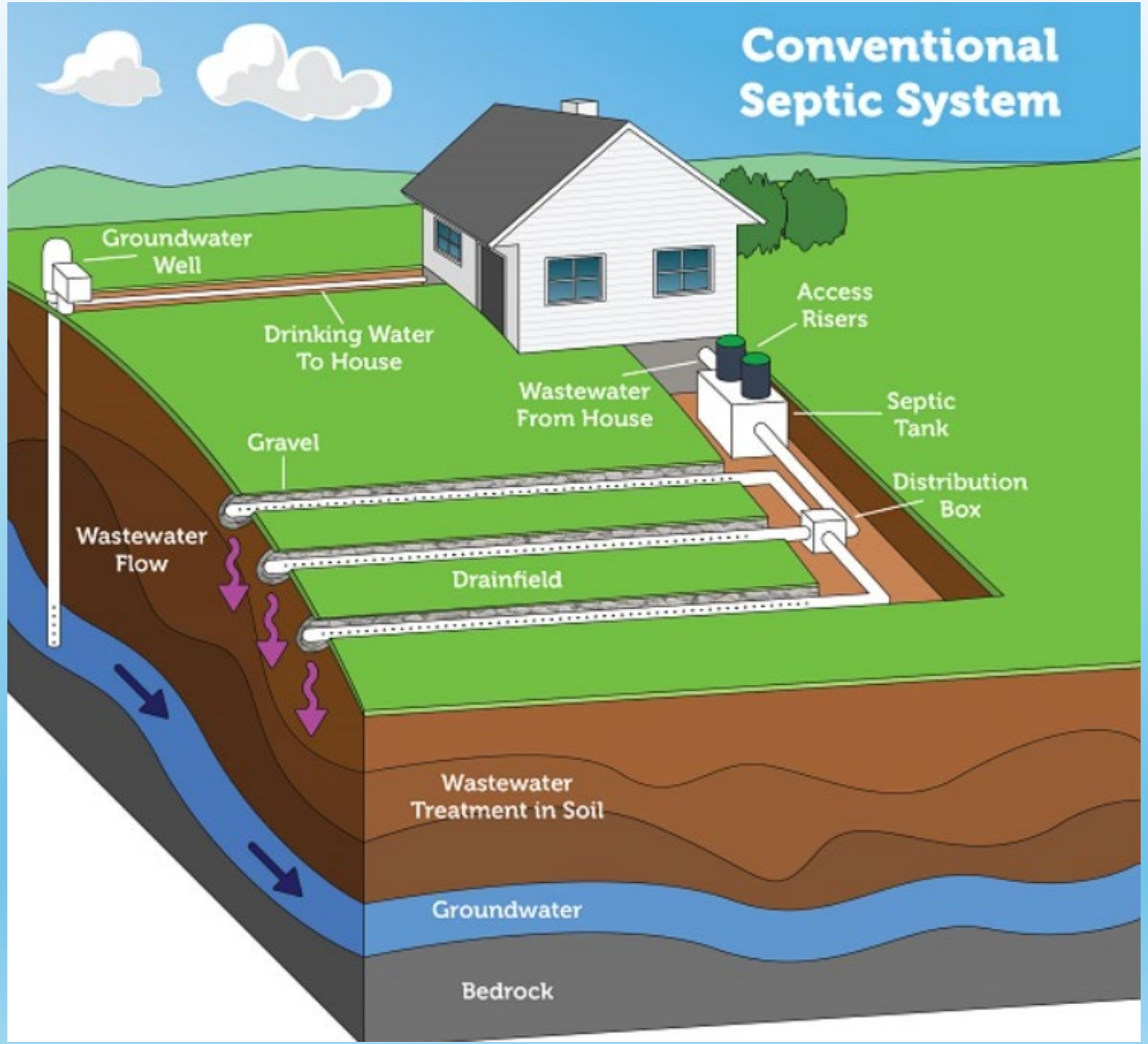
Jim Healy
Eastern Regional Sales Manager-Orenco Water

Media Filtration for Advanced Organic & Nutrient Treatment in Onsite Systems

Evolution of Sand Media/Manufactured Media For Use In Onsite Wastewater Treatment Systems

Overview

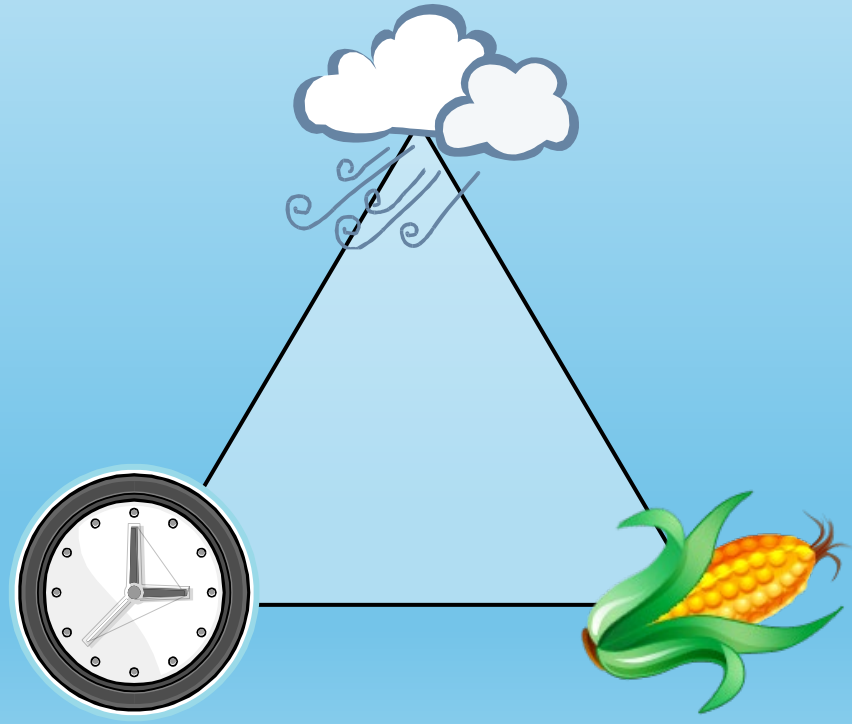
- OWTS Overview
- What is a Packed Bed Filter
- Benefits/Drawbacks of Technology
- Evolution of Media Utilized
- Projects Discussion


Conventional
Septic System
Groundwater
Well
Drinking Water
To House
Access
Risers
Wastewater
From House
Septic
Tank
Gravel
Distribution
Box
Wastewater
Flow
Drainfield
Wastewater
Treatment in Soil
Groundwater
Bedrock

Wastewater Treatment

- Food
- Air
- Time

Balance these 3 in the correct proportions and in the correct forms



Expected System Performance

- B. Treatment Potentials and Levels Normally Attained
  The quality of sewage treatment in on-site systems varies only slightly according to the type of system installed. In almost all cases, the final and highest degree of treatment occurs in the soil or soil substitute under unsaturated flow conditions over a vertical distance of 2 to 3 feet. Under these conditions***, treatment levels are often better than those achieved in all but the most advanced municipal systems***. Typically, the following levels of treatment can be expected from a properly functioning onsite system: biochemical oxygen demand ***(BODs) -10 mg/l; total suspended solids (TSS) -10 mg/l***; and fecal coliforms -less than 200 per 100 ml. These treatment levels are jeopardized when the when the flows in the drain field are saturated, the unsaturated flow is for less than 2-3 feet, the strength of the sewage is too high, toxic chemicals are being put into the system, or the system is too deep in the ground for air to reach the soil beneath the infiltrative surface. Proper siting, design, installation, operation and maintenance will promote optimal treatment levels *

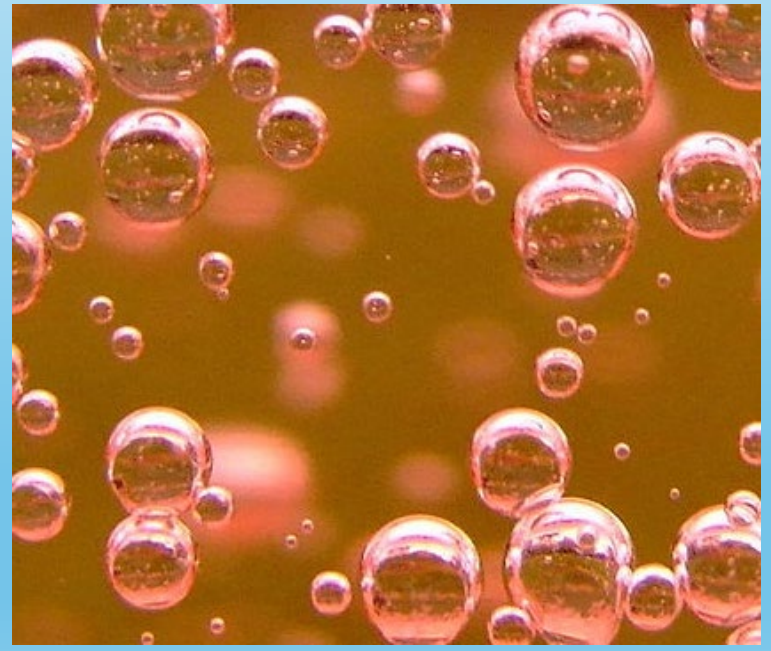
**Washington Department of Health Basic Principles of Onsite Sewage Handbook 11/1992*

Why I/A Treatment

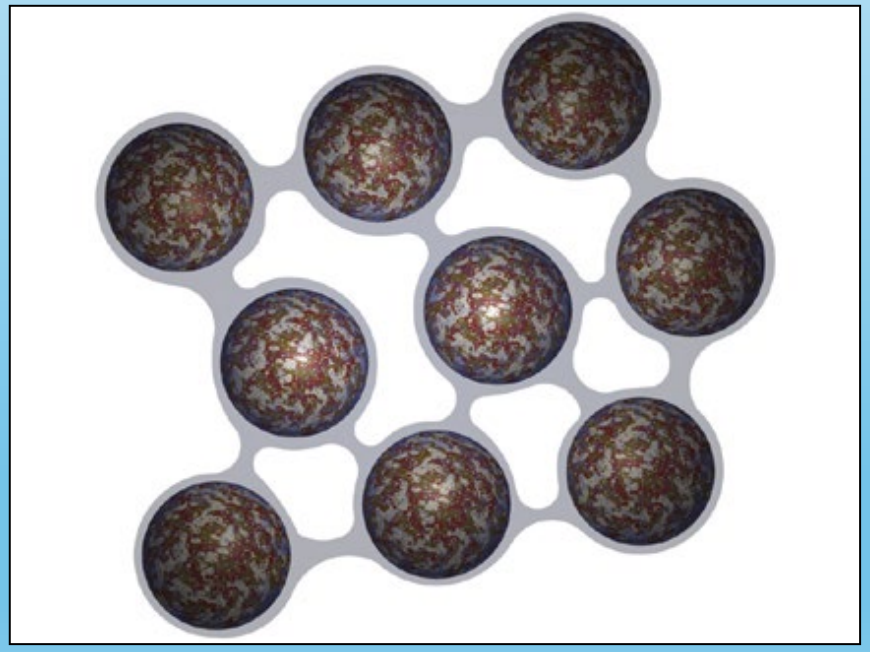
- Situations where conventional systems are insufficient
  - Proximity to water bodies/sources
  - Poorly draining soils
  - Small lots unable to accommodate a full-sized drain field
- Regulations
  - Sites requiring secondary treatment 30/30 BOD/TSS
  - Nitrogen reduction
    - TN typically 19 mg/l; many jurisdictions going lower
    - Ammonia 1-5 mg/l depending on weather conditions

Two General Types of Treatment:
Suspended and Attached Growth

Suspended growth



Attached growth submerged or non-submerged



Oxygen Availability in Air

≈ 275 mg/L oxygen in free air, which directly interfaces with the biomass
… in contrast to 9 mg/L DO holding capacity of water for oxygen transfer





