APPENDIX 1 - NOTES TO ACCOMPANY LAND CAPABILITY RATING TABLES

1. Total amount of water available to plants

This parameter is a measure of the amount of usable water in the soil for plant growth. It is determined from the difference between the amount of water retained by the soil after drainage (field capacity) and the moisture content of a soil at wilting (permanent wilting point). There is a reasonable correlation between soil texture and AWC (Salter and Williams 1969) viz;

Available Water Capacity **Texture**

Range	Average value for Calculations(mm/m)	Sands	Sandy	Loams	Clay	Clays
76-100	90	KS				
101-125	110	LKS	KSL			
126-150	130	S				SC, C
151-175	160	CS, LS	SL	L	SCL	
176-200	190	FS	FSL	CL, ZL	ZCL	ZC
201-225	210	LFS				

The total amount of water available to plants can be calculated by adding the amount of available water in each horizon down to a maximum depth of 2 metres, e.g.

Soil horizon	Texture	Depth of horizon mm/m	AWC of horizon	Avail. water in horizon (mm)
A	SL	0.15	160	24
B2	SC	1.25	130	143
		TOTAL AMOUNT OF WATER:		167 (Class 2)

2. Bearing capacity

For the Newham/Woodend and Marong land capability studies, these measurements were not taken. A simple, repeatable field measurement is being sought.

3. Coarse fragment sizes

Cobbles : 60 - 200 mm
Stones : 200 - 600 mm
Boulders 600 - 2000 mm

4. Linear Shrinkage

The Linear Shrinkage and depth of solum can replace the value for reactivity of a soil. Reactivity is used in the Australian Standard AS 2870.2 (1990) p. 16, and is based on the depth of the clay layer and its shrink-swell capacity. Different areas of Victoria are identified, with 0.6 m depth being a common cut-off mark between two categories. A table comparing the two values with Classes 1-5 is required.

5. Condition of the topsoil

The texture, organic matter content and the size/strength of soil aggregates all influence the general behaviour of soils when subjected to different agricultural land uses and management practices. The lack of knowledge relating the performance of soils to specific attributes does not allow values for the above criteria to be divided into meaningful classes - certainly not the 5-class system used in these land capability rating tables. The concept of "Condition of topsoil" combines the score placed on each criteria to give a total score which is then compared to a 5-class rating, viz.

Criteria	Description	Score
Texture	Sands	1
	Sandy loam's	2
	Loams	5
	Clay loam's	4
	Clays	3
Structure	Apedal, massive	1
(Grade)	Apedal, loose	2
	Weak	3
	Moderate	4
	Strong	5
Structure	Very large (> 200 mm)	1
(size)	Large (50 - 200 mm)	2
	Moderate (10 - 50 mm)	4
	Small (2- 10 mm)	5
	Very small (< 2 mm)	3
Organic matter content	Very low (< 1%)	1
(Org.0 x 1.72)	Low (1 - 2%)	2
	Moderate (2 - 3%)	4
	High (> 3%)	5
Nutrient status of topsoil*	Very low (<4 m.e.%)	1
(= sum of exch. Ca.Mg.K)	Low (4-8 m.e.%)	2
	Moderate (9-18 m.e.%)	3
	High (19-30 m.e.%)	4
	Very high (>30 m.e.%)	5

Rating for topsoil condition:

Class	Total Score
1	21 -25
2	16-20
3	11 -15
4	6-10
5	1-5

6. Depth of clay layer

This parameter identifies if there is a need to import clay or use a sealant for the dam bottom. For example, the red duplex soils on the Riverine Plain have only 25-30 cm of clay overlying the more permeable C horizon of alluvium.

7. Depth to hard rock or impermeable layer

This criterion provides a measure of the effectiveness of the soil profile in filtering the nutrient and bacterial content from the effluent. The EPA Septic Tank Code of Practice (1991) requires an arbitrary depth of at least one metre.

