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J7048 HIGHGATE CEMETERY LANDSCAPE MASTERPLAN – SURFACE WATER RUN OFF CALCULATION

This document is a professional surface water run off calculation to support planning application for Highgate Cemetery Landscape Masterplan. Calculation methodology of this document is in accordance to below guidance.

- CiRIA SuDS Manual (C753, 2015)
- Rainfall runoff management for developments report (R. Kellagher, 2013)

1 Allowable Peak Site Discharge Rates

Highgate cemetery is a 14.95 ha pre-development site. The standard that is set for the site is that peak flow rates for the 1:100-year events should be controlled to the equivalent for the pre-development condition. However, analysis below provides both peak site discharge based on greenfield and pre-development condition.

a. Greenfield Run off Rate

The hydrological characteristics of the region are given in Table 1 & Table 2.

Table 1 Hydrological characteristics of the West side

Area (ha)	7.1
SAAR (mm)	661
Soil Factor	0.47
Hydrometric area	6

Table 2 Hydrological characteristics of the East side

Area (ha)	7.85
SAAR (mm)	661
Soil Factor	0.47
Hydrometric area	6

Greenfield runoff rate can be estimate by IH124 equation. Since the site is less than 50 ha the formula should be applied for 50 ha and the result factored based on the ratio of areas.

$$Q_{BAR(rural)} = 0.00108 \times AREA^{0.89} \times SAAR^{1.17} \times SOIL^{2.17}$$

$$= 0.00108 \times 0.5^{0.89} \times 661^{1.17} \times 0.47^{2.17}$$

$$= 0.2257 \text{ m3/s for 50 ha site}$$

$$= 225.7 \text{ l/s for 50ha site}$$

$$= 4.5147 \text{ l/s/ha}$$

The total allowable Q_{BAR} from west side and east side are therefore:

- West side= 4.5147 x 7.1= 32.05 l/s
- East side= 4.5147 x 7.85= 35.44 l/s

To obtain the 1:1, 1:30 and 1:100-year allowable peak flow rates, the growth curve factors are:

- 1 year factor = 0.85
- 30-year factor = 2.40
- 100-year factor = 3.19

Therefore, Greenfield limiting discharge rates for the site are therefore as given in Table 3 & Table 4.

Table 3 Greenfield Runoff Rates of the west side

Return period	Whole site (l/s)	Unit value (l/s/m²)
1 year	27.25	0.000384
30-year	73.72	0.001038
100-year	102.25	0.001440

Table 4 Greenfield Runoff Rates of the east side

Return period	Whole site (l/s)	Unit value (l/s/m²)
1 year	30.12	0.000384
30-year	85.06	0.001084
100-year	113.05	0.001440

b. Pre-development run off rate

Where a site has been previously developed, it is reasonable to meet discharge limits that can correspond to rates that exist for the current state of the site, especially the proposed development will remain the function and use of the site as cemetery.

Where any drainage system is still operational, peak flow rates at the outfall for the relevant return periods can be demonstrated by producing a simulation model that includes an accurate representation of the drainage system and site area contributions, thus allowing derivation of an appropriate head-discharge relationship at the outfall. It is recognised that existing system will probably be overwhelmed for the 1:30 and 1:100-year events and therefore the actual rate of discharge from the site in such scenarios is likely to be increased by overland flow contributions or surcharging. Below calculation is solely based on the flow rate from the piped system which provides a conservative estimate.

Although the whole site measures 15 ha, there is 6.1 ha and 6.3 ha of land in west and east cemetery respectively remains green and will drain directly to the ground at greenfield rates without the need for storage. Therefore, the area to be considered in this calculation is 1 ha for west and 1.48 ha in east.

