BCOSSA Technical Review Committee
Technical Bulletin

Title: Linear Loading Rates (LLR)

Subject:

Provides a simplified clarification and guideline for the application of the LLR standards in the SPM V2.

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1. Linear Loading Rates

1.1 Introduction

The SPM V2 in Section 2.3.5 provides LLR standards for use with **all dispersal systems**.

There has been some confusion over this approach. This Technical Bulletin addresses these two types of LLR in turn, providing simplified explanation and clarification.

Section 1 of this bulletin provides simple explanation of the need for consideration of LLR. Section 2 provides clarification of how to apply LLR. Section 3 provides some example calculations.

1.2 Linear Hydraulic Loading rates Rationale and explanation

1.2.1 Vertical separation (VS)

Unsaturated vertical separation below the dispersal cell is needed to treat the effluent in the soil, and particularly for removal of pathogens (disease causing bacteria and viruses).

The amount of vertical separation needed to reliably remove pathogens varies with a large number of factors. More is needed with gravity distribution, coarser soils and with high loading rates. Less is needed when the effluent will spread sideways (laterally) more; this is the case with low hydraulic application rate timed dosing, or fine textured soils, for example.

If the effluent has very low levels of pathogens to start with, then less VS is needed (all else being equal). This is the case for sand mounds and for Type 3 effluent.

Good aeration (oxygen transport) to the dispersal cell and soil helps to make the VS more effective.

Research has demonstrated that, for most simple onsite systems, an unsaturated VS of at least 60cm and is needed to reliably remove pathogens from the effluent applied to the soil where pressure distribution is used. At least 90cm is needed with gravity distribution.

1.2.1.1 VERTICAL SEPARATION STANDARDS IN THE SPM—NOT CONSERVATIVE

The SPM allows for use of systems with shallow vertical separation (VS). Many jurisdictions ask for minimum 90cm VS, whereas in the SPM the minimum is 61cm for pressure distribution. The SPM also includes standards allowing sand mounds with very small vertical separations below the mound.

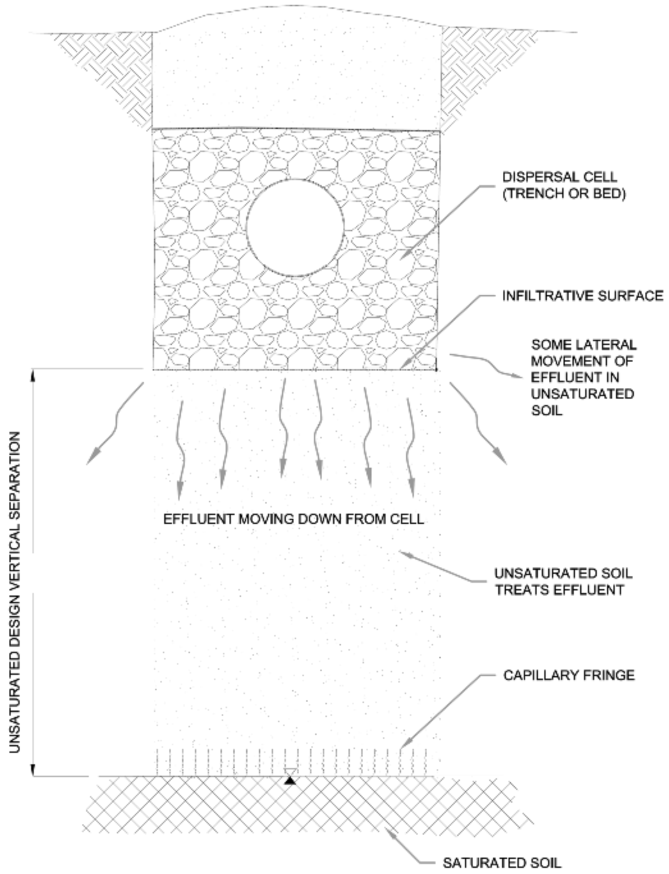
There are some soils which are a particular problem (for VS or for oxygen transport), and the SPM standards in SPM Section 2.3.3 and Table 2-12 as well as in Part 3 standards of the SPM include measures to address these situations. This is done by increases to VS, restrictions on type of application or type of effluent.

The SPM standards for VS are **not conservative**. This is necessary because large areas of BC have shallow soil. It means that special care must be taken to maintain the unsaturated VS over the life of the system on those sites with shallower soils.

This means the water applied to the dispersal area must be moved away. And that enough oxygen must get to the dispersal cell and soils so they work efficiently to remove pathogens.

1.2.2 Capillary fringe

The soil above a water table will become wet by capillary action—water "sucked" up in the small pores of the soil.



This capillary fringe is most saturated near the water table, and less saturated higher up.

Research indicates that reduced treatment in the capillary fringe can use up part of the design VS below the system. The capillary rise is larger in finer soils. Table 1 [1] provides an example of how serious this impact can be.

Table 1 Height of capillary fringe that may adversely affect soil treatment

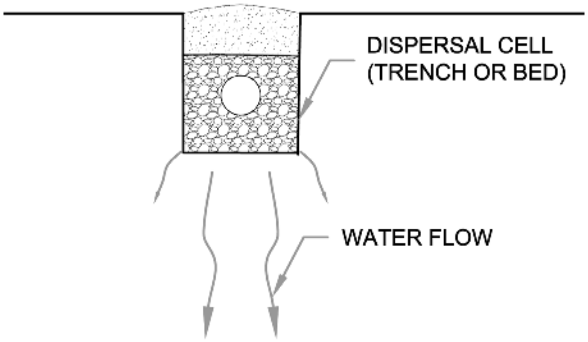
Soil Texture	Adverse effect of the capillary fringe (cm)
Sandy	2
Loamy	15
Clayey	30

The finer soils that suffer more from this problem also have the lowest loading rates, are normally more effective for pathogen removal, and (with proper application of effluent as recommended in the SPM) will have more lateral spread of effluent. These factors offset the affect of the capillary fringe, as long as the minimum design VS is not reduced excessively over time by **groundwater mounding**.

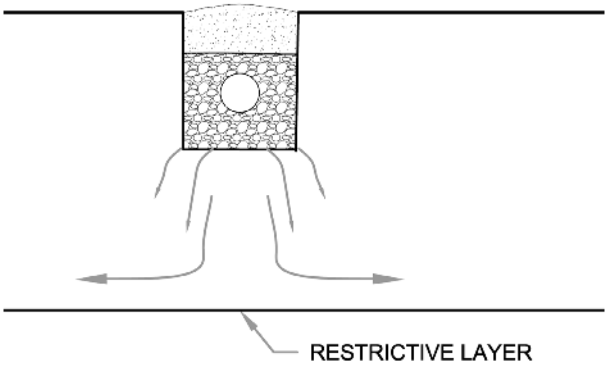
1.2.3 Groundwater mounding

When water is put into the ground by a dispersal system, the water must be able to move away from the site—otherwise the soil will become saturated below the dispersal area.