Packed Bed Filtration Technology Process

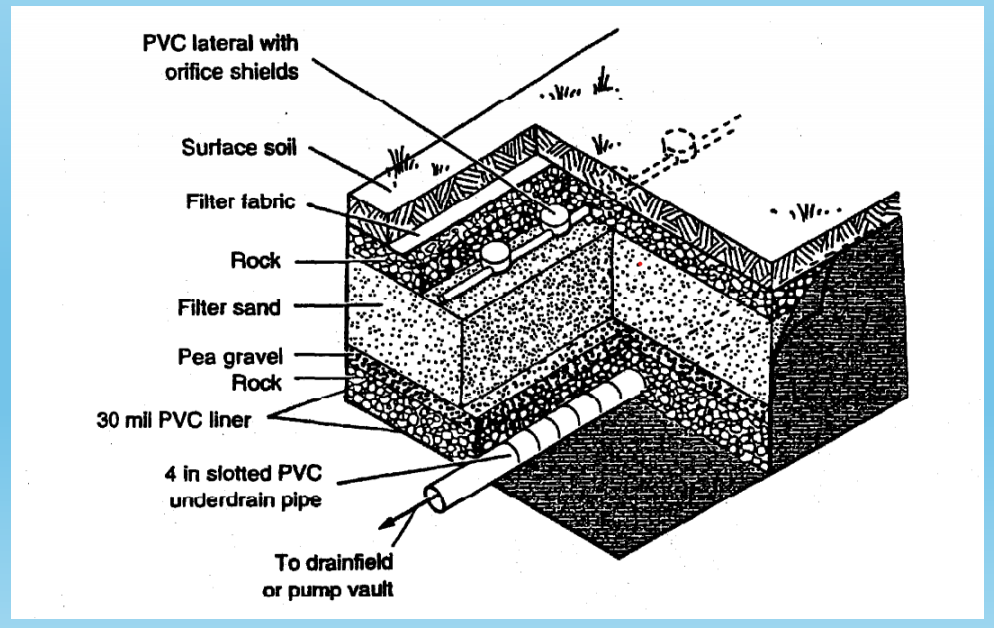
- Component of an Advanced Wastewater Treatment System Providing Secondary or Tertiary Treatment
- Follows Primary Treatment
- Non-Submerged Attached Growth
- Utilizes Atmospheric Oxygen
- PBF Consists of the Following Components
  - Container w/Liner for Holding Media
  - Distribution System for Dosing and Distributing the Liquid to be Treated
  - Underdrain for Removing Treated Fluid
  - Supporting Appurtenances

Packed-Bed Filter Process History

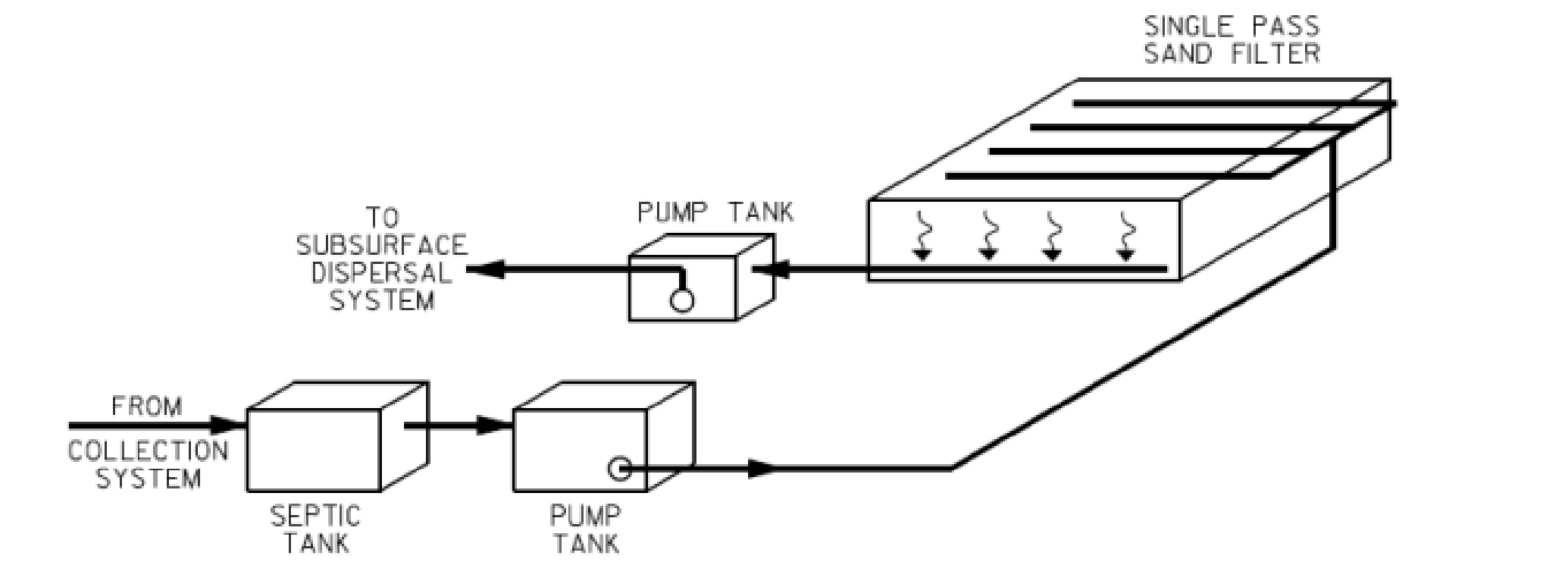
- Single and multiple pass
  - Dates to late 1800s
- Developed for small scale flows as supplementary septic system components
- Media types
  - Sand/Gravel
  - Peat/Coir
  - Foam
  - Textile

Packed Bed Filter History

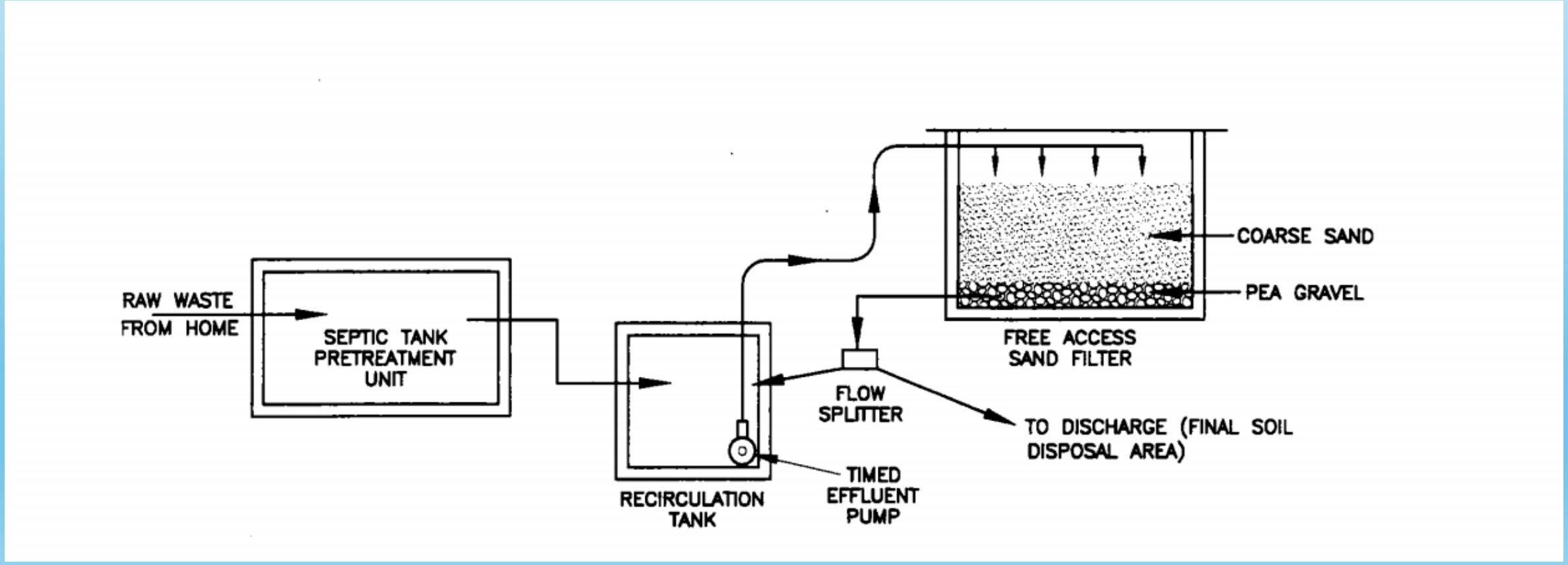
- First Used in England in the 1860s and Massachusetts in the 1870s
- Usage Waned Until the 1940s In Florida
- Modern-Day PBFs Gained Traction in the1980s
- Removal Rates of ~ 90% Organics and ~50% Nutrients



Single Pass Packed Bed Filter Process Schematic

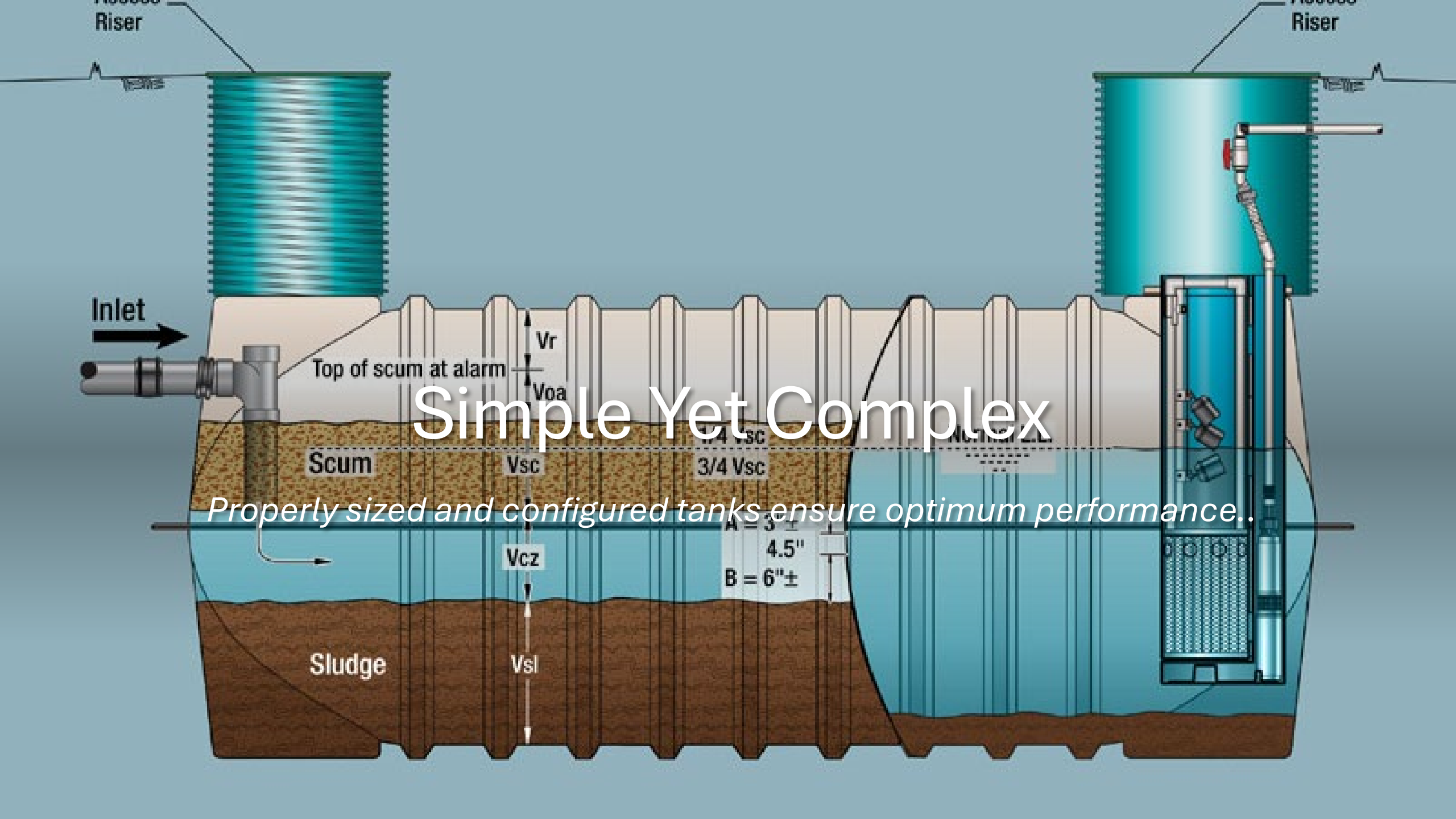


Recirculating Packed Bed Filter Process Schematic



Primary Treatment

Septic tanks
Sized for Two Days Design Flow in a Packed Bed Filter
>50% BOD_5
Up to 70% TSS
Fats/oils/grease (FOG) sequestering
Mandatory



