WATER BALANCE ANALYSIS WORKSHOP SESSION

Calculation of evapotranspiration-absorption area basal area by the water balance method.

Using the following information and your Course Notes, calculate the minimum basal area of an evapotranspiration-absorption area for a three bedroom / five person dwelling with tank water supply.

Bureau of Meteorology rainfall and pan evaporation data for the nearest station and appropriate crop factor data is provided below.

Site name: HOBART AIRPORT WEST					**Site number:** 094008							
Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Decile 5 (median) rainfall (mm)	32.2	27.2	29.3	28.5	30.5	27.9	31.2	42.1	34.4	39	40.3	43.4
Mean daily evaporation (mm)	6.3	5.5	4.2	2.9	1.9	1.3	1.4	2	3.1	4.1	4.9	6
Crop factor	0.8	0.8	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8

Three test pits excavated on the proposed effluent application area indicate that the soils are 475 mm weakly structured clay loam overlying moderately structured light clay to a depth of 2,000 mm. Use the recommended design loading rate derived from Table L1 of AS/NZS 1547:2012 (see the Field Workshop and Design Exercise section of these Course Notes).

Assume the site has a 5% slope.

Calculate the evapotranspiration-absorption area using the worksheet provided on the following page.

The evapotranspiration-absorption area is to be constructed of imported aggregate and is to have a maximum depth of 400 mm with a minimum of 50 mm freeboard (i.e. maximum depth of stored effluent is 350 mm).

Calculation of irrigation area by the water balance method.

For the same scenario, but with a slope of 12% and assuming the soil has no storage (i.e. has a void space ratio of 1.0), calculate the required irrigation area.

Key site and soil data is summarised below:

moderately structured light clay subsoil	DLR	5	mm/day		
moderately structured light clay subsoil	DIR	3	mm/day		
Retained Rainfall Coefficient	RrC	0.9	Bed	5% slope	
Retained Rainfall Coefficient	RrC	0.8	Irrigation	12% slope	
Void Space Ratio	V	0.3	Bed	gravel media	
Void Space Ratio	V	1	Irrigation	soil/ no storage	

A blank water balance spreadsheet template and two worked examples are presented on the following pages.

Model Parameter	Units	Symbol	Source	Value
Design Wastewater Load	L/day	Q	Wastewater generation	
Design Loading Rate (DLR) / Design Irrigation Rate (DIR)	mm/day	DLR / DIR	AS/NZS 1547:2012 and SSE	
Void Space Ratio	-	V	1 (soil/ no storage), 0.3 (gravel media) 0.45 (sand media), 0.5 (arch)[1]	
Retained Rainfall Coefficient	-	RrC	0.7 (>30% slope), 0.8 (10-30% slope), 0.9 (0-10% slope), 1.0 (flat ground)	
Nominated EAA	m^2	EAA_N	Nominated area by user	

KEY			
	User input		Calculated value

Notes

1. Patterson (2006)

Monthly Parameters	Units	Symbol		Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Annual
Days in month	days	D	-	31	28	31	30	31	30	31	31	30	31	30	31	365
Precipiation	mm/month	P	Median monthly data (BoM or SILO)													
Daily evaporation	mm/day	E_d	Mean daily data (BoM or SILO)													
Evaporation	mm/month	E	E_d x D													
Crop Factor	-	Cf	0.4-0.9[1] (varies with crop type and season)													
Model Inputs																
Retained rainfall	mm/month	Rr	P x RrC													
Applied Effluent	mm/month	W	$(Q*D) \div EAA_N$													
Inputs	mm/month	I	$(Rr + W)$													
Model Outputs																
Evapotranspiration	mm/month	Et	E x Cf													
Percolation	mm/month	B	DLR/DIR x D													
Outputs	mm/month	O	$(Et + B)$													
Model Storage																
Monthly storage	mm/month	S_M	$(I - O) \div V$													
Cumulative storage	mm/month	S_C	S_M + (S_M for month prior)													
Area required for no storage	m^2/month	EAA_S	$(Q$ x $D) \div (ET-Rr+B)$													
Model Results																
Limiting storage	mm/month	S_L	Maximum monthly S_c value													
EAA Required (no storage)	m^2	EAA	Maximum monthly EAA_S value													

