Recommendation & SWOT Form 34

RECOMMENDATION SUMMARY

NSF 245 and disinfection to 1000 Total Coliform MPN per 100 mL and 200 Fecal Coliform MPN per 100 mL for the following situations (complete freedom on disposal method provided it is subsurface disposal with no pooling):
- lava rock, seepage pit, cesspool for disposal.
- soil with less than or equal to 5 min/in percolation rate (instead of soil replacement).

Bonus: Explicitly require nitrogen and pathogen reduction in Wastewater Treatment Works with UIC permit disposal

INTERNAL FACTORS

STRENGTHS +	WEAKNESSES –
- Allows the department to address a large quantity of fringe cases in addition to more common cases. - Will improve internal rationale and puts the department in a productive trajectory to further meet our mission statement.	- Greater flexibility in design could lead to longer review times. - Will require revisions to our review procedure to be more performance based. Will need to address reviewing engineers concerns.

EXTERNAL FACTORS

OPPORTUNITIES +	THREATS –
- Addresses longstanding gap in rules that allowed potential groundwater contamination. - Makes it possible to test for pathogen reduction. - Addresses wastewater threats to public health and environment before even touching ground. - Gets ahead of potential future prohibition of seepage pits from the EPA. - Gives more flexibility when determining what wastewater system is best for a property.	- Owners will be required to perform more maintenance. - Engineers and owners may be required to provide lab results to demonstrate compliance. - Phosphorus pollution will still occur unless disposal is into soil. - Is not compatible with allowing chamber infiltrative area to be defined by manufacturer specification.

ADDITIONAL INFORMATION

See attached report. There is a lot more to consider, but I tried to be concise.

Once completed, please email this form to doh.wwb.cesspool@doh.hawaii.gov.

Section 1: What do soil absorption systems do?

In general terms, a wastewater system is expected to treat water to reduce the following metrics: Biochemical Oxygen Demand (BOD), Total Suspended Solids (TSS), nitrogen, phosphorus and pathogens. Secondary treatment seeks to reduce BOD and TSS, while tertiary treatment further reduces nutrients, like nitrogen and phosphorus, and disinfects to reduce pathogens [1]. There are other potential pollutants like inorganic pollutants, metals, and toxic organics, but these are typically not prioritized for residential onsite wastewater systems.

When just a septic tank is used for primary treatment, the soil absorption system must perform all of the remaining reductions before it reaches the groundwater. The size, depth, and soil characteristics of a soil absorption system all work together to prevent groundwater contamination.

Section 2: Eutrophication, turbidity, and disease

Broadly speaking, high levels of BOD, nitrogen, and phosphorus can contribute to eutrophication, which leads to a reduction in dissolved oxygen that cause fish kills, dead zones, and ocean acidification [2]. TSS increases the turbidity of water, which harms bottom-dwelling organisms in water bodies, and can be carriers for other unwanted nutrients or pollutants [3]. Pathogens can be broken down into four categories: bacteria, protozoa, helminths, and viruses. Exposure can lead to diseases like Legionnaires' disease, Typhoid fever, Shigellosis, and Cholera [1].

Section 3: Characteristics of a soil absorption system

This section will use an absorption trench as an example, but the principles and mechanisms can be applied to other absorption systems like absorption beds and seepage pits.

Directly below the perforated piping is gravel, which acts as a non-clogging backfill that supports and protects the infiltrative surface. A few centimeters deep into the infiltrative surfaces is known as the infiltration zone (see Figure 1). Infiltration zones are where the biomat develops. Biomats act as fixed-film reactors, develop in the saturated layer of soil, and require oxygen. The biomat filters out a significant amount of suspended solids and significantly reduces the BOD. The biomat also helps to increase retention time by decreasing the porosity and slowing down the percolation rate to allow for better aerobic treatment. This has the added benefit of consuming a significant amount of nitrogen, phosphorus, and pathogens [4]. In particular, pathogens typically seem to undergo an additional 3 log reduction with development of a biomat. There are tests that suggest that the development of the biomat typically takes around 180 days [5]. When combined with the vadose zone directly below the infiltration zone and biomat, the nutrient and pathogen reduction are meaningful [4].

It could be inferred that the sidewalls may also act as an infiltrative surface, but the sidewalls do not have the benefit of acting under gravity flow. There are equations to determine the additional effective infiltrative surface that the sidewall may yield. However, regions with regular rainfall or higher humidity are not recommended to include the sidewalls when calculating the infiltrative area because the reduction in hydraulic potential from saturated soil could make the sidewall infiltrative areas ineffective [7]. Conversely, if soil replacement is used in soil with very low percolation rates (min/inch), without proper controls, the sidewalls could allow the wastewater to 'short-circuit' the treatment process by bypassing the biomat and vadose zone altogether thereby contaminating groundwater.