8. Depth to seasonal watertable

The EPA Septic Tank Code of Practice (1991) requires a minimum of 1 m depth of unsaturated soil for the proper functioning of effluent disposal trenches. Ideally the groundwater table should be much lower than 1 m, thereby reducing the risk of a rising groundwater table influencing the effectiveness of the absorption trenches. The risk of surface salting problems also increases when a saline groundwater table rises to within 1-1.5 m of the soil surface.

9. Depth of topsoil

This measurement has been excluded since major differences in the topsoil depth do not influence the performance or stability of an earthen dam. Topsoil depth only influences the quantity of overburden that needs to be scraped clear and kept for spreading back on the embankment to establish a grass cover, once the construction is completed.

10. Dispersibility

Sustainable land use requires that the soil be able to withstand the physical forces of cultivation and compaction without adverse structural change. Soil aggregate stability can be measured by the Emerson Aggregate Test (Emerson 1977).

Because of the close correlation between dispersible soils and high exchangeable sodium percentages in those soils, it is unnecessary to include both criteria in the capability rating table.

11. Drainage

This parameter is the culmination of several criteria that influence the moisture status of the soil profile, viz slope, sub-surface and surface flow, water holding capacity, level of groundwater tables, perched or permanent, and permeability. Only because of its general usage, reasonable definition (McDonald et al, 1984) and direct relevance to effluent disposal fields and building foundations has this criterion been retained.

12. Electrical conductivity (Ns cm-l)

The electrical conductivity of a 1:5 soil-water suspension is a good indicator of the total dissolved salts - soil salinity - in a soil (USDA, Handbook No. 60, 1954, Matters and Bozon 1989). The following correlation between the electrical conductivity of soil samples taken from the 0 - 50 cm layer of the soil profile and soil salinity has been established:

Class	Severity of	E.C. μs cm^{-1} * salting	Site characteristics
1	Nil/Very low	< 300	Plant growth unaffected
2	Low	300 - 530	Growth of salt-sensitive plants Is restricted, e.g. cereals, clover
3	Moderate	530 -1260	Patchy pasture growth; salt-sensitive plants are replaced with species that are more salt tolerant
4	High	1260 - 2500	Small areas of bare ground; surviving plant species have high salt tolerance
5	Very high/ severe	> 2500	Large areas of bare ground; highly salt-tolerant plants; trees may be dead or dying

NB: 1000 μs cm^{-1} = 1 ds m^{-1}

13. Flooding risk

Building regulations prohibit building on flood-prone land, therefore land with some risk of flooding must be identified. Flooding is unlikely to cause a septic tank to fail, however the risk of polluting the floodwaters with P, N and bacterial organisms Increases with the number of effluent disposal fields Involved. The dilution factor will be dependant on the quantity of floodwater.

Dams are built to intercept and store runoff water. It is not possible in these tables to distinguish between seasonal runoff and seasonal flooding; the latter poses a threat to the stability of the dam, and the risk of flooding will depend on the intensity and duration of rainfall, the runoff characteristics of the catchment and the land use within the catchment. The location of the dam and the design of the overflow structure will greatly reduce the adverse effect of floods.

14. Length of the growing season

Agricultural production is governed by moisture, temperature and photoperiod (photoperiod is taken to be consistent throughout Victoria).

Length of growing season = 12

minus No. of months where P (monthly Et > Av. monthly R) > 50% (Newham & Woodend = 5)
minus No. of months were ay. mean monthly temp. < 60C (Newham & Woodend = 1)

where P : Probability
Et : Evapotranspiration
R : Rainfall

15. No. of months/yr when average daily rainfall > Ksat.

This parameter is included (although it is closely aligned to Drainage) to provide an indication from climatic, rather than soil and topographic data, of the period of time each year when effluent absorption trenches might cease to function.

