On-Site Rule Revision Issue –Hydraulic Loading Rates (HLR)
WAC 246-272A-0234 – Table VIII and other sizing criteria

Issue Statement

Section -0234 contains verbiage in the rule regarding the design (this paper is about sizing) of dispersal components. The current version of the rule was adopted in 2005, and implemented state-wide by 2007. Since then, this length of time has given various local health jurisdictions ample time to compile anecdotal data on the perceived ability of these HLR to function when applied in real-world scenarios. Also various sources of research literature have been collected. These pieces of information point to the possibility of increased HLR (smaller dispersal component sizing) combined with a known pre-treatment level.

Consequently, DOH-WWMS ask our Technical Advisory Group (TAG) to consider this possibility. The TAG was provided research findings, and met on May 16, 2019. The TAG made a recommendation from that meeting, intending that decision to go to the ORRC Technical Subcommittee. Somewhat unfortunately, two different versions of the recommendation surfaced, therefore the ORRC Technical Subcommittee received no official issue paper. Fortunately, the Technical Subcommittee did have a good discussion, and from that we came away with some guidance.

DOH again went to the TAG with additional research results. From that review, the TAG provided enough input to DOH to allow DOH to develop the recommended rule changes.

<u>TAG input:</u>

The vote at the May 16, 2019 meeting had a general consensus of agreement to increase the HLRs with TLB. The TAG was unable to meet for the proposed July 2019 meeting. Consequently there was no vote on the increased HLRs for OSS meeting TLC and TLB (and TLA). Some comments were provided via email. These are summarized here:

- ➢ With the higher level of treatment (TLC or TLB), there will be a substantial reduction of the biomat. Recommend a maximum increase of 20%.
- ➢ The Ksat (saturated hydraulic conductivity) of the soil will not be met, however the proposed increase for a soil type 5 is a 50% drainfield size reduction. Two members expressed a concern that the increased HLR for soil type 5 may be too much.
- ➢ Allow a combined reduction with the use of a gravelless distribution technology on a county by county basis – based on their needs and/or geology
- ➢ In some situations the distribution method such as drip, should be considered. A reduction in the loading rate may not be wise.
- ➢ Do not allow any reductions combined with gravelless distribution technology. Problems have been noted with reduced sized gravelless distribution products. A reference to Kitsap County for data was made.
- ➢ Hold the HLR increase at 25%
- ➢ The state should have a statewide permit and data management system to track what happens in the field.
- ➢ The proposed HLRs can be combined with gravelless technology
- ➢ Not all TAG members commented.

The following recommendations will allow increased loading rates (i.e. smaller drainfields) with higher quality effluent. A literature review by staff and the TAG support that these recommendations will provide adequate and appropriate public health protection.

Recommended Rule Language

Blue = Additions ~~Red~~ = Deletions

WAC 246-272A-0234

Design requirements—Soil dispersal components.

(1) All soil dispersal components, except one using a subsurface dripline product, shall be designed to meet the following requirements:

(a) Maximum hydraulic loading rates shall be based on the rates described in Table VIII;

TABLE VIII

Maximum Hydraulic Loading Rate

Soil Type	Soil Textural Classification Description	Loading Rate for Residential Effluent Using Gravity or Pressure Distribution gal./sq. ft./day
1	Gravelly and very gravelly coarse sands, all extremely gravelly soils excluding soil types 5 & 6, all soil types with greater than or equal to 90% rock fragments.	1.0
2	Coarse sands.	1.0
3	Medium sands, loamy coarse sands, loamy medium sands.	0.8
4	Fine sands, loamy fine sands, sandy loams, loams.	0.6
5	Very fine sands, loamy very fine sands; or silt loams, sandy clay loams, clay loams and silty clay loams with a moderate structure or strong structure (excluding a platy structure).	0.4
6	Other silt loams, sandy clay loams, clay loams, silty clay loams.	0.2
7	Sandy clay, clay, silty clay and strongly cemented firm soils, soil with a moderate or strong platy structure, any soil with a massive structure, any soil with appreciable amounts of expanding clays.	Not suitable