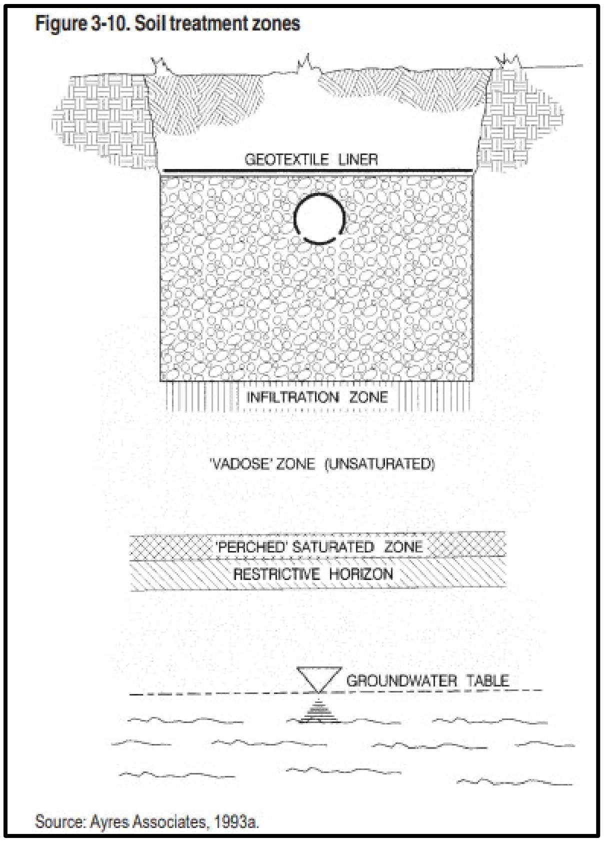

Figure 1. Excerpt from 2002 EPA manual [4] for ease of reference to understand the characteristics of an absorption system.

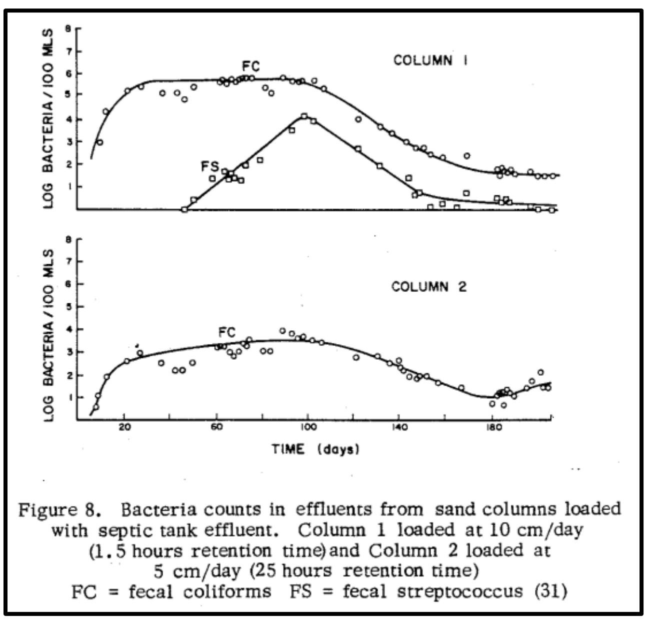

Figure 2. Excerpt from the 1977 "On-Site Disposal of Small Wastewater Flows" [5] for ease of understanding how retention time can affect the development of a biomat in an absorption system and how this affects the ability of the system to reduce bacteria.

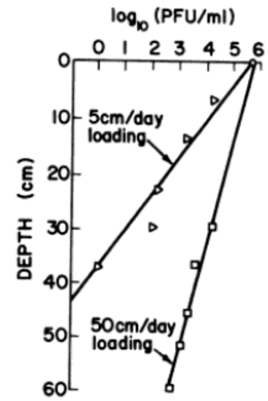

Figure 15. Penetration of poliovirus into packed sand columns at room temperature (Green and Cliver, 1974).

Figure 3. Excerpt from EPA-600/2-78-173 [6] for ease of reference to understand how retention time can affect the absorption systems capability to reduce the poliovirus.

Section 4: Soil absorption systems are not perfect

Soil absorption systems take advantage of the soil to perform the needed treatment without electricity costs or the need for moving parts. They are not without faults though.

Soil absorption systems are prone to clogging because of the biomat. This has been found to be dependent on the BOD and TSS loading, but more so the soil characteristics like the hydraulic conductivity. Nevertheless, poor treatment prior to disposal is more likely to result in clogging and failure of the absorption bed within a few years of installation [5, 6].

The effectiveness of soil absorption systems can also be influenced by varying groundwater levels, mischaracterization of soil, uneven distribution of wastewater, poor treatment prior to biomat development, limited options for monitoring effluent quality, and more.

The greatest downside of a soil absorption system, however, is the large amount of land area required to properly treat the wastewater.