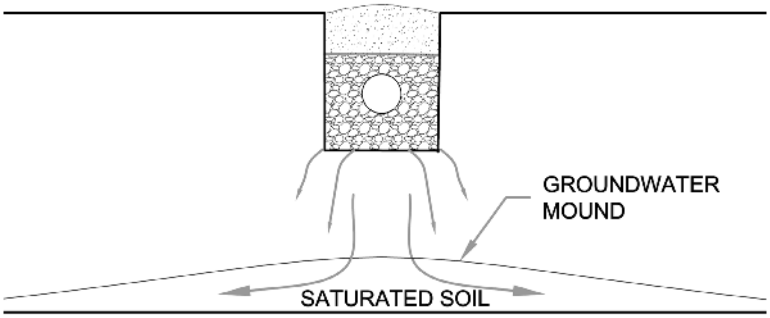
If the dispersal cell (trench or bed) is underlain by deep, permeable soils with no water table much of the water will flow vertically down through the upper soils, VS will not change over time.



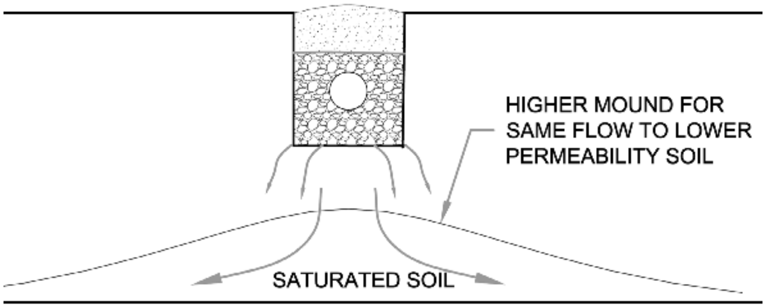
If the dispersal cell is located above a very low permeability layer, the water has to move to horizontally (sideways) to get out from underneath the dispersal area.



To move laterally, the water needs some head pressure to overcome the resistance to movement in the soil. On a flat site, this head can only come from the build up of a "mound" of groundwater under the dispersal area.

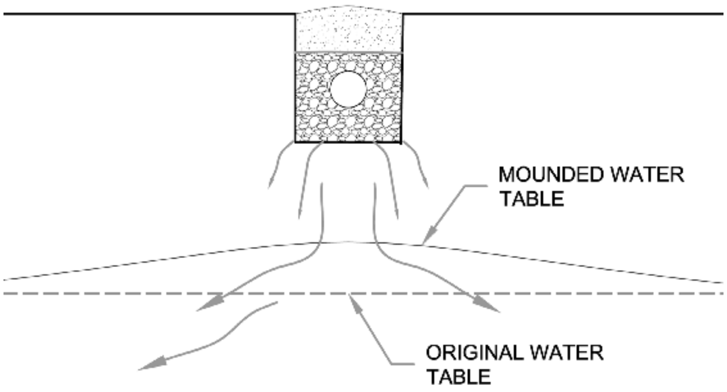


The head pressure drives the flow, and the finer the soil (with smaller pores) the more head is needed to drive the water through the soil, and so the higher the mound will become.

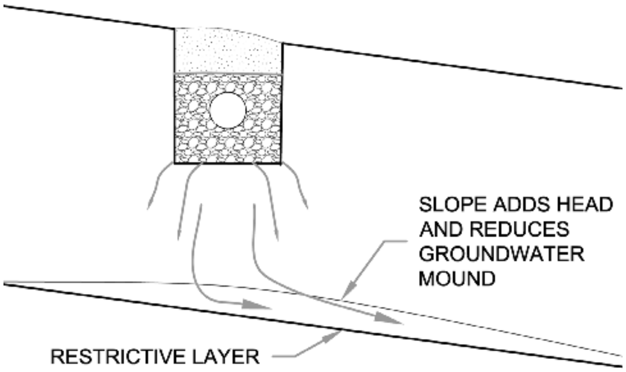


This is much the same with a water table below the dispersal area, the applied water will mound up to overcome the resistance of the saturated soil below the water table to sideways movement of the water.

This is similar to the mound that builds up if you pour thick syrup onto a plate.

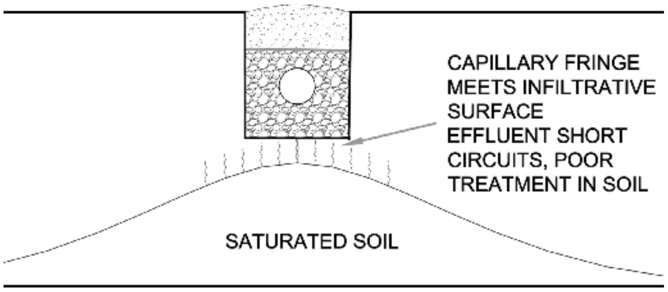


On a sloping site, the head pressure comes from a combination of the slope and the mound, and so the mound will be smaller as the slope gets steeper.



This groundwater mound continues to grow with time, and can reduce the VS below the system quite significantly. In many cases with poorly designed systems the mound will, over time, use up most of the VS.

If the capillary fringe of the groundwater mound rises up to the infiltrative surface, then effluent will short circuit straight to the water table.

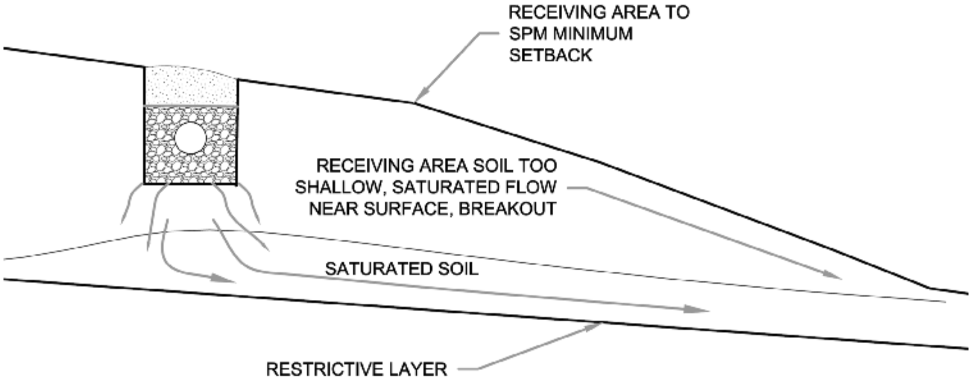


1.2.4 Breakout

On a sloping site the water will move down gradient, usually that means down hill (as long as the restrictive layer follows the shape of the ground).

The **receiving area** is the area of soils downslope of the system. The soil depth in this area is important too, because the water flowing downhill needs a certain depth of soil to do that in. This is similar to a pipe—the larger the pipe, the more flow for the same head.

If the soils in the receiving area are too shallow, the water flowing downhill may reach the surface and break out.



The capillary fringe is a problem here too—even if the water is near the surface contaminated water may wick up and cause a health hazard.

So when considering flow away from the dispersal area one needs to think of the receiving area soils as well as those below the dispersal cells.

