Consulting Civil & Structural Engineers

Proposed Surface Water Drainage Strategy
Proposed Care facility
Broadwater Road

Welwyn Garden City

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Our ref: RN/10528
Version 1.00
June 2019

njp

Consulting Civil & Structural Engineers

Proposed Surface Water Drainage Strategy

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Proposed Drainage Strategy

1.0 Introduction

1.1 NJP Consulting Civil & Structural Engineers Ltd has been appointed by the client, Marbrook Ltd to provide a drainage strategy to accompany a planning application, in respect of a proposed residential care development off Broadwater Road, Welwyn Garden City

1.2 This report provides a desk study review of the proposed drainage strategy based on CLA Architects drawing 110C Proposed site plan (Appendix 1) and the topographical survey (Appendix 2)

2.0 The Site

1. The proposed care home will be placed centrally on the site at an elevation of 86.500m AOD. The site is generally flat at an average level of 85.500 rising up on its southern boundary to 86.40m AOD

3.0 Existing Surface and Foul Water Sewers

1. There is an existing foul water sewer is located in Broadwater Road. The original office buildings were connected to this sewer.

2. The existing site is brownfield and is designated Previously Developed Land (PDL). A Betterment Rate of 2.0l/sec has been agreed with Thames Water (Appendix 3). The total site area is 0.375Ha and in its original form around 95% of the site was made up of car park and roof run off discharging uncontrolled into the public sewer in Broadwater Road generating a run off rate of:
   - 15 min 1 in 1 year storm 51 l/sec
   - 15 min 1 in 30 year storm 55 l/sec
   - 15 min 1 in 100 year storm 89 l/sec

4.0 Proposed Surface Water Drainage Strategy

1. Soil Infiltration tests were undertaken By Integral Geotechnique Ltd on 12th June 2019 and the results from their report to assess the suitability of SUDS methods to dispose of surface water from the new building plus associated car parking are contained within Appendix 3. Trial Pit 3 shows no infiltration and Trial Pit 4 provided an infiltration rate of 4.20×10^{-6} m/sec. This rate is relatively poor but does offer some infiltration at lower depths. Integral Geotechnique advise that some benefit may be taken for frequent smaller storm events but is not suitable for larger events including the 1:100 year event and 1 in 100 plus 30%ccf. (Appendix 4)

2. The SUDS system proposed will control the water at source in accordance with current best practice and National Planning Policy Guidelines, the CIRIA SUDS Manual 2015 and SuDS Design Guidance for Hertfordshire March 2015V2.The proposed development is in an urban area and is of high intensity with limited open space. The

proposals do however include for some limited soft landscaping and an opportunity to provide a permeable car park. (Appendix 5)

3. An infiltration system concrete block permeable paving solution, designed to cater for roof and yard drainage for the 1:100 year storm event plus a 30% climate change factor (ccf) will be incorporated into the design. A series of 300m diameter shafts will be installed to encourage flows to the limited permeable strata approximately 3.0m below ground level.

4. Due to the limited infiltration values strata below the system will include a flow control to the Thames Water combined sewer at an agreed rate of 2.0 l/sec. The existing surface water outlet will be utilised. The SUDS Manual 2015 recommends permeable paving as an efficient means of managing surface water run off at source, intercepting runoff, reducing the volume and frequency of run off and providing a treatment medium.

5. In line with best practice, improvements in water quality will be sought by capturing the first 5mm of rainfall falling on the site during a storm event within void spaces and filter media associated with the permeable surfaces, and topsoiled soft landscaping areas.

6. Surface water will filter through the permeable sub base of the car park and water quality will be improved by the process. The SuDS Manual 2015 Chapter 26 advises that roof run off requires 1 treatment, as it is deemed uncontaminated. The Interpave Guidance for Designers Developers, Planners and Local Authorities advises that permeable paving is preferable to oil interceptors and that it is considered as having 2 treatment stages. The Permafilter geotextile fabric layer also added within the system we are proposing, provides a third treatment. Permafilter fabric encourages the growth of amicrobic biofilm habitat. These microbes biodegrade any organic matter found in the run off, with a capacity to consume 400g of hydrocarbon per annum. Also, any non-degradable matter such as heavy metals and silts are trapped in the laying course optimising the cleansing of water.

7. When testing the 1:100 +30% ccf storm it can be seen from the calculations that the full capacity of the system is used with no exceedance and contained wholly within the storage structure. This system has been tested for a 1:1 year, 1in 30 year and 1:100+30%ccf events. (Appendix 6)

8. In the unlikely event of exceedances run off will be contained within the 125mm upstand kerns of the car park and also within the soft landscape areas. A line drain will be installed across the site entrance with an outlet pipe connected downstream of the flow control.

9. The existing site generates flows varying between 51 l/sec and 88 l/sec 3.2 above refers). This will be removed under the current proposals increasing capacity in the existing sewers and reducing the risk of flooding to third parties downstream.

5.0 Conclusions

1. The system has been designed in accordance with current best practice for a range of storms in excess of the 1 in 100 year storm event +30%.

2. The existing site originally flowed unrestricted into the Thames Water public sewer

3. As a result of the scheme the risk of flooding downstream to third parties is greatly reduced.

4. A maintenance regime will be provided and the responsibility for maintenance will be with the care provider at no cost to the public.

5. Foul water will drain using the same connection into the Thames Water sewer. Thames water confirmed in their letter dated 3rd June 2019 that there is sufficient foul capacity for the care home within the system

Document Production Record

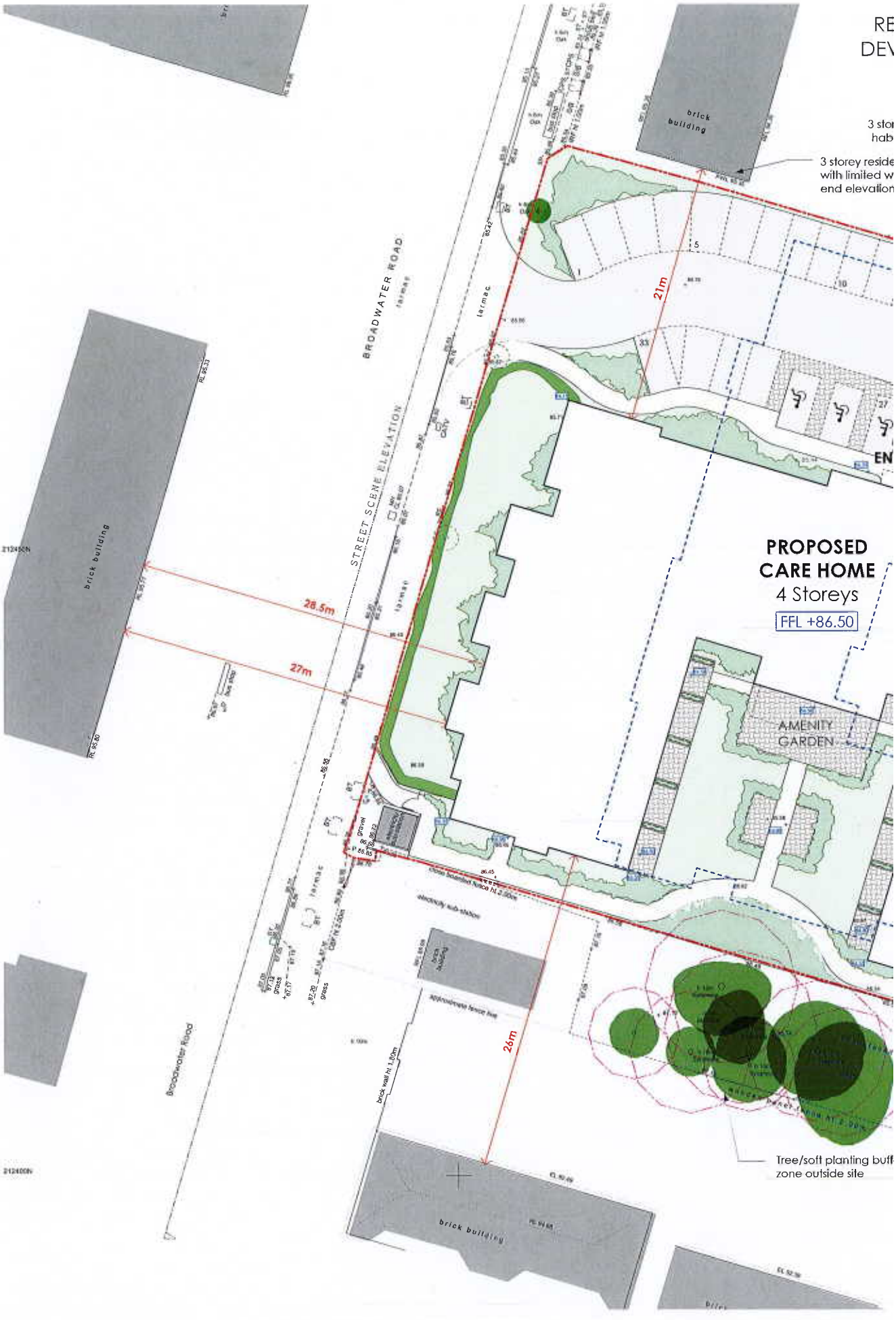
Issue Number 1.	Name	Signature
Prepared	R Nelson	
Checked	R Dean	
Approved	R Dean	

