CALCULATION SHEET

Client			Job Title	Job No
GOWER HOMES LTD			**PROPOSED RESIDENTIAL DEVELOPMENT, PACKSADDLE BANK, PENTRE BYCHAN**	**5009**
By **RW**	Date **08.16**	Chkd **RW**	Element **SURFACE WATER DRAINAGE ANALYSIS GEOCELLULAR SOAKAWAY DESIGN:**	Sheet No **P3 Drive/ 1**

DATA	CALCULATIONS	RESULTS

1. PURPOSE

The purpose of these calculations is to determine the size of the geocellular soakaways required to disperse the run-off from the shared private access roads, parking areas and roofs which are to be constructed as part of the above development. Separate Soakaways are to be constructed to disperse run-off from the adoptable access road.

2. SITE LAYOUT

The layout of the development site and associated drainage layout is shown on drawing Nº 5009/ 100 Drainage General Arrangement (as revised)

This drawing shows the proposed location of the geocellular soakaways within the gardens, shared parking areas / access roads including the impermeable area draining to these facilities.

3. POROSITY TESTS

Porosity tests were carried out by Groundsolve Ltd in March 2016. The results of their investigations and percolation tests are included in their report dated 16th March 2016 Ref: 1754/BPW/LetRepSA/erw.

The applicable results of these tests are summarised in Section 6

4. METHODOLOGY

Current best practice/design advice recommends that infiltration drainage systems should be designed to store the run-off from a 10% annual probability storm (1 in 10 year return period) and to half empty (by percolation) in a twenty-four hour period (CIRIA Report 156: Infiltration drainage - Manual of good practice). This latter requirement allows the system to cater for a succession of severe storm events

However in order to achieve consistency between conventional drainage techniques (as set out in Sewers for Adoption), recent recommendations (CIRIA Report Nº C609: Sustainable drainage systems - Hydraulic, structural and water quality advice) suggest that SUDS should be analysed for a 3.3% annual probability storm event (1 in 30 year return period) to ensure that internal flooding of properties and/or serious external flooding (SEF) does **not** occur.

In addition, the Environment Agency, in pursuance of the requirements of TAN 15 (in Wales) and PPG25 (in England), recommends that greenfield run-off rates and volumes should be maintained after development for storm events up to a 1% annual probability (1 in 100 year return period).

The additional water resulting from these severe storm events does not necessarily have to be stored within the SUDS, provided it can be contained by localised flooding of car parks and landscaped areas for short periods of time without adversely effecting residential or commercial property.

Client			Job Title	Job No
GOWER HOMES LTD			PROPOSED RESIDENTIAL DEVELOPMENT, PACKSADDLE BANK, PENTRE BYCHAN	5009
By RW	Date 08.16	Chkd RW	Element SURFACE WATER DRAINAGE ANALYSIS GEOCELLULAR SOAKAWAY DESIGN:	Sheet No P3 Drive/ 2

DATA	CALCULATIONS	RESULTS

4. **METHODOLOGY** (continued)

These calculations therefore adopt the following methodology:

1. Rainfall intensities for different storm conditions are to be determined using the Wallingford Procedure
2. The infiltration device is to be sized to store the run-off from a 10% annual probability storm **below** the level of the incoming pipe(s)
3. The infiltration device is to be analysed to ensure that the run-off from a 3.3% annual probability storm is contained without the system flooding (ie that there is sufficient storage provided within the facility)
4. The system is to be further tested against 1% annual probability storm events to assess the volume of flooding and to confirm that it will not adversely effect residential or commercial property

5. **METHOD OF ANALYSIS**

These calculations adopt the method of analysis for 3-D Infiltration Systems set out in CIRIA Report N° 156: Infiltration systems - Manual of good practice (Bettess 1996).

