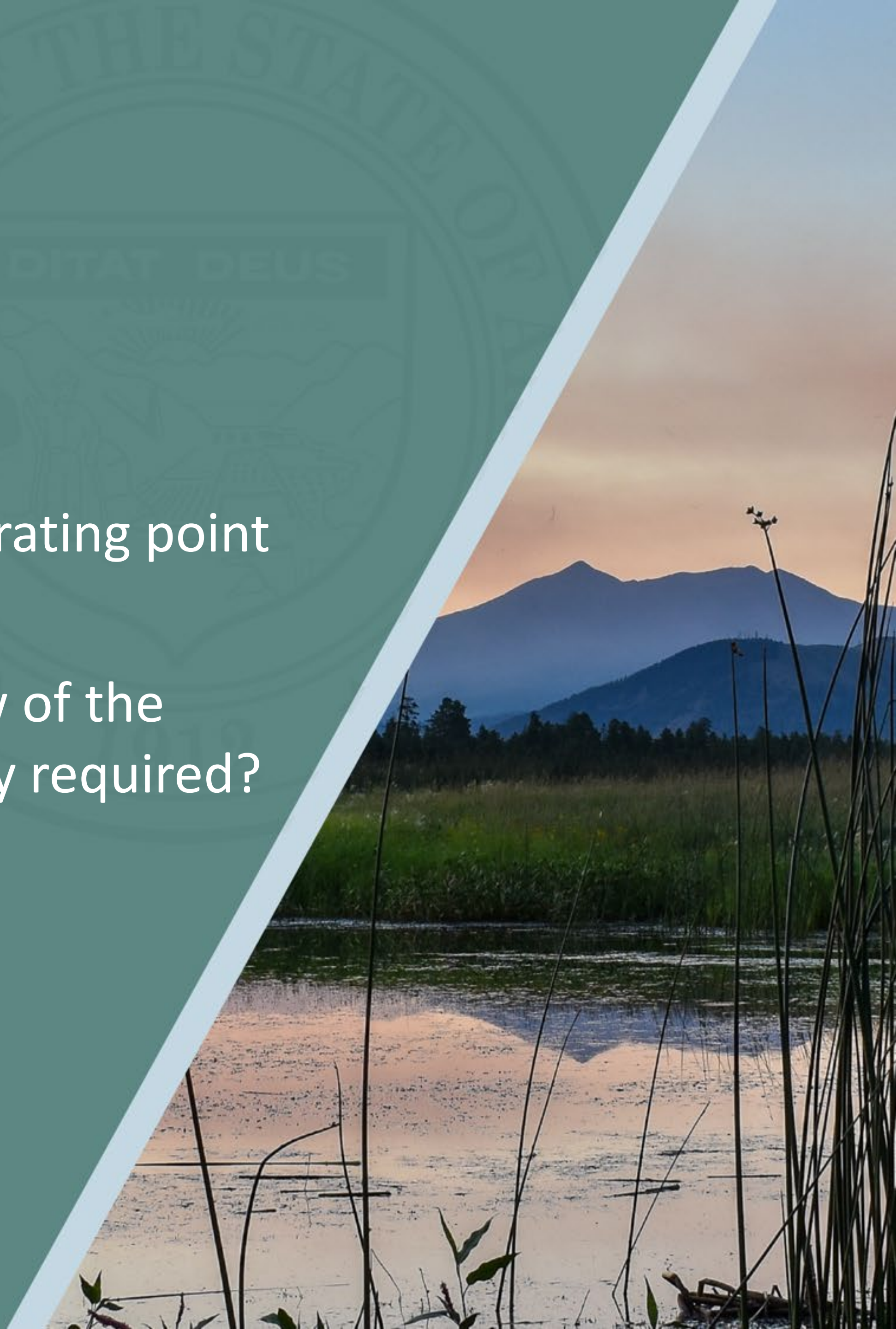
Delegated Agency Training
November 25, 2024
by Raymond Morgan, PE

1. How to determine a pump's operating point
2. Composting Toilets
3. When is a manufacturer's review of the onsite wastewater treatment facility required?