1.2.5 Problems with stacking of cells (high LLR)

When water will be flowing laterally from the dispersal area (shallower soils) it is important to make the dispersal area long and narrow.

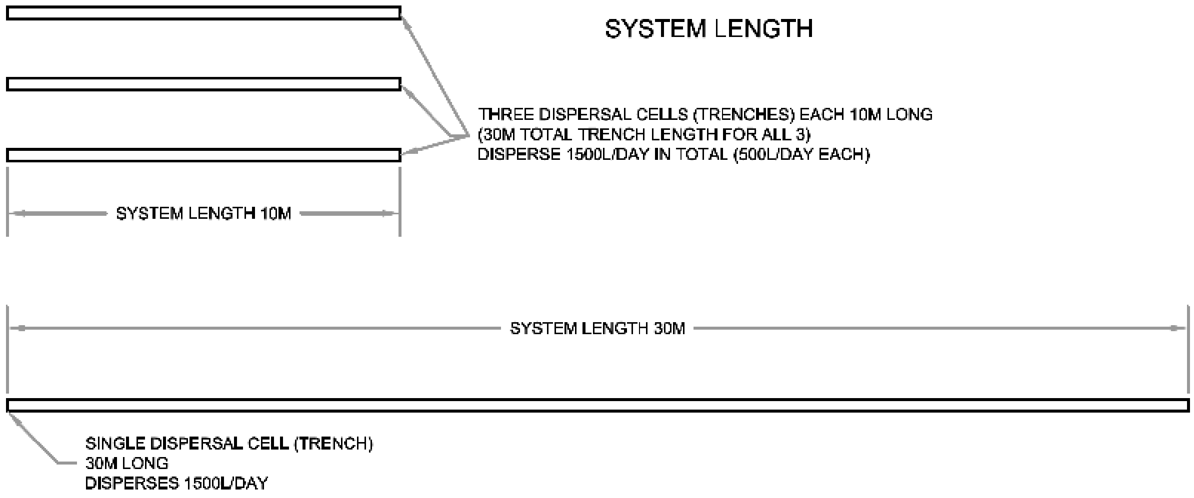
This is because the more effluent applied per meter of length, the more needs to move laterally (sideways) away from that meter—so the more head or the more soil depth needed.

So, for a dispersal area with a design flow of 1500L per day, if the area is 30m long each meter only receives 50L/day, if the same amount is dispersed over a 10m length each meter receives 150L/day.

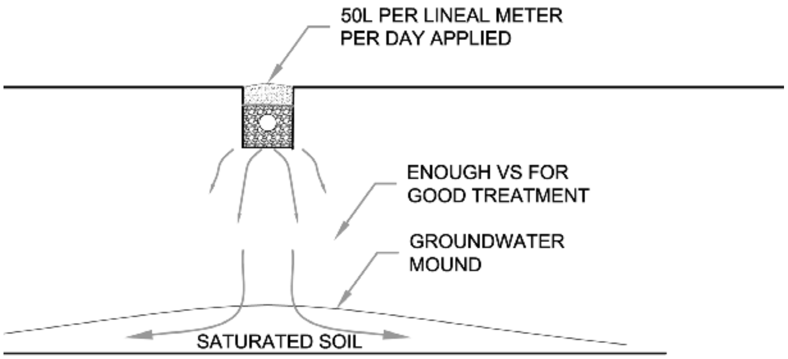
This is called the Linear Loading Rate (LLR).

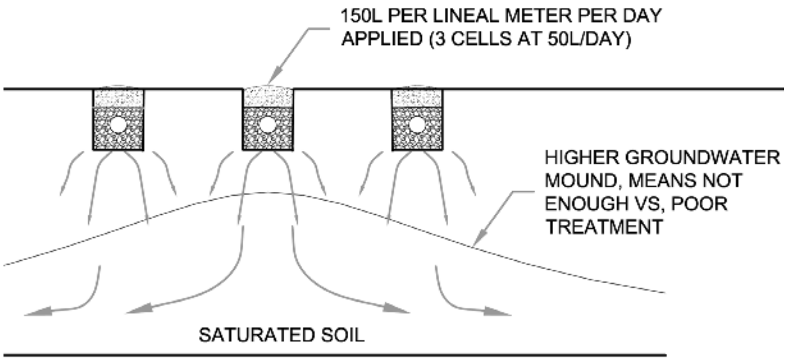
LLR = DDF ÷ SYSTEM LENGTH

SYSTEM LENGTH

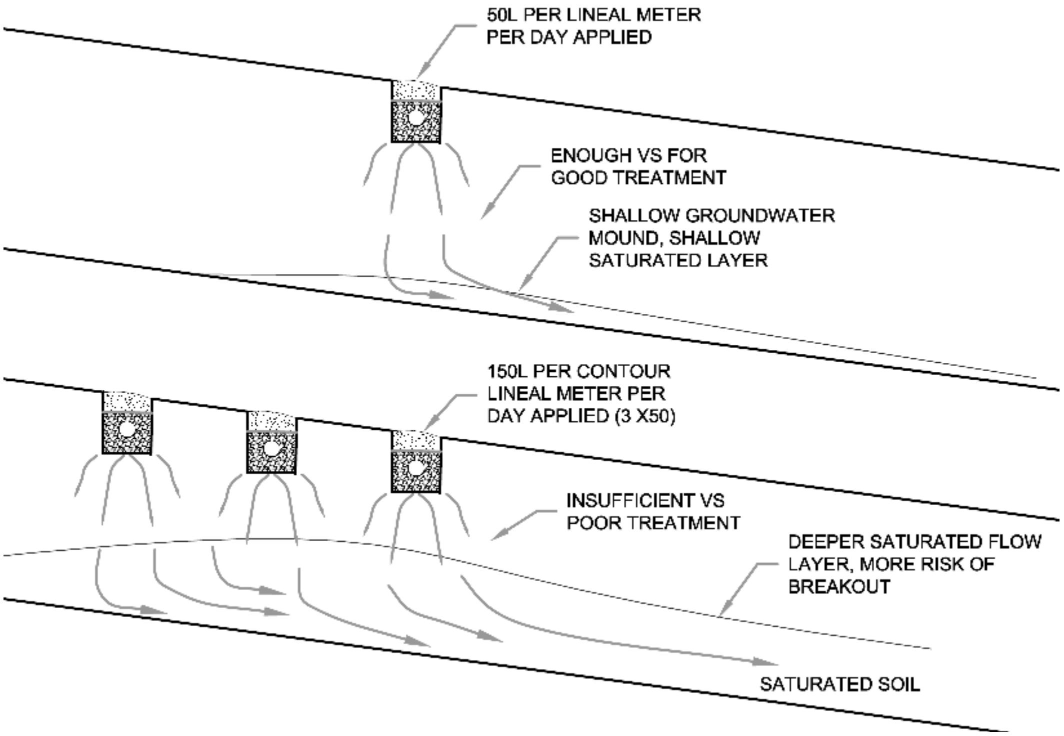


The short system will cause a higher mound on a flat site.