Proposed Table VIII

		A (no treatment)	B (any pre-treatment)
Soil Type	**Soil Textural Classification Description**	**Loading Rate for Residential Septic Tank Effluent ~~or Treatment Level E~~ Using Gravity or Pressure Distribution gal./sq. ft./day**	**Treatment Level C + DL3 or better Loading Rate for Residential Effluent Using ~~Gravity or~~ Pressure Distribution gal./sq. ft./day**
1	Gravelly and very gravelly coarse sands, all extremely gravelly soils excluding those with soil types 5 & 6 as the non-gravel portion, and all soil types with greater than or equal to 90% rock fragments.	1.0	**1.2**
2	Coarse sands.	1.0	**1.2**
3	Medium sands, loamy coarse sands, loamy medium sands.	0.8	**1.0**
4	Fine sands, loamy fine sands, sandy loams, loams.	0.6	**0.8**
5	Very fine sands, loamy very fine sands; or silt loams, sandy clay loams, clay loams and silty clay loams with a moderate structure or strong structure (excluding a platy structure).	0.4	**0.6**
6	Other silt loams, sandy clay loams, clay loams, silty clay loams.	0.2	**0.2**
7	Sandy clay, clay, silty clay and strongly cemented firm soils, soil with a moderate or strong platy structure, any soil with a massive structure, any soil with appreciable amounts of expanding clays.	Not suitable	**Not suitable**

(b) Calculation of the absorption area is based on:

(i) The design flow in WAC 246-272A-0230(2); and

(ii) Loading rates equal to or less than those in Table VIII applied to the infiltrative surface of the soil dispersal component or the finest textured soil within the vertical separation selected by the designer, whichever has the finest texture.

(c) Requirements for the method of distribution shall correspond to those in Table VI.

(d) Soil dispersal components having daily design flow between one thousand and three thousand five hundred gallons of sewage per day shall:

(i) Only be located in soil types 1-5;

(ii) Only be located on slopes of less than thirty percent, or seventeen degrees; and

(iii) Have pressure distribution including time dosing.

(2) All soil dispersal components using a subsurface dripline product must be designed to meet the following requirements:

(a) Calculation of the absorption area is based on:

(i) The design flow in WAC 246-272A-0230(2);

(ii) Loading rates that are dependent on the soil type, other soil and site characteristics, and the spacing of dripline and emitters;

(b) The dripline must be installed a minimum of six inches into original, undisturbed soil;

(c) Timed dosing; and

(d) Soil dispersal components having daily design flows greater than one thousand gallons of sewage per day may:

(i) Only be located in soil types 1-5;

(ii) Only be located on slopes of less than thirty percent, or seventeen degrees.

(3) All SSAS shall meet the following requirements:

(a) The infiltrative surface may not be deeper than three feet below the finished grade, except under special conditions approved by the local health officer. The depth of such system shall not exceed ten feet from the finished grade;

(b) A minimum of six inches of sidewall must be located in original undisturbed soil;

(c) Beds are only designed in soil types 1, 2, 3 or in fine sands with a width not exceeding ten feet;

(d) Individual laterals greater than one hundred feet in length must use pressure distribution;

(e) A layer of between six and twenty-four inches of cover material; and

(f) Other features shall conform with the "*On-site Wastewater Treatment Systems Manual*," United States Environmental Protection Agency EPA-625/R-00/008 February 2002 (available upon request to the department) except where modified by, or in conflict with this section or local regulations.

(4) For SSAS with drainrock and distribution pipe:

(a) A minimum of two inches of drainrock is required above the distribution pipe;

(b) The sidewall below the invert of the distribution pipe is located in original undisturbed soil.

(5) The local health officer may allow the infiltrative surface area in a SSAS to include six inches of the SSAS sidewall height when meeting the required absorption area where total recharge by annual precipitation and irrigation is less than twelve inches per year.

(6) The local health officer may permit systems consisting solely of a septic tank and a gravity SSAS in soil type 1 if all the following criteria are met:

(a) The system serves a single-family residence;

(b) The lot size is ~~greater than~~ a minimum of two and one-half acres;

(c) Annual precipitation in the region is less than twenty-five inches per year as described by "*Washington Climate*" published jointly by the Cooperative Extension Service, College of Agriculture, and Washington State University (available for inspection at Washington state libraries);

(d) The system is located outside the twelve counties bordering Puget Sound; and

(e) The geologic conditions beneath the dispersal component must satisfy the minimum unsaturated depth requirements to groundwater as determined by the local health officer. The method for determination is described by "*Design Guideline for Gravity Systems in Soil Type 1*" (available upon request to the department).