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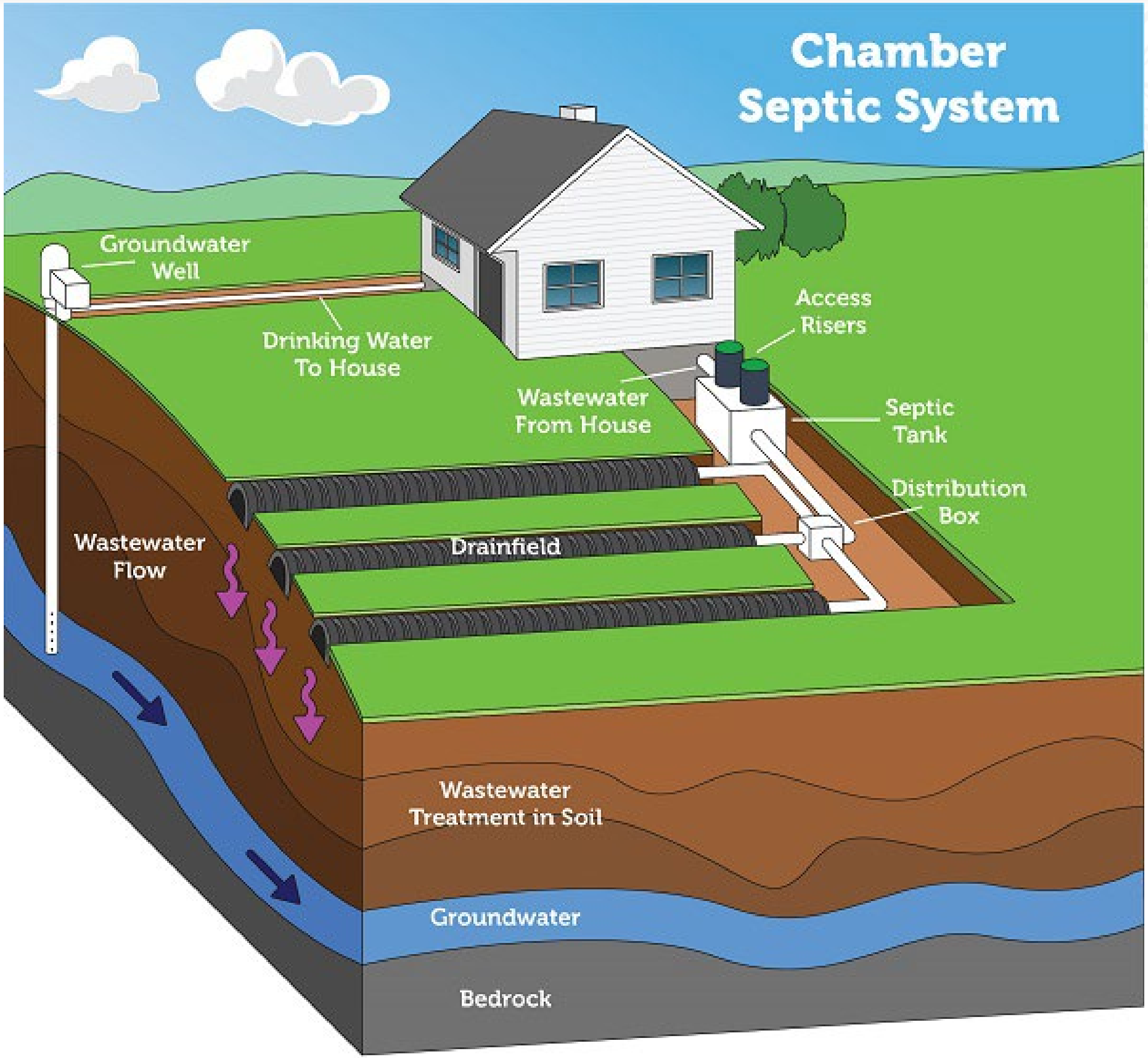
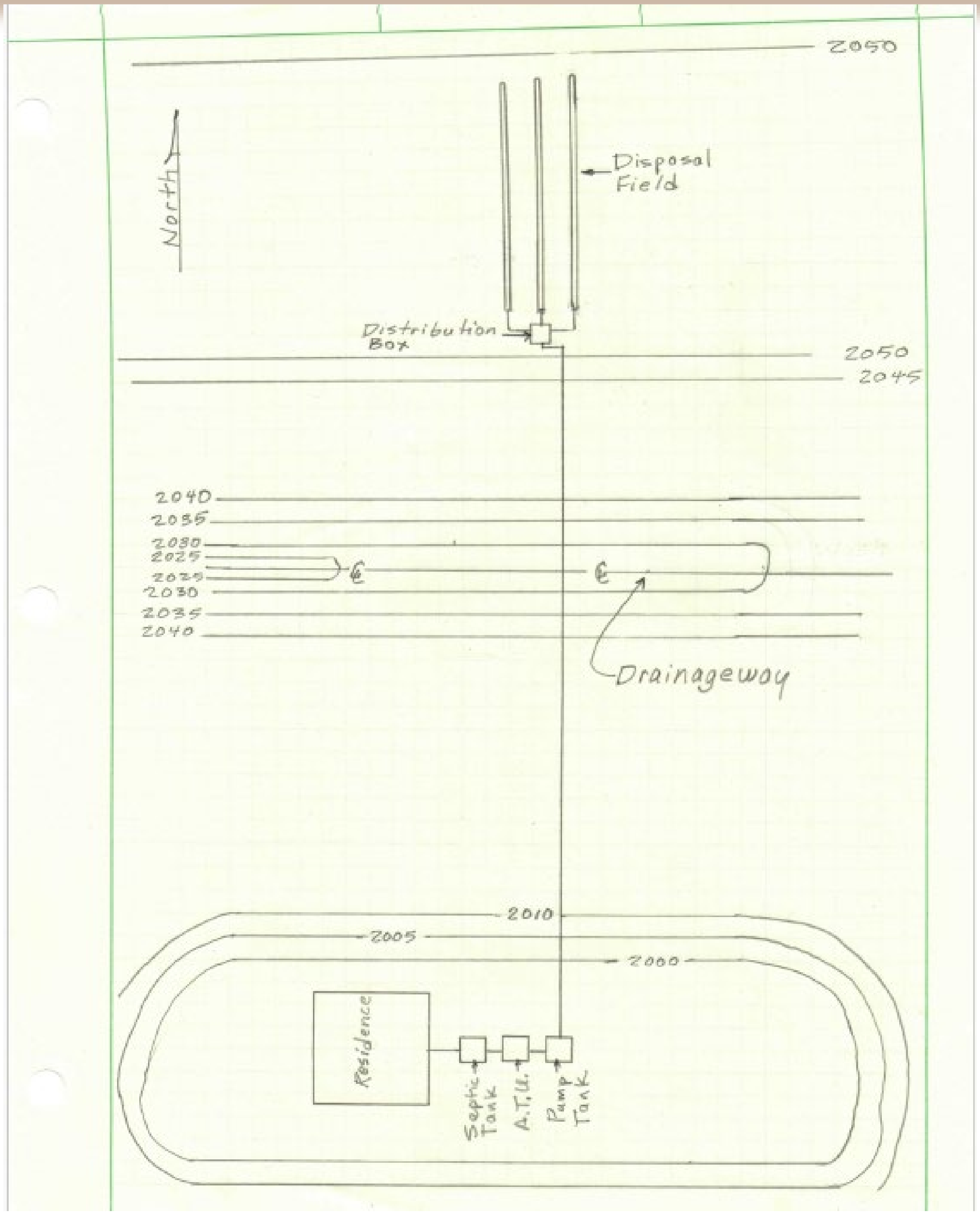
Clean Air, Safe Water, Healthy Land for Everyone