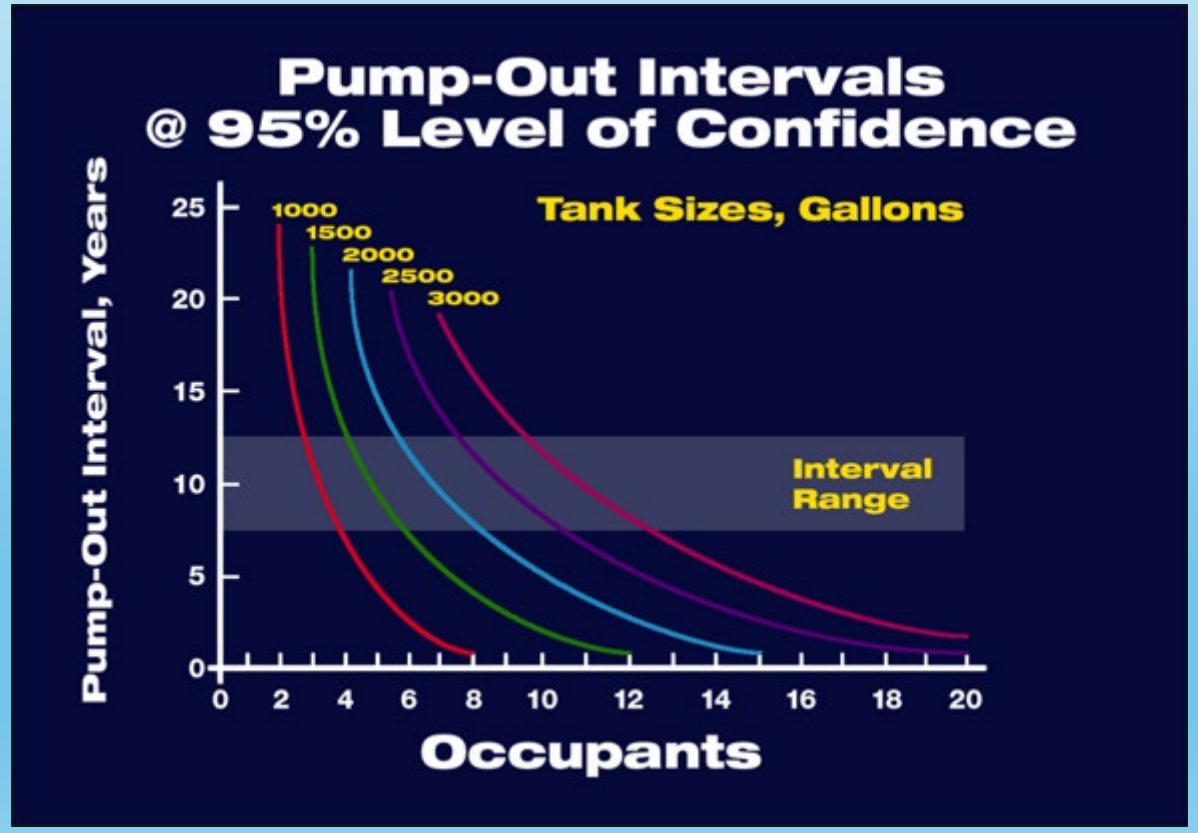
Simple Yet Complex

Properly sized and configured tanks ensure optimum performance..

Primary Treatment Screened Residential Effluent*

	Average *mg/L*	**Weekly Peak** *mg/L*	**Rarely Exceed** *mg/L*
$cBOD_5$	**150**	200	300
TSS	**40**	60	150
TKN	**65**	75	150
G&O	**20**	25	25

Tank Configuration and Pump-Out Intervals



- *The pumping interval for properly sized and managed watertight tanks is about 12-20 years.**
- *According to the US EPA "household septic tanks are typically pumped every 3-5 years".*

**Data gathered during an audit of 450 tanks in Glide, Oregon, in 1986*

Pumping to the Filter

Recirculation/Intermittent Pump Tank

Recirc tanks typically one day HRT

Recirc ratios ~4:1

Recirc flow splitting

Time dosed system

High head pumps preferable/required

Pumps

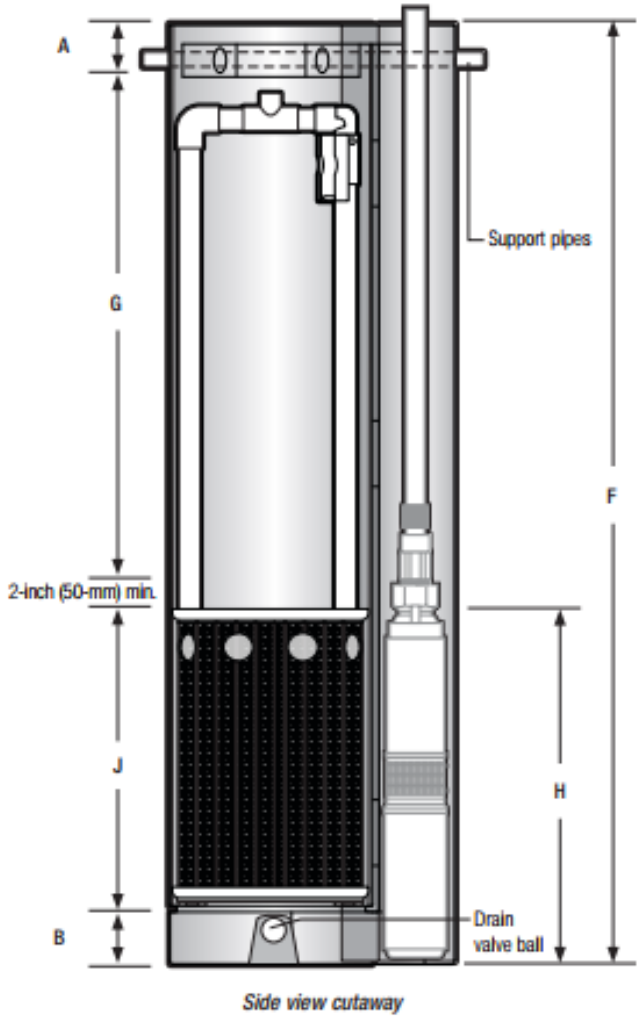
- Turbine well style pumps most prevalent
- Larger systems typically require more robust duty points to ensure even distribution over the filter
- Indexing zone valves also common
- Many pressure distribution programs available to calculate system curves