(7) The local health officer may ~~increase~~ allow the loading rates ~~as shown in the far right column~~ in Table VIII. ~~up to a factor of two for soil types 1-4 and up to a factor of 1.5 for soil types 5 and 6 if a product tested to meet treatment level D is used.~~ This reduction ~~may~~ shall not be combined with any other ~~SSAS~~ dispersal component size reductions.

(8) Both primary and reserve areas shall be sized at one-hundred percent of the approved loading rate. The local health officer may allow the primary area to be sized with column A or B. The LHO may require the reserve area to use the loading rate in column A for a column B sized primary area.

~~(a) The primary and reserve areas must be sized to at least one hundred percent of the loading rates listed in the second column from the right of Table VIII~~.

~~(b) However, the local health officer may allow a legal lot of record created prior to the effective date of this chapter that cannot meet this primary and reserve area requirement to be developed if all the following conditions are met:~~

~~(i) The lot cannot meet the minimum primary and reserve area requirements due to the loading rates for medium sand, fine sand and very fine sand listed in Table VIII of this chapter;~~

~~(ii) The primary and reserve areas are sufficient to allow installation of a SSAS using maximum loading rates of 1.0 gallons/square foot per day for medium sand, 0.8 gallons/square foot/day for fine sand, and 0.6 gallons/square foot/day for very fine sand; and~~

~~(iii) A treatment product meeting at least Treatment Level D and pressure distribution with timed-dosing is used.~~

Supporting Information

The current proposal is to treat the septic tank effluent (TL E) to Treatment Level C (TL C) and increase the soil Hydraulic Loading Rates (HLR) based on the enhanced effluent treatment.

Hydraulic Loading Rates (HLR) refer to the maximum amount of septic tank effluent in gallons per day per square foot (gpd/sq.ft.) that a drainfield is expected to release into the surrounding soil for final treatment. Loading rates vary by soil type and structure, and are used to determine the (minimum required) size of the drainfield. The higher the HLR, the smaller the size of the required drainfield.

There are several factors that contribute to the ability of soil to treat effluent. The most significant are the soil texture and soil structure. Other critical items include the depth of soil, quality of the effluent, and how much effluent is dosed to the soil over a specified time. Other factors may include the amount of precipitation, temperature, and pH. The current HLR for all soil textures and structures is outlined in WAC 246 272A Table VIII. The WA HLRs are based on the formation of a biomat, from septic tank effluent. The long-term acceptance rate (LTAR) is the amount of wastewater that can be applied each day over an indefinite period of time to a square foot of soil. We will not be addressing the LTAR.

Septic tank effluent (TL E) parameters in the current WAC 246 272A are:

E	125 CBOD5	80 TSS	20 O&G	----Fecal Coliforms #100 ml	---- Nitrogen

Existing TL C parameters:

C	25 CBOD5	30 TSS	---- O&G	50,000 Fecal Coliforms #100 ml	---Nitrogen

Due to the high level of treatment in TL C and TL B, there are minimal suspended solids and the amount of microorganisms is substantially reduced. Without these particulates, the formation of a biomat is minimal. The current WA DOH HLR is based on the existence of a biomat.

The infiltrative surface is where the applied effluent meets the vadose zone. The vadose zone is commonly referred to as the bottom of the trench or bed. Below the infiltrative surface is the vadose zone which is aerated, undisturbed and unsaturated native soil. The vadose zone must be present in all soil profiles to treat the effluent. In the vadose zone, the aerobic microorganisms prevail, digesting anaerobic microorganisms including some pathogens. If the application of effluent exceeds the infiltration ability of the soil, the effluent may not be fully treated and may surface.

The constituents of effluent are adsorbed to soil particles. Microorganisms live in the micropores consuming the suspended solids in the effluent and the associated pathogens traveling in it. The soil micro and macropores provide aeration supporting aerobic bacteria which then out compete the anaerobic bacteria. These processes are sensitive to temperature, pH, oxygen levels and moisture content of the soil. There must be enough retention time in the soil for the aerobic bacteria to outcompete the anaerobic bacteria.