Document Issue Record

Issue Number	Date	Revision Details
1	20 June 2019	

NJP Consulting Engineers Limited has produced this report in accordance with the instructions from the client for their sole specific use. Any third parties who may use the information contained herein do so at their own risk

APPENDIX 1

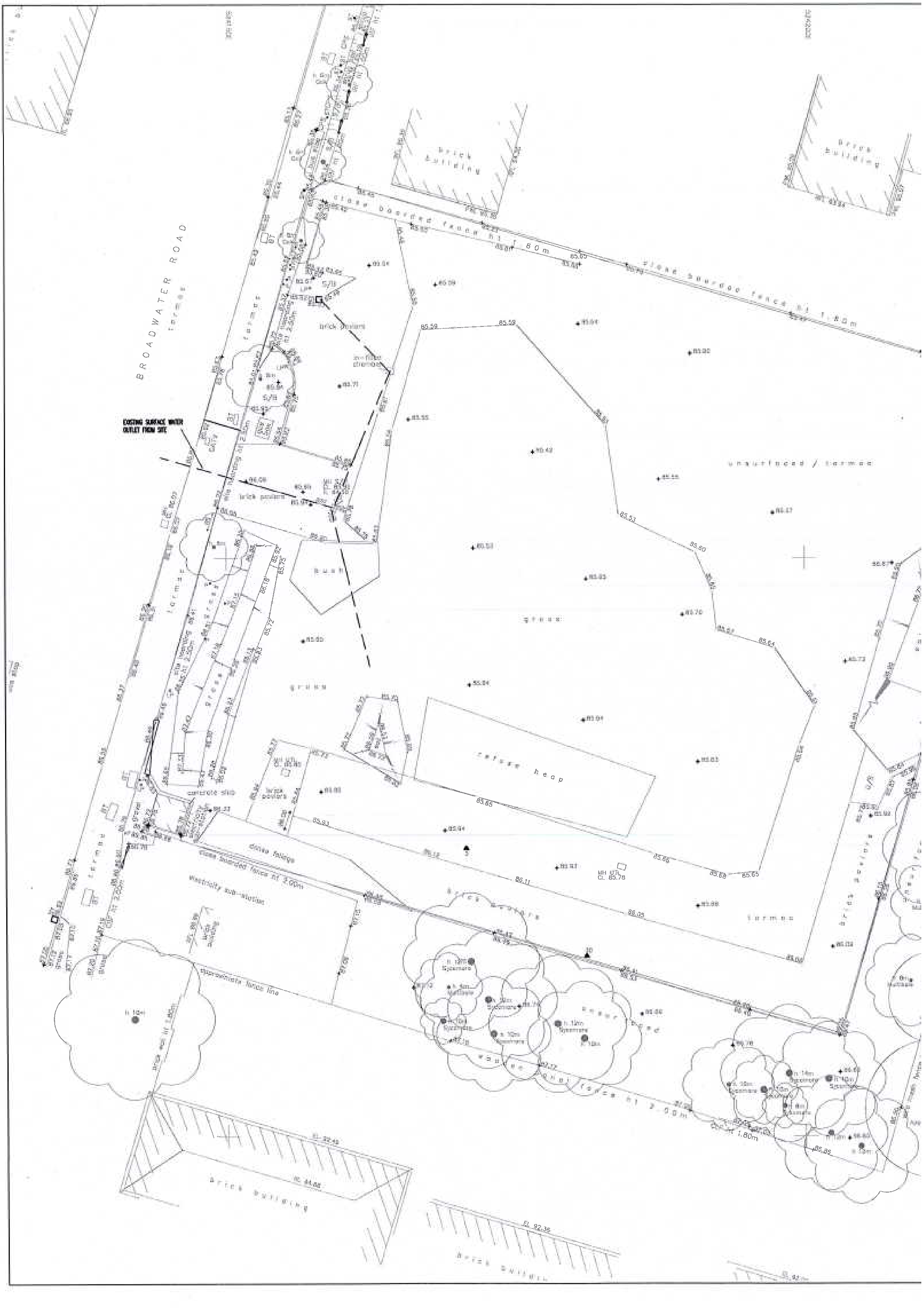


0 5 10 15 20 Metres

Scale Bar

SITE PLAN - AS PROPOSED

APPENDIX 2



BROADWATER ROAD
tarmac
brick building
close boarded fence ht 1.80m
EXISTING SURFACE WATER OUTLET FROM SITE
brick pavers
bush
grass
unsurfaced / tarmac
refuse heap
concrete slab
dense foliage
close boarded fence ht 2.00m
electricity sub-station
approximate fence line
MH UTL CL 85.76
brick building

APPENDIX 3

Mr Robert Nelson

NJP Consulting Engineers Ltd
20 St Andrews Crescent,
Cardiff,
South Wales,
CF10 3DD

Wastewater pre-planning
Our ref DS6062238

03 June 2019

Pre-planning enquiry: Capacity Confirmation

Dear Robert,

Thank you for providing information on your development.

Site: Highways House, Broadwater Road, Welwyn Garden City, Hertfordshire - AL7 3AX

Existing site: Offices (Demolished).
Proposed site: Care Home (88 beds).
Proposed foul water discharge by gravity into manhole TL24121403.
Proposed surface water discharge at 2.0 l/s for all storm events up to and including 1:100yr+40%CC into manhole TL24121404.

We're pleased to confirm that there will be sufficient foul and surface water capacity in our sewerage network to serve your development.

This confirmation is valid for 12 months or for the life of any planning approval that this information is used to support, to a maximum of three years.

You'll need to keep us informed of any changes to your design – for example, an increase in the number or density of homes. Such changes could mean there is no longer sufficient capacity.

What happens next?

Please make sure you submit your connection application, giving us at least 21 days' notice of the date you wish to make your new connection/s.

If you've any further questions, please contact me on 020 3577 7608.