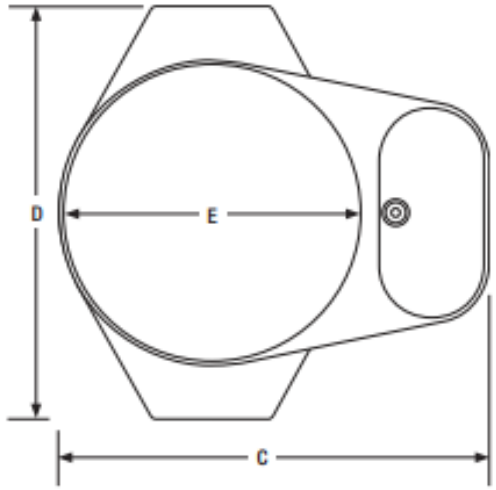




Filtered Pump Vault



Side view cutaway

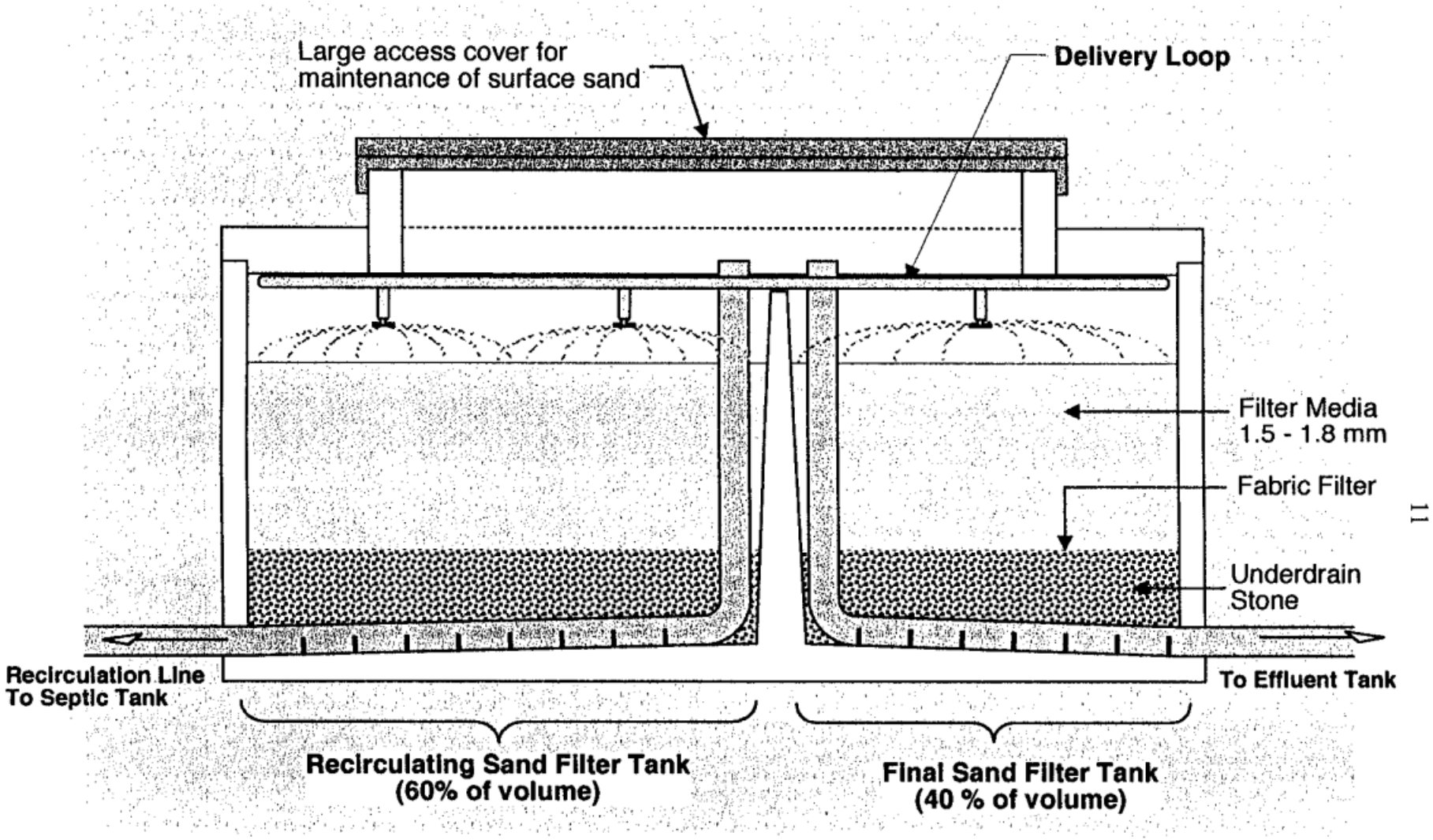


Top view

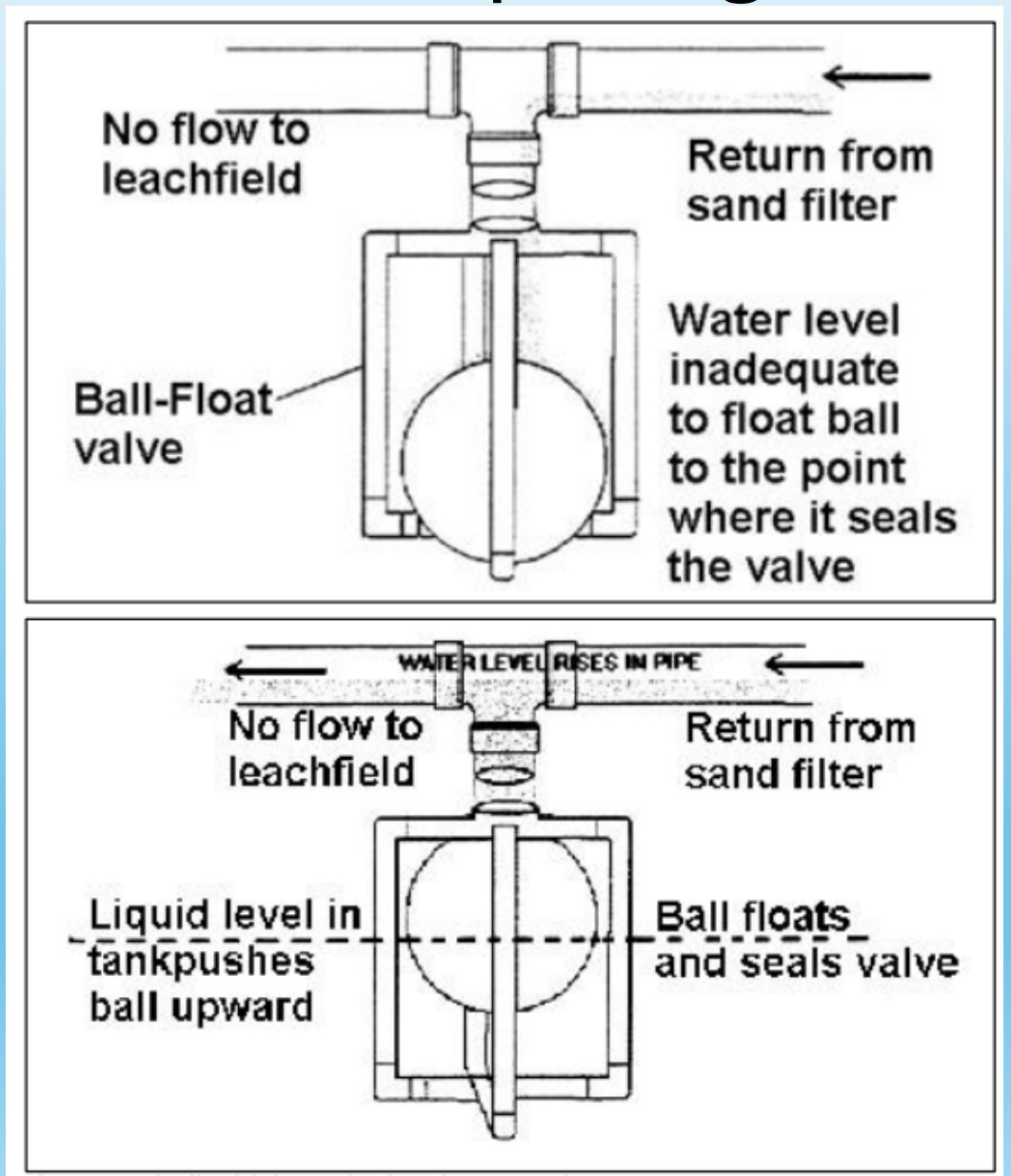
Dimensions

A, in. (mm)	3 (76)
B, in. (mm)	4 (102)
C, in. (mm)	17.3 (439)
D, in. (mm)	16.6 (422)
E, in. (mm)	12 (305)

Flow Splitting



Flow Splitting



Control Panel

- Must incorporate time dosing
- Counters and timers preferable
- Many can accommodate multiple functions to facilitate flow splitting utilizing float and timer settings
- In larger commercial applications can be used to control venting equipmemt





Attributes of Packed Bed Filters

- Quick start-up
- Efficient performance with highly variable wastewater strengths and flows, including occasional hydraulic and biologic overloads
- No release of untreated sewage if a malfunction occurs
- Consistent trouble-free operation; low maintenance (e.g. annual service call recommended; on-site routine service time 1 hour ±)
- Ease of maintenance (components should be easily accessible and serviceable)
- Low energy consumption
- Adequate storage during power outages (normally 24 hours or more at typical flows)
- Recoverable and expandable
- Reliability in providing the level of treated water required to final dispersal treatment processes

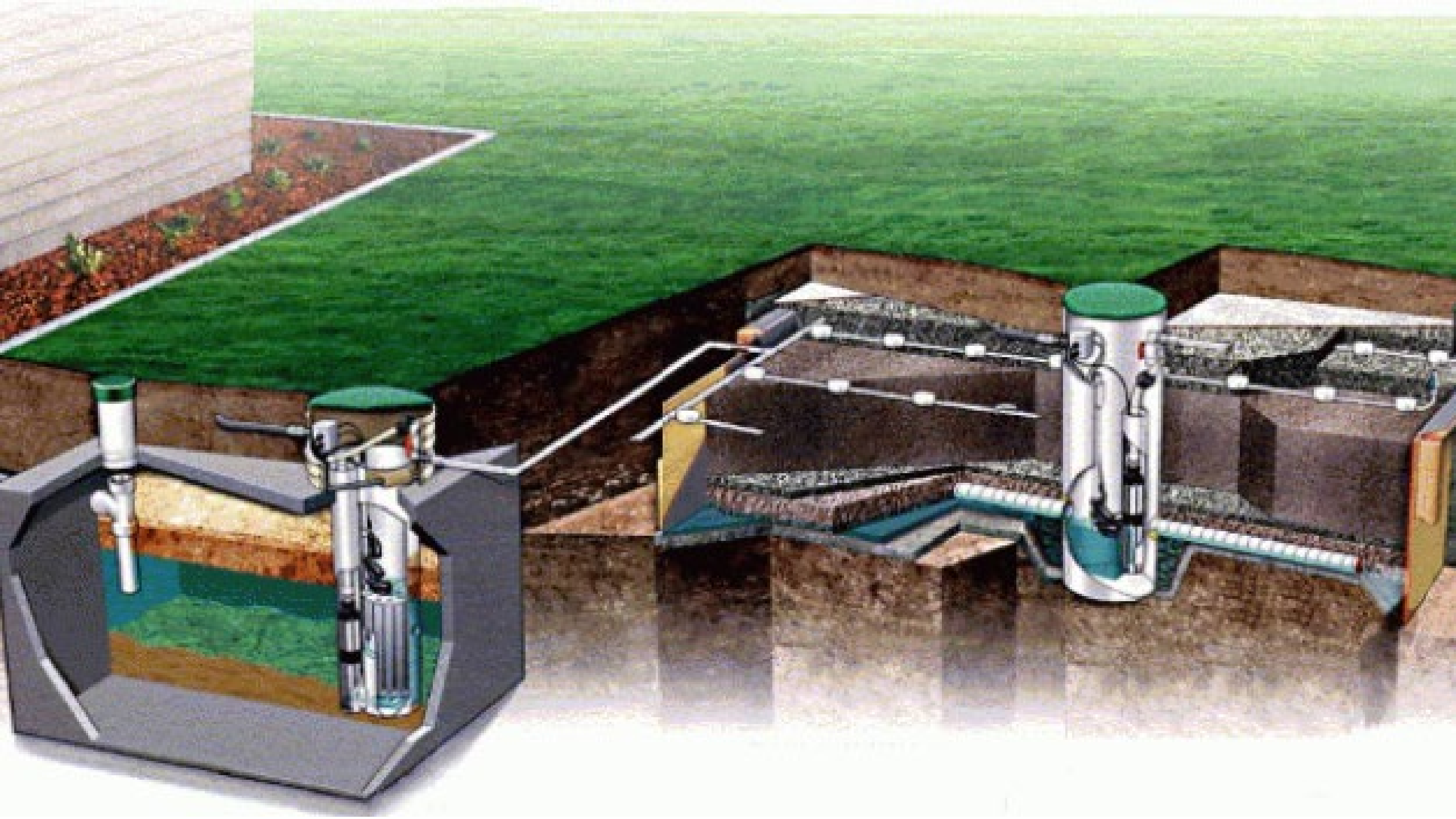
Pros & Cons of Packed Bed Filters

- RPBF Pros
  - Utilizes passive ventilation
  - Consistent high-quality treatment
  - Full access to components for service
  - Process Control
  - Low power costs
  - Able to handle seasonal or increasing flows
  - Excels in lower flow application
  - Comparatively easy expansion
  - BOD_5 and nitrogen reduction

- RPFB Cons
  - Tend to have larger footprints
  - Most can’t be placed in traffic rated areas.
  - Higher initial cost
  - Installation/assembly tends to be more complicated
  - Can be difficult to blend in aesthetically
  - Insect infestation

Intermittent Sand Filters

- Single Pass Using Sand as the Media
- Passively Vented Utilizing Atmospheric Oxygen
- Typical Loading Rate ~ 1GPD/SF Resulting in Significant Land Requirement
- BOD/TSS Typically 30/30, Nitrate ~30 mg/l
- Sand Gradation Critical to Performance
- Consistent Performance Difficult to Achieve Due to Construction Variability
- 12-72 Doses Over the Media Per Day. 24 Doses Is Typical





Department Standards and Guidance for Performance, Application, Design, and Operation & Maintenance

Intermittent Sand Filter Systems

July 2025

Publication Number
337-007

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Prepared by
Wastewater Management Section
Environmental Public Health

Washington State Department of HEALTH

3.2.2. Filter Bed Sizing

3.2.2.1. Hydraulic Loading Rate: The loading rate to the sand filter must not exceed 1.0 gallons/day/square foot, using appropriate daily wastewater flow design estimate.

3.2.2.2. Surface area of filter bed: The surface area must be determined by dividing the design flow estimate by the loading rate.