How to determine a pump's operating point



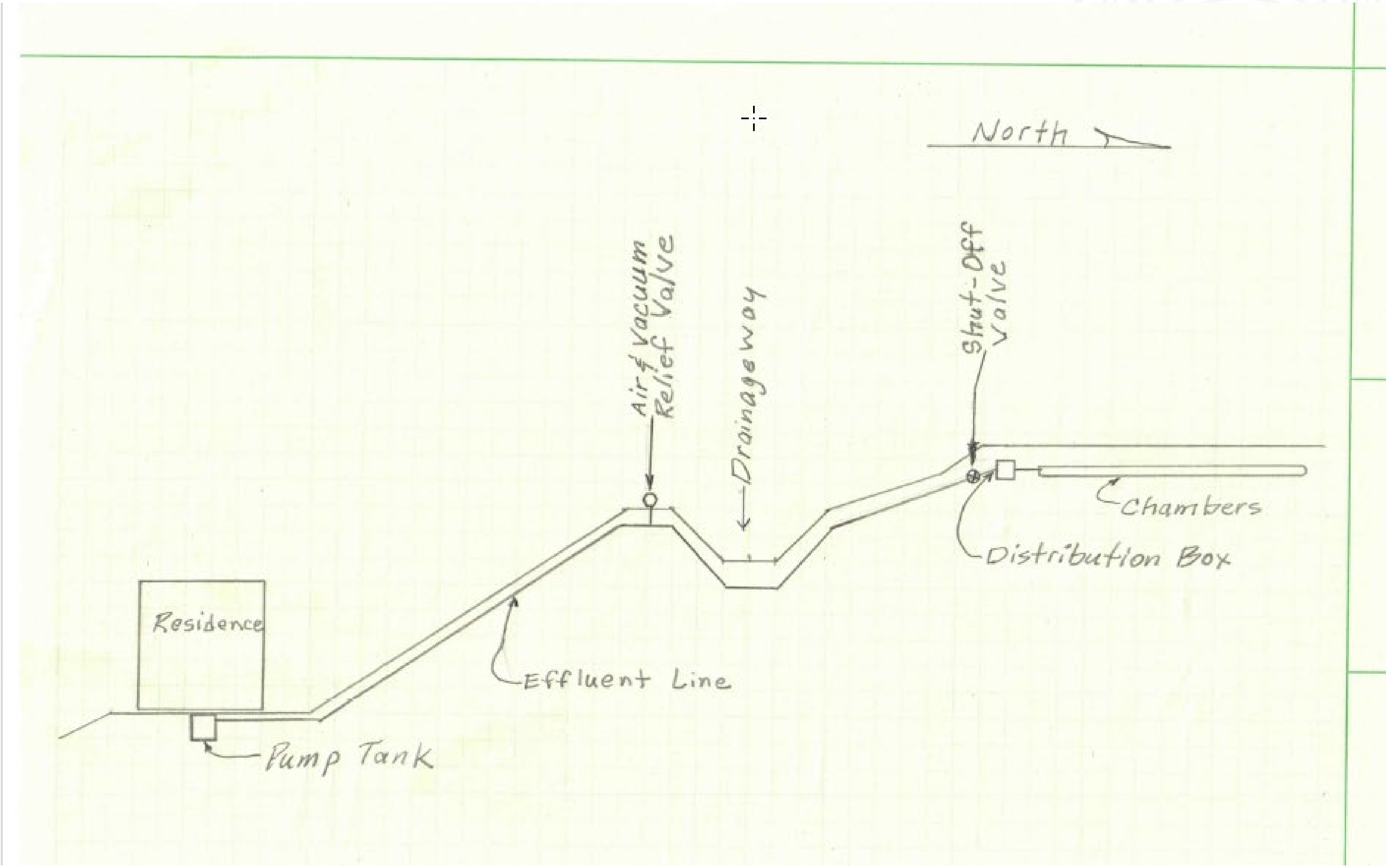
Please note: The ends of the chamber system lines are open for illustrative purposes only. In reality, and when properly installed, these lines are closed at the end. Septic systems vary. Diagram is not to scale.

How to determine a pump's operating point



Site Plan

How to determine a pump's operating point



Cross Section View of the OWTF

How to determine a pump's operating point

Basic Design Parameters

1. Three-bedroom single family residence
2. Design Flow = 450 gpd
3. Type 4.15 permit (aerobic treatment unit)
   Pump
   a. 5 hp
   b. Flow velocity – Depends upon the pump selected
   c. Static Head – 50'
   d. System Head – Depends upon the pump selected
4. Forcemain – 1.25" diameter, 200' in length'
5. SAR = 0.40 gpd/sf
6. High Disposal Capacity Chamber Area – 28.4 sf/chamber
7. Disposal Area – 1125 sf
8. Number of Chambers needed = 1125/28.4 = 39.6 Use - 42 (3 rows at 14 chambers each)
9. Distribution Box – polyethylene or concrete

System Head Calculation

A. Use the Hazen Williams Formula to calculate the **friction head** in the pumping system

$$h_{100ft} = 0.2083\ (100 / c)^{1.852}\ q^{1.852} / d^{4.8655} \qquad (1)$$

where

h_{100ft} = *friction head loss in feet of water per 100 feet of pipe* (ft_{h20} */100 ft pipe)*