Peak run off rate from impermeable area, based on modified rational method.

$$Q = 2.78 \times C \times i \times A$$

Where:

- Q = design event peak rate of runoff (l/s)
- C = non-dimensional runoff coefficient which is dependent on the catchment characteristics
- $C = C_v * C_r$
  - C_v = volumetric runoff coefficient
  - C_r = dimensionless routing coefficient
- i = rainfall intensity for the design return period (in mm/hr) and for a duration equal to the "time of concentration" of the network
- A = total catchment area being drained (ha)

Note: 2.78 is a conversion factor to address the rainfall unit being in mm/hr.

Existing site condition of west side is:

- Site area: 7.1 ha
- Catchment area of existing drainage system: 1 ha

Table 5 Characteristics of west side for pre-development run off calculation.

C	0.8	For paved area runoff a value between 0.8-1.0 depending how effective the catchment is drained and level of permeability
I (mm/hr)	39	1:100-year, 60min
A (ha)	1	Area of existing catchment area

$Q_{100\ year} = 2.78 \times 0.8 \times 39 \times 1 = 86.736\ l/s$

Existing site condition of east side is:

- Site area: 7.85 ha
- Catchment area of existing drainage system: 0.34 ha

Table 6 Characteristics of east side for pre-development run off calculation.

C	0.8	For paved area runoff a value between 0.8-1.0 depending how effective the catchment is drained and level of permeability
I (mm/hr)	39	1:100 year, 60min
A (ha)	0.34	Area of existing catchment area

$Q_{100\ year} = 2.78 \times 0.8 \times 39 \times 0.34 = 29.49\ l/s$

2 Proposed development site peak run off

Proposed site condition of west side is:

- Site area: 7.1 ha
- Catchment area of existing drainage system: 0.82 ha

Table 7 Characteristics of west side for proposed development run off calculation

C	0.8	For paved area runoff a value between 0.8-1.0 depending how effective the catchment is drained and level of permeability
I (mm/hr)	39	1:100 year, 60min
A (ha)	0.82	Area of proposed catchment area

$Q_{100\ year} = 2.78 \times 0.8 \times 39 \times 0.82 = 71.1235\ l/s$

Existing site condition of east side is:

- Site area: 7.85 ha
- Catchment area of existing drainage system: 1.48 ha

Table 8 Characteristics of east side for proposed development run off calculation

C	0.8	For paved area runoff a value between 0.8-1.0 depending how effective the catchment is drained and level of permeability
I (mm/hr)	39	1:100 year, 60min
A (ha)	1.48	Area of proposed catchment area

$Q_{100\ year} = 2.78 \times 0.8 \times 39 \times 148 = 128.3693\ l/s$

3 Estimate attenuation storage volumes

Greenfield condition

There are two methods of undertaking preliminary assessments of the attenuation storage volumes required for a site. For simplicity the Kellagher (2013) approximate approach is used here.

Table 9 Catchment development details

Sub-catchment	West side	East side
Area (ha)	7.1	7.8
PIMP (%)	12.68	20.68
Impermeable area (ha)	0.82	1.48
Impervious area drained to infiltration systems (ha)	0.18	0
Return period for infiltration system design (years)	10	N/A
Impervious area drained to rainwater harvesting systems (ha)	0	0
Return period for rainwater harvesting system design (years)	N/A	N/A

