

**PROPOSED DEVELOPMENT OF THREE HOUSES AT 68 STONEGATE COWBIT**  
**SPALDING**  
**SURFACE WATER DRAINAGE STRATEGY**

|              |                                                            |
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## **Introduction**

A development of 3 detached houses is proposed on a site at 68 Stonegate, Cowbit Spalding, PE12 6AH. The site is located north of the existing house. The development has outline planning approval (Reference No H01-0759-18) and this report has been commissioned to provide the details of proposed method of surface water disposal to discharge the planning condition in the approval.

S M Hemmings has been appointed by Mr P Cooper to produce a suitable scheme to dispose of the surface water from the development.

All new developments are now encouraged to include SuDS in the design of the surface water disposal. The CIRIA SuDS Manual 2015 explains the philosophy of SuDS in Chapter 1 of the manual as follows:

The philosophy of sustainable drainage systems is about maximising the benefits and minimising the negative impacts of surface water runoff from developed areas.

The SuDS approach involves slowing down and reducing the quantity of surface water runoff from a developed area to manage downstream flood risk, and reducing the risk of that runoff causing pollution. This is achieved by harvesting, infiltrating, slowing, storing, conveying and treating runoff on site and, where possible, on the surface rather than underground. Water then becomes a much more visible and tangible part of the built environment, which can be enjoyed by everyone.

The Technical Standards for Sustainable Drainage produced by the Local Authority SuDS Officer Organisation (LASOO) states that generally the aim for should be to discharge surface water runoff as high up the following hierarchy of drainage options as reasonably practicable:

- 1) Into the ground (infiltration).
- 2) To a surface water body.
- 3) To a surface water sewer or highway drain.
- 4) To a combined sewer.

## **The Site**

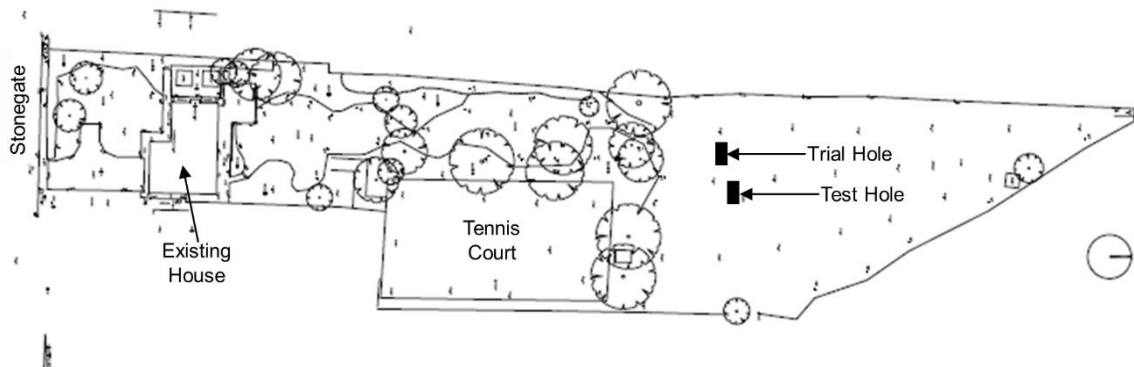
The area of the site is approximately 0.35hA with the three proposed houses and two separate garages having an area of approximately 384 square metres.

There are dykes on both the eastern and western boundaries of the site which flow northwards and it is presumed these discharge into the watercourse north of the site which is a drain maintained by South Holland Internal Drainage Board.

## **Site Investigations**

On the 22<sup>nd</sup> June 2021 one trial hole was excavated on the site. The hole was excavated to a depth of 1.3 metres and at this depth ground water was encountered. The upper 300mm of the ground was topsoil, and between this and a depth of 1.0 metres the soil was fen silt. Deeper than 1.0 metres the silt was mixed with small amounts of clay. The ground water rose to a depth of 1.2 metres below the surface after ten minutes.

A second hole was excavated 800mm deep, and a number of percolation tests were carried out in this hole over three days. The results of these tests are shown on pages 5, 6 and 7 of this report. The location of both holes is shown on the plan below.



Water was discharged into the hole from large plastic barrels. On the first day only one barrel was available which produced water depths of 150mm and 200mm at the start of the tests on the first day. On the second and third day three barrels were available which allowed depths of water in the hole of between 500mm and 600mm when the tests were commenced, as shown below.



The water in the hole drained away in 5 minutes and 7 minutes on the first day, 13 and 15 minutes on the second day and 15 and 16 minutes on the third day.

### **Calculation of Soil Infiltration Rates**

A graph was drawn of the results on the third day, and both tests were used to ascertain a time of 7.5 minutes for the water to fall from 75% full to 25% full.

The calculation of the soil infiltration rate is shown on page 8 and a rate of  $2.2 \times 10^{-4}$  m/sec was calculated.

## **Recommendations for Surface Water Disposal**

The soil infiltration rate indicates that soakaways should work satisfactorily on this site, as long as the test represents the conditions on the whole of the site.

Because of the high water table the soakaway should be placed at the shallowest depth possible to reduce the risk of a raised ground level affecting the operation of the soakaway.