<u>Soil Treatment Units</u>

Soil has structure – macropores and texture - micropores. The macropores provide structure and saturated flow of effluent. The unsaturated micropores provide treatment. The flow is a result of differences in pressure and gravitational potential.

Pressure Potential is determined by the amount of pressure on soil water - usually zero, but there are exceptions:
Flooded Soil
Soil with water tables

Gravitational Potential is determined by the height of water above a reference point - water flows downward under gravity. Water flows from areas of wet soil to dry soil.

Matric Potential is determined by the strength of the attraction of water to the soil matrix - most important for unsaturated flow (dry soils).

"If water is applied below the soil surface, it can move in any direction following the matric potential gradient". (Amador, Joes A. and Loomis, George W.)

The micropores must be unsaturated to provide treatment of the effluent. The flow of effluent in the micropores is a result of differences in matric and gravitational potential and is much slower than saturated flow.

Saturated Hydraulic Conductivity (Ksat)

Saturated hydraulic conductivity is the ease with which pores of a saturated soil transmit water. Formally, it is the proportionality coefficient that expresses the relationship of the rate of water movement to hydraulic gradient in Darcy's Law (a law that describes the rate of water movement through porous media via the relationship among the instantaneous rate of discharge through porous medium and pressure drop at a distance.)

Source: U.S. Department of Agriculture, Natural Resources Conservation Service. National soil survey handbook, title 430-VI. Available online. Accessed 9/13/2012.

Darcy' Law:

"Saturated flow occurs when the soil water (not effluent) pressure is positive; that is, when the soil matric potential is zero (saturated). In most soils this situation takes place when about 95 percent of the total pore space is filled with water. The remaining 5 percent is filled with entrapped air. Saturated hydraulic conductivity cannot be used to describe water movement under unsaturated conditions". (Soil Survey Manual, 1993). The upper limit of the HLR should not exceed 5 – 10% of the Ksat. (Siegrist 2014)

Darcy's Law equation

$Q = -KA\, dh/dl$

Wherein:

Q is the rate of water flow

K is the hydraulic conductivity

A is the column cross section area

dh/dl indicates hydraulic gradient.

The maximum HLR even for a high quality effluent can cause soil clogging and permeability loss if the HLR is too high compared to the saturated soil hydraulic conductivity resulting in clogging. The increase in application rates for higher quality effluent may be limited by the hydraulic properties of the natural soil. (Lowe, K.S. et al). Siegrist points out that a maximum HLR for a given soil should recognize that even a highly treated effluent can cause clogging and permeability loss if the HLR exceeds the clean-water hydraulic conductivity of the native soil (Van Cuyk et al., 2005)

For STE, the HLR typically ranges from 0.24 to 1.2 gal/day /sq. ft. The HLR is limited to 5 - 10% of the saturated hydraulic conductivity. The HLR for a highly treated effluent (packaged biofilter or membrane bioreactor (WA TL A)) can be as high as 10x more without compromising service life or treatment efficiency (Siegrist 2017). The wastewater dispersal method is a very important factor in the success of a higher HLR. Uniform application and therefore uniform infiltration are necessary for the desired treatment. In all of the studies reviewed, uniform, pressurized distribution is required.

Bacteria are primarily removed by filtration which is controlled by soil texture and structure, treatment depth and the presence of unsaturated soil below the infiltrative surface. WERF research did not find that the HLR was a consistent factor in bacterial removal. WERF Final Report states that “other factors, such as oxygen availability, and system age, may be more important than HLR in controlling bacterial removal.” This statement does not speak to the recommended depth of the vadose zone.

“Erickson and Tyler developed a model for soil oxygen delivery based on the oxygen flow of soil properties which include the porosity of soil characteristics such as soil texture, structure, consistence, and the water content, and the supply of oxygen necessary to maintain aerobic conditions. They found that the soil could accept onsite wastewater at rates two to three orders of magnitude higher than the current design loading rates if a clogging mat at the wastewater infiltration surface was limited or not present. The clogging mat controls system design, loading rate and life. Maintaining aerobic conditions at the wastewater infiltration surface could substantially reduce or eliminate clogging. They suggest that to maximize delivery of oxygen, soil components should be shallow, narrow and have separated infiltration areas. Their study developed models that incorporate system depth, geometry, and oxygen diffusion coefficients in soil, allowing efficient loading rates to be estimated. They found that in many cases, oxygen transport will be limiting and therefore the basis for design.” (Erickson, J. and Tyler, E. J.)