On a sloping site, the mound will be higher and also the amount of effluent flowing downhill per meter of contour length will be higher, and this may be too much for the available soil depth and head—resulting in breakout.



1.2.6 How to design and avoid these problems

For large systems or very difficult sites a professional or hydrogeologist can perform a full scale test to see what will happen, and after interpreting the results design accordingly. Models can also be used by the professional or hydrogeologist.

For most small (and many medium sized) systems this is too expensive and time consuming, so a simplified method is needed to provide conservative assurance that the VS below the dispersal area and in the receiving area will be adequate, and that VS will be maintained for the life of the system.

Since the problem differs with slope and with soil type (permeability) if the method is too simplistic (example a single figure) it will be very conservative for many sites. In some jurisdictions simple methods are used, but these result in the need for large VS for all systems—which would be a problem for many areas of BC.

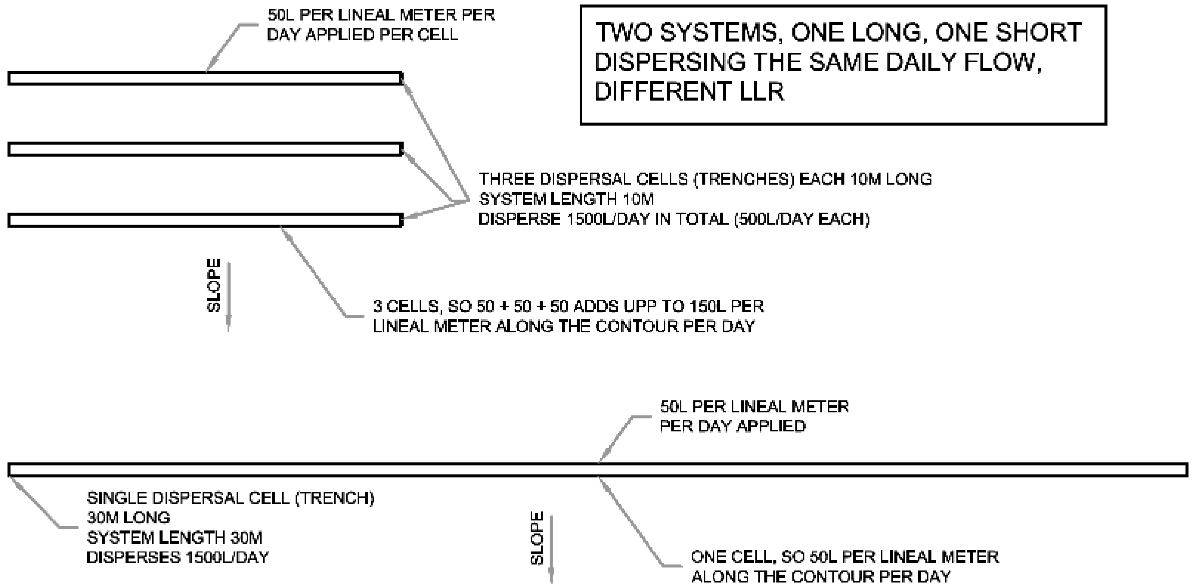
Other jurisdictions use very complex approaches which are less conservative, but harder to apply.

1.2.6.1 LLR tables as a simplified, conservative approach

In BC it was decided to use a method developed by Tyler [2], which is widely used throughout North America. The method is conservative, but that is needed to balance the less conservative VS standards we use in BC.

This method uses a set of LLR tables, which represent the maximum amount of effluent that should be applied per meter of dispersal area length.

This is not per meter of dispersal cell length (e.g. trench length); it is for the whole system along the contour.



The tables take into account:

- soil depth available in the dispersal and receiving area;
- the soil permeability; and
- the slope.

Hydraulic LLR is about moving water away from the dispersal area, so the tables are the same for all types of effluent (Type 1, Type 2 or Type3).

The hydraulic LLR applies to sites where effluent must move away from the dispersal area horizontally (sideways).

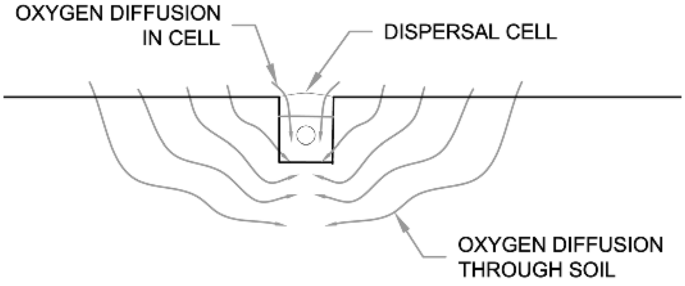
Tyler's method was adapted to address particular issues in BC, including that of small systems on existing small lots.

The SPM provides flexibility in application of the Tyler method, and also allows for site and project specific design by or under the supervision or review of a professional. In this way sites with length constraints are still usable.

1.3 Oxygen Linear Loading Rates Rationale

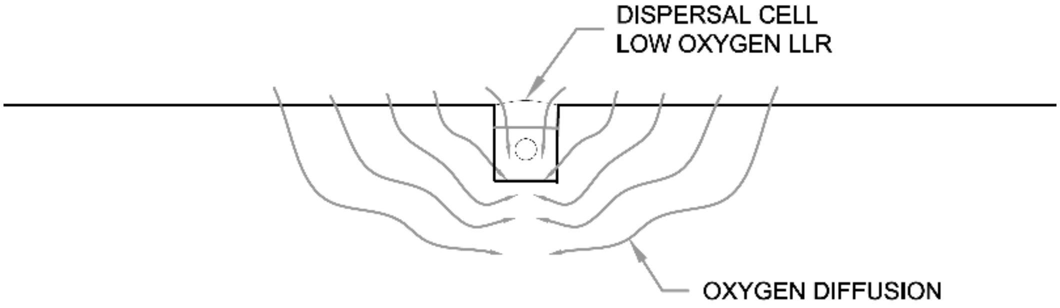
The infiltrative surface of the dispersal cell (example bed) needs a supply of oxygen from the air. This is to allow the aerobic bacteria and organisms to work on the organic matter in the effluent. If the cell does not get enough oxygen the infiltrative surface may plug and cause system malfunction

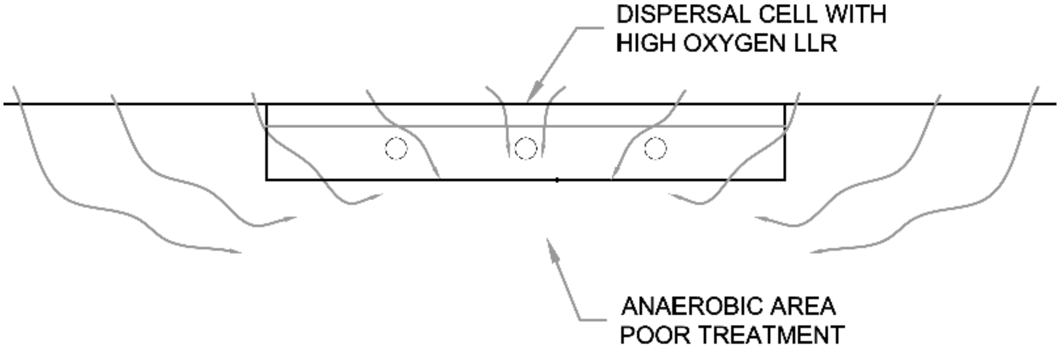
The soils below the dispersal cell also need oxygen, which must come from the air. This is needed to maintain an aerobic environment. If the soil does not get enough oxygen it will not work well to treat the effluent and remove pathogens.