Yours sincerely

Zaid Kazi

Development Engineer
Developer Services – Sewer Adoptions Team

APPENDIX 4

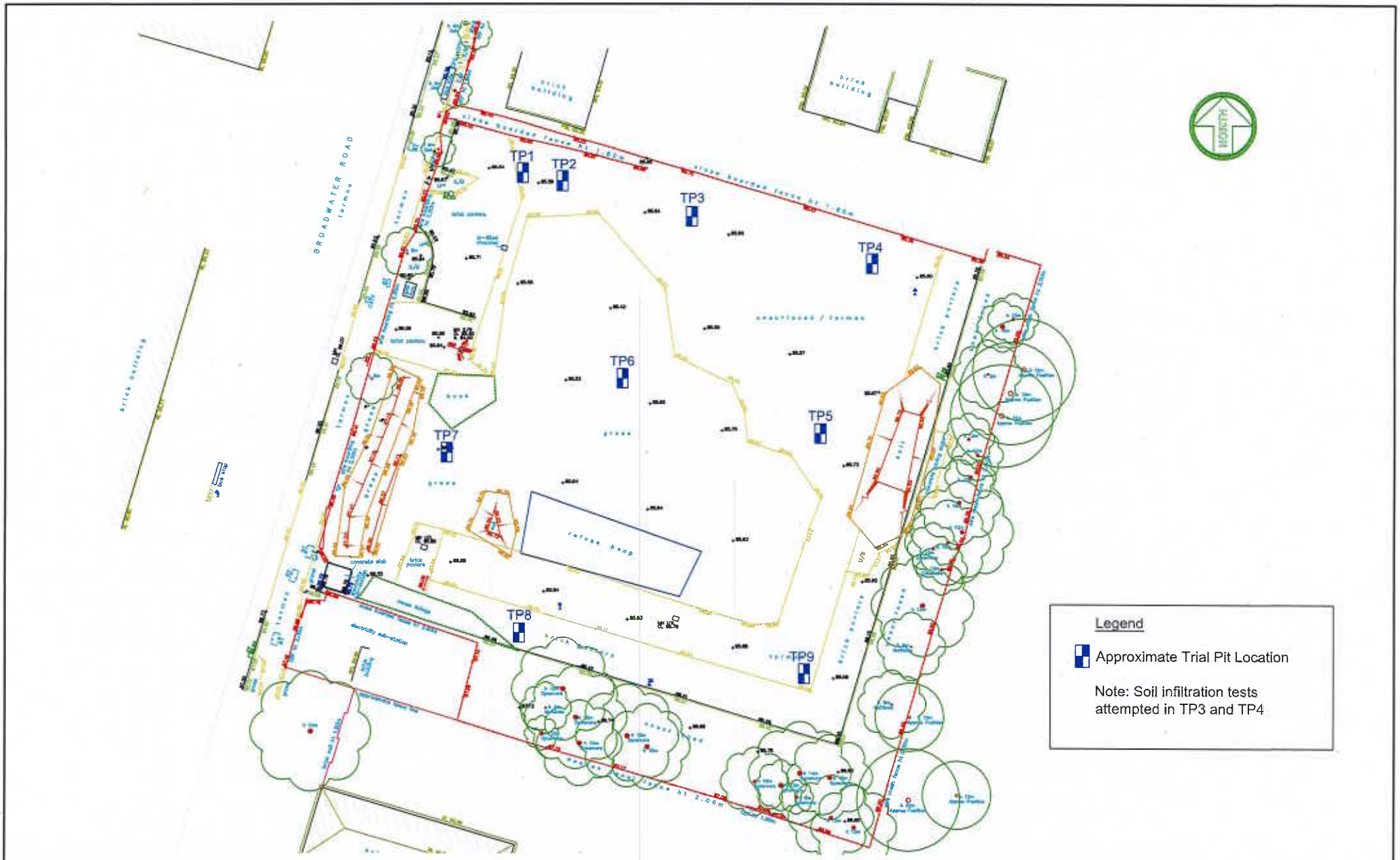


Figure 2: Site Plan

Project: Broadwater Road, Welwyn Garden City	Job No.: 12454	Intégral Géotechnique
Client: Signia Developments	Scale: 1:400 at A3	Integral House, 7 Beddau Way, Castlegate Business Park, Caerphilly, CF83 2AX. Tel: 029 2080 7991

BRE365 SOIL INFILTRATION RATE TEST - TP3

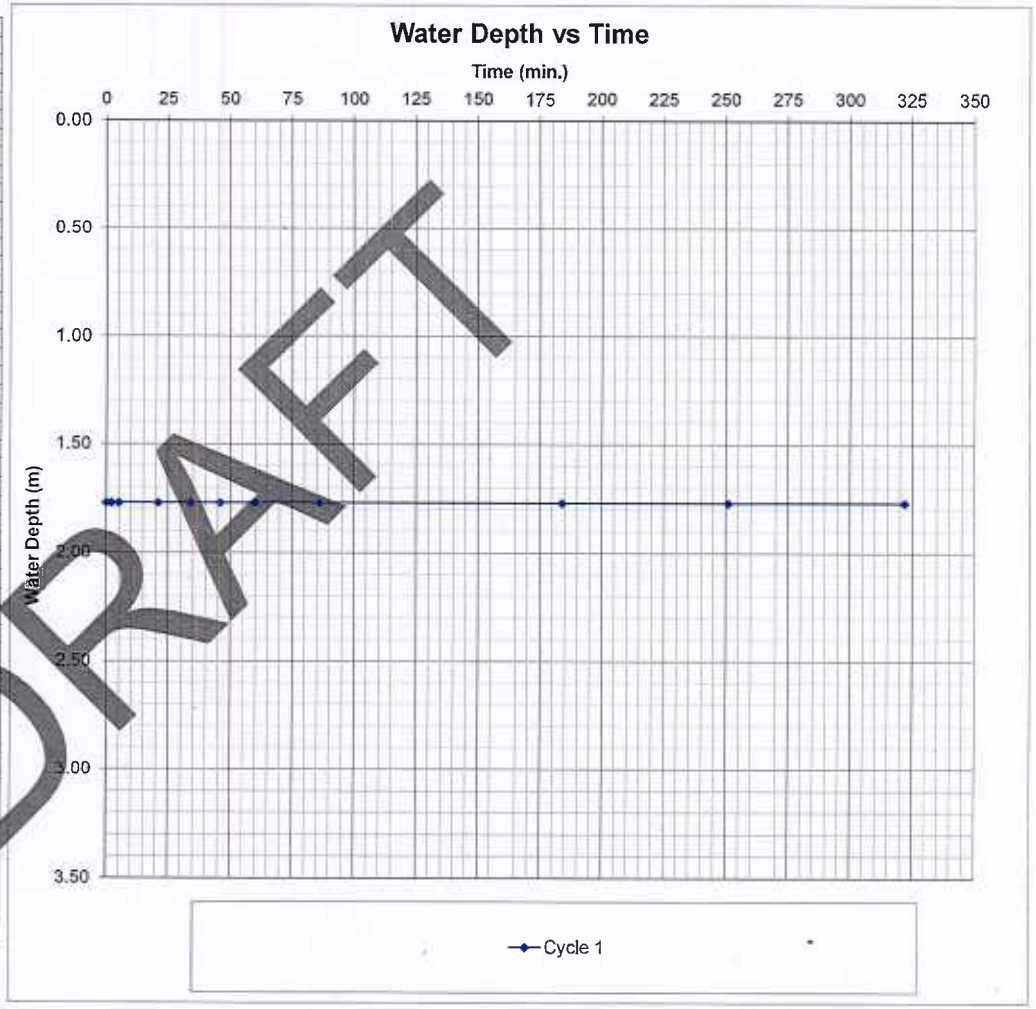
12454 Broadwater Road, Welwyn Garden City

Trial Pit Information	
Length (m)	2.40
Width (m)	0.60
Depth (m)	3.50
Groundwater	Dry
Weather Conditions	Rain
Date	12.06.19

Remarks
Insufficient infiltration to calculate infiltration rate

Cycle 1		Cycle 2		Cycle 3	
Time (min)	Depth (m)	Time (min)	Depth (m)	Time (min)	Depth (m)
0	1.77				
2	1.77				
5	1.77				
21	1.77				
34	1.77				
46	1.77				
60	1.77				
88	1.77				
184	1.77				
251	1.77				
322	1.77				

Final Excavation Depth (m)	Cycle 1	Cycle 2	Cycle 3
At end of testing cycle	3.50		
Water Depths (m)			
Water depth at start of test	1.77		
Water depth at end of test	1.77		
Effective depth (measured)	0.00		
% Effective storage depth	0.00		
Effective Storage Depths (m)			
Effective storage depth (100%)	1.73		
Effective storage depth (75%)	1.30		
Effective storage depth (50%)	0.87		
Effective storage depth (25%)	0.43		
Outflow Time (min)			
Time for measured outflow	322		
Time for 100% outflow			
Time for 75-25% outflow	-		
Volume of Outflow (m^3)			
Over measured effective depth	0.00		
Over 100% effective depth	2.49		
From 75% - 25% effective depth	1.25		
Surface Area (m^2)			
For 100% effective storage	11.82		
For 50% effective storage	6.63		
Over measured depth	1.44		
Soil Infiltration Rate (m/s)	Cycle 1	Cycle 2	Cycle 3
Over 100% effective depth	#DIV/0!		
Over measured depth	0.0E+00		
Over 75% - 25% effective depth	#DIV/0!		