## **Suitability of Soakaways and Alternative Solutions**

The design of the soakaways on this site conforms with BRE365 which sets out a guidance for soakaway design in the United Kingdom. This guide states

*“Ground water should not rise to a level of the base of the soakaway during annual variations in the water table. Planning authorities should advise where fluctuations in ground water level may cause a problem in the long term for any proposed depth of excavation.”*

Referring recent publications the SuDS Manual published by CIRIA gives the following guidance:

### **25.2.2 Groundwater level**

Groundwater levels should be investigated to ensure that the base of the proposed infiltration component is at least 1 m above the maximum anticipated groundwater level (taking account of seasonal variations in levels and any underlying trends). This should include assessment of relevant groundwater/borehole records, maps and on-site monitoring in wells. Guidance on the design of SuDS in areas with high groundwater is set out in **Section 8.3**. A 1 m separation distance ensures a depth of unsaturated soils to help ensure the infiltration performance of the component and protect underlying groundwater from contamination (**Section 25.2.5**).

The first paragraph of Section 8.3 of the Manual is shown on the next page:

### **8.3 HIGH GROUNDWATER LEVELS BELOW THE SITE**

#### **8.3.1 The challenges**

When designing a surface water management system for a site that overlies high groundwater levels (ie maximum likely groundwater levels are within 1 m of the base of the SuDS component – see **Section 25.2.2**), the following challenges should be considered within the design process:

- The use of infiltration may not be suitable due to reduced hydraulic and treatment capacity.
- If SuDS are constructed below the maximum likely groundwater level, then groundwater can potentially enter the SuDS component and reduce the storage capacity.

As the groundwater level on the site is high then the option of discharge to a surface water body will be considered. There are dykes on either side of the site into which the surface water could be discharged. As stated above it is presumed that these discharge into the IDB drain north of the site. Investigations would need to be carried out to check the efficacy of the short lengths of dyke or pipework connecting to the IDB drain.

The advantages and disadvantages of the option is tabulated on the next page.

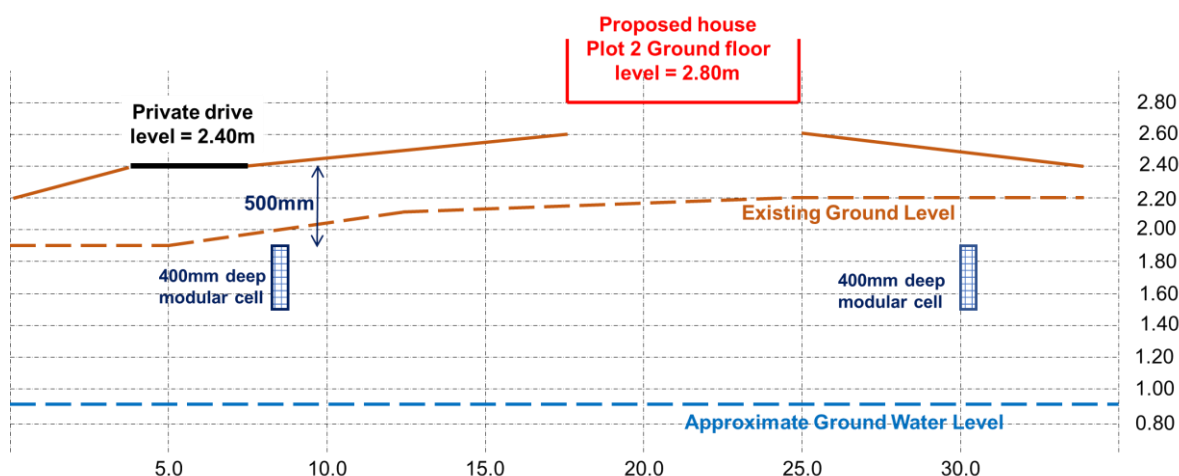
| Position in hierarchy   | Advantage and disadvantage                                                                                                                  | Recommendation                                                                                     |
|-------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------|
| Infiltration            | Design indicates this method would work satisfactorily but the high ground water levels could reduce the storage capacity of the soakaways. | Preferred solution.<br>Surface water from the existing building seems to be drained into soakaways |
| To a surface water body | Efficacy of section of dyke leading to IDB drain needs to be confirmed. Requires consent from South Holland IDB.                            | Would drain site satisfactorily.                                                                   |
| To a combined sewer     | Subject to Anglian Water approval and not considered a suitable solution.                                                                   | Discounted                                                                                         |

It is considered that infiltration with the use of soakaways is the preferred method of disposal for the surface water from the roofs of the proposed buildings.

### **Recommendation**

A design has been carried out using geocellular crates. The standard size of these units are 1.0 metre x 500mm wide x 400mm deep. The manufacturers of these units specify that there should be a minimum depth of 500mm of cover over the crates. Therefore the base of these units should be 900mm below ground level, which would initially place the crates only 300mm above the ground water level on the site.

The Flood Risk Assessment for the site specifies that the finished ground floor level of the proposed houses should be at a minimum level of 2.80m ODN which is 800mm higher than the average ground level on the site. A cross section has been drawn west to east across the site through plot 2 and the relevant levels are shown.



It can be seen that by raising the ground levels on the site that the geocellular crates can be positioned so that they are at least 600mm above the average groundwater level. This will mitigate the risk of the storage volume of the soakaways being reduced by high groundwater levels.