This oxygen has to diffuse through surrounding soil to get to the cell and to the soil below. This is not rapid; it is faster in dry soils and coarser soils. It is faster if the system is shallow so the oxygen has less distance to travel.

If the dispersal cell is long and narrow it needs less oxygen per lineal meter of cell. It is also easier for the oxygen to diffuse into the narrower system as there is less distance to travel.





The maximum permitted effluent load per meter length of cell can be calculated. However, a simpler method was needed to address this and in BC we use two maximum LLR ranges to represent the “oxygen LLR” for a system.

This requirement is similar to that for hydraulic LLR, and so they are considered together.

These apply to **all sites**—whether water will move away vertically or horizontally makes no difference to the oxygen LLR.

Currently these oxygen LLR are not varied based on oxygen demand (Type 3 effluent will demand less oxygen than Type 1), although a professional could vary them for this condition based on calculation with suitable reference per the SPM.

2. Application of LLR

2.1 Long and narrow

Although there is a limit to the length of a single lateral (for good distribution) there is no limit to the length of the system as a whole.

The standards of the SPM result in a recommended minimum system length, you can always make it longer.

2.2 Application of Table 2-11 LLR

2.2.1 Hydraulic LLR (Table 2-11)

For use where flows away from the dispersal area are **largely horizontal**.

The same for all types of effluent.

Vertical flow:

Where vertical separation in native material to the restrictive layer (water table or low permeability layer) below the **infiltrative surface** in the discharge area and receiving area is over 120cm (48") for pressure distribution or over 152cm (60") for gravity distribution, flow is considered to be largely vertical. In these cases, do not need to apply the hydraulic LLR table.

For large systems (over 4500L/day DDF) flat or low slope (<1% slope) sites it is recommended that groundwater mounding calculations or full scale tests be used.

2.2.2 Oxygen LLR (Table 2-11 footnote)

Maximum (oxygen flux) LLRs for oxygen transport. Applies to **all systems**, whether water flow is vertical or horizontal.

Apply **per cell** (example per trench or per bed) as long as the cells are spaced apart. Apply to all systems including sand mounds and sand lined trenches.

Minimum cell spacing is1.83m center to center for trenches, 1.83 m minimum (2.0m or more preferred) between bed edges or edge of cover soil for beds, 6 m minimum between edges of cover soil for at grade beds on clay textured soils or Kfs<60mm/dy-Perc >40min/inch).

For sand mounds and sand lined trenches, apply the oxygen LLR to the bed (where the effluent is applied).

Apply on sloping or flat sites.

- 99 to 124 L/day/m for well structured Silt Loam or more permeable soil types.
- 45 to 60 L/day/m for soil types finer than well structured silt loam/silt.

Divide the DDF by this oxygen LLR to get the minimum system length for oxygen LLR.

Daily Design Flow ÷ oxygen Linear Loading Rate =

minimum Length of System for oxygen LLR

Always make the system as long as possible! Remember that if flow is largely horizontal will also have to meet hydraulic LLR standards.

2.2.3 Applying hydraulic LLR where flow is largely horizontal

Information needed:

- Soil type determined when selecting HLR
- Slope of dispersal and receiving area
- Depth from infiltrative surface to restrictive layer or water table, in dispersal area but also in receiving area.
- Receiving area extends to the limit of the SPM horizontal separation standards for breakout (example 15m for gravity distribution system).

Use this information to select a LLR from Table 2-11.

Divide the DDF by this LLR to get the minimum system length.

Daily Design Flow ÷ Linear Loading Rate =

minimum Length of System for hydraulic LLR

Always make the system as long as possible!

2.2.4 Adjustment of Table 2-11 LLR

2.2.4.1 INCREASES TO LLR (SHORTER SYSTEM):

In all cases must also meet the **oxygen LLR**.

Increases to LLR for all systems

VERTICAL FLOW:

Where vertical separation in native material to a low permeability layer or water table (restrictive layer) below the **infiltrative surface** in the discharge area and receiving area is over 120cm (48") for pressure distribution or over 152cm (60") for gravity distribution, flow is considered to be largely vertical.

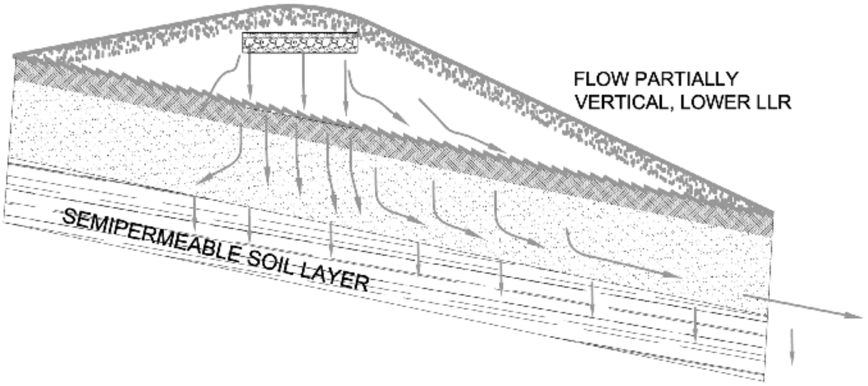
Do not need to apply the hydraulic LLR table.

System must still meet oxygen LLR requirements.

Keep the LLR as low as possible in all cases. This means make the system as long as possible.

PARTIAL VERTICAL FLOW:

Proportional increase in LLR is permitted. This may be difficult to assess, so if you are unsure consult a professional.



SLOPE:

Since greater slope will improve water flow from the dispersal area an increase is allowed.

Only if native soil VS in dispersal AND receiving area is over 12″.

Then if slope is over 15% allows 1.25 x increase.

For slope over 15%

LLR = 1.25 × Linear Loading Rate from Table 2-11

Be careful with very steep slopes since breakout may be a risk; remember to think of the receiving area as well as the dispersal area.

System must still meet oxygen LLR requirements.

SITE REMEDIATION

Vertical separation can be improved, and so allowable LLR increased.

Drainage, raised systems and toe blankets may be used. Drainage should be verified and monitored for effectiveness (see SPM Section 3.7.13 for details). A toe blanket is suitable soil or sand with soil cover installed downslope from the system, including as an extension of the toe area of a sand mound, which serves to effectively deepen available VS in the receiving area. The toe blanket is installed in a similar fashion to sand mound sand install.