c = Hazen-Williams roughness constant

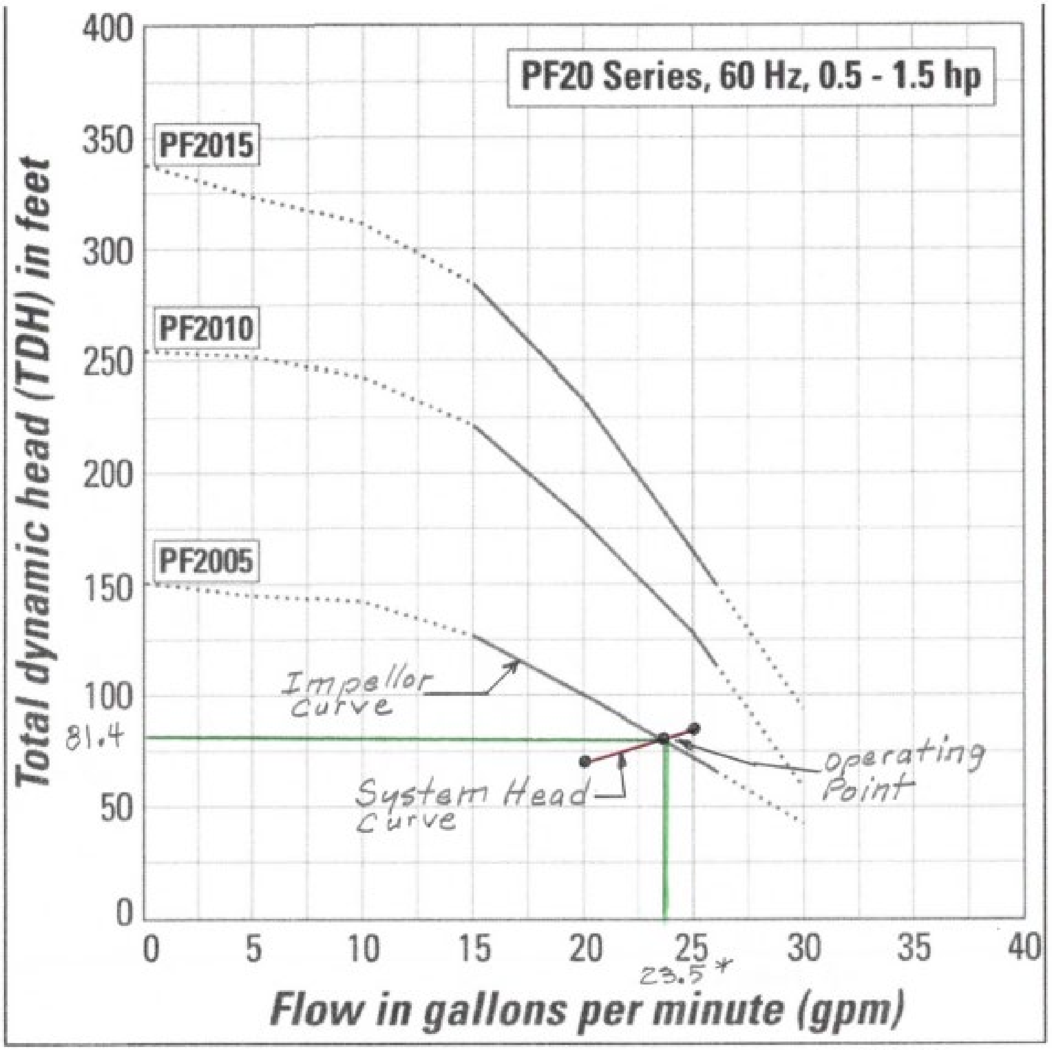
q = volume flow (gal/min)

d = inside diameter of pipe (inches)

System Head Calculations

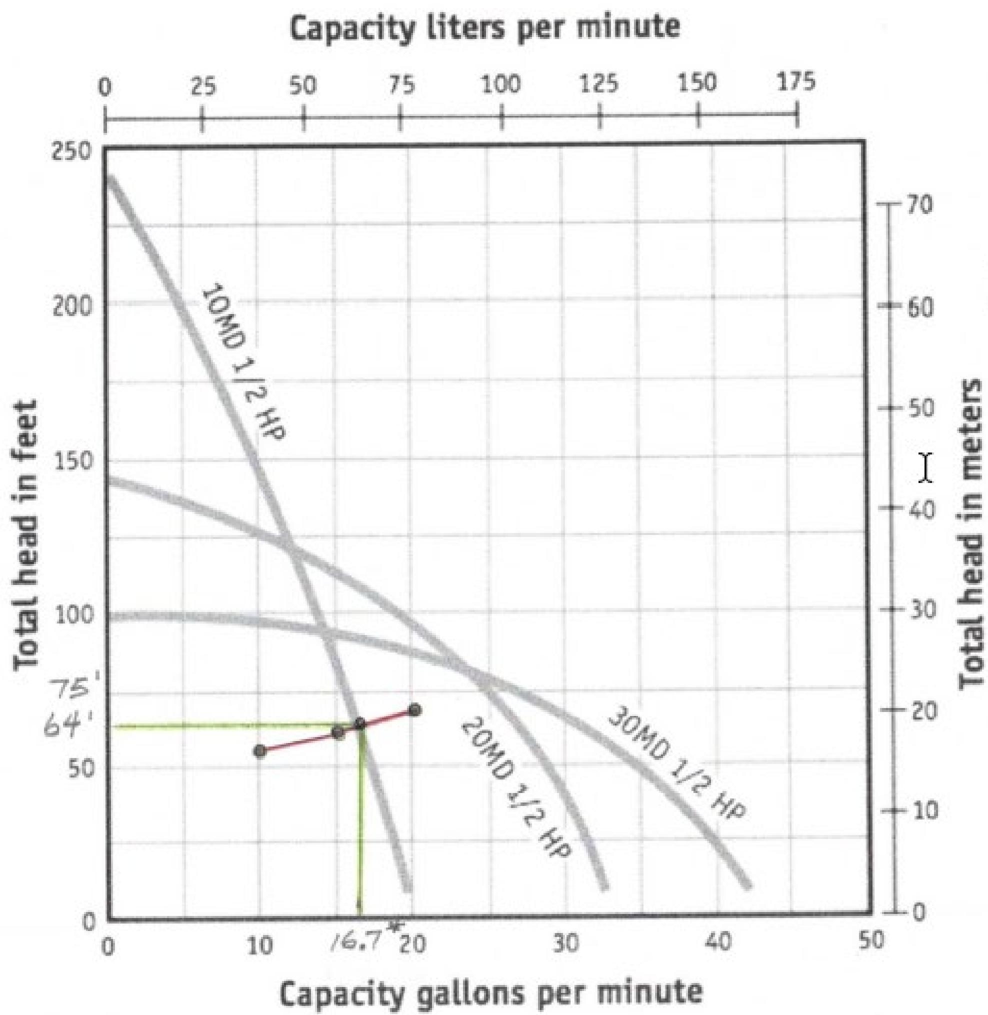
1. System Head = Static Head (ft.) + Friction Head (ft.) assuming a Flow (gpm)
2. System Head = 50' + 29.3' = 79.3'; assuming Flow = 25 gpm & v = 6.54 fps
3. System Head = 50' + 19.4' = 69.4'; assuming Flow = 20 gpm & v = 5.23 fps
4. System Head = 50' + 11.4' = 61.4'; assuming Flow = 15 gpm & v = 3.92 fps
5. System Head = 50' + 5.37' = 55.37'; assuming Flow = 10 gpm & v = 2.62 fps