DESIGN EXAMPLE

Hydraulic Loading Rate

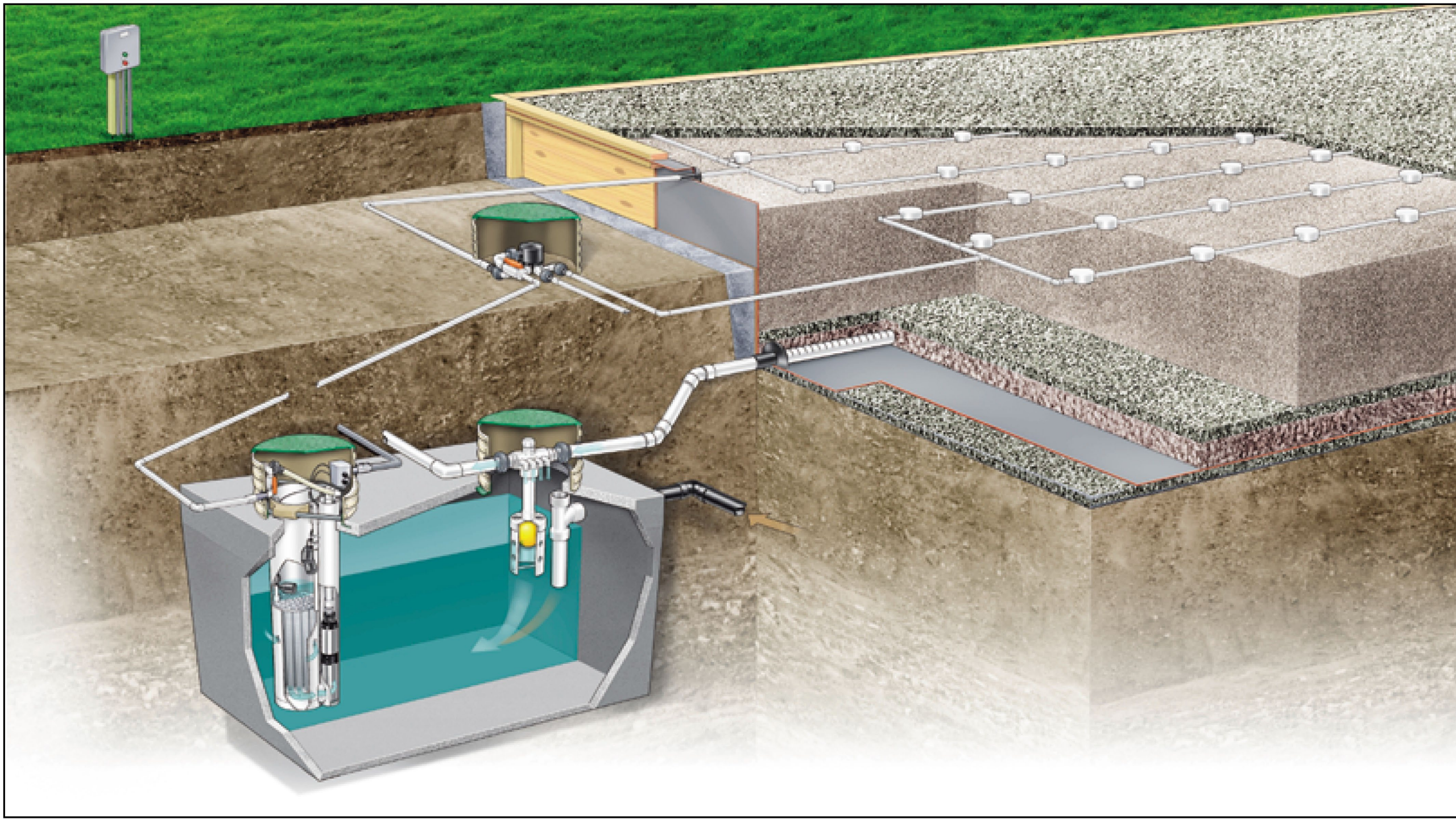
- 440 GPD
- 150 mg/l BOD Primary Treated Effluent
- 440GPD/1 GPD/SF=440 SF RSF

Organic Loading Rate

- STE must be residential strength to allow for the 1 GPD loading rate
- For systems with greater than residential strength waste aerobic pre-treatment can be utilized

Recirculating Sand Filters

- Multiple Passes Over the Media achieving 10/10 BOD/TSS ~30 mg/l nitrate
- Passively Vented Using Atmospheric Oxygen
- More Aggressive Loading Rates ~5 GPD/SF
- Design Based on the More Stringent of Hydraulic vs Organic Requirements
- Better Utilization of Land Making It a More Effective Choice for Commercial/Municipal Applications
- Needs Additional Components to achieve aggressive permit limits
- 72-100 Doses Per Day to Achieve 5:1 Recirc Ratios





COMMONWEALTH OF MASSACHUSETTS
EXECUTIVE OFFICE OF ENVIRONMENTAL AFFAIRS
DEPARTMENT OF ENVIRONMENTAL PROTECTION
ONE WINTER STREET, BOSTON, MA 02108 617-292-5500

JANE SWIFT
Governor

BOB DURAND
Secretary

LAUREN A. LISS Commissioner

TITLE 5 RECIRCULATING SAND FILTERS DESIGN GUIDANCE

Effective Date: June 24, 2002 (updated April 2006) Policy # : BRP/BWP/WPeP/G02-3

Program Applicability: BRP/DWM/Watershed Permitting/ Title 5 Program

Supersedes: Recirculating Sand Filters (RSF) Design Guide
Regulation Reference: 310 CMR 15.202

Approved By: ____ [signed] _____
Cynthia Giles, Assistant Commissioner, Bureau of Resource Protection

4. Size the sand filter based on the appropriate loading rate, either hydraulic, 3 to 5 GPD/SF or organic limit, 0.005 lbs BOD_5/SF. When the organic loading rate is the criteria that control the sizing of the filter a hydraulic loading rate of less than 3 GPD/SF may be required.

DESIGN EXAMPLE

Hydraulic Loading Rate

- 440 GPD
- 150 mg/l BOD Primary Treated Effluent
- 440GPD/4GPD/SF=110 SF RSF

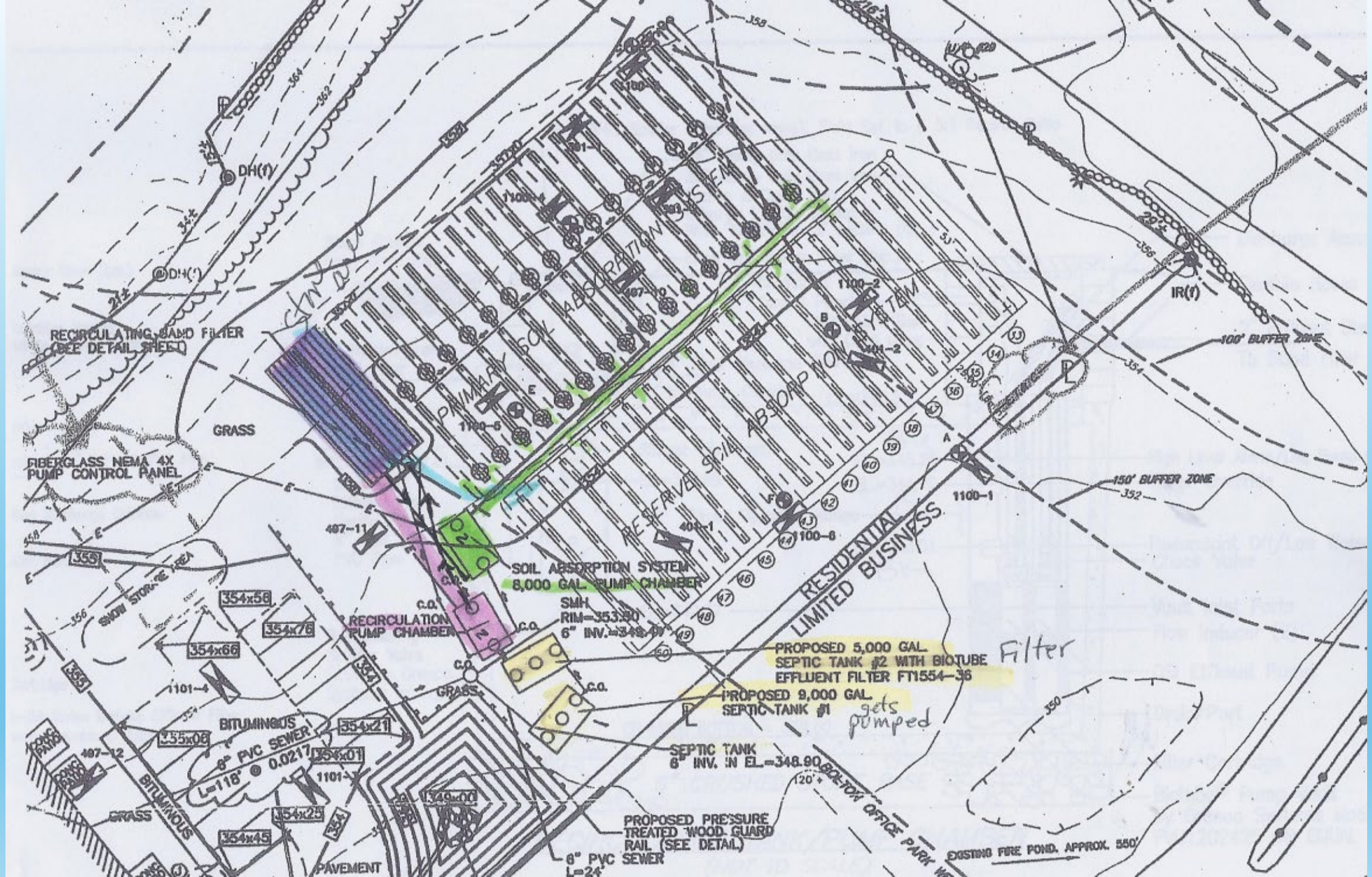
Organic Loading Rate

- 440 GPD
- 150 mg/l BOD Primary Treated Effluent
- (150X440X8.34)/1MM=.6lb BOD
- .6lb BOD/.005 lbs BOD/SF=120 SF

Use the greater of the HLR vs OLR
RSF=120 SF
Effective HLR=3.7GPD/SF

Massachusetts Senior Housing

- 28 Unit subsidized housing ~3,500 GPD
- Recirculating Sand Filter OWTS permitted and built in 2005
- Originally permitted as a Provisional Use System with limits set at 30/30/25 BOD/TSS/TN
- Problems reported in spring of 2025
- Recirculation pumps constantly in high level
- One side of the sand filter had ponding