As can be seen on the plan on the next page the following soakaways are proposed.

- Plot 1: 2 No 4.5 metre long x 1.0 metre wide x 400mm deep soakaways using 9 geocellular crates each
- Plot 2: 2 No 5.5 metre long x 1.0 metre wide x 400mm deep soakaways using 11 geocellular crates each
- Plot 3: 2 No 5.0 metre long x 1.0 metre wide x 400mm deep soakaways using 10 geocellular crates each

The geocellular crates should be wrapped with a permeable geotextile membrane, and there should be at least 500mm cover above the crates to finished ground level. Soakaways should be a minimum of 5.0 metres from buildings and 2.0 metres from boundaries.

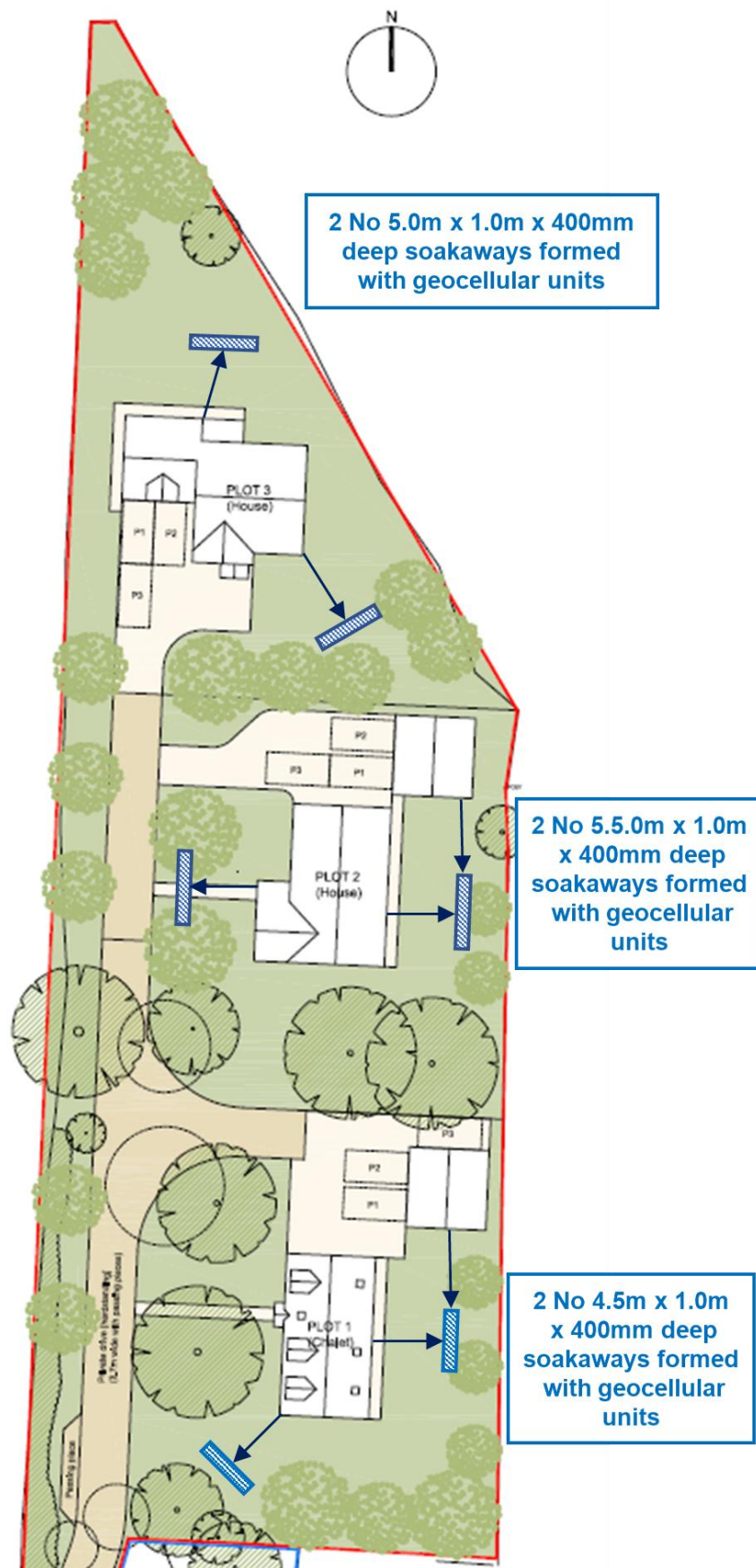
### **OVERLAND FLOOD FLOW AND EXCEEDANCE ROUTES**

It is inevitable that as a result of heavy or extreme rainfall the capacities of the drainage systems designed will be exceeded on some occasion. The design parameters using 1 in 100 year rainfall with a 30% increase reduce the possibility of flooding to the building in an extreme event. As the proposed houses will be raised to a level of 2.80m ODN as required in the flood risk assessment this will provide adequate mitigation of flood to the proposed houses.

### **MAINTENANCE OF DRAINAGE ASSETS**

The gullies and manholes should be kept clear of siltation and debris such as leaves should be regularly be removed to reduce the risk of siltation flowing into the geocellular crates.