The practice of increasing the hydraulic loading rate based on the higher level of effluent quality may be sound based on hydraulics. Purification of contaminants of concern, especially pathogenic bacteria and viruses have not been adequately addressed. The research studies reviewed do not identify the relationship between hydraulic loading rate and quality of applied effluent and their effect on pathogen purification. (Van Cuyk, S. and Siegrist, R.L 2001).

Darby, Tchobanoglous, Nor and Maciolek did a comprehensive study on the intermittent loading of shallow sand filters. One of their conclusions was that if the HLR is increased as well as media size and uniform coefficient and the dosing frequency was increased, these increases were mitigated significantly. They found that as a result of the frequent dosing, the result is small doses of effluent. This results in the development of “thin-film flow through the media and subsequently maximum oxygen diffusion and contact time”.

Tyler 2000 table
** this is not a peer reviewed article and Tyler states that the figures in his table are estimates based on experience and a proponent of further research.

PDF
tyler chart with
hydraulic lilnear loa

An example using the directions for Tyler’s chart:

“Assume a site has a 7% slope on the limiting horizon. From the top of the limiting horizon to the bottom of the infiltration is 36 cm (14 inches). The horizon is a silt loam, abbreviation SIL, with weak, abbreviation 1, fine subangular blocky, abbreviation BK, structure that is friable and not smetitic (expanding clay). The infiltration loading rate for a wastewater with BOD >30 mg L-1 would be 16 L m-2 d-1 (0.4 gpd/ft2) and 24 L m-2 d-1 (0.6 gpd/ft2) if the BOD were <30 mg L-1 the hydraulic linear loading rate is 11.4 L m-1 d-1 (3.0 gpd/ft) regardless of the wastewater type.

For design, there is no need to calculate areas. First determine the linear loading rate from Table 1. From the example above, with a linear loading rate of 11.4 L m-1 d-1 (3.0 gpd/ft) and a wastewater volume of 1700 L d-1 (450 gpd), divide the wastewater volume by the hydraulic linear loading rate to get the length of the system of 46 m (150 feet). The width of a trench is the hydraulic linear loading rate divided by the infiltration hydraulic loading rate. For septic tank effluent and an infiltration hydraulic loading rate of 16 L m-2 d-1 (0.4 gpd/ft2), the width of the system would be 2.3 m (7.5 ft.). This width would be acceptable hydraulically but may not account for the oxygen demand."

The 2002 EPA Onsite Wastewater Treatment Systems Manual has adopted Tyler's 2000 chart as "suggested hydraulic and organic loading rates for sizing infiltration surfaces":

EPA Tyler 4 3.pdf

The Minnesota Rules, Chapters 7080 through 7083 Subsurface Sewage Treatment Systems Program HLR charts follow the University of Minnesota HLRs

Minn Rules charts
on HLR.pdf

Virginia Health Department HLRs, M. Degan ***note that all Pad columns are rescinded