Increases to LLR for systems under 9100L/dy DDF where standards cannot be met:

LOW HYDRAULIC APPLICATION RATE (HAR) TIMED DOSING:

Only where 24″ VS in native soil in the dispersal area.

Low HAR timed dosing allows 1.25 x increase, may be applied to LLR already increased by slope 1.25 factor.

Low HAR timed dosing

LLR = 1.25 × Linear Loading Rate from Table 2-11

For slope over 15% and low HAR timed dosing

LLR = 1.25 ×1.25 × Linear Loading Rate from Table 2-11

System must still meet oxygen LLR requirements. Applies to all systems, including sand mounds. The dosing must meet SPM part 3 dosing standards and SPM Appendix Q.

This increase is allowed for two reasons:

- With this type of dosing, soil treatment is much more effective.
- This type of dosing improves lateral spread of effluent by keeping the soils drier, this reduces mounding and increases the amount of water lost to evapotranspiration.

2.2.5 What to do when the site is too short

Increases to LLR for systems under 2500L/dy DDF where standards cannot be met:

Only where 24″ VS in native soil VS in dispersal area, a system with maximum 75 L/day/m LLR may be constructed.

This increase **is not to be used with** sand mounds and sand lined trench systems.

Otherwise

Consult a professional. Professional will use water table mounding calculations, full-scale mounding tests or another appropriate standard method to calculate a design linear loading rate.

This should be fully documented by the professional.

2.2.6 Water table mounding tests or calculations, use of results

It is recommended that the professional, when interpreting the results of full scale tests or water table mounding modelling, adjust system length and or vertical separation to ensure maintenance of the SPM minimum vertical separation standards below the system. The professional should take into account potential soil treatment impact of the capillary fringe.

3. Examples of applying LLR

3.1 Hydraulic LLR for simple site

3.1.1 Site and soils:

- Daily Design Flow 1363L/day
- Loam (Weak blocky, Friable), Kfs 132 mm/Day
- Site slope 12%, 20″ soil depth below proposed infiltrative surface (worst case for receiving area within 7.5m of dispersal area) to restrictive layer.
- Applies for 15m downslope
- No system length constraint

Soil type selected for HLR is Loam (Weak blocky structure).

3.1.2 LLR selection

Flow will be largely horizontal (shallow soil). From Table 2-11, LLR is 50.9L/m/day maximum