Data required:	Average monthly rainfall figures Average number of wet days for each month Ksat values
Assumptions made:	Evapotranspiration = 0 for winter months The winter-early spring months are usually when problems arise The soil profile is at field capacity Where slope is significant, runoff = run-on

16. Nutrient status of topsoil

The topsoil is considered the major source of nutrients for plant growth whereas the subsoil is the more reliable source of moisture. Nutrient status of topsoil = sum of exchangeable base cations (Ca, Mg, K) (Lorimer & Schoknecht, 1987) and should be calculated on the A_1 and A_2 horizons separately because of major differences in these horizons of some profiles.

17. Permeability of a soil profile (Ksat.)

Permeability is controlled by the least permeable layer of a soil profile and its ability to transmit water; permeability is independent of climate and surface drainage. The rate at which water moves down through the soil profile is also an indicator of the tendancy of a soil to saturate - an important feature if plant growth is to be maintained in areas where rainfall is spasmodic or unreliable. High permeability in high rainfall areas and low permeability in low rainfall areas could be an advantage for plant growth.

Permeability provides a measure of the rate at which a saturated soil profile will conduct water to depth. Ksat. measurements may give an over-estimated value for the disposal of effluent because the soil macropores are transmitting water, whereas the real situation must take into account the clogging effect of effluent on the bottom of effluent disposal trenches, thereby reducing the rate of water movement into the soil. Ksat. values have been measured using the Double-ring infiltration method which has been correlated by Lorimer, Bowman and Boyle (unpubl.) to the Auger-hole method used by the EPA in "A Code of Practice for Septic Tanks -1991 ".

The measurement of Ksat. often produces quite variable results even between replicates on the same site, so the setting of class limits is difficult and by necessity must be very broad. Estimates of permeability can be made using the features of the least permeable soil horizon if Ksat. values are not available, however it should be clearly indicated where estimates have been made, viz.

Estimated permeability	K_{sat} range	Time taken for saturated soil to drain to field capacity	Soil features
Very slow	< 10 mm/d	Months	Absence of visible pores.
Slow	10 -100 mm/d	Weeks	Some pores visible.
Moderate	100 - 500 mm/d	Days	Moderate blocky structure; clearly visible pores.
Rapid	500 -1500 mm/d	Hours	Large, continuous clearly-visible pores.
Very rapid	1500 - 3000 mm/d	Rarely saturated	Abundant large pores.
Excessive	> 3000 mm/d	Never saturated	No restriction to water movement through the soil profile.

18. Index for permeability - rainfall

This relationship has been included to take into account the situation where a strongly structured soil with very high permeability would be assessed as having a major limitation. In a dry climate, this would be correct because the soil would be drought-prone most of the year, however in a high rainfall area such a soil may be highly productive. Conversely a soil with low permeability may experience waterlogging for extended periods in a high rainfall area, but store sufficient moisture to extend the average growing season of a low rainfall area. A method of combining permeability and rainfall is shown below:

Index for permeability/rainfall						
Permeability		**Average annual rainfall (mm/yr)**				
Estimated	**Ksat mm/d**	**< 400**	**400 - 600**	**600 - 800**	**800 - 1000**	**> 1000**
Very slow	< 10	High	High	Moderate	Low	Very low
Slow	10 - 100	High	Very high	High	Moderate	Low
Moderate	100 - 500	Moderate	High	Very high	High	Moderate
Rapid	500 - 1500	Low	Moderate	High	Very high	High
Very rapid	> 1500	Very low	Low	Moderate	High	Very high

19. Rock outcrop

This estimate has not been included as a parameter which influences the performance of earthen dams because the parameter, depth to hard rock, is inversely correlated to the proportion of rock outcropping at the soil surface, and is a good surrogate.

20. Slope

As the slope increases, so too does the chance of run-on water entering effluent disposal trenches and saturating the system. In addition, runoff of unfiltered effluent is more likely to enter minor drainage depressions and water courses. The increasing incidence of algal blooms in water storages emphasises the need to eliminate the entry of unfiltered effluent into watercourses.