## Plan of Site showing Proposed Soakaways



## **RESULTS OF PERCOLATION TESTS**

### **First Percolation Test on 22<sup>nd</sup> June 2021**

| Time    | Time (mins) | Measurement | Water Depth |
|---------|-------------|-------------|-------------|
| 10.35am | 0           | 710         | 150         |
| 10.38am | 3           | 790         | 70          |
| 10.40am | 5           | 860         | 0           |

### **Second Percolation Test on 22<sup>nd</sup> June 2021**

| Time    | Time (mins) | Measurement | Water Depth |
|---------|-------------|-------------|-------------|
| 10.52am | 0           | 640         | 210         |
| 10.53am | 1           | 670         | 180         |
| 10.54am | 2           | 700         | 150         |
| 10.55am | 3           | 740         | 110         |
| 10.56am | 4           | 770         | 80          |
| 10.57am | 5           | 800         | 50          |
| 10.58   | 6           | 820         | 30          |
| 10.59am | 7           | 840         | 10          |
| 11.00am | 8           | Empty       | 0           |

### **First Percolation Test on 23<sup>rd</sup> June 2021**

| Time    | Time (mins) | Measurement | Water Depth |
|---------|-------------|-------------|-------------|
| 9.47am  | 0           | 180         | 580         |
| 9.48am  | 1           | 240         | 520         |
| 9.49am  | 2           | 300         | 460         |
| 9.50am  | 3           | 340         | 420         |
| 9.51am  | 4           | 380         | 380         |
| 9.52am  | 5           | 420         | 340         |
| 9.53am  | 6           | 470         | 290         |
| 9.54am  | 7           | 520         | 240         |
| 9.55am  | 8           | 540         | 220         |
| 9.56am  | 9           | 590         | 170         |
| 9.57am  | 10          | 630         | 130         |
| 9.58am  | 11          | 660         | 100         |
| 9.59am  | 12          | 700         | 60          |
| 10.00am | 13          | 740         | 20          |
| 10.01am | 14          | Empty       | 0           |

**Second Percolation Test on 23<sup>rd</sup> June 2021**

| Time    | Time (mins) | Measurement | Water Depth |
|---------|-------------|-------------|-------------|
| 10.54am | 0           | 230         | 600         |
| 10.55am | 1           | 270         | 560         |
| 10.56am | 2           | 310         | 530         |
| 10.57am | 3           | 350         | 420         |
| 10.58am | 4           | 380         | 380         |
| 10.59am | 5           | 420         | 340         |
| 11.00am | 6           | 460         | 290         |
| 11.01am | 7           | 500         | 250         |
| 11.02am | 8           | 530         | 220         |
| 11.03am | 9           | 570         | 160         |
| 11.04am | 10          | 600         | 130         |
| 11.05am | 11          | 630         | 100         |
| 11.06am | 12          | 670         | 60          |
| 11.07am | 13          | 700         | 30          |
| 11.08am | 14          | 720         | 10          |
| 11.09am | 15          | Empty       | 0           |

**First Percolation Test on 24<sup>th</sup> June 2021**

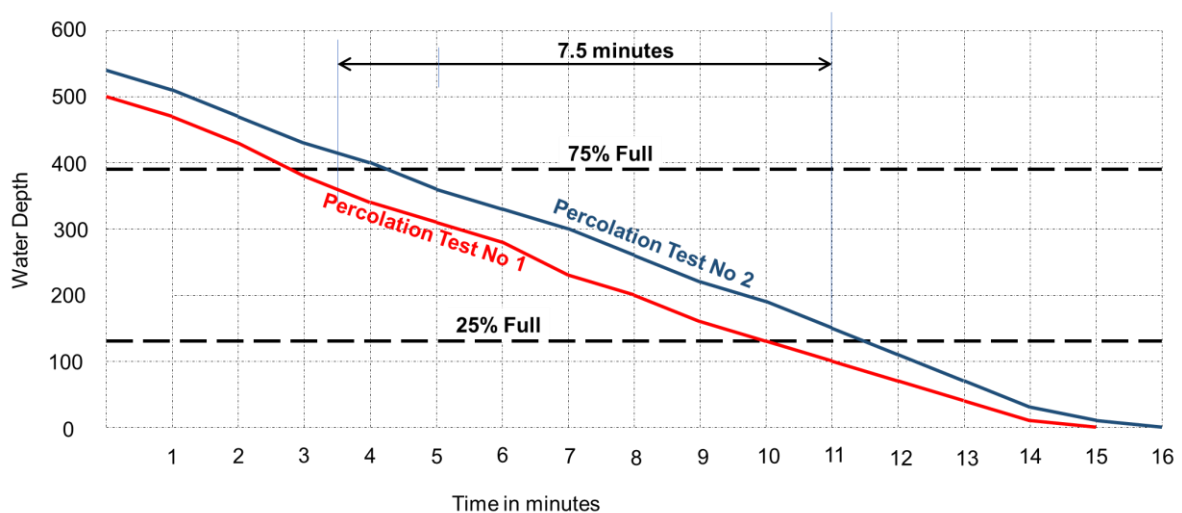
| Time   | Time (mins) | Measurement | Water Depth |
|--------|-------------|-------------|-------------|
| 9.16am | 0           | 200         | 500         |
| 9.17am | 1           | 230         | 470         |
| 9.18am | 2           | 270         | 430         |
| 9.19am | 3           | 320         | 380         |
| 9.20am | 4           | 360         | 340         |
| 9.21am | 5           | 390         | 310         |
| 9.22am | 6           | 420         | 280         |
| 9.23am | 7           | 470         | 230         |
| 9.24am | 8           | 500         | 200         |
| 9.25am | 9           | 540         | 160         |
| 9.26am | 10          | 570         | 130         |
| 9.27am | 11          | 600         | 100         |
| 9.28am | 12          | 630         | 70          |
| 9.29am | 13          | 660         | 40          |
| 9.30am | 14          | 690         | 10          |
| 9.31am | 15          | Empty       | 0           |