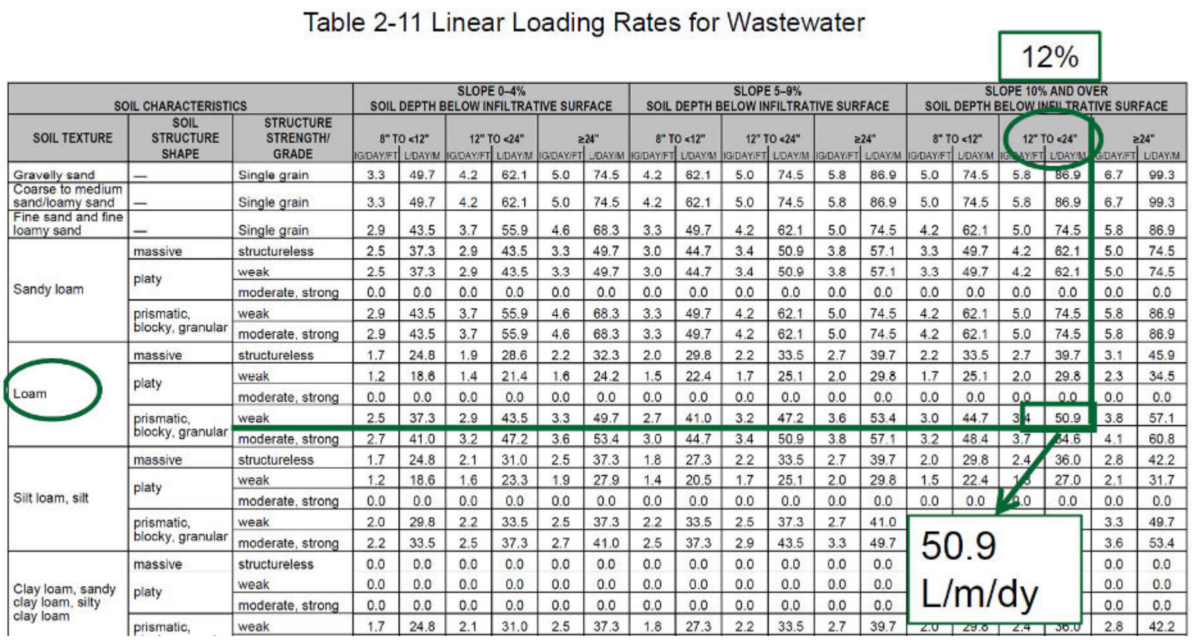


Table 2-11 Linear Loading Rates for Wastewater

SOIL CHARACTERISTICS			SLOPE 0–4% SOIL DEPTH BELOW INFILTRATIVE SURFACE						SLOPE 5–9% SOIL DEPTH BELOW INFILTRATIVE SURFACE						SLOPE 10% AND OVER SOIL DEPTH BELOW INFILTRATIVE SURFACE					
SOIL TEXTURE	SOIL STRUCTURE SHAPE	STRUCTURE STRENGTH/ GRADE	8" TO <12"		12" TO <24"		≥24"		8" TO <12"		12" TO <24"		≥24"		8" TO <12"		12" TO <24"		≥24"	
			IG/DAY/FT	L/DAY/M	IG/DAY/FT	L/DAY/M	IG/DAY/FT	L/DAY/M	IG/DAY/FT	L/DAY/M	IG/DAY/FT	L/DAY/M	IG/DAY/FT	L/DAY/M	IG/DAY/FT	L/DAY/M	IG/DAY/FT	L/DAY/M	IG/DAY/FT	L/DAY/M
Gravelly sand	—	Single grain	3.3	49.7	4.2	62.1	5.0	74.5	4.2	62.1	5.0	74.5	5.8	86.9	5.0	74.5	5.8	86.9	6.7	99.3
Coarse to medium sand/loamy sand	—	Single grain	3.3	49.7	4.2	62.1	5.0	74.5	4.2	62.1	5.0	74.5	5.8	86.9	5.0	74.5	5.8	86.9	6.7	99.3
Fine sand and fine loamy sand	—	Single grain	2.9	43.5	3.7	55.9	4.6	68.3	3.3	49.7	4.2	62.1	5.0	74.5	4.2	62.1	5.0	74.5	5.8	86.9
Sandy loam	massive	structureless	2.5	37.3	2.9	43.5	3.3	49.7	3.0	44.7	3.4	50.9	3.8	57.1	3.3	49.7	4.2	62.1	5.0	74.5
	platy	weak	2.5	37.3	2.9	43.5	3.3	49.7	3.0	44.7	3.4	50.9	3.8	57.1	3.3	49.7	4.2	62.1	5.0	74.5
		moderate, strong	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	prismatic, blocky, granular	weak	2.9	43.5	3.7	55.9	4.6	68.3	3.3	49.7	4.2	62.1	5.0	74.5	4.2	62.1	5.0	74.5	5.8	86.9
		moderate, strong	2.9	43.5	3.7	55.9	4.6	68.3	3.3	49.7	4.2	62.1	5.0	74.5	4.2	62.1	5.0	74.5	5.8	86.9
Loam	massive	structureless	1.7	24.8	1.9	28.6	2.2	32.3	2.0	29.8	2.2	33.5	2.7	39.7	2.2	33.5	2.7	39.7	3.1	45.9
	platy	weak	1.2	18.6	1.4	21.4	1.6	24.2	1.5	22.4	1.7	25.1	2.0	29.8	1.7	25.1	2.0	29.8	2.3	34.5
		moderate, strong	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	prismatic, blocky, granular	weak	2.5	37.3	2.9	43.5	3.3	49.7	2.7	41.0	3.2	47.2	3.6	53.4	3.0	44.7	3.4	50.9	3.8	57.1
		moderate, strong	2.7	41.0	3.2	47.2	3.6	53.4	3.0	44.7	3.4	50.9	3.8	57.1	3.2	48.4	3.7	54.6	4.1	60.8
Silt loam, silt	massive	structureless	1.7	24.8	2.1	31.0	2.5	37.3	1.8	27.3	2.2	33.5	2.7	39.7	2.0	29.8	2.4	36.0	2.8	42.2
	platy	weak	1.2	18.6	1.6	23.3	1.9	27.9	1.4	20.5	1.7	25.1	2.0	29.8	1.5	22.4	[illegible]	27.0	2.1	31.7
		moderate, strong	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	prismatic, blocky, granular	weak	2.0	29.8	2.2	33.5	2.5	37.3	2.2	33.5	2.5	37.3	2.7	41.0	[illegible]	[illegible]	[illegible]	[illegible]	3.3	49.7
		moderate, strong	2.2	33.5	2.5	37.3	2.7	41.0	2.5	37.3	2.9	43.5	3.3	49.7	[illegible]	[illegible]	[illegible]	[illegible]	3.6	53.4
Clay loam, sandy clay loam, silty clay loam	massive	structureless	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	[illegible]	[illegible]	[illegible]	[illegible]	0.0	0.0
	platy	weak	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	[illegible]	[illegible]	[illegible]	[illegible]	0.0	0.0
		moderate, strong	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	[illegible]	[illegible]	[illegible]	[illegible]	0.0	0.0
	prismatic,	weak	1.7	24.8	2.1	31.0	2.5	37.3	1.8	27.3	2.2	33.5	2.7	39.7	2.0	29.8	2.4	36.0	2.8	42.2

3.1.3 Hydraulic LLR minimum system length:

Minimum system length = Daily Design Flow ÷ Linear Loading Rate

= 1363L/day ÷ 50.9L/day/m

= 26.8 meters

Oxygen LLR minimum system length: oxygen LLR for this soil is in the 99 to 124 L/day/m range (higher than the hydraulic LLR), so this will not be a constraint.

3.1.4 Potential system layout:

HLR for this soil from Table 2-8 for Type 1 effluent is 15L/sqm/dy.

AIS = Daily Design Flow ÷ Hydraulic Loading Rate = 1363 ÷ 15 = 90.9 sqm

For 0.61m (2ft) wide trenches, minimum trench length:

Minimum trench length = AIS ÷ trench width = 90.9 ÷ 0.61 = 149 meters.

Divide minimum trench length by minimum system length to get approximate number of trenches. 149 ÷ 26.8 = 5.56 trenches.

Since there is no constraint on system length, use 5 trenches (making the system longer).

Final trench length = minimum trench length ÷ trench number

= 149 ÷ 5 = 29.8 meters

So final system layout will be 5 trenches at 0.61m width and 29.8m length.

3.2 Site with vertical flow

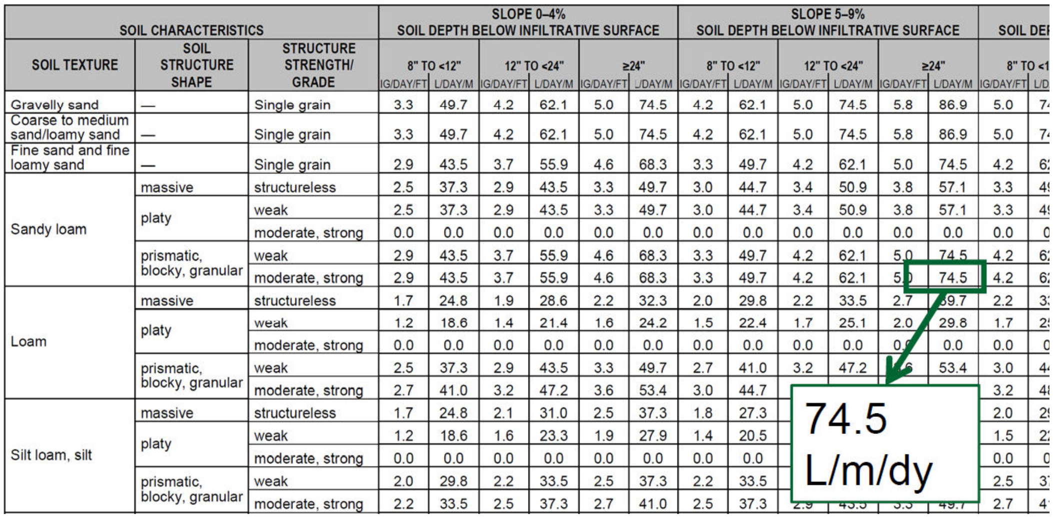
3.2.1 Site and soils

- DDF 1700 L/Day
- Sandy Loam (Strong granular, Loose), Kfs 705 mm/Day
- Site slope 6%, 50″ soil depth below infiltrative surface (dispersal and receiving area) to restrictive layer
- Applies for 7.5m down slope
- System length constraint 15.3m (50 feet)
- Width constraint—bed preferred

Soil type selected for HLR is Sandy Loam (Strong granular structure).

3.2.2 LLR selection

From Table 2-11, hydraulic LLR is 74.5L/m/day maximum.