How to determine a pump's operating point



V 1" = 71'
H 1" = 7.2 gpm
*V = 6.17 fps

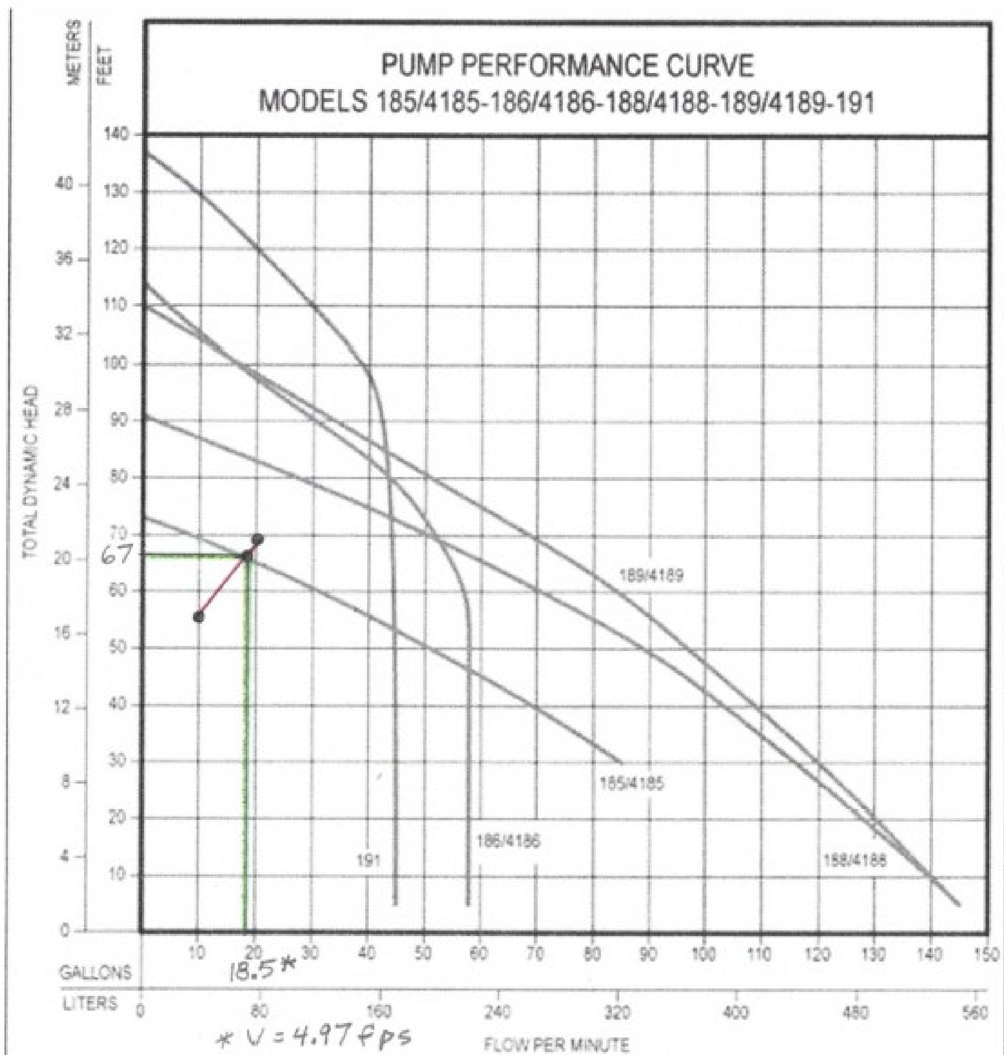
How to determine a pump's operating point