## Second Percolation Test on 24<sup>th</sup> June 2021

| Time    | Time (mins) | Measurement | Water Depth |
|---------|-------------|-------------|-------------|
| 11.31am | 0           | 190         | 540         |
| 11.32am | 1           | 220         | 510         |
| 11.33am | 2           | 260         | 470         |
| 11.34am | 3           | 300         | 430         |
| 11.35am | 4           | 330         | 400         |
| 11.36am | 5           | 370         | 360         |
| 11.37am | 6           | 400         | 330         |
| 11.38am | 7           | 430         | 300         |
| 11.39am | 8           | 470         | 260         |
| 11.40am | 9           | 510         | 220         |
| 11.41am | 10          | 540         | 190         |
| 11.42am | 11          | 580         | 150         |
| 11.43am | 12          | 620         | 110         |
| 11.44am | 13          | 660         | 70          |
| 11.45am | 14          | 700         | 30          |
| 11.46am | 15          | 720         | 10          |
| 11.47am | 16          | Empty       | 0           |

## Graph of Water Level and Time

Percolation Tests 1 & 2 24<sup>th</sup> June 2021



## **CALCULATION OF SOIL INFILTRATION RATE**

### **Percolation Test on 24<sup>th</sup> June 2021**

Referring to the graph of the results the estimated time taken to drain between 75% and 25% of the depth filled in the first test was 7.5 minutes.

The average size of the pit was 1200mm x 450mm

The water depth was 520mm

The soil infiltration rate will be calculated as follows:

$$\text{Soil Infiltration Rate} = \frac{V_{p75-25}}{A_{p50} \times t_{p75-25}}$$

Volume outflowing between 75% and 25% effective depth:

$$V_{p75-25} = 0.26 \times 1.2 \times 0.45 = \underline{0.14 \text{ cu m}}$$

The mean surface area through which the outflow occurs, taken to be the pit sides to 50% effective depth and including the base of the pit:

$$A_{p50} = (1.2 \times 0.26 \times 2) + (0.45 \times 0.26 \times 2) + (0.45 \times 1.2) = \underline{1.398 \text{ s m}}$$

The time of outflow between 75% and 25% effective depth

$$t_{p75-25} = 7.5 \times 60 = \underline{38,160}$$

$$\text{Soil Infiltration Rate} = \frac{0.14}{1.398 \times 450} = \underline{2.2 \times 10^{-4} \text{ m/sec}}$$

## **DESIGN OF SOAKAWAYS FOR PLOT 1**

Area of building = 78.0sq metres and area of garage = 38.5 sq metres.

Total area for design of soakaways = 116.5 sq metres.