For a vertically sided structure (ie a soakaway or infiltration trench) the maximum depth of water (h_{max}) can be calculated by solving the following equation

$$h_{max} = a\,(e^{(-bD)} - 1)$$

where $a = (A_b / P) - (Adi / Pq)$ and $b = (Pq) / (nA_b)$

The time to half empty ($t_{½}$) can be determined from the following equation:

$$t_{½} = \frac{n\,A_b}{q\,P}\,\mathrm{Log}_e\left\{\frac{h_{max} + A_b / P}{h_{max}/2 + A_b / P}\right\}$$

The required inputs are:

A_b	area of base of infiltration device	(m^2)
P	perimeter of infiltration device	(m)
A_D	area to be drained	(m^2)
f	infiltration rate from percolation tests	(m/h)
i, D	intensity and duration of rainfall events with the required return period at the site location	(m/h, h)
n	porosity of fill material (void volume/total volume)	

The results of these calculations are set out below

CALCULATION SHEET

Client			Job Title	Job No
GOWER HOMES LTD			PROPOSED RESIDENTIAL DEVELOPMENT, PACKSADDLE BANK, PENTRE BYCHAN	5009
By RW	Date 08.16	Chkd RW	Element SURFACE WATER DRAINAGE ANALYSIS GEOCELLULAR SOAKAWAY DESIGN:	Sheet No P3 Drive/ 3

DATA	CALCULATIONS	RESULTS

6. **PERCOLATION TEST RESULTS**

Porosity tests were carried out in March 2016 by GroundSolve Ltd to determine the infiltration rates within the underlying glacial sands and gravel's which are present at varying depths across the site. The location of the trial pits is shown on Figure 1 of their report.

Below is a summary of the lowest infiltration rates derived from the trial pits where tests were undertaken.

Trial Pit	Measured Soil Infiltration Rate f (m/s)	
TP 1 Test 3	2.862E-05	
TP 2 Test 2	2.312E-06	
TP 3 Test 3	1.476E-04	
TP 4 Test 3	8.784E-05	
TP 5 Test 2	2.053E-05	
TP 8 Test 3	1.776E-05	
	Applicable Infiltration Rate	
Plot 1 & 2 Front	2.458E-05	Median of all
Plot 1 Rear	1.776E-05	TP8
Plot 2 Rear	2.053E-05	TP5
Plot 3 & 5-6 Drive	8.811E-05	Ave TP1 & 3
Plot 3 Drive	7.496E-05	Ave TP2 & 3
Plot 4 & 5	2.862E-05	TP1
Plot 6, 7 & 8 Rear	8.784E-05	TP4
Plot 7 Front	1.476E-04	TP3
Plot 8 Front	2.053E-05	TP5
Private Drive P9-11	2.053E-05	TP5
Plot 9/10 Garage	1.915E-05	Ave TP5 & 8
Plot 9 to 11 front	1.776E-05	TP8

CALCULATION SHEET

Client			Job Title	Job No
GOWER HOMES LTD			PROPOSED RESIDENTIAL DEVELOPMENT, PACKSADDLE BANK, PENTRE BYCHAN	5009
By RW	Date 08.16	Chkd RW	Element SURFACE WATER DRAINAGE ANALYSIS GEOCELLULAR SOAKAWAY DESIGN:	Sheet No P3 Drive/ 4

DATA	CALCULATIONS	RESULTS

7. **DRAINED AREA: Roofs & Parking**

The following impermeable areas drain to each of the geocellular soakaways

Description	Drained Area (m^2)
Plot 1 Front	98.10
Plot 2 Front	71.70
Plot 1 Rear	55.10
Plot 2 Rear	35.90
Plot 3	91.20
Plot 3 - 4 Drive	76.00
Plot 4 & 5	249.80
Plot 6, 7 & 8 Rear	42.40
Plot 5-6 Drive	212.90
Plot 7 Front	69.00
Plot 8 Front	80.20
Private Drive P9-11	77.60
Plot 9/10 Garage	106.10
Plot 9 & 10 front	69.45
Plot 11	135.60

CALCULATION SHEET

Client			Job Title	Job No
GOWER HOMES LTD			PROPOSED RESIDENTIAL DEVELOPMENT, PACKSADDLE BANK, PENTRE BYCHAN	5009
By RW	Date 08.16	Chkd RW	Element SURFACE WATER DRAINAGE ANALYSIS GEOCELLULAR SOAKAWAY DESIGN:	Sheet No P3 Drive/ 5

DATA	CALCULATIONS	RESULTS

7. RAINFALL DATA

Ratio (M5-60min/M5-2day)	r	31	%
M5-2day Rainfall	M5-2day	58.06	mm
M5-60min Rainfall	M5-60	18.00	mm
M5-D Rainfall	M5-D	Z1(M5-60)	
MT-D Rainfall	MT D	Z2(M5-D)	
Rainfall Intensity	I	(MT-D)/D	mm/hr