* V = 4.11 fps

V 1" = 60'
H 1" = 11.1 gpm

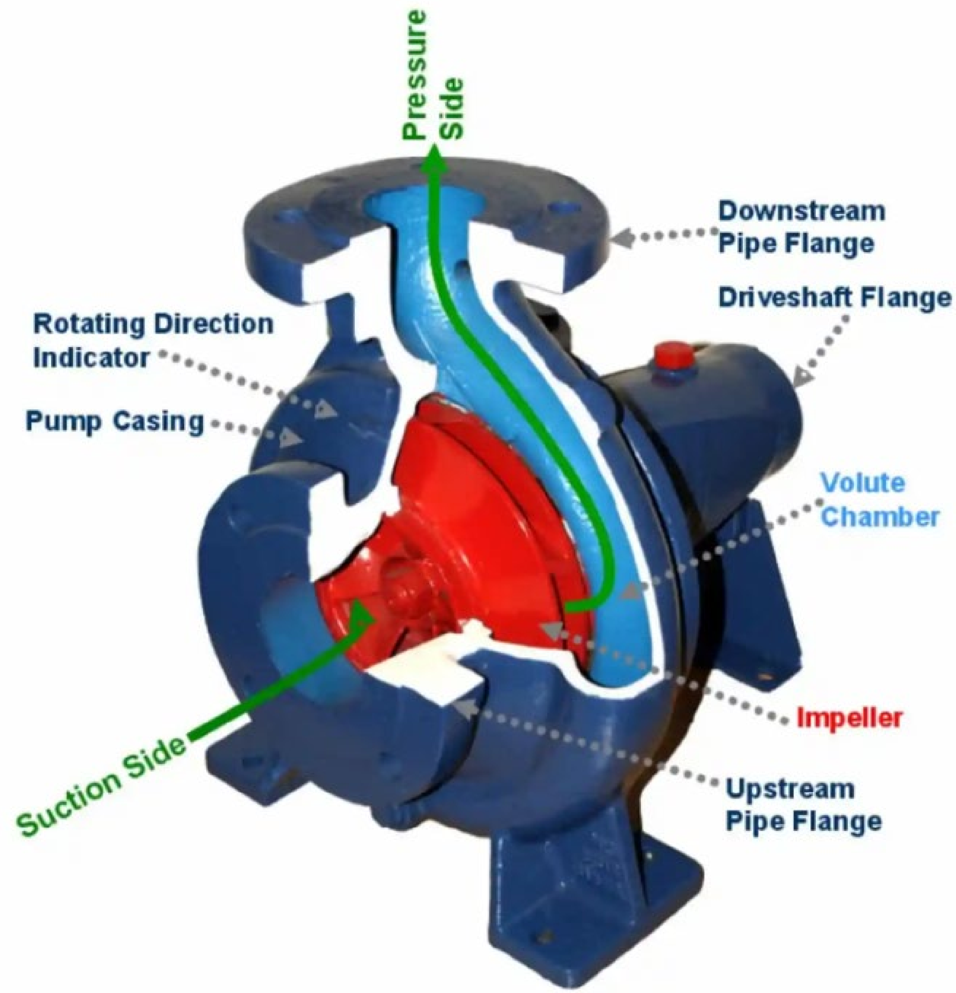
How to determine a pump's operating point



V 1" = 28.3'
H 1" = 28.0 gpm

How to determine a pump's operating point

A centrifugal pump uses an impellor to move the effluent from the suction side of the volute inlet to the discharge side of the volute outlet. As the impellor rotates, the impellor blades move the effluent out the discharge side of the volute which creates a suction on the inlet side of the volute.

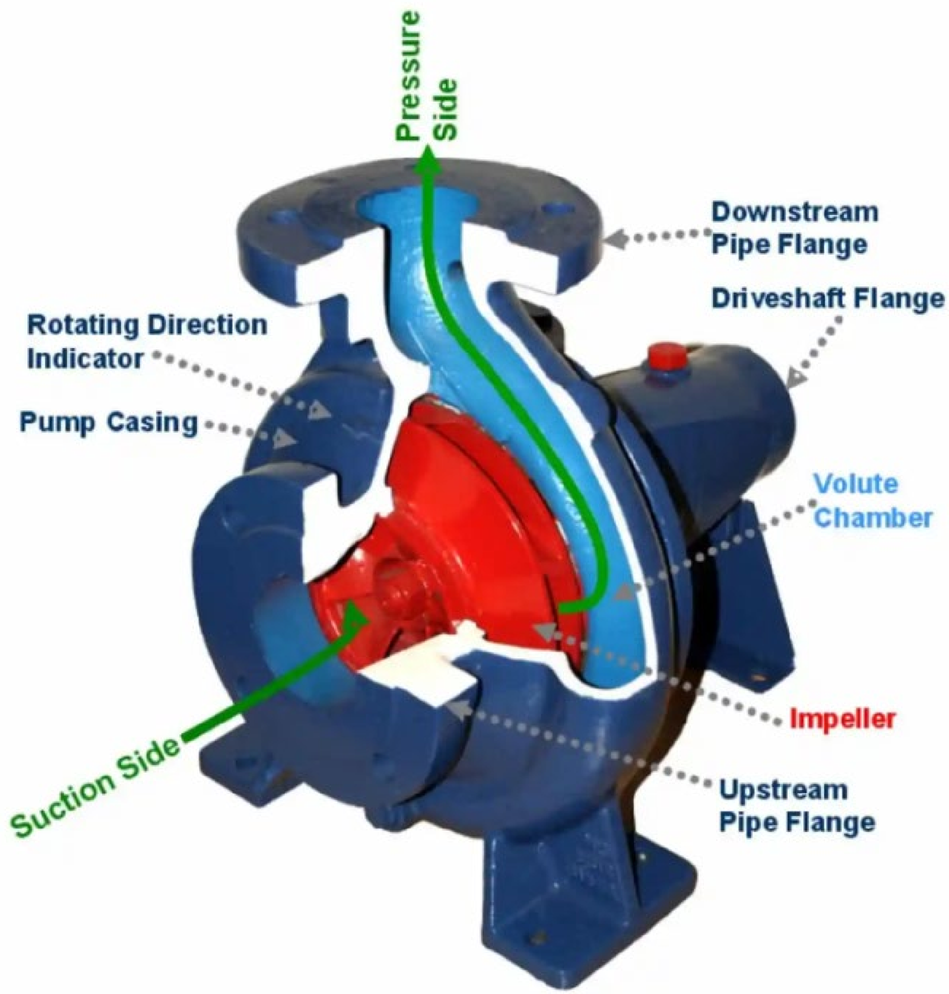


How to determine a pump's operating point

A submersible pump (or electrical submersible pump) is a pump which has a hermetically sealed motor that is bolted to the volute which contains the pump impellor. The submersible pump is submerged in the effluent which is then pumped to a discharge point at a higher elevation. One of the advantages of the submersible pump is it does not need to be primed and won't ever need to be primed. Another advantage of a submersible pump is that it is not as prone to cavitation if the operational point on the impellor curve is in the correct location on the impellor curve.

How to determine a pump's operating point

Wastewater effluent pumps are used to pump only effluent with minimal solids present (usually no more ¾" in diameter). They are normally used after a septic tank or some type of secondary treatment process where the solids have been mostly removed. The effluent is then discharged to a distribution box or to pressure disposal piping in the disposal field.