2017-02-07 Loading
Rates VA M Degan.p

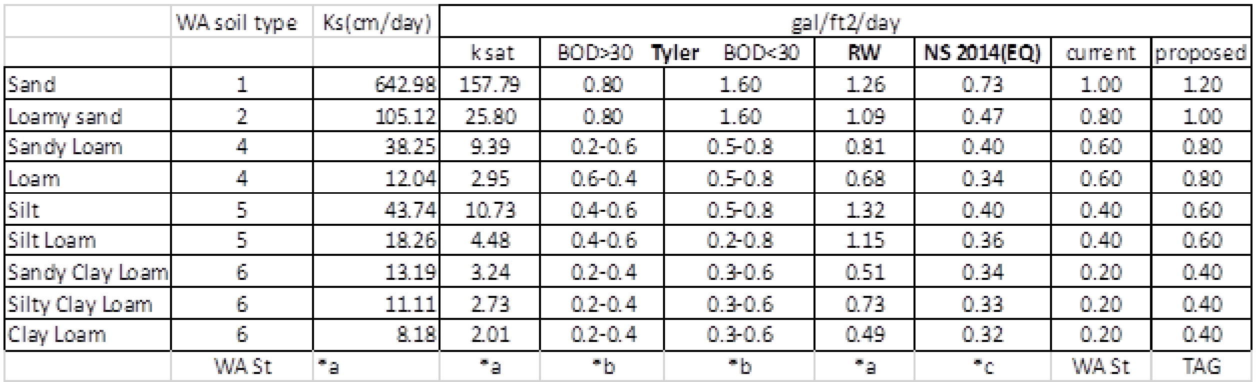
Notes from VA: The Table presents loadings in two forms, square feet of trench bottom per 100 gallons or square feet of trench bottom per bedroom. For this analysis, the square feet of trench bottom per 100 gallons was converted to gallons per day per square foot to create the base loading rates.

Treatment level 2 effluent" or "TL-2 effluent" means secondary effluent as defined in 12VAC5- 610-120 that has been treated to produce BOD5 and TSS concentrations equal to or less than 30 mg/l each. "Treatment level 3 effluent" or "TL-3 effluent" means effluent that has been treated to produce BOD5 and TSS concentrations equal to or less than 10 mg/l each.

The WA Soil FC Reductions chart summarizes several studies listing HLRs, depth of vadose zone, and removal efficiency of effluent fecal coliforms.

FC chart.docx

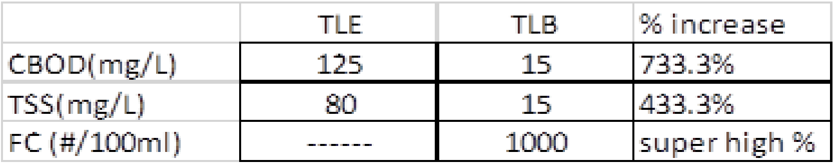
The following 2 charts were compiled from 3 research papers. The compilations are by TAG member Justin Hartmann, Certified Professional Soil Scientist:



	WA soil type	Ks(cm/day)	gal/ft2/day						
			ksat	BOD>30 Tyler	BOD<30	**RW**	**NS 2014(EQ)**	current	proposed
Sand	1	642.98	157.79	0.80	1.60	1.26	0.73	1.00	1.20
Loamy sand	2	105.12	25.80	0.80	1.60	1.09	0.47	0.80	1.00
Sandy Loam	4	38.25	9.39	0.2-0.6	0.5-0.8	0.81	0.40	0.60	0.80
Loam	4	12.04	2.95	0.6-0.4	0.5-0.8	0.68	0.34	0.60	0.80
Silt	5	43.74	10.73	0.4-0.6	0.5-0.8	1.32	0.40	0.40	0.60
Silt Loam	5	18.26	4.48	0.4-0.6	0.2-0.8	1.15	0.36	0.40	0.60
Sandy Clay Loam	6	13.19	3.24	0.2-0.4	0.3-0.6	0.51	0.34	0.20	0.40
Silty Clay Loam	6	11.11	2.73	0.2-0.4	0.3-0.6	0.73	0.33	0.20	0.40
Clay Loam	6	8.18	2.01	0.2-0.4	0.3-0.6	0.49	0.32	0.20	0.40
	WA St	*a	*a	*b	*b	*a	*c	WA St	TAG

*a – (**RW**) West and Radcliffe 2009
*b – **Tyler** (2001)
*c1 – (**NS 2014**) Niec and Spychala (2014) // equation [1] // LTAR = $5K_s - 1.2/(\log_{10}K_s)$

Percentage of treatment increase to TL B by Justin Hartmann:



	TLE	TLB	% increase
CBOD(mg/L)	125	15	733.3%
TSS(mg/L)	80	15	433.3%
FC (#/100ml)	------	1000	super high %

The current WAC 246 272A 0234 (7) states “The local health officer may increase the loading rate in Table VIII up to a factor of two for soil types 1-4 and up to a factor of 1.5 for soil types 5 and 6 if a product tested to meet treatment level D is used. This reduction may not be combined with any other SSAS size reductions.”