Intégral Géotechnique

BRE365 SOIL INFILTRATION RATE TEST - TP4

12454 Broadwater Road, Welwyn Garden City

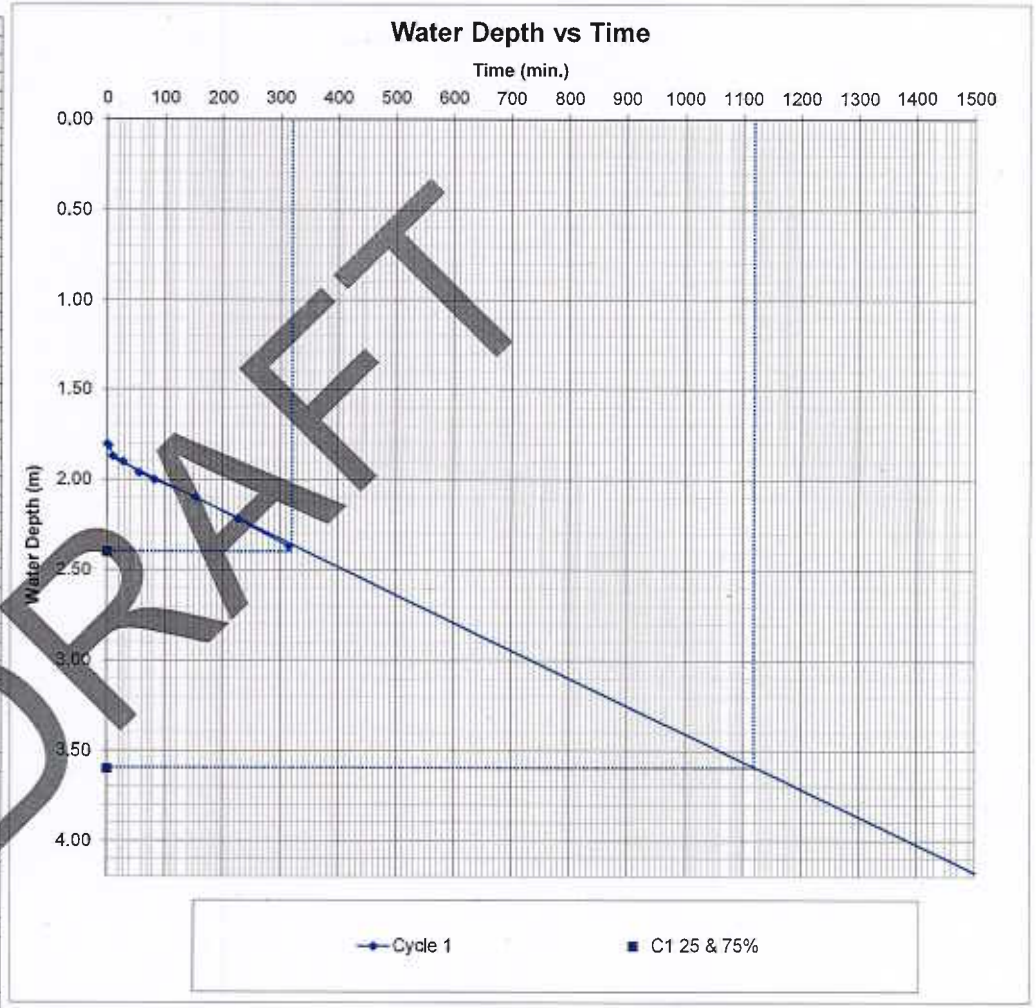
Trial Pit Information	
Length (m)	2.40
Width (m)	0.60
Depth (m)	4.20
Groundwater	1.5
Weather Conditions	Rain
Date	12.06.19

Remarks

Soil infiltration rate calculated from extrapolation of flow rate and line of best fit.

Cycle 1		Cycle 2		Cycle 3	
Time (min)	Depth (m)	Time (min)	Depth (m)	Time (min)	Depth (m)
0	1.80				
3	1.81				
10	1.87				
28	1.90				
55	1.96				
82	2.00				
154	2.10				
227	2.22				
315	2.37				

Final Excavation Depth (m)	Cycle 1	Cycle 2	Cycle 3
At end of testing cycle	4.20		
Water Depths (m)			
Water depth at start of test	1.80		
Water depth at end of test	2.37		
Effective depth (measured)	0.57		
% Effective storage depth	0.24		
Effective Storage Depths (m)			
Effective storage depth (100%)	2.40		
Effective storage depth (75%)	1.80		
Effective storage depth (50%)	1.20		
Effective storage depth (25%)	0.60		
Outflow Time (min)			
Time for measured outflow	315		
Time for 100% outflow	1550		
Time for 75-25% outflow	800		
Volume of Outflow (m^3)			
Over measured effective depth	0.82		
Over 100% effective depth	3.46		
From 75% - 25% effective depth	1.73		
Surface Area (m^2)			
For 100% effective storage	15.84		
For 50% effective storage	8.64		
Over measured depth	4.86		
Soil Infiltration Rate (m/s)	**Cycle 1**	**Cycle 2**	**Cycle 3**
Over 100% effective depth	2.3E-06		
Over measured depth	8.9E-06		
Over 75% - 25% effective depth	4.2E-06		



Intégral Géotechnique

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Intégral House, 7 Beddau Way
Castlegate Business Park
Caerphilly CF83 2AX
Tel. 029 20807991
Fax. 029 20862176
mail@integralgeotec.com

Project Name:	Project No.:	Trial Pit No.:
Broadwater Road	**12454**	**TP3** Sheet 1 of 1
Location: Welwyn Garden City	Client: Signia Developments	Logged By: GNS / Scale: 1:25
Equipment: JCB 3CX	Coordinates:	**Dimensions** 2.40m; Depth : 3.50m; 0.60m
Date Excavated: 12/06/2019	Level: 85.60mAOD	

Samples & In-situ Testing			Depth (m)	Level (m AOD)	Legend	Stratum Description
Depth (m)	Type	Results				
						Soft to firm orange brown and grey slightly silty slightly sandy gravelly clay with frequent cobbles and occasional boulder (0.3m x 0.4m) of concrete, brick and metal. Gravel is fine to coarse angular and subangular concrete, brick, tarmac/bitumen, flint and plastic (MADE GROUND).
			2.30	83.30		Soft to firm orange brown locally grey silty slightly sandy to sandy slightly gravelly clay. Gravel is fine to coarse angular and subangular flint and occasional tarmac/bitumen and brick (MADE GROUND).
			2.70	82.90		Firm to stiff orange brown silty slightly gravelly clay. Gravel is fine to coarse angular and subangular flint.
			3.10	82.50		Medium dense orange brown very clayey silty slightly gravelly SAND. Gravel is fine to coarse rounded, subrounded, subangular and angular flint.
			3.50	82.10		End of Trialpit at 3.50 m

Remarks:
Soil infiltration test attempted in trial pit.

Groundwater: No groundwater encountered

Stability: Stable in the short term

Key:
D - Small disturbed sample
B - Bulk disturbed sample
ES - Environmental soil sample
W - Water sample

AGS

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Project Name: **Broadwater Road**		Project No.: **12454**	Trial Pit No.: **TP4** Sheet 1 of 1
Location: Welwyn Garden City	Client: Signia Developments	Logged By: GNS	Scale 1:25
Equipment: JCB 3CX	Coordinates:	**Dimensions** 2.50m; Depth : 4.20m; 0.60m	
Date Excavated: 12/06/2019	Level: 85.60mAOD		

Samples & In-situ Testing			Depth (m)	Level (m AOD)	Legend	Stratum Description
Depth (m)	Type	Results				
						Loose mid brown and orange brown silty sandy gravel with frequent cobbles of brick. Gravel is fine to coarse subangular brick and plastic and rounded flint (MADE GROUND).
0.80	ES		0.70	84.90		Firm grey and dark grey locally black slightly silty slightly sandy slightly gravelly clay. Gravel is fine to coarse angular and subangular brick, ash, glass, metal and concrete (MADE GROUND). - Soils discoloured with a slight hydrocarbon odour between 0.7m and 1.5m depth.
1.60	D		1.50	84.10		Firm and firm to stiff orange brown slightly silty sandy slightly gravelly CLAY. Gravel is fine to coarse angular and subangular flint.
			2.60	83.00		Medium dense orange brown and yellow brown clayey silty slightly gravelly SAND. Gravel is fine to coarse rounded and subrounded flint.
			4.20	81.40		End of Trialpit at 4.20 m

Remarks:
Soil infiltration test attempted in trial pit.