How to determine a pump’s operating point

Cavitation damage to the impellor

What is cavitation? This is a phenomenon that occurs within pumping systems. The fluid being pumped develops vapor bubbles within it due to pressure variations in the fluid. The vapor bubbles in turn can cause significant damage to the pump impellor and the pump casing as they collapse.

How to determine a pump's operating point

Cavitation Damage to the Pump Casing

"**Discharge cavitation** occurs when the pressure at the discharge end of the pump is too high and the fluid cannot flow out easily. High discharge pressure thus limits the fluid flow of the pump, causing high velocity fluid to recirculate between the pump impellor and the housing, causing cavitation." The pump is, in essence, running too slow for the available fluid flow.

Suction cavitation occurs when the pump is starved of incoming liquid and has a low fluid flow into the pump and a high suction lift. This low flow then causes vapor bubbles to form right at the eye of the impellor. These vapor bubbles then move outwards to the discharge point where they collapse, implode, and damage the impellor. The pump is, in essence, running too fast for the available fluid flow.

How to determine a pump's operating point

Cavitation Damage to the Pump Casing

How do you recognize that cavitation is occurring? Cavitation sounds like marbles or gravel is being pumped. A person could look for the following signs of cavitation:

- Noise
- Vibration
- Seal/bearing failure
- Impellor or casing erosion
- Higher than usual power consumption

How to determine a pump's operating point

"**Air scouring velocities** (per Table B-9) can be reached by decreasing the diameter of the pipe at knees or in any pipe laid flat or at downward gradients. To minimize friction losses, only the pipe on a flat or downward gradient need be made small to obtain the high velocities required. (Note that the custom of never decreasing the diameter of a sewer line does not apply to force mains. Reducing pipeline diameter may however, preclude the use of pigs for cleaning.) Air-scouring velocities must be reached frequently – at least once per day. It is wise to include pigging facilities because pigging removes bacterial slimes that produce hydrogen sulfide."

Reference: Pumping Station Design by Garr M. Jones

How to determine a pump's operating point

Table B-9. Velocities Required to Scour Air Pockets from Pipelines. Values computed by Wheeler [10] using Equation B-1 developed by Wisner, Mohsen, and Kouwen [11].

Pipe diameter, mm	Velocities, m/s					Velocities, ft/s					Pipe diameter, in.
	Slope					Slope					
	0%	5%	25%	45°	90°	0%	5%	25%	45°	90°	
25	0.4	0.4	0.5	0.5	0.5	1.4	1.4	1.6	1.7	1.8	1
50	0.6	0.6	0.7	0.7	0.8	1.9	2.0	2.2	2.4	2.5	2
75	0.7	0.8	0.8	0.9	0.9	2.3	2.5	2.7	2.9	3.1	3
100	0.8	0.9	0.9	1.0	1.1	2.7	2.9	3.1	3.4	3.5	4
150	1.0	1.1	1.2	1.3	1.3	3.3	3.5	3.8	4.2	4.3	6
200	1.2	1.2	1.3	1.5	1.5	3.8	4.1	4.4	4.8	5.0	8
250	1.3	1.4	1.5	1.6	1.7	4.3	4.6	4.9	5.4	5.6	10
300	1.4	1.5	1.6	1.8	1.9	4.7	5.0	5.4	5.9	6.1	12
350	1.6	1.6	1.8	1.9	2.0	5.1	5.4	5.8	6.3	6.6	14
375	1.6	1.7	1.8	2.0	2.1	5.2	5.6	6.0	6.6	6.8	15
400	1.6	1.8	1.9	2.1	2.1	5.4	5.8	6.2	6.8	7.0	16
450	1.7	1.9	2.0	2.2	2.3	5.7	6.1	6.6	7.2	7.5	18
500	1.8	2.0	2.1	2.3	2.4	6.0	6.5	6.9	7.6	7.9	20
525	1.9	2.0	2.2	2.4	2.5	6.2	6.6	7.1	7.8	8.1	21
600	2.0	2.2	2.3	2.5	2.6	6.6	7.1	7.6	8.3	8.6	24
675	2.1	2.3	2.5	2.7	2.8	7.0	7.5	8.1	8.8	9.2	27
750	2.3	2.4	2.6	2.8	2.9	7.4	7.9	8.5	9.3	9.6	30
825	2.4	2.5	2.7	3.0	3.1	7.8	8.3	8.9	9.7	10.1	33
900	2.5	2.7	2.8	3.1	3.2	8.1	8.7	9.3	10.2	10.6	36
1050	2.7	2.9	3.1	3.4	3.5	8.8	9.4	10.1	11.0	11.4	42
1200	2.9	3.0	3.3	3.6	3.7	9.4	10.0	10.8	11.8	12.2	48
1500	3.2	3.4	3.7	4.0	4.1	10.5	11.2	12.0	13.1	13.6	60
1800	3.5	3.7	4.0	4.4	4.5	11.5	12.2	13.2	14.4	14.9	72

- Air problems do not occur where the pipe gradient is positive in the direction of flow [4].
- Avoid excessive head loss by using smaller-diameter pipe (to obtain higher velocities) only where gradient is flat or slopes downward.
- For air scouring to be effective, the tabular velocities must occur frequently (e.g., daily or more often).
- Air release valves in small pipes may be of little or no value.
- Blowback from clearing air in large pipes may cause surges that cannot be estimated. See Wisner, Mohsen, and Kouwen [4].
- Before designing piping systems for air scouring, it is advisable to read "Air Binding in Pipes" by Edmunds [5], the chapter on closed conduit flow in Falvey [7], and, for wastewater, "Hydraulics of Corrosive Gas Pockets in Force Mains" by Walski et al. [6]

Summary

1. The pump operating point can be determined by locating the intersection of the impellor curve with the system curve.
2. An air relief valve does not have to be used if the fluid velocities are high enough to scour off any air bubbles on the high point. However, a vacuum relief valve may still be needed.
3. A point should be chosen where the pump operating point is located outside of a zone of cavitation.
4. Cavitation can damage both the impellor and the wall of the pump volute.

Are there any questions?