Treatment Level D parameters:

D	25 CBOD5	30 TSS	---- O&G	---- Fecal Coliforms #100 ml	----Nitrogen

WAC 246 272A 0234 (8) (a) states:

“The primary and reserve areas must be sized to at least one hundred percent of the loading rates listed in Table VIII.” This means that any increase in the current loading rates listed in the existing Table VIII must be accounted for in the design for both the primary and reserve drainfields. If the new Table with the increased loading rates is approved, the smaller drainfield sizes will be the 100% primary and reserve areas.

The current increased HLR allowance in WAC 246 272A 0234 (7) with effluent quality better than TLD is:

Maximum Hydraulic Loading Rate

Soil Type	**Soil Textural Classification Description**	**Loading Rate for Residential Effluent Meeting /TL D or greater (gal./sq. ft./day)**
1	Gravelly and very gravelly coarse sands, all extremely gravelly soils excluding Soil types 5 & 6, all soil types with greater than or equal to 90% rock fragments.	2.0
2	Coarse sands.	2.0
3	Medium sands, loamy coarse sands, loamy medium sands.	1.6
4	Fine sands, loamy fine sands, sandy loams, loams.	1.2
5	Very fine sands, loamy very fine sands; or silt loams, sandy clay loams, clay loams and silty clay loams with a moderate structure or strong structure (excluding a platy structure.	0.6
6	Other silt loams, sandy clay loams, clay loams, silty clay loams.	0.3
7	Sandy clay, clay, silty clay and strongly cemented firm soils soil with a moderate or strong platy structure any soil with a massive structure any soil with appreciable amounts of expanding clays.	Not suitable

Current TABLE VI

Treatment Component Performance Levels and Method of Distribution[1]

Vertical Separation in inches	Soil Type		
	1	2	3-6
12 < 18	**A** - pressure with timed dosing	**B** - pressure with timed dosing	**B** - pressure with timed dosing
≥ 18 < 24	**B** - pressure with timed dosing	**B** - pressure with timed dosing	**B** - pressure with timed dosing
≥ 24 < 36	**B** - pressure with timed dosing	**C** - pressure	**E** - pressure
≥ 36 < 60	**B** - pressure with timed dosing	**E** - pressure	**E** - gravity
≥ 60	**C** - pressure	**E** - gravity	**E** - gravity

[1] The treatment component performance levels correspond with those established for treatment components under the product testing requirements in WAC 246-272A-0110.

Pharmaceuticals are contaminants of concern in effluent. The impacts of pharmaceuticals in effluent are just beginning to be understood and investigated thoroughly. There is not enough available information to make informed decisions about HLRs that are appropriate for attenuation of pharmaceuticals.

Virus, bacteria and other pathogen attenuation information/studies are emerging. Virus attenuation is generally achieved by dispersion, dilution, and inactivation. (Nicosia et al.) Florida specifies a 0.6 m (2 ft) vertical separation to the water table. A study done by Nicosia et al., indicates that rainfall may cause virus to move downward in the soil column towards the water table. One of their theories is that the vertical separation may not provide sufficient removal of viruses during the wet season.

Another study demonstrated that more movement of viruses occurred in a strongly structured clay than a less structured clay (Pang et al 2008.) This may be due to the easy passage of water in the macropores surrounding the peds. Due to the small size of viruses, they are not considered to be filtered by the biomat as are many bacteria and protozoa.

In aerated conditions, survival of the septic (anaerobic) bacteria and viruses is low because they do not compete well with the aerobic microorganisms. “Acid soils increase the die off of septic bacteria but encourage viral persistence likely due to increased adsorption.” (Loomis 1996).

Water Environment Research Foundation (WERF) 2009 State of the Science: Review of Quantitative Tools to Determine Wastewater Soil Treatment Unit Performance publication sums up factors which primarily control the fate of viruses, bacteria, and protozoa in soil. The report finds that virus treatment is not dependent on soil texture or depth. However, pH and clay mineralogy, organic matter in the effluent and the presence of unsaturated soil below the infiltrative surface are significant factors. Protozoa are primarily removed by mechanical filtration.

More studies are needed in these topics.

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