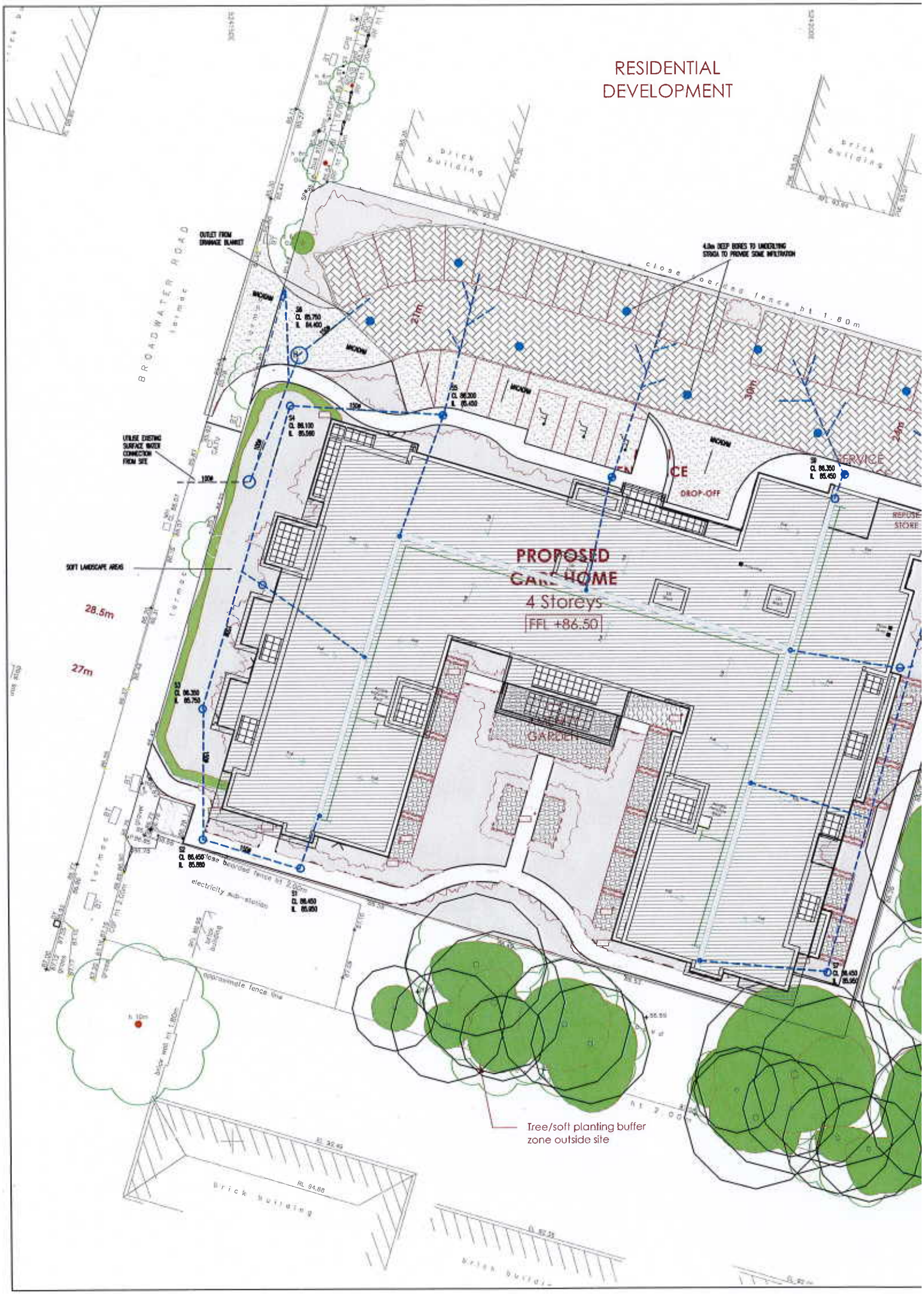
Groundwater: Minor water seepage at 1.5m depth

Stability: Stable in the short term

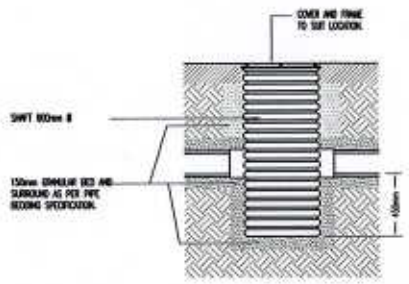
Key:
D - Small disturbed sample
B - Bulk disturbed sample
ES - Environmental soil sample
W - Water sample

AGS

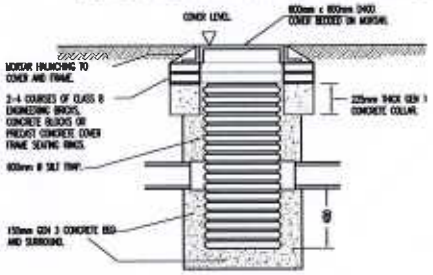
APPENDIX 5


RESIDENTIAL
DEVELOPMENT
BROADWATER ROAD
OUTLET FROM DRAINAGE BLANKET
4.0m DEEP BORES TO UNDERLYING STRATA TO PROVIDE SOME INFILTRATION
close boarded fence ht 1.80m
21m
30m
24m
UTILISE EXISTING SURFACE WATER CONNECTION FROM SITE
SOFT LANDSCAPE AREAS
28.5m
27m
DROP-OFF
PROPOSED
CARE HOME
4 Storeys
FFL +86.50
GARDEN
electricity sub-station
opaque mesh fence line
Tree/soft planting buffer zone outside site
Brick building
RL 94.88

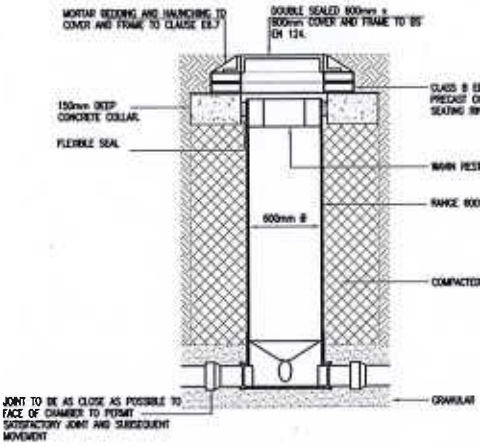
SILT TRAP



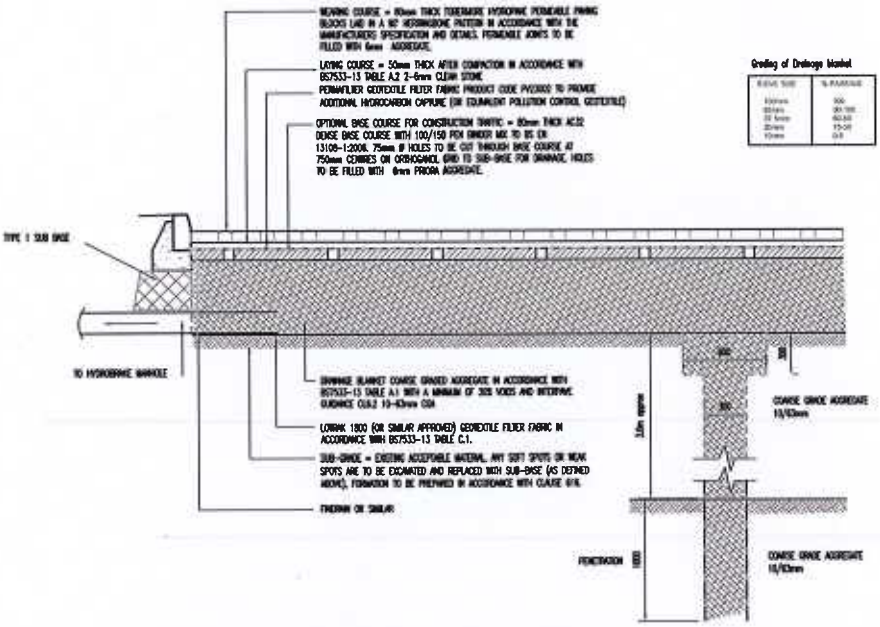
SILT TRAP WITH HEAVY DUTY D400 COVER AND FRAME



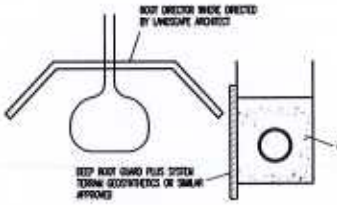
TYPICAL WAVIN RANGE 600 INSPECTION CHAMBER DETAIL (R600)