D	Z1	M5	10 Year Return			30 Year Return			100 Year Return		
			Z2	M10	I	Z2	M30	I	Z2	M100	I
(min)		(mm)		(mm)	(mm/hr)		(mm)	(mm/hr)		(mm/hr)	(mm/hr)
5	0.34	6.18	1.2	7.42	88.99	1.44	8.90	106.78	1.82	11.25	134.96
10	0.49	8.88	1.21	10.74	64.46	1.48	13.14	78.85	1.88	16.69	100.16
15	0.60	10.74	1.22	13.10	52.41	1.50	16.11	64.43	1.92	20.62	82.48
20	0.66	11.80	1.23	14.51	43.54	1.50	17.70	53.10	1.94	22.89	68.67
25	0.71	12.86	1.23	15.82	37.96	1.51	19.42	46.60	1.96	25.20	60.49
30	0.77	13.92	1.24	17.26	34.52	1.52	21.16	42.31	1.97	27.42	54.84
45	0.89	15.96	1.24	19.79	26.39	1.53	24.42	32.56	2.00	31.92	42.56
60	1.00	18.00	1.24	22.32	22.32	1.54	27.72	27.72	2.01	36.18	36.18
90	1.12	20.19	1.24	25.03	16.69	1.54	31.09	20.73	2.03	40.98	27.32
120	1.24	22.38	1.24	27.75	13.87	1.54	34.46	17.23	2.02	45.20	22.60
240	1.56	28.02	1.23	34.46	8.62	1.52	42.59	10.65	1.99	55.76	13.94
360	1.76	31.74	1.21	38.40	6.40	1.51	47.92	7.99	1.96	62.21	10.37
600	2.09	37.68	1.2	45.21	4.52	1.48	55.76	5.58	1.91	71.96	7.20
1440	2.76	49.68	1.17	58.12	2.42	1.42	70.54	2.94	1.81	89.91	3.75

CALCULATION SHEET

Client			Job Title	Job No
GOWER HOMES LTD			PROPOSED RESIDENTIAL DEVELOPMENT, PACKSADDLE BANK, PENTRE BYCHAN	5009
By RW	Date 08.16	Chkd RW	Element SURFACE WATER DRAINAGE ANALYSIS GEOCELLULAR SOAKAWAY DESIGN:	Sheet No P3 Drive/ 6

DATA	CALCULATIONS				RESULTS
8.	**DESIGN DATA**				
From porosity tests	Measured infiltration rate		f	**2.70E-01** m/hr	
CIRIA C753 Pg. 553	Factor of safety	(major inconvenience - access road)	Fs	**10.0**	
CIRIA C697 Pg. 4-31	Porosity	(geocellular units)	n	**0.95**	
From Plan	Area to be drained		A_D	**76.00** m^2	
	Geocellular soakaway in a rectangular excavation backfilled with clean stone				
	Length, say		L	**2.50** m	
	Width, say		W	**1.00** m	
9.	**SOAKAWAY DESIGN**				
By Calculation, q = f/Fs	Effective infiltration coefficient (measured infiltration rate/factor of safety)		q	0.0270 m/hr	
From Plan	Area to be drained		A_D	76.00 m^2	
By Calculation, A_b = L * W	Base Area of Filter Drain		A_b	2.50 m^2	
By Calculation, P = 2L + 2W	Perimeter of Soakaway		P	7.00 m	
CIRIA 156 Pg. 57 Factor a = $(A_b/P) - (iA_D/Pq)$	Factor a		a	varies	
CIRIA 156 Pg. 57 Factor b = (Pq/nA_b)	Factor b		b	0.080	

CALCULATION SHEET

Client	Job Title	Job No
GOWER HOMES LTD	PROPOSED RESIDENTIAL DEVELOPMENT, PACKSADDLE BANK, PENTRE BYCHAN	5009

By	Date	Chkd	Element	Sheet No
RW	08.16	RW	SURFACE WATER DRAINAGE ANALYSIS GEOCELLULAR SOAKAWAY DESIGN:	P3 Drive/ 7