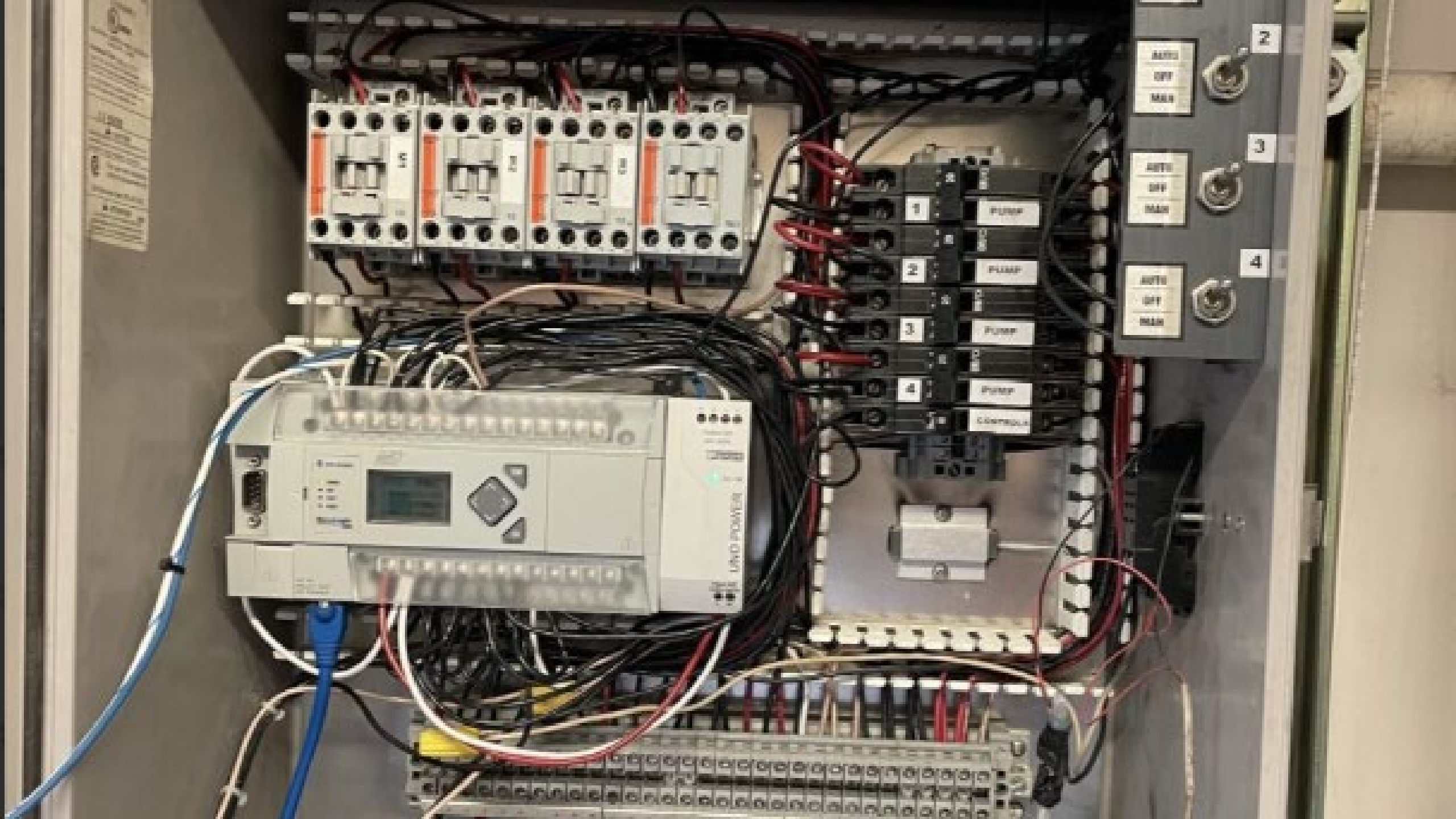

RECIRCULATING SAND FILTER
(SEE DETAIL SHEET)
FIBERGLASS NEMA 4X
PUMP CONTROL PANEL
GRASS
SOIL ABSORPTION SYSTEM
8,000 GAL. PUMP CHAMBER
SMH
RIM=353.90
6" INV.=348.01
RECIRCULATION
PUMP CHAMBER
PROPOSED 5,000 GAL.
SEPTIC TANK #2 WITH BIOTUBE
EFFLUENT FILTER FT1554-36
PROPOSED 9,000 GAL.
SEPTIC TANK #1
SEPTIC TANK
6" INV. IN EL.=348.90
BITUMINOUS
6" PVC SEWER
L=118' @ 0.0217
PROPOSED PRESSURE
TREATED WOOD GUARD
RAIL (SEE DETAIL)
6" PVC SEWER
L=24'
PAVEMENT
SNOW STORAGE AREA
PRIMARY SOIL ABSORPTION SYSTEM
RESERVE SOIL ABSORPTION SYSTEM
100' BUFFER ZONE
150' BUFFER ZONE
RESIDENTIAL
LIMITED BUSINESS
BOLTON OFFICE PARK
EXISTING FIRE POND, APPROX. 550'
DH(1)
IR(1)
1100-1
1100-2
1100-3
1100-4
1100-5
1100-6
401-1
401-2
487-10
487-11
487-12
1101-4
354x56
354x76
354x66
355x06
354x21
354x01
349x00
354x25
354x45
Filter
gets pumped

Quarter	Sample Date	BOD (<30)	TSS (<30)	Nitrite	Nitrate	TKN	TN (<25)
2022 Q2							
2022 Q3							
2022 Q4	10/28/2022	?	?	?	?	?	42
2023 Q1							0
2023 Q2	4/28/2023	<10	7.0	0.05	9.3	1.5	10.85
2023 Q3	7/5/2023	<3	<2	0.05	29	0.5	29.55
2023 Q4							0
2024 Q1	1/18/2024	OK	OK	OK	OK	OK	OK
2024 Q2	Did not sample	x	x	x	x	x	x
2024 Q3	7/29/2024	<10	10.00	0.05	0.05	21	21.1
2024 Q4	10/9/2024	<10	2.7	0.11	30	0.5	30.61
2025 Q1	3/18/2025	<4	<2	0.59	12.7	2.06	15.35
2025 Q2	6/9/2025	<3	2	<0.05	8.4	<0.5	8.4
2025 Q3	8/6/2025	<3.0	<2.0	<0.05	13.2	<0.05	103.2
2025 Q4	10/28/2025	86.2	32.4	>0.05	<0.05	31.3	31.3








AUTO
OFF
MAN
1
PUMP
2
PUMP
3
PUMP
4
PUMP
CONTROLLER
2
3
4











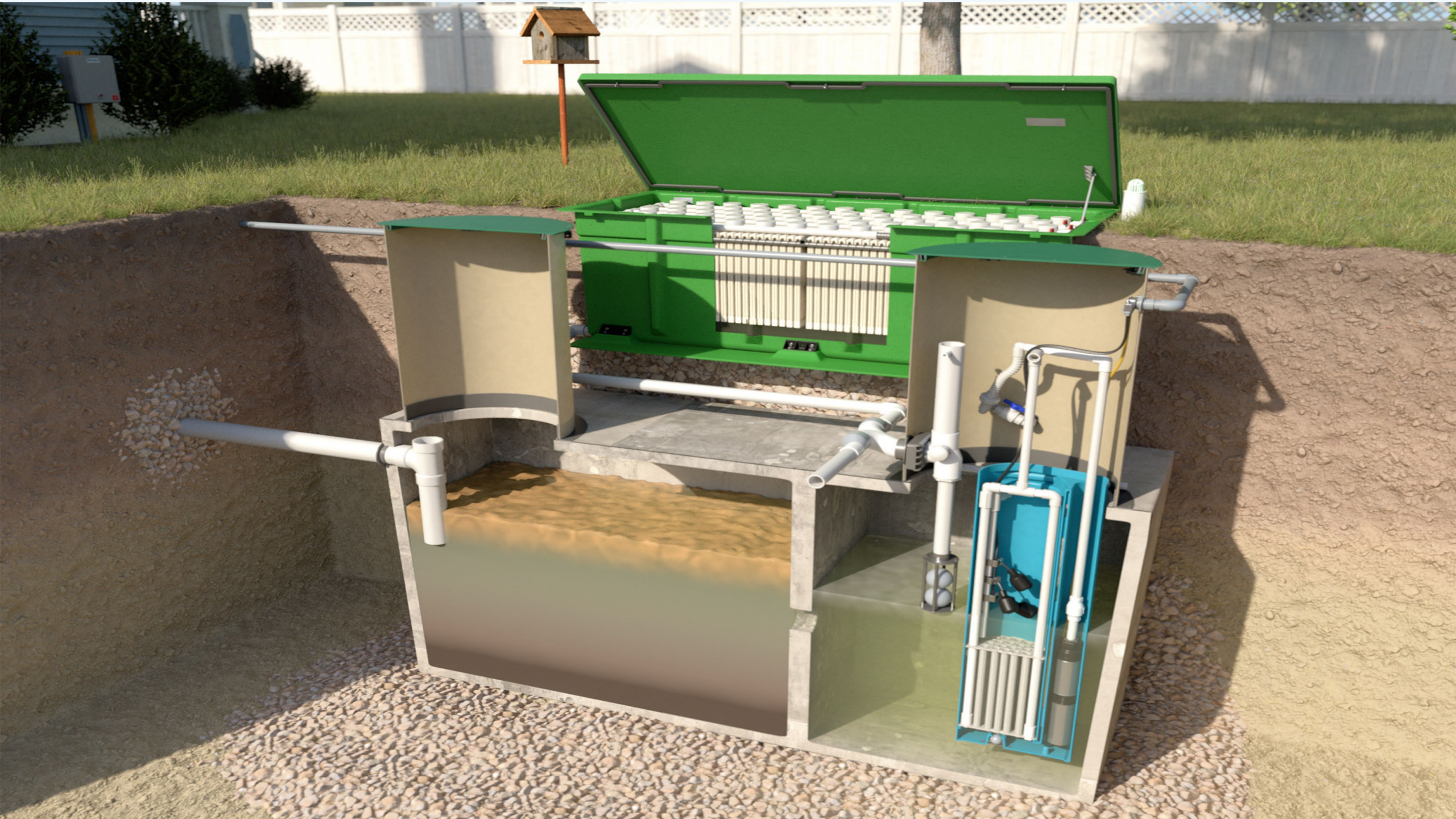
November 17, 2025
Upgrades

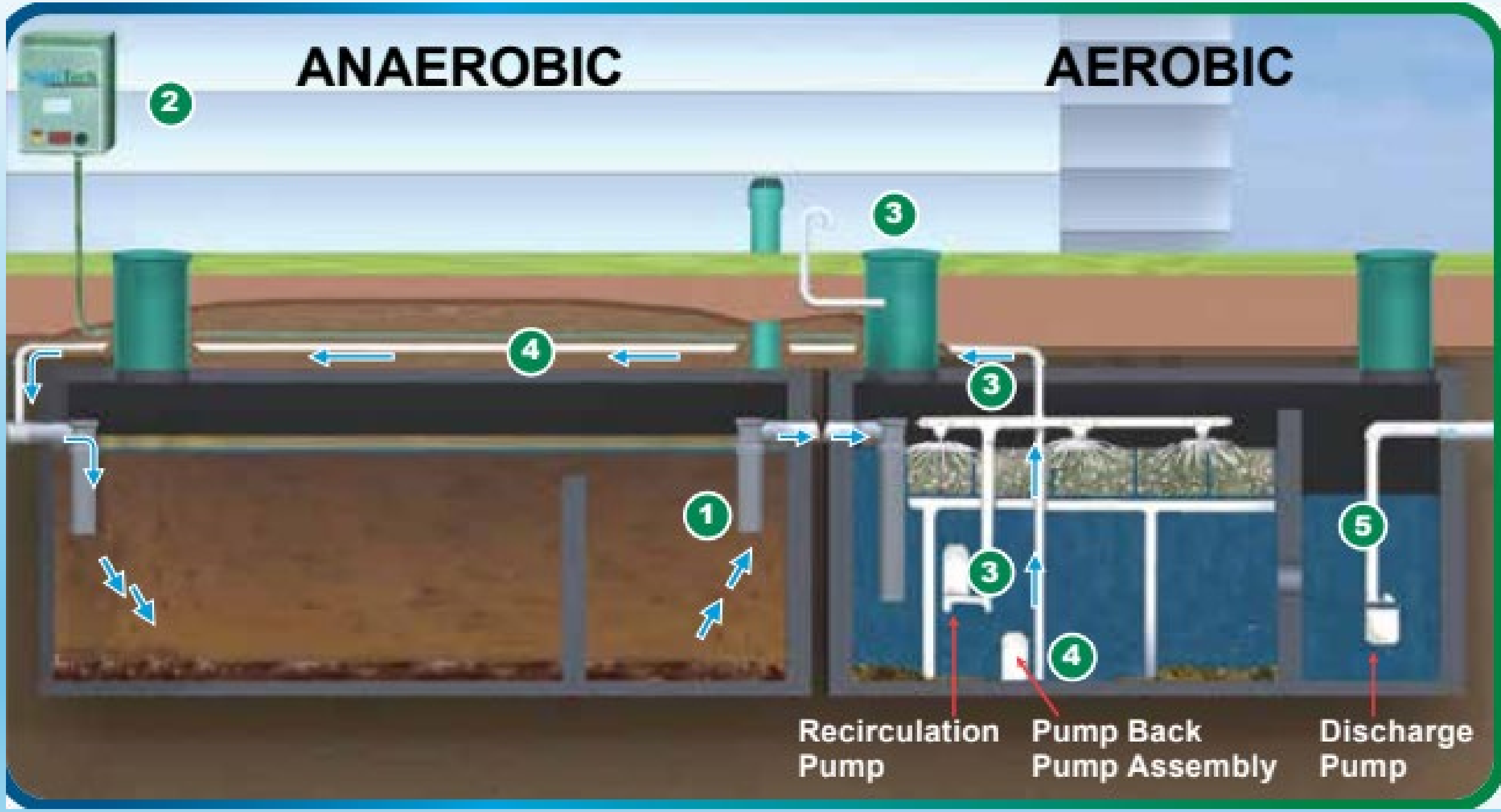
- Replace all risers with watertight PVC material
- Replace recirc and discharge pumps
- Remove the indexing valve regulating flow to either side of the sand filter with alternating dedicated lines from the recirc basin
- Install new flow splitting valve in between recirc and discharge tanks
- Install new telemetry control panel mounted adjacent to system in line of sight