Section 5: Emulating a soil absorption system

To emulate the benefits of a soil absorption system, the wastewater system must provide primary, secondary and tertiary treatment before the effluent even touches the ground. With performance-based criteria and regular monitoring this represents a solution to properties where soil absorption systems cannot operate properly. An example of how this could be readily implemented would be an NSF 245 wastewater system that is paired with a disinfection system. Properly designed small onsite wastewater systems are known to achieve pathogen reduction to levels of less than 1000 Total Coliform per 100 mL and 100 Fecal Coliform per 100 mL [5]. NSF 245 also contains standard reductions in BOD, TSS, and nitrogen.

However, the problem lies in that NSF 245 does not perform as well in some ways when compared to a properly designed soil absorption system (see Figure 4). In particular, it does not address potential phosphorus pollution. Currently, however, this seems to be the best available option for land that cannot have a properly designed soil absorption system.

Table 3-19. Wastewater constituents of concern and representative concentrations in the effluent of various treatment units

Constituents of concern	Example direct or indirect measures (Units)	Tank-based treatment unit effluent concentrations					SWIS percolate into ground water at 3 to 5 ft depth (% removal)
		Domestic STE[1]	Domestic STE with N-removal recycle[2]	Aerobic unit effluent	Sand filter effluent	Foam or textile filter effluent	
Oxygen demand	BOD_5 (mg/L)	140-200	80-120	5-50	2-15	5-15	>90%
Particulate solids	TSS (mg/L)	50-100	50-80	5-100	5-20	5-10	>90%
Nitrogen	Total N (mg N/L)	40-100	10-30	25-60	10-50	30-60	10-20%
Phosphorus	Total P (mg P/L)	5-15	5-15	4-10	<1-10[3]	5-15[3]	0-100%
Bacteria (e.g., *Clostridium perfringens*, *Salmonella*, *Shigella*)	Fecal coliform (organisms per 100 mL)	10^6-10^8	10^6-10^8	10^3-10^4	10^1-10^3	10^1-10^3	>99.99%
Virus (e.g., hepatitis, polio, echo, coxsackie, coliphage)	Specific virus (pfu/mL)	0-10^5 (episodically present at high levels)	0-10^5 (episodically present at high levels)	0-10^5 (episodically present at high levels)	0-10^5 (episodically present at high levels)	0-10^5 (episodically present at high levels)	>99.9%
Organic chemicals (e.g., solvents, petro-chemicals, pesticides)	Specific organics or totals (µg/L)	0 to trace levels (?)	0 to trace levels (?)	0 to trace levels (?)	0 to trace levels (?)	0 to trace levels (?)	>99%
Heavy metals (e.g., Pb, Cu, Ag, Hg)	Individual metals (µg/L)	0 to trace levels	0 to trace levels	0 to trace levels	0 to trace levels	0 to trace levels	>99%

[1] Septic tank effluent (STE) concentrations given are for domestic wastewater. However, restaurant STE is markedly higher particularly in BOD_5, COD, and suspended solids while concentrations in graywater STE are noticeably lower in total nitrogen.
[2] N-removal accomplished by recycling STE through a packed bed for nitrification with discharge into the influent end of the septic tank for denitrification.
[3] P-removal by adsorption/precipitation is highly dependent on media capacity, P loading, and system operation.

Source: Siegrist, 2001 (after Siegrist et al., 2000)

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Figure 4. Excerpt from the 2002 EPA manual [4] for ease of reference to understand the effectiveness of soil absorption systems (also known as Subsurface Wastewater Infiltration Systems (SWIS)) when compared to NSF 245.

References

[1] Metcalf & Eddy, Inc. (2003) Wastewater Engineering Treatment and Reuse (4th ed). McGraw-Hill.

[2] National Ocean Service (2024) What is eutrophication?. *United States National Oceanic and Atmospheric Administration.* https://oceanservice.noaa.gov/facts/eutrophication.html

[3] United States Environmental Protection Agency (2012) Water Monitoring & Assessment: Total Solids. *United States Environmental Protection Agency.* https://archive.epa.gov/water/archive/web/html/vms58.html

[4] United States Environmental Protection Agency (2002) Onsite Wastewater Treatment Systems Manual EPA/ 625/R-00/008. United States Environmental Protection Agency. https://www.epa.gov/sites/default/files/2015-06/documents/2004_07_07_septics_septic_2002_osdm_all.pdf

[5] Otis, R.J., Boyle, W.C., Converse, J.C., Tyler, E.J. (1977) On-Site Disposal of Small Wastewater Flows. *University of Wisonsin.* https://soilsfacstaff.cals.wisc.edu/sswmp/pubs/13.11.pdf

[6] Small Scale Waste Management Project, University of Wisconsin-Madison (1978) Management of Small Waste Flows EPA-600/2-78-173. *Environmental Protection Agency Wastewater Research Division*.

[7] Otis, R.J., G. D. Plews, and D. H. Patterson (1978) *Design of Conventional Soil Absorption Trenches and Beds* (pp. 86-99). In: Proceedings of the Second National Home Sewage Treatment Symposium, Chicago, Illinois. American Society of Agricultural Engineers.