The best ratio of earth moved : water stored occurs on land with slopes between 3-7%. Gentler slopes involve greater expense as the above ratio approaches unity, whereas steeper slopes require higher embankments for proportionally less water stored.

21. Susceptibility to gully erosion

No single factor can adequately represent the susceptibility of an area to the gully erosion process. A number of factors are involved and each should be scored independently and then the sum of the scores can be related back to a 5 - class rating

Criteria	Description	Score
Slope	< 1%	1
	1 -3%	2
	4-10	3
	11 -32	4
	> 32	5
Sub-soil dispersibility	El	5
	E2,E3.1,E3.2	4
	E3.3, E3.4	3
	E4, E5	2
	E6	1
Depth to rock/hardpan	0 - 0.5	1
	0.6 - 1.0	2
	1.1 - 1.5	3
	1.6 - 2.0	4
	> 2.0	5
Subsoil structure	Apedal, massive	1
	Weak fine, < 2 mm	3
	mod. 2 -10 mm	2
	coarse, > 10 mm	1
	Mod. fine, < 2 mm	4
	mod. 2 -10 mm	3
	coarse, > 10 mm	2
	Strong fine, < 2 mm	5
	mod. 2 -10 mm	3
	coarse, > 10 mm	1
	Apedal, loose	5
Lithology of substrate	Basalt	1
	Volcanic	2
	Rhyodacite	2
	Granite	4
	Alluvium	3
	Colluvium	5
	Tillite	4
	Sediments	
	Ordov.sandst./mudst.	5
	Silur.sands/mudst.	4

Rating for susceptibility to gully erosion:

Class	Total score
1	1 -10
2	11 -13
3	14-17
4	18-20
5	21 -25

22. Susceptibility to slope failure

The instability of slopes in a catchment area of a dam poses a threat to the storage capacity of that dam. Additional costs are also involved if the dam requires regular desludging. This assessment considers that land slips are the result of factors such as, soil depth, slope, soil texture, volume of water held in the soil, and the permeability of the solum and the underlying parent material. Since the quantity of water in a profile is itself a product of soil texture, depth and permeability, the table below is presented as a first attempt to assess the susceptibility of land to slope failure by relating the total amount of water in the soil profile to the slope.

Susceptibility to slope failure			
Total amount of water in the soil profile			
Slope	**Low** **< 70 mm H2O**	**Moderate** **70-170 mm H2O**	**High** **> 170 mm H2O**
Gentle, < 10%	Very low	Very low	Low
Moderate, 10-32%	Low	Moderate	High
Steep, > 32%	Moderate	High	Very high

23. Susceptibility to sheet/rill erosion by water

The table below has been adapted from Elliott and Leys (1991). The erodibility index for a range of soil properties closely relates to the susceptibility of soils to erosion by water, and in the tables below, the same soil properties have been used (texture, structure grade, topsoil depth and dispersibility (Emerson Aggregate Test)) and then related to slope to determine a rating for susceptibility. The final rating for susceptibility to sheet/rill erosion is read off Table 2 once the erodibility of the topsoil and the slope of the area have been assessed.