| CALCULATION OF SIZE OF SOAKAWAY FOR PLOT 1                                                |                  |             |                  |                        |              |         |                  |
|-------------------------------------------------------------------------------------------|------------------|-------------|------------------|------------------------|--------------|---------|------------------|
| 1 in 100 year rainfall with Soil Infiltration Rate of 2.2 x 10-4                          |                  |             |                  |                        |              |         |                  |
|                                                                                           |                  |             |                  |                        |              |         |                  |
| Impermeable area to be drained                                                            |                  |             |                  | 117                    | sm           |         |                  |
| Length of units                                                                           |                  |             |                  | 9                      |              |         |                  |
| Width of units                                                                            |                  |             |                  | 1                      |              |         |                  |
| Depth of units                                                                            |                  |             |                  | 0.4                    |              |         |                  |
| Volume of storage                                                                         |                  |             |                  | 3.42                   |              |         |                  |
| Wetted area of soakaway as50                                                              |                  |             |                  | 4                      |              |         |                  |
| Number of crates                                                                          |                  |             |                  | 18                     |              |         |                  |
| Soil infiltration rate f                                                                  |                  |             |                  | 0.00022                |              |         |                  |
|                                                                                           |                  |             |                  |                        |              |         |                  |
| Duration                                                                                  | Growth Factor Z1 | M5 rainfall | Growth Factor Z2 | 10 Year Rainfall       | Inflow       | Outflow | Storage Required |
| 5                                                                                         | 0.37             | 7.4         | 1.98             | 14.7                   | 1.71         | 0.26    | 1.45             |
| 10                                                                                        | 0.52             | 10.4        | 1.98             | 20.6                   | 2.41         | 0.53    | 1.88             |
| 15                                                                                        | 0.63             | 12.6        | 1.98             | 24.9                   | 2.92         | 0.79    | 2.13             |
| 30                                                                                        | 0.8              | 16.0        | 1.97             | 31.5                   | 3.69         | 1.58    | 2.10             |
| 60                                                                                        | 1                | 20.0        | 1.93             | 38.6                   | 4.52         | 3.17    | 1.35             |
| 120                                                                                       | 1.21             | 24.2        | 1.89             | 45.7                   | 5.35         | 6.34    | -0.98            |
| 240                                                                                       | 1.45             | 29.0        | 1.86             | 53.9                   | 6.31         | 12.67   | -6.36            |
| 360                                                                                       | 1.6              | 32.0        | 1.83             | 58.6                   | 6.85         | 19.01   | -12.16           |
| 600                                                                                       | 1.79             | 35.8        | 1.81             | 64.8                   | 7.58         | 31.68   | -24.10           |
| 1440                                                                                      | 2.24             | 44.8        | 1.81             | 81.1                   | 9.49         | 76.03   | -66.54           |
|                                                                                           |                  |             |                  |                        |              |         |                  |
| Time to empty =                                                                           |                  | 0.34        | hours            |                        | SATISFACTORY |         |                  |
|                                                                                           |                  |             |                  |                        |              |         |                  |
| 1 in 100 year rainfall with Soil Infiltration Rate of 2.20 x 10-4 with 30% climate change |                  |             |                  |                        |              |         |                  |
|                                                                                           |                  |             |                  |                        |              |         |                  |
| Impermeable area to be drained                                                            |                  |             |                  | 117                    | sm           |         |                  |
| Length of units                                                                           |                  |             |                  | 9                      |              |         |                  |
| Width of units                                                                            |                  |             |                  | 1                      |              |         |                  |
| Depth of units                                                                            |                  |             |                  | 0.4                    |              |         |                  |
| Volume of storage                                                                         |                  |             |                  | 3.42                   |              |         |                  |
| Wetted area of soakaway as50                                                              |                  |             |                  | 4                      |              |         |                  |
| Number of crates                                                                          |                  |             |                  | 18                     |              |         |                  |
| Soil infiltration rate f                                                                  |                  |             |                  | 0.00022                |              |         |                  |
|                                                                                           |                  |             |                  |                        |              |         |                  |
| Duration                                                                                  | Growth Factor Z1 | M5 rainfall | Growth Factor Z2 | 10 Year Rainfall + 30% | Inflow       | Outflow | Storage Required |
| 5                                                                                         | 0.37             | 7.4         | 1.98             | 19.0                   | 2.23         | 0.26    | 1.96             |
| 10                                                                                        | 0.52             | 10.4        | 1.98             | 26.8                   | 3.13         | 0.53    | 2.60             |
| 15                                                                                        | 0.63             | 12.6        | 1.98             | 32.4                   | 3.79         | 0.79    | 3.00             |
| 30                                                                                        | 0.8              | 16.0        | 1.97             | 41.0                   | 4.79         | 1.58    | 3.21             |
| 60                                                                                        | 1                | 20.0        | 1.93             | 50.2                   | 5.87         | 3.17    | 2.70             |
| 120                                                                                       | 1.21             | 24.2        | 1.89             | 59.5                   | 6.96         | 6.34    | 0.62             |
| 240                                                                                       | 1.45             | 29.0        | 1.86             | 70.1                   | 8.20         | 12.67   | -4.47            |
| 360                                                                                       | 1.6              | 32.0        | 1.83             | 76.1                   | 8.91         | 19.01   | -10.10           |
| 600                                                                                       | 1.79             | 35.8        | 1.81             | 84.2                   | 9.86         | 31.68   | -21.82           |
| 1440                                                                                      | 2.24             | 44.8        | 1.81             | 105.4                  | 12.33        | 76.03   | -63.70           |
|                                                                                           |                  |             |                  |                        |              |         |                  |
| Time to empty =                                                                           |                  | 0.51        | hours            |                        | SATISFACTORY |         |                  |

## DESIGN OF SOAKAWAYS FOR PLOT 2

Area of building = 101.2 sq metres and area of garage = 38.5 sq metres.

Total area for design of soakaways = 139.7 sq metres.