DATA	CALCULATIONS	RESULTS

9. **SOAKAWAY DESIGN (continued)**

Duration		10 Year Return			30 Year Return			100 Year Return		
min	hr	i m/hr	Factor a	Max Depth m	i m/hr	Factor a	Max Depth m	i m/hr	Factor a	Max Depth m
5	0.083	0.089	-35.4	0.234	0.107	-42.6	0.281	0.135	-53.9	0.356
10	0.167	0.064	-25.6	0.337	0.079	-31.3	0.413	0.100	-39.9	0.526
15	0.250	0.052	-20.7	0.408	0.064	-25.6	0.503	0.082	-32.8	0.646
20	0.333	0.044	-17.2	0.449	0.053	-21.0	0.550	0.069	-27.3	0.714
25	0.417	0.038	-14.9	0.486	0.047	-18.4	0.600	0.060	-24.0	0.782
30	0.500	0.035	-13.5	0.528	0.042	-16.7	0.650	0.055	-21.7	0.846
45	0.750	0.026	-10.3	0.594	0.033	-12.7	0.738	0.043	-16.8	0.971
60	1.000	0.022	-8.6	0.659	0.028	-10.8	0.825	0.036	-14.2	1.085
90	1.500	0.017	-6.4	0.715	0.021	-8.0	0.898	0.027	-10.6	1.196
120	2.000	0.014	-5.2	0.768	0.017	-6.6	0.967	0.023	-8.7	1.285
240	4.000	0.009	-3.1	0.847	0.011	-3.9	1.070	0.014	-5.2	1.431
360	6.000	0.006	-2.2	0.842	0.008	-2.9	1.084	0.010	-3.8	1.447
600	10.000	0.005	-1.5	0.802	0.006	-1.9	1.035	0.007	-2.5	1.392
1440	24.000	0.002	-0.6	0.525	0.003	-0.8	0.703	0.004	-1.1	0.979

For 1 in 10 year return period storm

From Table — Maximum depth of water h_{max} **0.847 m**

By calculation — Time for half emptying $t_{1/2}$ **5.45 hr** — <24 hrs OK

For 1 in 30 year return period storm

Depth of storage required additional to 1 in 10 year return period **0.237 m**

Total depth of geocellular units to be provided. (Overall depth to suit drainage strata). **1.200 m**

CALCULATION SHEET

Client			Job Title	Job No
GOWER HOMES LTD			PROPOSED RESIDENTIAL DEVELOPMENT, PACKSADDLE BANK, PENTRE BYCHAN	5009
By RW	Date 08.16	Chkd RW	Element SURFACE WATER DRAINAGE ANALYSIS GEOCELLULAR SOAKAWAY DESIGN:	Sheet No P3 Drive/ 8

DATA	CALCULATIONS	RESULTS

9. **SOAKAWAY DESIGN (continued)**

For 1 in 100 year return period storm

Potential flood volume (in excess of storage provided) **0.587 m^3**

Assume flooding uniformly over length and width of filter drain either side, then average depth of flooding: **0.235 m**

In reality flood water will flow over to the storage area south & west of the access road. The actual flood depth will be significantly less. This volume does not take into account additional storage in the granular surround & beneath the geocells or the catchpits and pipework which will reduce the surface flood volume & depth.

10. **SUMMARY**

The results of the analysis indicate the following:

Required depth of Filter Drain below lowest incoming pipe (ie depth for a 10% annual probability storm event) **0.847 m**

Minimum depth above incoming pipe invert and below ground level (ie additional storage for a 3.3% annual probability storm event) **0.237 m**

Potential flood volume from a 1% annual probability storm event **0.587 m^3**

Total depth of geocells to be provided **1.200 m**

11. **Additional Storage Provided For More Severe Events & Climate Change**

Additional depth is provided in the soakaway above the 1 in 30 year event level. The stone surround, 0.45m diameter catchpits and 100mm diameter pipework is not included in the calculations. The volume of storage will therefore be greater reducing the potential flood volume under 1 in 100 year return period storms and makes an allowance for climate change. Additional Storage Provided:

		Within geocellular units	0.276 m^3
	1 No at	0.90 m min deep catchpits (at say 80% volume)	0.115 m^3
~	3.0 m at	0.1 m diameter within trench (at say 75% volume)	0.018 m^3
			0.408 m^3