Quarter	Sample Date	BOD (<30)	TSS (<30)	Nitrite	Nitrate	TKN	TN (<25)	Field pH	Alk
2022 Q2									
2022 Q3									
2022 Q4	10/28/2022	?	?	?	?	?	42	4.03	
2023 Q1							0		
2023 Q2	4/28/2023	<10	7.0	0.05	9.3	1.5	10.85	6.37	X
2023 Q3	7/5/2023	<3	<2	0.05	29	0.5	29.55	5.72	X
2023 Q4							0		
2024 Q1	1/18/2024	OK	OK	OK	OK	OK	OK		
2024 Q2	Did not sample	x	x	x	x	x	x		
2024 Q3	7/29/2024	<10	10.00	0.05	0.05	21	21.1	5.69	X
2024 Q4	10/9/2024	<10	2.7	0.11	30	0.5	30.61	6.36	X
2025 Q1	3/18/2025	<4	<2	0.59	12.7	2.06	15.35	6.51	55
2025 Q2	6/9/2025	<3	2	<0.05	8.4	<0.5	8.4	6.16	120
2025 Q3	8/6/2025	<3.0	<2.0	<0.05	13.2	<0.05	13.2	6.3	67.5
2025 Q4	10/28/2025	86.2	32.4	>0.05	<0.05	31.3	31.3	6.85	250
2026 Q1	3/9/2026	<3.00	<2.00	0.398	29.4	<0.5	29.8	5.98	36.1
2026 Q2	5/26/2026	10.8	10.7	0.612	16.5	4.58	21.69	6.33	81.7
2026 Q3	7/20/2026	4.5	<2	0.427	29.3	<0.5	29.7	6.01	27.1

Single Pass/Recirculating Media Filters Utilizing Engineered Media

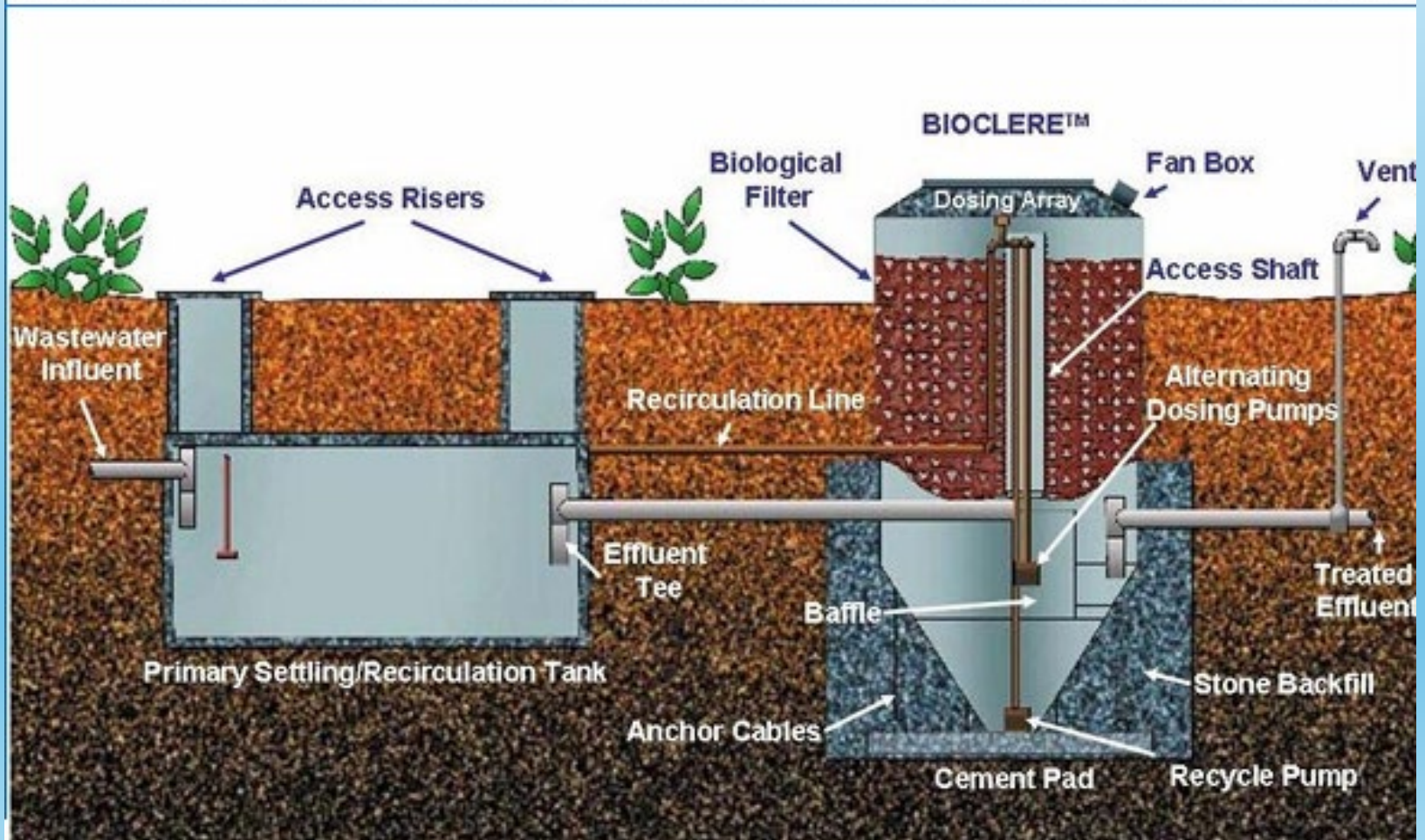
- Consistent Performance Utilizing Manufactured Media
- Single or Multiple Passes Over the Media
- Passively Vented Using Atmospheric Oxygen
- More Aggressive Loading Rates ~25 GPD/SF ADF
- Best Utilization of Land Making It the Most Effective Choice for Commercial/Municipal Applications
- 72-100 Doses Per Day to Achieve 4:1 Recirc Ratios
- Media configurations include hanging textile sheets, foam bead pillows, foam cubes, peat or coir fibers




ANAEROBIC
AEROBIC
2
3
4
3
1
3
4
5
Recirculation Pump
Pump Back Pump Assembly
Discharge Pump

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Standard Installation:





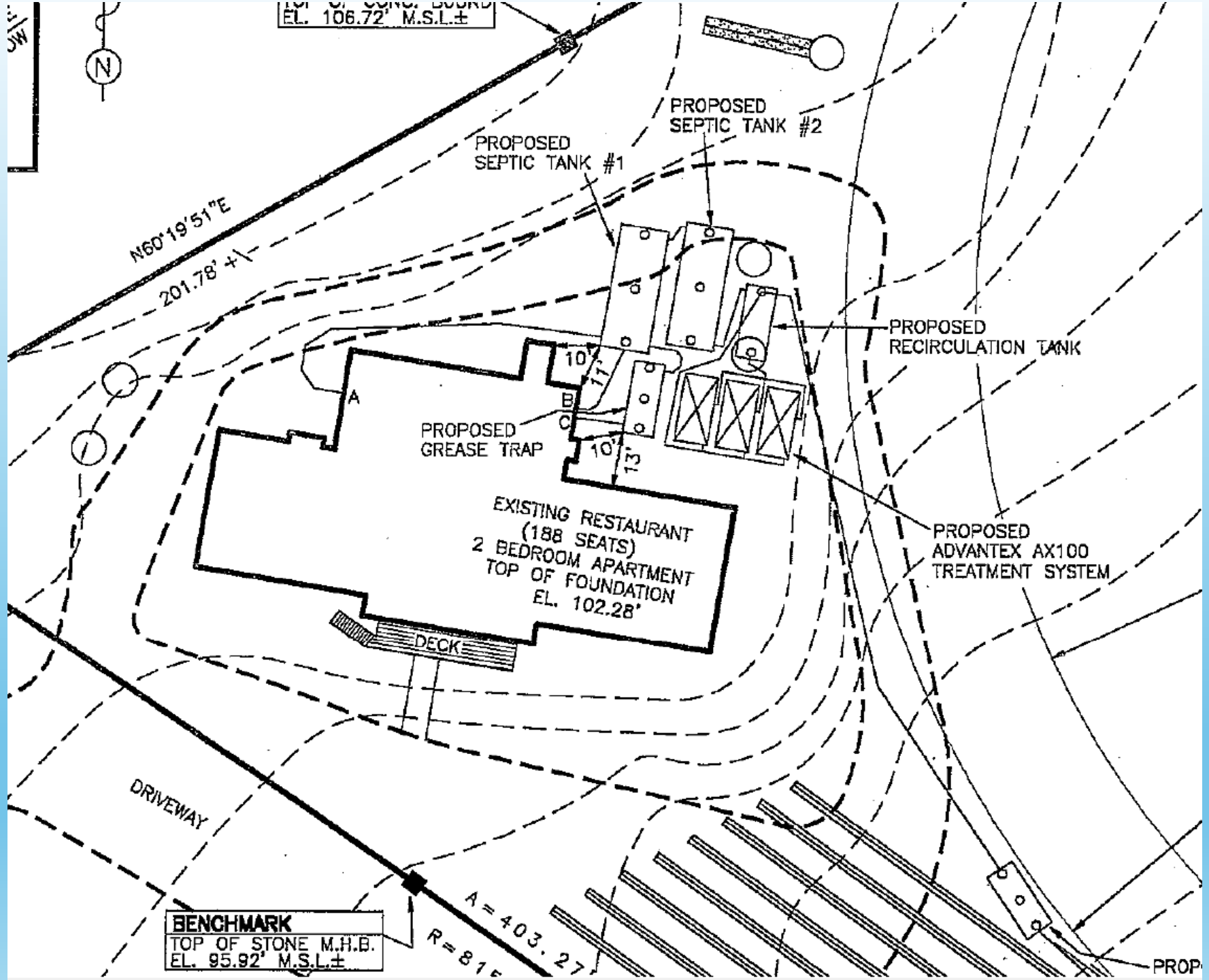




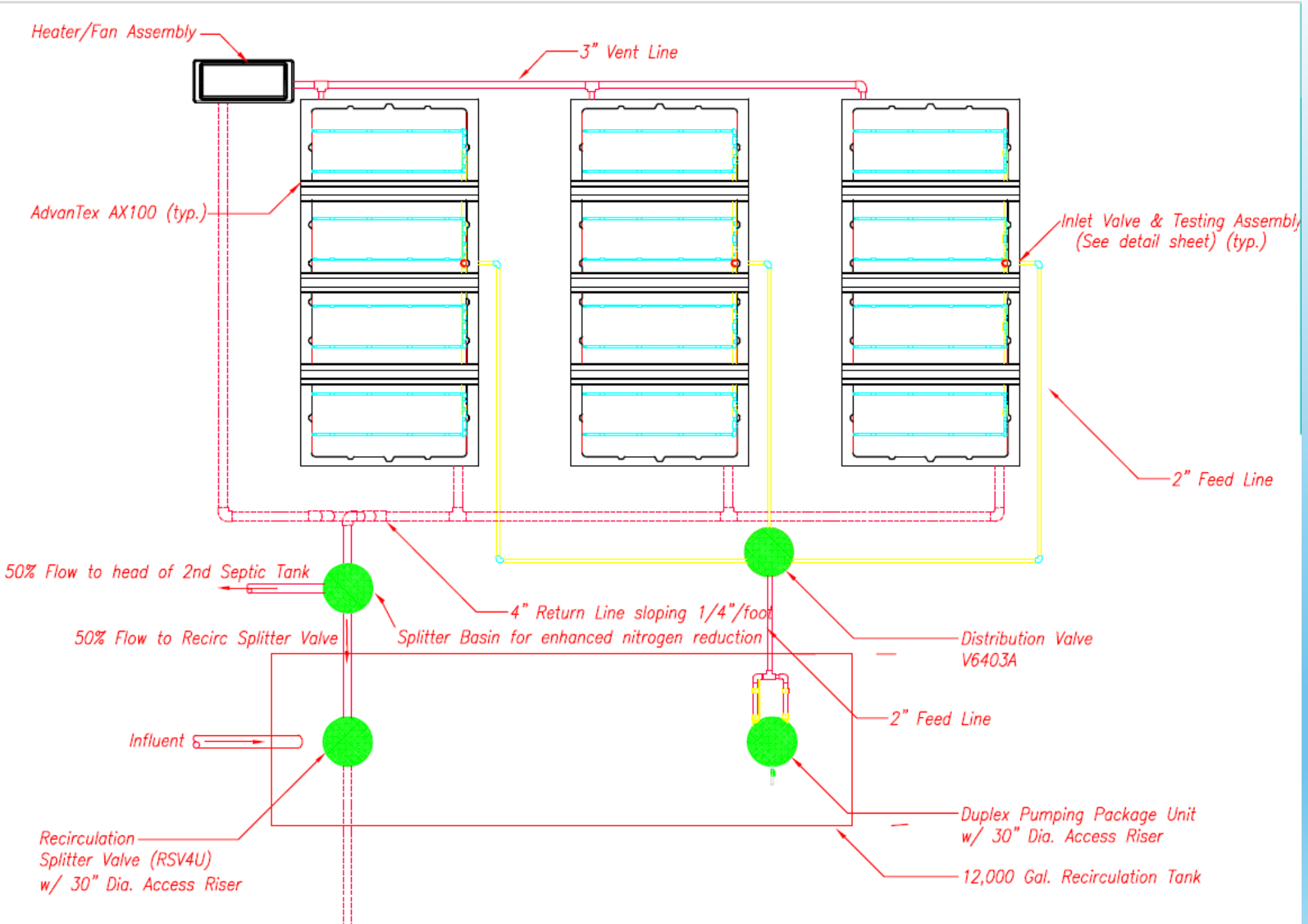


Cape Cod Restaurant

- Year-round restaurant on Cape Cod open evenings w/permitted flow of 6,880 GPD
- Recirculating Textile Filter OWTS permitted and built in 2005
- Originally permitted as a Provisional Use System with limits set at 30/30/25 BOD/TSS/TN
- Problems reported in early 2023
- Excess solids build-up on textile caused support framework to collapse
- System was pumped, sheets removed, framework repaired


EL. 106.72' M.S.L.±
N
PROPOSED
SEPTIC TANK #2
PROPOSED
SEPTIC TANK #1
N60°19'51"E
201.78' +\-
PROPOSED
RECIRCULATION TANK
10'
11'
A
B
C
PROPOSED
GREASE TRAP
10'
12'
EXISTING RESTAURANT
(188 SEATS)
2 BEDROOM APARTMENT
TOP OF FOUNDATION
EL. 102.28'
DECK
PROPOSED
ADVANTEX AX100
TREATMENT SYSTEM
DRIVEWAY
A=403.27
R=81
BENCHMARK
TOP OF STONE M.H.B.
EL. 95.92' M.S.L.±
PROP

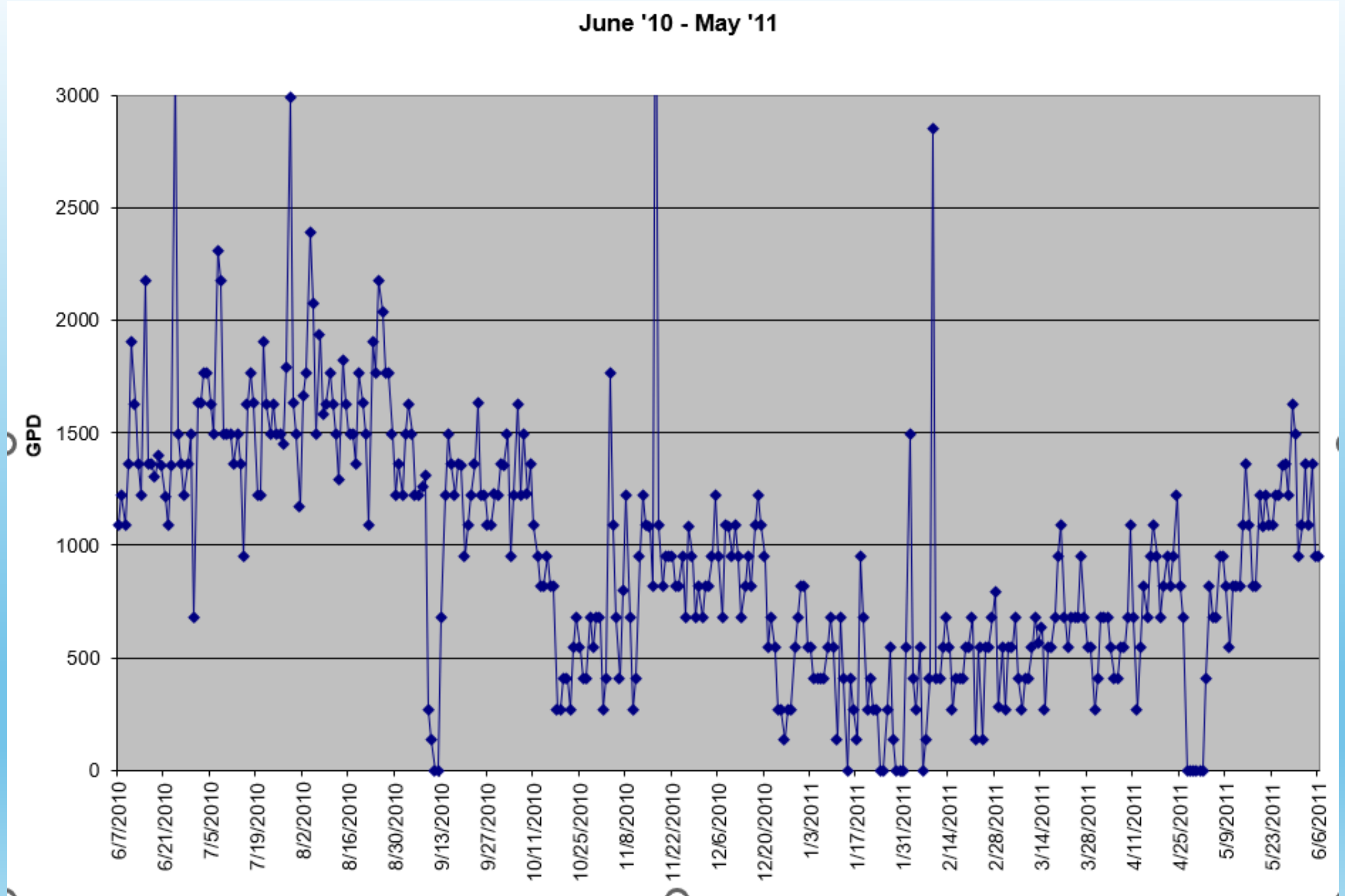
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Heater/Fan Assembly
3" Vent Line
AdvanTex AX100 (typ.)
Inlet Valve & Testing Assembly
(See detail sheet) (typ.)
2" Feed Line
50% Flow to head of 2nd Septic Tank
4" Return Line sloping 1/4"/foot
50% Flow to Recirc Splitter Valve
Splitter Basin for enhanced nitrogen reduction
Distribution Valve
V6403A
2" Feed Line
Influent
Duplex Pumping Package Unit
w/ 30" Dia. Access Riser
Recirculation
Splitter Valve (RSV4U)
w/ 30" Dia. Access Riser
12,000 Gal. Recirculation Tank




Montano's
Restaurant
CAT
320C
CAT
CAT




June '10 - May '11
GPD
3000
2500
2000
1500
1000
500
0
6/7/2010
6/21/2010
7/5/2010
7/19/2010
8/2/2010
8/16/2010
8/30/2010
9/13/2010
9/27/2010
10/11/2010
10/25/2010
11/8/2010
11/22/2010
12/6/2010
12/20/2010
1/3/2011
1/17/2011
1/31/2011
2/14/2011
2/28/2011
3/14/2011
3/28/2011
4/11/2011
4/25/2011
5/9/2011
5/23/2011
6/6/2011

Restaurant, MA (6,000 GPD Design Flow)

		Effluent Performance Results										
		BOD	CBOD	TSS	pH	Temp	Alkalinity	NH3	TKN	NO2	NO3	TN
System ID	Sample Date	mg/l	mg/l	mg/l	su	C	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
	11/21/2005	2		2	7.75	17.4		0.05	1	0.01	3	4.01
	3/9/2006	3		2				0.2	0.9	0.03	3	3.93
	8/31/2006	2		4	7.4			0.5	1.8			8.5
	9/29/2006	6		2	7.4							8
	1/5/2007		2	3	7.9		410	0.1	6.6	0.01	5.6	12.21
	3/28/2007		3	2	6.87	15.6	280	0.2	2.2	0.03	5.8	8.03
	7/3/2007		6	4	7.4	3.7	160	1.2	2.7	0.21	14	16.91
	10/22/2007		2	9	7.8		260	0.3	1.3	0.02	6.8	8.12
	12/28/2007		2	2	7.7		210	0.2	3	0.08	15	18.08
	3/12/2008		0	0			210	0.6	1.9	0.08	9.1	11.08
	9/4/2008		8	4			270	1.7	6.7	1.4	8.3	16.4
	10/26/2009		2	4			250	0.2	0.06	0.2	21	21.26
	6/1/2010			2			110	0.3	2	0.1	6.9	9
	11/18/2010		2	2			86	0.05	0.58	0.2	12	12.78
	2/2/2011		2	2			57	0.2	0.5	0.02	29	29.52
Average		**3.3**	**2.9**	**2.9**	**7.5**	**12.2**	**209.4**	**0.4**	**2.2**	**0.2**	**10.7**	**12.5**


DEWALT
DEWALT
20V







Restaurant - Truro, MA (6,000 GPD Design Flow)

Effluent Performance Results

System ID	Sample Date	BOD	CBOD	TSS	pH	Temp	Alkalinity	NH3	TKN	NO2	NO3	TN
		mg/l	mg/l	mg/l	su	C	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
	11/21/2025	16.5		5.6	7.0	17.4			5.6	0.0	6.1	11.7
	3/26/2026	16.5		7.9	7.1				8.8	0.1	3.1	12.0
	5/21/2026	20.0		13.0	7.1				6.8	0.1	4.9	11.8
	8/13/2026	42.0		52.5	7.3				17.4	0.1	4.8	22.3
Average		**23.8**		**19.8**	**7.1**	**17.4**			**9.7**	**0.1**	**4.7**	**14.5**

Packed Bed Filtration Takeaways

- Time-tested technology for organics and nutrient removal in OWTS
- Robust, dependable performance based on proper design, installation and maintenance
- Evolution of media utilized has enabled packed bed filtration in virtually all applications
- Process control allows for adjustments based on changes in system requirements
- Underperforming systems can be resuscitated

Questions?

WWETT Conference 2026

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