| CALCULATION OF SIZE OF SOAKAWAY FOR PLOT 2                                                |                  |             |                  |                        |              |         |                  |
|-------------------------------------------------------------------------------------------|------------------|-------------|------------------|------------------------|--------------|---------|------------------|
| 1 in 100 year rainfall with Soil Infiltration Rate of 2.2 x 10-4                          |                  |             |                  |                        |              |         |                  |
|                                                                                           |                  |             |                  |                        |              |         |                  |
| Impermeable area to be drained                                                            |                  |             |                  | 140                    | sm           |         |                  |
| Length of units                                                                           |                  |             |                  | 11                     |              |         |                  |
| Width of units                                                                            |                  |             |                  | 1                      |              |         |                  |
| Depth of units                                                                            |                  |             |                  | 0.4                    |              |         |                  |
| Volume of storage                                                                         |                  |             |                  | 4.18                   |              |         |                  |
| Wetted area of soakaway as50                                                              |                  |             |                  | 4.8                    |              |         |                  |
| Number of crates                                                                          |                  |             |                  | 22                     |              |         |                  |
| Soil infiltration rate f                                                                  |                  |             |                  | 0.00022                |              |         |                  |
|                                                                                           |                  |             |                  |                        |              |         |                  |
| Duration                                                                                  | Growth Factor Z1 | M5 rainfall | Growth Factor Z2 | 10 Year Rainfall       | Inflow       | Outflow | Storage Required |
| 5                                                                                         | 0.37             | 7.4         | 1.98             | 14.7                   | 2.05         | 0.32    | 1.73             |
| 10                                                                                        | 0.52             | 10.4        | 1.98             | 20.6                   | 2.88         | 0.63    | 2.25             |
| 15                                                                                        | 0.63             | 12.6        | 1.98             | 24.9                   | 3.49         | 0.95    | 2.54             |
| 30                                                                                        | 0.8              | 16.0        | 1.97             | 31.5                   | 4.41         | 1.90    | 2.51             |
| 60                                                                                        | 1                | 20.0        | 1.93             | 38.6                   | 5.40         | 3.80    | 1.60             |
| 120                                                                                       | 1.21             | 24.2        | 1.89             | 45.7                   | 6.40         | 7.60    | -1.20            |
| 240                                                                                       | 1.45             | 29.0        | 1.86             | 53.9                   | 7.55         | 15.21   | -7.65            |
| 360                                                                                       | 1.6              | 32.0        | 1.83             | 58.6                   | 8.20         | 22.81   | -14.61           |
| 600                                                                                       | 1.79             | 35.8        | 1.81             | 64.8                   | 9.07         | 38.02   | -28.94           |
| 1440                                                                                      | 2.24             | 44.8        | 1.81             | 81.1                   | 11.35        | 91.24   | -79.89           |
|                                                                                           |                  |             |                  |                        |              |         |                  |
| Time to empty =                                                                           |                  | 0.33 hours  |                  |                        | SATISFACTORY |         |                  |
|                                                                                           |                  |             |                  |                        |              |         |                  |
| 1 in 100 year rainfall with Soil Infiltration Rate of 2.20 x 10-4 with 30% climate change |                  |             |                  |                        |              |         |                  |
|                                                                                           |                  |             |                  |                        |              |         |                  |
| Impermeable area to be drained                                                            |                  |             |                  | 140                    | sm           |         |                  |
| Length of units                                                                           |                  |             |                  | 11                     |              |         |                  |
| Width of units                                                                            |                  |             |                  | 1                      |              |         |                  |
| Depth of units                                                                            |                  |             |                  | 0.4                    |              |         |                  |
| Volume of storage                                                                         |                  |             |                  | 4.18                   |              |         |                  |
| Wetted area of soakaway as50                                                              |                  |             |                  | 4.8                    |              |         |                  |
| Number of crates                                                                          |                  |             |                  | 22                     |              |         |                  |
| Soil infiltration rate f                                                                  |                  |             |                  | 0.00022                |              |         |                  |
|                                                                                           |                  |             |                  |                        |              |         |                  |
| Duration                                                                                  | Growth Factor Z1 | M5 rainfall | Growth Factor Z2 | 10 Year Rainfall + 30% | Inflow       | Outflow | Storage Required |
| 5                                                                                         | 0.37             | 7.4         | 1.98             | 19.0                   | 2.67         | 0.32    | 2.35             |
| 10                                                                                        | 0.52             | 10.4        | 1.98             | 26.8                   | 3.75         | 0.63    | 3.11             |
| 15                                                                                        | 0.63             | 12.6        | 1.98             | 32.4                   | 4.54         | 0.95    | 3.59             |
| 30                                                                                        | 0.8              | 16.0        | 1.97             | 41.0                   | 5.74         | 1.90    | 3.84             |
| 60                                                                                        | 1                | 20.0        | 1.93             | 50.2                   | 7.03         | 3.80    | 3.22             |
| 120                                                                                       | 1.21             | 24.2        | 1.89             | 59.5                   | 8.32         | 7.60    | 0.72             |
| 240                                                                                       | 1.45             | 29.0        | 1.86             | 70.1                   | 9.82         | 15.21   | -5.39            |
| 360                                                                                       | 1.6              | 32.0        | 1.83             | 76.1                   | 10.66        | 22.81   | -12.15           |
| 600                                                                                       | 1.79             | 35.8        | 1.81             | 84.2                   | 11.79        | 38.02   | -26.22           |
| 1440                                                                                      | 2.24             | 44.8        | 1.81             | 105.4                  | 14.76        | 91.24   | -76.48           |
|                                                                                           |                  |             |                  |                        |              |         |                  |
| Time to empty =                                                                           |                  | 0.50 hours  |                  |                        | SATISFACTORY |         |                  |

## DESIGN OF SOAKAWAYS FOR PLOT 3

Area of building = 126.3 sq metres

Total area for design of soakaways = 126.3 sq metres.