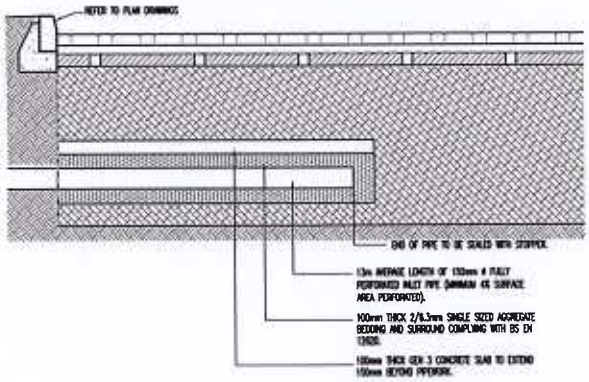
TYPICAL SECTION THROUGH BLOCK PAVED PARKING BAY AND PERMEABLE DRAINAGE



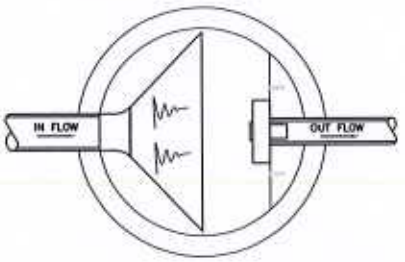
ROOT PROTECTION



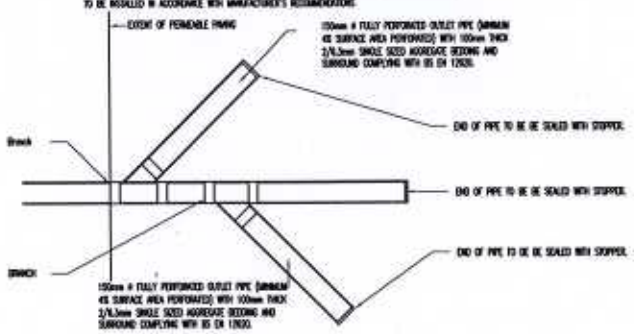
SECTION THROUGH DISTRIBUTION PIPE WITHIN DRAINAGE BLANKET

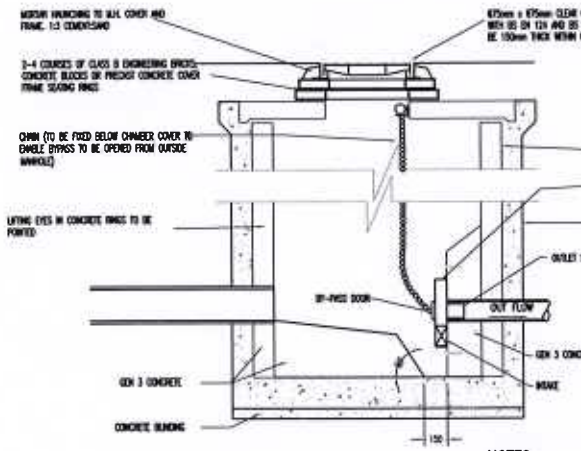


HYDRO BRAKE CHAMBER PLAN



PLAN OF DISTRIBUTION PIPE WITHIN DRAINAGE BLANKET





HYDRO BRAKE CHAMBER SECTION

NOTES

APPENDIX 6

Summary of Results for 1 year Return Period

Half Drain Time : 53 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	84.851	0.061	1.2	1.6	2.7	10.2	O K
30 min Summer	84.865	0.075	1.2	1.6	2.7	12.5	O K
60 min Summer	84.875	0.085	1.2	1.6	2.7	14.1	O K
120 min Summer	84.878	0.088	1.2	1.6	2.7	14.7	O K
180 min Summer	84.876	0.086	1.2	1.6	2.7	14.3	O K
240 min Summer	84.872	0.082	1.2	1.6	2.7	13.6	O K
360 min Summer	84.862	0.072	1.2	1.6	2.7	12.1	O K
480 min Summer	84.854	0.064	1.2	1.6	2.7	10.6	O K
600 min Summer	84.846	0.056	1.2	1.5	2.7	9.3	O K
720 min Summer	84.839	0.049	1.1	1.5	2.7	8.2	O K
960 min Summer	84.829	0.039	0.9	1.5	2.4	6.5	O K
1440 min Summer	84.814	0.024	0.6	1.5	2.1	4.1	O K
2160 min Summer	84.801	0.011	0.3	1.5	1.8	1.8	O K
2880 min Summer	84.793	0.003	0.1	1.5	1.6	0.5	O K
4320 min Summer	84.790	0.000	0.0	1.2	1.2	0.0	O K
5760 min Summer	84.790	0.000	0.0	1.0	1.0	0.0	O K
7200 min Summer	84.790	0.000	0.0	0.9	0.9	0.0	O K
8640 min Summer	84.790	0.000	0.0	0.7	0.7	0.0	O K
10080 min Summer	84.790	0.000	0.0	0.7	0.7	0.0	O K
15 min Winter	84.862	0.072	1.2	1.6	2.7	12.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	31.320	0.0	12.3	23
30 min Summer	19.320	0.0	15.9	34
60 min Summer	11.917	0.0	20.3	56
120 min Summer	7.351	0.0	25.7	90
180 min Summer	5.542	0.0	29.3	124
240 min Summer	4.535	0.0	32.2	158
360 min Summer	3.418	0.0	36.8	224
480 min Summer	2.797	0.0	40.2	288
600 min Summer	2.394	0.0	43.1	350
720 min Summer	2.109	0.0	45.6	410
960 min Summer	1.723	0.0	49.8	532
1440 min Summer	1.295	0.0	56.0	776
2160 min Summer	0.974	0.0	63.0	1132
2880 min Summer	0.796	0.0	68.3	1476
4320 min Summer	0.595	0.0	75.7	0
5760 min Summer	0.484	0.0	81.1	0
7200 min Summer	0.412	0.0	85.3	0
8640 min Summer	0.362	0.0	88.7	0
10080 min Summer	0.324	0.0	91.6	0
15 min Winter	31.320	0.0	14.2	23

Summary of Results for 1 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
30 min Winter	84.878	0.088	1.2	1.6	2.7	14.6	O K
60 min Winter	84.889	0.099	1.2	1.6	2.7	16.6	O K
120 min Winter	84.892	0.102	1.2	1.6	2.8	17.0	O K
180 min Winter	84.887	0.097	1.2	1.6	2.7	16.3	O K
240 min Winter	84.880	0.090	1.2	1.6	2.7	15.1	O K
360 min Winter	84.865	0.075	1.2	1.6	2.7	12.5	O K
480 min Winter	84.851	0.061	1.2	1.6	2.7	10.1	O K
600 min Winter	84.839	0.049	1.1	1.5	2.7	8.3	O K
720 min Winter	84.832	0.042	1.0	1.5	2.5	7.0	O K
960 min Winter	84.819	0.029	0.7	1.5	2.2	4.9	O K
1440 min Winter	84.802	0.012	0.3	1.5	1.8	2.0	O K
2160 min Winter	84.790	0.000	0.0	1.5	1.5	0.0	O K
2880 min Winter	84.790	0.000	0.0	1.2	1.2	0.0	O K
4320 min Winter	84.790	0.000	0.0	0.9	0.9	0.0	O K
5760 min Winter	84.790	0.000	0.0	0.7	0.7	0.0	O K
7200 min Winter	84.790	0.000	0.0	0.6	0.6	0.0	O K
8640 min Winter	84.790	0.000	0.0	0.5	0.5	0.0	O K
10080 min Winter	84.790	0.000	0.0	0.5	0.5	0.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
30 min Winter	19.320	0.0	18.2	35
60 min Winter	11.917	0.0	23.1	60
120 min Winter	7.351	0.0	29.0	96
180 min Winter	5.542	0.0	33.1	134
240 min Winter	4.535	0.0	36.4	172
360 min Winter	3.418	0.0	41.6	240
480 min Winter	2.797	0.0	45.5	304
600 min Winter	2.394	0.0	48.7	364
720 min Winter	2.109	0.0	51.6	428
960 min Winter	1.723	0.0	56.2	550
1440 min Winter	1.295	0.0	63.3	794
2160 min Winter	0.974	0.0	71.3	0
2880 min Winter	0.796	0.0	77.3	0
4320 min Winter	0.595	0.0	85.8	0
5760 min Winter	0.484	0.0	92.0	0
7200 min Winter	0.412	0.0	97.0	0
8640 min Winter	0.362	0.0	101.0	0
10080 min Winter	0.324	0.0	104.5	0

Rainfall Details

Rainfall Model	FEH
Return Period (years)	1
Site Location	GB 524150 212350 TL 24150 12350
C (1km)	-0.028
D1 (1km)	0.303
D2 (1km)	0.297
D3 (1km)	0.282
E (1km)	0.321
F (1km)	2.478
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.750
Cv (Winter)	0.840
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+0

Time Area Diagram

Total Area (ha) 0.260

Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)
0	4	0.087	4	8	0.087	8	12	0.087

Model Details

Storage is Online Cover Level (m) 85.700

Porous Car Park Structure

Infiltration Coefficient Base (m/hr)	0.01510	Width (m)	10.4
Membrane Percolation (mm/hr)	3000	Length (m)	53.5
Max Percolation (l/s)	463.7	Slope (1:X)	0.0
Safety Factor	2.0	Depression Storage (mm)	5
Porosity	0.30	Evaporation (mm/day)	3
Invert Level (m)	84.790	Membrane Depth (m)	0