12WE.3

Model Parameter	Units	Symbol	Source	Value		KEY			
Design Wastewater Load	L/day	Q	Wastewater generation	600	3-bedroom house with on-site (tank) supply		User input		Calculated value
Design Loading Rate (DLR) / Design Irrigation Rate (DIR)	mm/day	DLR / DIR	AS/NZS 1547:2012 and SSE	5	Table L1 AS/NZS 1547:2012 moderately structured light clay subsoil	**Notes**			
Void Space Ratio	-	V	1 (soil/ no storage), 0.3 (gravel media) 0.45 (sand media), 0.5 (arch)[1]	0.3	Piped gravel bed EAA proposed	1. Patterson (2006)			
Retained Rainfall Coefficient	-	RrC	0.7 (>30% slope), 0.8 (10-30% slope), 0.9 (0-10% slope), 1.0 (flat ground)	0.9	5% slope in proposed EAA				
Nominated EAA	m^2	EAA_N	Nominated area by user	120					

Monthly Parameters	Units	Symbol		Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Annual
Days in month	days	D	-	31	28	31	30	31	30	31	31	30	31	30	31	365
Precipitation	mm/month	P	Richmond UWS Hawkesbury (BoM 067021)	74.3	75.8	66.5	50.4	30.9	38.6	27.6	24.0	32.8	43.2	66.2	55.6	1093.4
Daily evaporation	mm/day	E_d	Richmond UWS Hawkesbury (BoM 067021)	5.9	4.9	4.0	3.0	2.1	1.7	1.9	2.7	3.8	4.6	5.2	5.7	5.0
Evaporation	mm/month	E	E_d x D	182.9	137.2	124.0	90.0	65.1	51.0	58.9	83.7	114.0	142.6	156.0	176.7	1825.0
Crop Factor	-	Cf	0.4-0.9[1] (varies with crop type and season)	0.8	0.8	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8	
Model Inputs																
Retained rainfall	mm/month	Rr	P x RrC	66.87	68.22	59.85	45.36	27.81	34.74	24.84	21.6	29.52	38.88	59.58	50.04	
Applied Effluent	mm/month	W	$(Q \times D) \div EAA_N$	155.0	140.0	155.0	150.0	155.0	150.0	155.0	155.0	150.0	155.0	150.0	155.0	
Inputs	mm/month	I	(Rr + W)	221.9	208.2	214.9	195.4	182.8	184.7	179.8	176.6	179.5	193.9	209.6	205.0	
Model Outputs																
Evapotranspiration	mm/month	Et	E x Cf	146.3	109.8	99.2	63.0	45.6	35.7	41.2	58.6	79.8	114.1	124.8	141.4	
Percolation	mm/month	B	DLR/DIR x D	155.0	140.0	155.0	150.0	155.0	150.0	155.0	155.0	150.0	155.0	150.0	155.0	
Outputs	mm/month	O	(Et + B)	301.3	249.8	254.2	213.0	200.6	185.7	196.2	213.6	229.8	269.1	274.8	296.4	
Model Storage																
Monthly storage	mm/month	S_M	$(I - O) \div V$	-264.8	-138.5	-131.2	-58.8	-59.2	-3.2	-54.6	-123.3	-167.6	-250.7	-217.4	-304.4	
Cumulative storage	mm/month	S_C	S_M + (S_M for month prior)	0	0	0	0	0	0	0	0	0	0	0	0	
Area required for no storage	m^2/month	EAA_S	$(Q \times D) \div (ET-Rr+B)$	79	93	96	107	108	119	109	97	90	81	84	76	