Composting Toilets

Definition. "For purposes of this Section, "composting toilet" means a manufactured turnkey or kit form treatment technology that receives human waste from a waterless toilet directly into an aerobic composting chamber where dehydration and biological activity reduce the waste volume and the content of nutrients and harmful microorganisms to an appropriate level for later disposal at the site or by other means." R18-9-E303.A.1

Composting Toilets

"A permittee may use a composting toilet only if:

a. Wastewater is managed as provided in this Section and, if gray water is separated and reused, the gray water reuse complies with18 A.A.C. 9, Article 7; and

b. Soil conditions support subsurface disposal of all wastewater sources."

R18-9-E303.A.3

Composting Toilets

"Performance. An applicant shall ensure that:

1. The composting toilet provides containment to prevent the discharge of toilet contents to the native soil except leachate, which may drain to the wastewater disposal works described in subsection (F);
2. The composting toilet limits access by vectors to the contained waste; and
3. Wastewater is disposed into the subsurface to prevent any wastewater from surfacing."

R18-9-E303.C

Notice of Intent to Discharge
Wastewater - Wastewater

a. “The number of bedrooms in the dwelling or persons served on a daily basis, as applicable, and the corresponding design flow of the disposal works for the wastewater;

b. The results from soil evaluation or percolation testing that adequately characterize the soils into which the wastewater will be dispersed and the locations of soil evaluation and percolation testing on the site plan; and

c. The design for the disposal works in subsection (F), including the location of the interceptor, the location and configuration of the trench or bed used for wastewater dispersal, the location of connecting wastewater pipelines, and the location of the reserve area.”

R18-9-E303.D.2

Composting Toilets

e. Minimum interceptor size is based on design flow.

i. For a dwelling, the following apply:

No. of Bedrooms	Design Flow (gallons per day)	Minimum Interceptor Size (gallons)	
		Kitchen Wastewater Only (All gray water sources are collected and reused)	**Combined Non-Toilet Wastewater (Gray water is not separated and reused)**
1 (7 fixture units or less)	90	42	200
1-2 (greater than 7 fixture units)	180	84	400
3	270	125	600
4	330	150	700
5	380	175	800
6	420	200	900
7	460	225	1000

ii. For other than a dwelling, minimum interceptor size in gallons is 2.1 times the design flow from Table 1, Unit Design Flows.

R18-9-E303.F.1.e.i

"Dispersal of wastewater. An applicant shall ensure that the design complies with the following:

a. A trench or bed is used to disperse the wastewater into the subsurface;

b. Sizing of the trench or bed is based on the design flow as determined in subsection (F)(1)(e), including all black and gray water, and an SAR determined under R18-9-A312(D);

c. The minimum vertical separation from the bottom of the trench or bed to a limiting subsurface condition is at least 5 feet; and

d. Other aspects of trench or bed design follow R18-9-E302, as applicable." ref. R18-9-E303.F.2

Summary

1. A composting toilet is an aerobic treatment process. If the air supply is cut off due to inadequate bulking material being added or saturated conditions develop due to inadequate fluid drainage, it becomes a latrine. This situation will lead to odor problems and inadequate treatment of the waste material.
2. The size of the interceptor can be adjusted depending upon whether or not the gray water is combined with the blackwater as it flows through the interceptor to the dispersal field.
3. This size of the dispersal field is based upon the Design Flow shown in the table at R18-9-E303.F.1.e.i. The Design Flow includes both black and gray water.
4. A home that uses a composting toilet still requires a site investigation report, an SAR determination, an interceptor, and a dispersal field.

Are there any questions?

When is a manufacturer's review of the onsite wastewater treatment facility (OWTF) required?

A manufacturer's review is needed whenever the wastewater being discharged to the OWTF exceeds the limits of typical sewage.

- This language is included in the Proprietary Products Listing (PPL) approval certificate.
- R18-9-A309.A.7.d. requires that a person pretreat a sewage flow that does not meet the numerical levels for typical sewage to meet the numerical levels before entry into an on-site wastewater treatment facility authorized by this Article.

Manufacturer's Review of the OWTF

Texas Restaurant Wastewater Analysis, 2003

- Pretreatment is necessary to prevent system failure
- Highlighted the need for a design manual for restaurants

Parameter	Typical domestic waste (range, mg/L)	Restaurant waste (average, mg/L)
BOD	100-400	1,202
COD	100-300	1,717
TSS	100-350	318
FOG	16-65	131

Study funded by the Texas Onsite Wastewater Research Council

Manufacturer's Review of the OWTF

Texas Restaurant Wastewater Analysis, 2003

	n	BOD mg/L	COD mg/L	TSS mg/L	FOG mg/L	BOD lbs/day
Hand wash	5	2,617	2,575	366	120	30.5
Commercial Dishwasher	22	1,037	1,912	418	153	36.9

Values shown are averages

Manufacturer's Review of the OWTF

Table 2

	BOD_5 (mg/L)	pH
Soda	Up to 79 500	2.4
Beer	Up to 80 000	
Whole milk	104 600	
Skim milk	67 000	
Orange juice	7.85 lb/100 lb	
Potatoes	4.20 lb/ 100 lb	
Potato chips	1.25 lb/ 100 lb	

Ref: Carawan, R.E., NC State University, Water and Wastewater Management in Food Processing (1979)

Restaurant type	Average BOD (mg/l)
Fast Food	2,137
Pizza	1,856
Chinese	1,364
Mexican	1,254
American	1,063
American Buffet	792
Steakhouse	601
Seafood	555

Source: 2013 Study conducted by the Harris County Public Infrastructure Department

Manufacturer's Review of the OWTF

Summary

1. Some non-residential wastewater sources are producing high strength wastewater.
2. High strength wastewater being treated by a permitted OWTF will probably produce a wastewater effluent that exceeds the performance requirements for that permit.
3. Wastewater that has a BOD5 and TSS that exceeds the performance requirements of the permit for that facility will probably produce a thicker biomat which in turn can contribute to the failure of the dispersal field.

Any Questions?

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