Hydro-Brake Optimum® Outflow Control

Unit Reference	MD-SHE-0061-2000-1490-2000
Design Head (m)	1.490
Design Flow (l/s)	2.0
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	61
Invert Level (m)	84.000
Minimum Outlet Pipe Diameter (mm)	75
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.490	2.0
Flush-Flo™	0.270	1.6
Kick-Flo®	0.545	1.3
Mean Flow over Head Range	-	1.6

The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake Optimum® as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	1.3	1.200	1.8	3.000	2.8	7.000	4.1
0.200	1.5	1.400	1.9	3.500	3.0	7.500	4.2
0.300	1.6	1.600	2.1	4.000	3.2	8.000	4.4
0.400	1.5	1.800	2.2	4.500	3.3	8.500	4.5
0.500	1.4	2.000	2.3	5.000	3.5	9.000	4.6
0.600	1.3	2.200	2.4	5.500	3.7	9.500	4.7
0.800	1.5	2.400	2.5	6.000	3.8		
1.000	1.7	2.600	2.6	6.500	4.0		

Summary of Results for 30 year Return Period

Half Drain Time : 214 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	85.063	0.273	1.2	1.7	2.9	45.6	O K
30 min Summer	85.100	0.310	1.2	1.7	2.9	51.7	O K
60 min Summer	85.131	0.341	1.2	1.8	2.9	57.0	O K
120 min Summer	85.146	0.356	1.2	1.8	2.9	59.4	O K
180 min Summer	85.140	0.350	1.2	1.8	2.9	58.4	O K
240 min Summer	85.130	0.340	1.2	1.8	2.9	56.8	O K
360 min Summer	85.109	0.319	1.2	1.7	2.9	53.3	O K
480 min Summer	85.089	0.299	1.2	1.7	2.9	49.9	O K
600 min Summer	85.070	0.280	1.2	1.7	2.9	46.8	O K
720 min Summer	85.053	0.263	1.2	1.7	2.9	43.8	O K
960 min Summer	85.019	0.229	1.2	1.7	2.8	38.2	O K
1440 min Summer	84.960	0.170	1.2	1.6	2.8	28.4	O K
2160 min Summer	84.894	0.104	1.2	1.6	2.8	17.4	O K
2880 min Summer	84.852	0.062	1.2	1.6	2.7	10.4	O K
4320 min Summer	84.820	0.030	0.7	1.5	2.2	5.1	O K
5760 min Summer	84.804	0.014	0.3	1.5	1.8	2.3	O K
7200 min Summer	84.794	0.004	0.1	1.5	1.6	0.6	O K
8640 min Summer	84.790	0.000	0.0	1.4	1.4	0.0	O K
10080 min Summer	84.790	0.000	0.0	1.2	1.2	0.0	O K
15 min Winter	85.100	0.310	1.2	1.7	2.9	51.7	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	105.845	0.0	48.7	25
30 min Summer	61.140	0.0	56.7	39
60 min Summer	35.317	0.0	65.9	66
120 min Summer	20.400	0.0	76.5	122
180 min Summer	14.798	0.0	83.5	168
240 min Summer	11.784	0.0	88.8	198
360 min Summer	8.548	0.0	96.7	260
480 min Summer	6.807	0.0	102.7	330
600 min Summer	5.705	0.0	107.6	396
720 min Summer	4.938	0.0	111.8	464
960 min Summer	3.925	0.0	118.5	598
1440 min Summer	2.840	0.0	128.4	852
2160 min Summer	2.055	0.0	138.9	1208
2880 min Summer	1.634	0.0	146.7	1536
4320 min Summer	1.175	0.0	157.1	2248
5760 min Summer	0.930	0.0	164.5	2944
7200 min Summer	0.776	0.0	170.4	3672
8640 min Summer	0.669	0.0	175.1	0
10080 min Summer	0.590	0.0	178.9	0
15 min Winter	105.845	0.0	54.9	25

Summary of Results for 30 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
30 min Winter	85.143	0.353	1.2	1.8	2.9	58.8	O K
60 min Winter	85.180	0.390	1.2	1.8	3.0	65.1	O K
120 min Winter	85.202	0.412	1.2	1.8	3.0	68.8	O K
180 min Winter	85.200	0.410	1.2	1.8	3.0	68.5	O K
240 min Winter	85.188	0.398	1.2	1.8	3.0	66.5	O K
360 min Winter	85.162	0.372	1.2	1.8	3.0	62.1	O K
480 min Winter	85.134	0.344	1.2	1.8	2.9	57.5	O K
600 min Winter	85.106	0.316	1.2	1.7	2.9	52.7	O K
720 min Winter	85.079	0.289	1.2	1.7	2.9	48.3	O K
960 min Winter	85.028	0.238	1.2	1.7	2.9	39.7	O K
1440 min Winter	84.941	0.151	1.2	1.6	2.8	25.2	O K
2160 min Winter	84.854	0.064	1.2	1.6	2.7	10.6	O K
2880 min Winter	84.826	0.036	0.8	1.5	2.4	6.0	O K
4320 min Winter	84.800	0.010	0.2	1.5	1.7	1.7	O K
5760 min Winter	84.790	0.000	0.0	1.4	1.4	0.0	O K
7200 min Winter	84.790	0.000	0.0	1.2	1.2	0.0	O K
8640 min Winter	84.790	0.000	0.0	1.0	1.0	0.0	O K
10080 min Winter	84.790	0.000	0.0	0.9	0.9	0.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
30 min Winter	61.140	0.0	63.8	39
60 min Winter	35.317	0.0	74.2	66
120 min Winter	20.400	0.0	86.1	122
180 min Winter	14.798	0.0	93.7	176
240 min Winter	11.784	0.0	99.8	226
360 min Winter	8.548	0.0	108.7	282
480 min Winter	6.807	0.0	115.5	358
600 min Winter	5.705	0.0	121.0	432
720 min Winter	4.938	0.0	125.8	504
960 min Winter	3.925	0.0	133.2	644
1440 min Winter	2.840	0.0	144.4	898
2160 min Winter	2.055	0.0	156.2	1216
2880 min Winter	1.634	0.0	165.1	1536
4320 min Winter	1.175	0.0	176.9	2256
5760 min Winter	0.930	0.0	185.6	0
7200 min Winter	0.776	0.0	192.3	0
8640 min Winter	0.669	0.0	197.7	0
10080 min Winter	0.590	0.0	202.2	0

Rainfall Details

Rainfall Model	FEH
Return Period (years)	30
Site Location	GB 524150 212350 TL 24150 12350
C (1km)	-0.028
D1 (1km)	0.303
D2 (1km)	0.297
D3 (1km)	0.282
E (1km)	0.321
F (1km)	2.478
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.750
Cv (Winter)	0.840
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+0

Time Area Diagram

Total Area (ha) 0.260

Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)
0	4	0.087	4	8	0.087	8	12	0.087

Model Details

Storage is Online Cover Level (m) 85.700

Porous Car Park Structure

Infiltration Coefficient Base (m/hr)	0.01510	Width (m)	10.4
Membrane Percolation (mm/hr)	3000	Length (m)	53.5
Max Percolation (l/s)	463.7	Slope (1:X)	0.0
Safety Factor	2.0	Depression Storage (mm)	5
Porosity	0.30	Evaporation (mm/day)	3
Invert Level (m)	84.790	Membrane Depth (m)	0

Hydro-Brake Optimum® Outflow Control

Unit Reference	MD-SHE-0061-2000-1490-2000
Design Head (m)	1.490
Design Flow (l/s)	2.0
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	61
Invert Level (m)	84.000
Minimum Outlet Pipe Diameter (mm)	75
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.490	2.0
Flush-Flo™	0.270	1.6
Kick-Flo®	0.545	1.3
Mean Flow over Head Range	-	1.6

The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake Optimum® as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	1.3	1.200	1.8	3.000	2.8	7.000	4.1
0.200	1.5	1.400	1.9	3.500	3.0	7.500	4.2
0.300	1.6	1.600	2.1	4.000	3.2	8.000	4.4
0.400	1.5	1.800	2.2	4.500	3.3	8.500	4.5
0.500	1.4	2.000	2.3	5.000	3.5	9.000	4.6
0.600	1.3	2.200	2.4	5.500	3.7	9.500	4.7
0.800	1.5	2.400	2.5	6.000	3.8		
1.000	1.7	2.600	2.6	6.500	4.0		

Summary of Results for 100 year Return Period (+30%)