Model Results	Units	Symbol		Value
Limiting storage depth	mm/month	S_L	Maximum monthly S_c value	**0**
EAA Required (no storage)	m^2	EAA	Maximum monthly EAA_S value	**119**

12WE.4

Model Parameter	Units	Symbol	Source	Value													
Design Wastewater Load	L/day	Q	Wastewater generation	600	3-bedroom house with on-site (tank) supply												
Design Loading Rate (DLR) / Design Irrigation Rate (DIR)	mm/day	DLR / DIR	AS/NZS 1547:2012 and SSE	3	Table M1 AS/NZS 1547:2012 moderately structured light clay subsoil												
Void Space Ratio	-	V	1 (soil/ no storage), 0.3 (gravel media) 0.45 (sand media), 0.5 (arch)[1]	1	Subsurface irrigation EAA proposed												
Retained Rainfall Coefficient	-	RrC	0.7 (>30% slope), 0.8 (10-30% slope), 0.9 (0-10% slope), 1.0 (flat ground)	0.8	12% slope in proposed EAA												
Nominated EAA	m^2	EAA_N	Nominated area by user	190													

KEY			
	User input		Calculated value

Notes

1. Patterson (2006)

Monthly Parameters				Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Annual
Days in month	days	D	-	31	28	31	30	31	30	31	31	30	31	30	31	365
Precipitation	mm/month	P	Richmond UWS Hawkesbury (BoM 067021)	74.3	75.8	66.5	50.4	30.9	38.6	27.6	24.0	32.8	43.2	66.2	55.6	1093.4
Daily evaporation	mm/day	E_d	Richmond UWS Hawkesbury (BoM 067021)	5.9	4.9	4.0	3.0	2.1	1.7	1.9	2.7	3.8	4.6	5.2	5.7	5.0
Evaporation	mm/month	E	$E_d \times D$	182.9	137.2	124.0	90.0	65.1	51.0	58.9	83.7	114.0	142.6	156.0	176.7	1825.0
Crop Factor	-	Cf	0.4-0.9[1] (varies with crop type and season)	0.8	0.8	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8	
Model Inputs																
Retained rainfall	mm/month	Rr	$P \times RrC$	59.44	60.64	53.2	40.32	24.72	30.88	22.08	19.2	26.24	34.56	52.96	44.48	
Applied Effluent	mm/month	W	$(Q \times D) \div EAA_N$	97.9	88.4	97.9	94.7	97.9	94.7	97.9	97.9	94.7	97.9	94.7	97.9	
Inputs	mm/month	I	$(Rr + W)$	157.3	149.1	151.1	135.1	122.6	125.6	120.0	117.1	121.0	132.5	147.7	142.4	
Model Outputs																
Evapotranspiration	mm/month	Et	$E \times Cf$	146.3	109.8	99.2	63.0	45.6	35.7	41.2	58.6	79.8	114.1	124.8	141.4	
Percolation	mm/month	B	$DLR/DIR \times D$	93.0	84.0	93.0	90.0	93.0	90.0	93.0	93.0	90.0	93.0	90.0	93.0	
Outputs	mm/month	O	$(Et + B)$	239.3	193.8	192.2	153.0	138.6	125.7	134.2	151.6	169.8	207.1	214.8	234.4	
Model Storage																
Monthly storage	mm/month	S_M	$(I - O) \div V$	-82.0	-44.7	-41.1	-17.9	-16.0	-0.1	-14.3	-34.5	-48.8	-74.6	-67.1	-92.0	
Cumulative storage	mm/month	S_C	S_M + (S_M for month prior)	0	0	0	0	0	0	0	0	0	0	0	0	
Area required for no storage	m^2/month	EAA_S	$(Q \times D) \div (ET-Rr+B)$	103	126	134	160	163	190	166	140	125	108	111	98	

Model Results				
Limiting storage depth	mm/month	S_L	Maximum monthly S_c value	**0**
EAA Required (no storage)	m^2	EAA	Maximum monthly EAA_S value	**190**

12WE.5