| CALCULATION OF SIZE OF SOAKAWAY FOR PLOT 3                                                |                  |             |                  |                        |              |         |                  |
|-------------------------------------------------------------------------------------------|------------------|-------------|------------------|------------------------|--------------|---------|------------------|
| 1 in 100 year rainfall with Soil Infiltration Rate of 2.2 x 10-4                          |                  |             |                  |                        |              |         |                  |
|                                                                                           |                  |             |                  |                        |              |         |                  |
| Impermeable area to be drained                                                            |                  |             |                  | 127                    | sm           |         |                  |
| Length of units                                                                           |                  |             |                  | 10                     |              |         |                  |
| Width of units                                                                            |                  |             |                  | 1                      |              |         |                  |
| Depth of units                                                                            |                  |             |                  | 0.4                    |              |         |                  |
| Volume of storage                                                                         |                  |             |                  | 3.8                    |              |         |                  |
| Wetted area of soakaway as50                                                              |                  |             |                  | 4.4                    |              |         |                  |
| Number of crates                                                                          |                  |             |                  | 20                     |              |         |                  |
| Soil infiltration rate f                                                                  |                  |             |                  | 0.00022                |              |         |                  |
|                                                                                           |                  |             |                  |                        |              |         |                  |
| Duration                                                                                  | Growth Factor Z1 | M5 rainfall | Growth Factor Z2 | 10 Year Rainfall       | Inflow       | Outflow | Storage Required |
| 5                                                                                         | 0.37             | 7.4         | 1.98             | 14.7                   | 1.86         | 0.29    | 1.57             |
| 10                                                                                        | 0.52             | 10.4        | 1.98             | 20.6                   | 2.62         | 0.58    | 2.03             |
| 15                                                                                        | 0.63             | 12.6        | 1.98             | 24.9                   | 3.17         | 0.87    | 2.30             |
| 30                                                                                        | 0.8              | 16.0        | 1.97             | 31.5                   | 4.00         | 1.74    | 2.26             |
| 60                                                                                        | 1                | 20.0        | 1.93             | 38.6                   | 4.90         | 3.48    | 1.42             |
| 120                                                                                       | 1.21             | 24.2        | 1.89             | 45.7                   | 5.81         | 6.97    | -1.16            |
| 240                                                                                       | 1.45             | 29.0        | 1.86             | 53.9                   | 6.85         | 13.94   | -7.09            |
| 360                                                                                       | 1.6              | 32.0        | 1.83             | 58.6                   | 7.44         | 20.91   | -13.47           |
| 600                                                                                       | 1.79             | 35.8        | 1.81             | 64.8                   | 8.23         | 34.85   | -26.62           |
| 1440                                                                                      | 2.24             | 44.8        | 1.81             | 81.1                   | 10.30        | 83.64   | -73.34           |
|                                                                                           |                  |             |                  |                        |              |         |                  |
| Time to empty =                                                                           |                  | 0.33 hours  |                  |                        | SATISFACTORY |         |                  |
|                                                                                           |                  |             |                  |                        |              |         |                  |
| 1 in 100 year rainfall with Soil Infiltration Rate of 2.20 x 10-4 with 30% climate change |                  |             |                  |                        |              |         |                  |
|                                                                                           |                  |             |                  |                        |              |         |                  |
| Impermeable area to be drained                                                            |                  |             |                  | 127                    | sm           |         |                  |
| Length of units                                                                           |                  |             |                  | 10                     |              |         |                  |
| Width of units                                                                            |                  |             |                  | 1                      |              |         |                  |
| Depth of units                                                                            |                  |             |                  | 0.4                    |              |         |                  |
| Volume of storage                                                                         |                  |             |                  | 3.8                    |              |         |                  |
| Wetted area of soakaway as50                                                              |                  |             |                  | 4.4                    |              |         |                  |
| Number of crates                                                                          |                  |             |                  | 20                     |              |         |                  |
| Soil infiltration rate f                                                                  |                  |             |                  | 0.00022                |              |         |                  |
|                                                                                           |                  |             |                  |                        |              |         |                  |
| Duration                                                                                  | Growth Factor Z1 | M5 rainfall | Growth Factor Z2 | 10 Year Rainfall + 30% | Inflow       | Outflow | Storage Required |
| 5                                                                                         | 0.37             | 7.4         | 1.98             | 19.0                   | 2.42         | 0.29    | 2.13             |
| 10                                                                                        | 0.52             | 10.4        | 1.98             | 26.8                   | 3.40         | 0.58    | 2.82             |
| 15                                                                                        | 0.63             | 12.6        | 1.98             | 32.4                   | 4.12         | 0.87    | 3.25             |
| 30                                                                                        | 0.8              | 16.0        | 1.97             | 41.0                   | 5.20         | 1.74    | 3.46             |
| 60                                                                                        | 1                | 20.0        | 1.93             | 50.2                   | 6.37         | 3.48    | 2.89             |
| 120                                                                                       | 1.21             | 24.2        | 1.89             | 59.5                   | 7.55         | 6.97    | 0.58             |
| 240                                                                                       | 1.45             | 29.0        | 1.86             | 70.1                   | 8.91         | 13.94   | -5.03            |
| 360                                                                                       | 1.6              | 32.0        | 1.83             | 76.1                   | 9.67         | 20.91   | -11.24           |
| 600                                                                                       | 1.79             | 35.8        | 1.81             | 84.2                   | 10.70        | 34.85   | -24.15           |
| 1440                                                                                      | 2.24             | 44.8        | 1.81             | 105.4                  | 13.39        | 83.64   | -70.25           |
|                                                                                           |                  |             |                  |                        |              |         |                  |
| Time to empty =                                                                           |                  | 0.50 hours  |                  |                        | SATISFACTORY |         |                  |