Half Drain Time : 410 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	85.373	0.583	1.2	1.9	3.1	97.4	O K
30 min Summer	85.440	0.650	1.2	2.0	3.1	108.5	O K
60 min Summer	85.502	0.712	1.2	2.0	3.2	118.9	O K
120 min Summer	85.547	0.757	1.2	2.0	3.2	126.3	O K
180 min Summer	85.555	0.765	1.2	2.0	3.2	127.7	O K
240 min Summer	85.547	0.757	1.2	2.0	3.2	126.4	O K
360 min Summer	85.513	0.723	1.2	2.0	3.2	120.7	O K
480 min Summer	85.480	0.690	1.2	2.0	3.2	115.2	O K
600 min Summer	85.450	0.660	1.2	2.0	3.1	110.2	O K
720 min Summer	85.423	0.633	1.2	2.0	3.1	105.6	O K
960 min Summer	85.371	0.581	1.2	1.9	3.1	97.0	O K
1440 min Summer	85.282	0.492	1.2	1.9	3.0	82.2	O K
2160 min Summer	85.170	0.380	1.2	1.8	3.0	63.5	O K
2880 min Summer	85.078	0.288	1.2	1.7	2.9	48.1	O K
4320 min Summer	84.941	0.151	1.2	1.6	2.8	25.1	O K
5760 min Summer	84.862	0.072	1.2	1.6	2.7	12.0	O K
7200 min Summer	84.833	0.043	1.0	1.5	2.5	7.2	O K
8640 min Summer	84.819	0.029	0.7	1.5	2.2	4.9	O K
10080 min Summer	84.809	0.019	0.4	1.5	2.0	3.1	O K
15 min Winter	85.448	0.658	1.2	2.0	3.1	109.8	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	213.112	0.0	101.0	26
30 min Summer	120.231	0.0	114.3	40
60 min Summer	67.831	0.0	129.3	68
120 min Summer	38.268	0.0	146.1	126
180 min Summer	27.379	0.0	157.2	184
240 min Summer	21.589	0.0	165.3	242
360 min Summer	15.446	0.0	177.5	322
480 min Summer	12.180	0.0	186.5	382
600 min Summer	10.130	0.0	193.9	442
720 min Summer	8.714	0.0	200.1	508
960 min Summer	6.860	0.0	210.1	644
1440 min Summer	4.896	0.0	224.6	914
2160 min Summer	3.494	0.0	239.9	1304
2880 min Summer	2.751	0.0	251.3	1676
4320 min Summer	1.951	0.0	266.1	2380
5760 min Summer	1.529	0.0	276.8	3008
7200 min Summer	1.266	0.0	285.1	3680
8640 min Summer	1.085	0.0	291.7	4408
10080 min Summer	0.952	0.0	297.4	5144
15 min Winter	213.112	0.0	113.5	26

Summary of Results for 100 year Return Period (+30%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
30 min Winter	85.524	0.734	1.2	2.0	3.2	122.6	O K
60 min Winter	85.598	0.808	1.2	2.1	3.2	134.8	O K
120 min Winter	85.655	0.865	1.2	2.1	3.3	144.3	Flood Risk
180 min Winter	85.671	0.881	1.2	2.1	3.3	147.1	Flood Risk
240 min Winter	85.670	0.880	1.2	2.1	3.3	146.9	Flood Risk
360 min Winter	85.641	0.851	1.2	2.1	3.3	142.1	Flood Risk
480 min Winter	85.599	0.809	1.2	2.1	3.2	135.1	O K
600 min Winter	85.563	0.773	1.2	2.0	3.2	129.0	O K
720 min Winter	85.527	0.737	1.2	2.0	3.2	123.0	O K
960 min Winter	85.455	0.665	1.2	2.0	3.1	111.0	O K
1440 min Winter	85.325	0.535	1.2	1.9	3.1	89.4	O K
2160 min Winter	85.161	0.371	1.2	1.8	3.0	62.0	O K
2880 min Winter	85.029	0.239	1.2	1.7	2.9	39.9	O K
4320 min Winter	84.858	0.068	1.2	1.6	2.7	11.3	O K
5760 min Winter	84.823	0.033	0.8	1.5	2.3	5.4	O K
7200 min Winter	84.807	0.017	0.4	1.5	1.9	2.8	O K
8640 min Winter	84.796	0.006	0.1	1.5	1.6	0.9	O K
10080 min Winter	84.790	0.000	0.0	1.4	1.4	0.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
30 min Winter	120.231	0.0	128.4	40
60 min Winter	67.831	0.0	145.2	68
120 min Winter	38.268	0.0	164.1	124
180 min Winter	27.379	0.0	176.3	182
240 min Winter	21.589	0.0	185.4	238
360 min Winter	15.446	0.0	199.1	346
480 min Winter	12.180	0.0	209.4	438
600 min Winter	10.130	0.0	217.6	474
720 min Winter	8.714	0.0	224.7	550
960 min Winter	6.860	0.0	235.6	702
1440 min Winter	4.896	0.0	252.0	990
2160 min Winter	3.494	0.0	269.5	1392
2880 min Winter	2.751	0.0	282.1	1764
4320 min Winter	1.951	0.0	298.9	2376
5760 min Winter	1.529	0.0	311.1	2992
7200 min Winter	1.266	0.0	320.6	3680
8640 min Winter	1.085	0.0	328.3	4416
10080 min Winter	0.952	0.0	334.9	0

Rainfall Details

Rainfall Model	FEH
Return Period (years)	100
Site Location	GB 524150 212350 TL 24150 12350
C (1km)	-0.028
D1 (1km)	0.303
D2 (1km)	0.297
D3 (1km)	0.282
E (1km)	0.321
F (1km)	2.478
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.750
Cv (Winter)	0.840
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+30

Time Area Diagram

Total Area (ha) 0.260

Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)
0	4	0.087	4	8	0.087	8	12	0.087

Model Details

Storage is Online Cover Level (m) 85.700

Porous Car Park Structure

Infiltration Coefficient Base (m/hr)	0.01510	Width (m)	10.4
Membrane Percolation (mm/hr)	3000	Length (m)	53.5
Max Percolation (l/s)	463.7	Slope (1:X)	0.0
Safety Factor	2.0	Depression Storage (mm)	5
Porosity	0.30	Evaporation (mm/day)	3
Invert Level (m)	84.790	Membrane Depth (m)	0

Hydro-Brake Optimum® Outflow Control

Unit Reference	MD-SHE-0061-2000-1490-2000
Design Head (m)	1.490
Design Flow (l/s)	2.0
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	61
Invert Level (m)	84.000
Minimum Outlet Pipe Diameter (mm)	75
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.490	2.0
Flush-Flo™	0.270	1.6
Kick-Flo®	0.545	1.3
Mean Flow over Head Range	-	1.6

The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake Optimum® as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	1.3	1.200	1.8	3.000	2.8	7.000	4.1
0.200	1.5	1.400	1.9	3.500	3.0	7.500	4.2
0.300	1.6	1.600	2.1	4.000	3.2	8.000	4.4
0.400	1.5	1.800	2.2	4.500	3.3	8.500	4.5
0.500	1.4	2.000	2.3	5.000	3.5	9.000	4.6
0.600	1.3	2.200	2.4	5.500	3.7	9.500	4.7
0.800	1.5	2.400	2.5	6.000	3.8		
1.000	1.7	2.600	2.6	6.500	4.0		

APPENDIX 7

Maintenance Schedule

Maintenance of the SUDS permeable paving. This maintenance schedule must be included within the as built drawings with the Operations Manual. Marbrook Ltd are responsible for maintenance

Actions required	Frequency	Comments
Litter removal and general debris	Monthly	
Inspect for evidence of poor operation and/ or weed growth. If required take remedial action.	Three times per year preferably 48 hrs after large storms	
Stabilise and mow adjacent landscape areas where appropriate	Three times per year	
Inspect silt accumulation rates and establish appropriate brushing frequencies. Remove weeds	Annually	
Check silt traps for accumulation of debris and remove	Three times per year	
Upvc distribution pipes are located under the access road and car park as the as built drawings. Inspect the locality for signs of collapse in the blockwork as this may mean an unexpected failure of the distribution pipes has occurred	Annually	This is highly unlikely however a contractor with knowledge of the systems should replace accordingly
Brushing and suction sweeping or alternatively jet washing and suction sweeping to remove silt and debris. This is particularly important during autumn with falling leaves. Replacing of lost grit/material may be required	As required but expected annually	a contractor with knowledge of the systems should carry out these works
Resetting of uneven blocks by lifting block area, removing bedding materials and relaying to match original design.	As required (if infiltration performance is reduced as a result of significant blocking)	