Table 1 Erodibility of Topsoils

Texture Group (A1)	Structure Grade (A1)	Horizon Depth (A1 + A2)	Dispersibility		
			VL-L $E_{3.4/3}$,E_4,E_5	M-H E_2,$E_{3.2/1}$	VH E_1
Sand	apedal	< 0.2m	M		
		0.2-0.4m	L		
		> 0.4m	L		
Sandy Loam	apedal	< 0.2m	M	H	
		0.2-0.4m	L	M	
		> 0.4m	L		
	weakly pedal	< 0.2m	H	E	
		0.2-0.4m	M	V	
		>0.4m	M		
Loam	apedal	< 0.2m	M	H	
		0.2-0.4m	L	M	
		> 0.4m	L		
	weakly pedal	< 0.2m	H	E	
		0.2-0.4m	M	V	
		> 0.4m	M		
	peds evident	< 0.2m	H	E	
		0.2-0.4m	H		
		> 0.4m	H		
Clay Loam	apedal	< 0.2m	M	H	
		0.2-0.4m	L	M	
		> 0.4m	L		
	weakly pedal	< 0.2m	H	E	
		0.2-0.4m	M	V	
		>0.4m	M		
	peds evident	< 0.2m	H	E	
		0.2-0.4m	H	E	
		> 0.4m	M		
Light Clay	weakly pedal	< 0.2m	H	E	E
		0.2-0.4m	M	V	E
		> 0.4m	M	V	E
	peds evident	< 0.2m	M	V	E
		0.2-0.4m	M	H	E
		> 0.4m	M	H	E
	highly pedal	< 0.2m	H	E	
		0.2-0.4m	M	V	
		> 0.4m	M	V	
Medium to Heavy Clay	weakly pedal	< 0.2m	M	H	E
		0.2-0.4m	M	H	V
		> 0.4m	M	H	V
	peds evident	< 0.2m	H	E	E
		0.2-0.4m	M	V	E
		>0.4m	M	V	E
	highly pedal	< 0.2m	H	E	E
		0.2-0.4m	M	V	E
		> 0.4m	M	V	E

L - Low M - Moderate H - High VH - Very High E - Extreme

Table 2 Susceptibility to Sheet/Rill Erosion *

Topsoil erodibility (from Table 1)					
Slope	**Low**	**Moderate**	**High**	**Very high**	**Extreme**
< 1	Very low	Very low	Low	Low	Moderate
1-3 %	Very low	Low	Moderate	Moderate	High
4-10%	Low	Moderate	High	High	Very high
11-32%	Moderate	High	Very high	Very high	Very high
> 32%	High	Very high	Very high	Very high	Very high

* Topsoil erodibility is determined from the texture, structure, depth and dispersibility of the topsoil (Table 1). The susceptibility of the topsoil to sheet/rill erosion relates to the combined effect of slope and topsoil erodibility (Table 2).

24. Susceptibility to erosion by wind (Lorimer 1985)

The susceptibility of land to wind erosion (S. wind) is expressed as a function of soil erodibility, the probability of erosive winds (Pew) when the soil is dry and the exposure of the land component to wind Ew; viz. S. wind = f(Se . Pew . Ew). Although Pew and Ew are important, the soil erodibility (Se) is the initial, most important factor to assess for the land capability rating tables.

Soil erodibility (Se)		Rating
1	Surface soil has a strong blocky structure (aggregates > 0.8 mm), or is apedal and cohesive or has a dense layer of stones, rock or gravel	Very low
	Surface soil has strong fine structure (aggregates < 0.8 mm)	Moderate
	Surface soil has a weak-moderate structure or is apedal and loose	2
2	Surface soils with organic matter > 20%	High
	Surface soils with organic matter 7 - 20%	Moderate
	Surface soils with organic matter < 7%	3
3	Surface soils with the following texture:	
	Fine-medium sands	Very high
	Loamy sands	High
	Sandy loams, silty loams	High
	Loams, coarse sands	Moderate
	Clay loams	Low
	Clays	Very low

25. Transpiration beds

Transpiration beds are more suitable than absorption trenches when:

- i) soil depths are shallow, e.g. < 75 cm deep
- ii) and/or when Ksat. values are low, e.g. < 10 mm/day
- iii) and/or when rainfall is < 900 mm/yr.

26. Unified Soil Group

As this classification is an interpretation of several soil parameters, the original data may as well be used. It is an oversimplification to say that a CH fits into a Class 3 or a CL fits into a Class 2, because the actual clay percentage, the dispersibility and the linear shrinkage of that clay, all influence the ability of that soil to behave as desirable material for an earthen dam.