SOIL CHARACTERISTICS			SLOPE 0–4% SOIL DEPTH BELOW INFILTRATIVE SURFACE						SLOPE 5–9% SOIL DEPTH BELOW INFILTRATIVE SURFACE						SOIL DE	
SOIL TEXTURE	SOIL STRUCTURE SHAPE	STRUCTURE STRENGTH/ GRADE	8" TO <12"		12" TO <24"		≥24"		8" TO <12"		12" TO <24"		≥24"		8" TO <1	
			IG/DAY/FT	L/DAY/M	IG/DAY/FT	L/DAY/M	IG/DAY/FT	L/DAY/M	IG/DAY/FT	L/DAY/M	IG/DAY/FT	L/DAY/M	IG/DAY/FT	L/DAY/M	IG/DAY/FT	L/D
Gravelly sand	—	Single grain	3.3	49.7	4.2	62.1	5.0	74.5	4.2	62.1	5.0	74.5	5.8	86.9	5.0	7
Coarse to medium sand/loamy sand	—	Single grain	3.3	49.7	4.2	62.1	5.0	74.5	4.2	62.1	5.0	74.5	5.8	86.9	5.0	7
Fine sand and fine loamy sand	—	Single grain	2.9	43.5	3.7	55.9	4.6	68.3	3.3	49.7	4.2	62.1	5.0	74.5	4.2	6
Sandy loam	massive	structureless	2.5	37.3	2.9	43.5	3.3	49.7	3.0	44.7	3.4	50.9	3.8	57.1	3.3	4
	platy	weak	2.5	37.3	2.9	43.5	3.3	49.7	3.0	44.7	3.4	50.9	3.8	57.1	3.3	4
		moderate, strong	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
	prismatic, blocky, granular	weak	2.9	43.5	3.7	55.9	4.6	68.3	3.3	49.7	4.2	62.1	5.0	74.5	4.2	6
		moderate, strong	2.9	43.5	3.7	55.9	4.6	68.3	3.3	49.7	4.2	62.1	5.0	74.5	4.2	6
Loam	massive	structureless	1.7	24.8	1.9	28.6	2.2	32.3	2.0	29.8	2.2	33.5	2.7	39.7	2.2	3
	platy	weak	1.2	18.6	1.4	21.4	1.6	24.2	1.5	22.4	1.7	25.1	2.0	29.8	1.7	2
		moderate, strong	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
	prismatic, blocky, granular	weak	2.5	37.3	2.9	43.5	3.3	49.7	2.7	41.0	3.2	47.2	[illegible]	53.4	3.0	4
		moderate, strong	2.7	41.0	3.2	47.2	3.6	53.4	3.0	44.7	[illegible]	[illegible]	[illegible]	[illegible]	3.2	4
Silt loam, silt	massive	structureless	1.7	24.8	2.1	31.0	2.5	37.3	1.8	27.3	[illegible]	[illegible]	[illegible]	[illegible]	2.0	2
	platy	weak	1.2	18.6	1.6	23.3	1.9	27.9	1.4	20.5	[illegible]	[illegible]	[illegible]	[illegible]	1.5	2
		moderate, strong	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	[illegible]	[illegible]	[illegible]	[illegible]	0.0	0
	prismatic, blocky, granular	weak	2.0	29.8	2.2	33.5	2.5	37.3	2.2	33.5	[illegible]	[illegible]	[illegible]	[illegible]	2.5	3
		moderate, strong	2.2	33.5	2.5	37.3	2.7	41.0	2.5	37.3	2.9	43.5	3.3	49.7	2.7	4

Oxygen LLR for this soil type is in the 99 to 124 L/day/m range.

3.2.3 LLR minimum system length:

Minimum system length = Daily Design Flow ÷ Linear Loading Rate

Hydraulic LLR:

Min. Length for hydraulic LLR = 1700L/day ÷ 74.5L/day/m = 22.8 meters

Oxygen LLR (consider range):

Min. length for oxygen LLR = 1700L/day ÷ 99L/day/m = 17.2 meters

Min. length for oxygen LLR = 1700L/day ÷ 124L/day/m = 13.7 meters

3.2.4 Choice of system length:

The hydraulic LLR results in a system too long for the site. However, soil is deep. The SPM states that: "*Where vertical separation in native material to a low permeability layer or water table below the **infiltrative surface** in the discharge area and receiving area is over 120cm (48") for pressure distribution or over 152cm (60") for gravity distribution, flow is considered to be largely vertical*."

If a pressure distribution system is used here then flow is considered vertical and only the oxygen LLR need be considered. So choose a pressure distribution system.

System should still be as long as possible, in this case 15.3 meters (per site constraints).

This fits in the range for oxygen LLR (system length calculated 13.7 to 17.2m).

If a seepage bed is used, check that the bed HLR is OK with this length (due to maximum width constraint for seepage beds). May need to use Type 2 effluent or two beds (spaced minimum 1.83m edge to edge).

3.3 Hydraulic LLR for more difficult site

3.3.1 Site and soils

- DDF 1700 L/Day
- Sandy Loam (Strong granular, Loose), Kfs 705 mm/Day (Same soil type as before)
- Site slope 17%, 30″ soil depth available (dispersal and receiving area) to restrictive layer
- Applies for 7.5m down slope
- System length constraint 15.3m (50 feet)

Soil type selected for HLR is Sandy Loam (Strong granular structure).

3.3.2 LLR selection

Assume system can be installed shallow to give 24″ soil depth below infiltrative surface (dispersal and receiving area).

From Table 2-11, hydraulic LLR is 74.5L/m/day maximum, same as the last example.

Oxygen LLR for this soil type is in the 99 to 124 L/day/m range.

3.3.3 LLR minimum system length:

Minimum system length = Daily Design Flow ÷ Linear Loading Rate

Hydraulic LLR:

Min. Length for hydraulic LLR = 1700L/day ÷ 74.5L/day/m = 22.8 meters

Oxygen LLR (consider range):

Min. length for oxygen LLR = 1700L/day ÷ 99L/day/m = 17.2 meters

Min. length for oxygen LLR = 1700L/day ÷ 124L/day/m = 13.7 meters

3.3.4 Choice of system length:

The hydraulic LLR results in a system too long to fit on the site. At this point the designer must look at a range of strategies and see what will suit the site best.

Strategies include:

- Site remediation, example splitting the system to two areas with an interceptor drain above the lower system (at SPM setback from the upper system).
- Adjustments to LLR

In this example we will try the LLR adjustments. The slope is over 15%, which allows for a 1.25 factor increase in LLR.

This can be used on this site because the soil depth is adequate (meets test that native soil VS in dispersal AND receiving area is over 12″)

LLR = 1.25 × Linear Loading Rate from Table 2-11

LLR = 1.25 × 74.5L/dy/m = 93.1L/dy/m

Min. Length for hydraulic LLR = 1700L/day ÷ 93.1L/day/m = 18.3 meters

This hydraulic LLR is still too long for the site. Low HAR timed dosing allows for a further 1.25 factor increase in LLR.

This can be used on this site because:

- the VS is adequate (meets the test that there is minimum 24″ VS in native soil in the dispersal area)

- DDF is under 9100L/dy and
- the system will not fit without further adjustment to LLR.

LLR = 1.25 × hydraulic LLR *(including other adjustments)*

LLR = 1.25 × 93.1L/dy/m = 116.4L/dy/m

Min. Length for hydraulic LLR = 1700L/day ÷ 116.4L/day/m = 14.6 meters

Available length is 15.3m, this hydraulic LLR fits within that length.

15.3m length also addresses oxygen LLR (per previous example).

Plan the system at 15.3m length (as long as possible). Use shallow placed system, with pressure distribution and low HAR timed dosing.

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