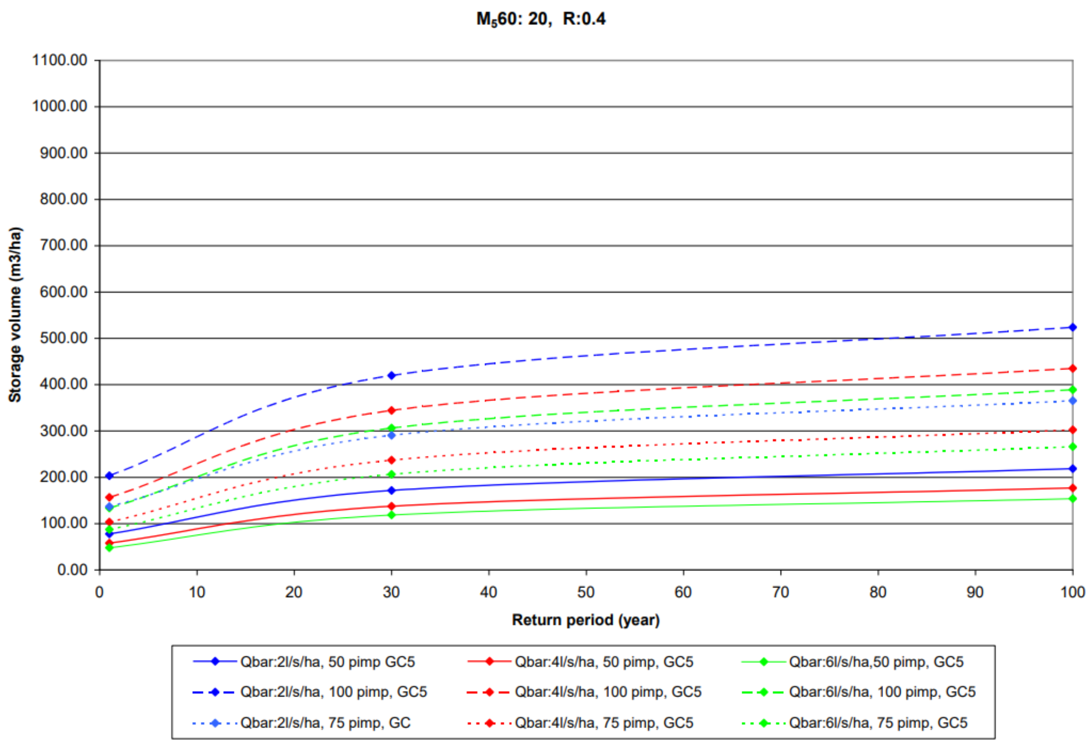

Figure A7.8 Attenuation storage volume as a function of Q_{BAR}/A and PIMP ($M_5$60:20, "r":0.4)

Using the catchment characteristics and design assumptions this outputs the required attenuation storage volumes as:

- West side 100-year attenuation storage volume = 220m³/ha x 0.82 x 1.4 = 252m³
- East side 100-year attenuation storage volume = 220m³/ha x 1.48 x 1.4 = 456m³

Note: This includes a climate change allowance 1.4.

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Pre-development condition
Calculation of storage required to estimate the extra run off volume from the development site compared to previously developed site is based on the methodology of sizing long term storage.

$$Vol_{xs} = RD \times A \times 10\ [(0.8 - SPR)\frac{PIMP_2}{100} + (SPR - 0.8) \times \frac{PIMP_1}{100}]$$

where:

- Vol_{xs} = extra runoff volume of the proposed development runoff over the runoff volume from the previously developed site (m^2)
- RD = rainfall depth for the 1:100 year, 6 hour event (mm)
- A = area of the site (ha)
- SPR = SPR index for the SOIL or HOST class (specified as a decimal proportion); this specifies the proportion of runoff from pervious surfaces (if SPRHOST values are used, the minimum value should be set to 0.1)
- $PIMP_2$ = percentage impermeability of the proposed site
- $PIMP_1$ = percentage impermeability of the previously developed site

West Side

Table 10 Characteristics of west side for long term storage calculation

RD (with climate change factor 1.4 and urban creep factor 1.1)	88.2
SPR	0.37
PIMP2	12.68%
PIMP1	14.06%

Vol_{xs} = -0.372m^3

East Side

Table 11 Characteristics of east side for long term storage calculation

RD (with climate change factor 1.4 and urban creep factor 1.1)	88.2
SPR	0.1
PIMP2	20.68%
PIMP1	4.24%

Vol_{xs} = 7.97m^3

The calculations indicate a minimum long-term storage requirement of 7.97 m^3 for the east side to accommodate the anticipated increase in runoff from the proposed development compared to the existing conditions. No additional storage is necessary for the west side due to a projected decrease in impermeable area. It is important to note that these assessments incorporate adjustments for climate change (40%) and urban creep (10%).