APPENDIX C FLOW ESTIMATION FOR UNDEVELOPED AREAS

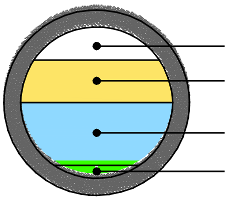
C1 GENERAL

The use of this Appendix requires Water Agency approval.

Design flow estimates are required for designing pipe networks and input to pump station designs. Design flow is the peak flow to be contained within the sewer system.

Design flow is the sum of the three components of flow, illustrated in Figure 3.1 (reproduced below).

Design flow = PDWF + GWI + RDI



NOTES:

1 *Components are indicative only and will differ due to location, rainfall, strata, pipe material and jointing methods and other factors.*

2 Reticulation sewer pipes shall be sized to provide at least 30% air space during wet weather flows (refer to Clause 5.5.3).

C2 PEAK DRY WEATHER (SANITARY) FLOW

The Peak Dry Weather Flow (PDWF) is defined as the most likely peak sanitary flow in the pipe during a normal day. It exhibits a regular pattern of usage with morning and evening peaks related to water usage for toilets, showers, baths, washing and other household activities.

Peak dry weather flow is related to the average dry weather flow (AWDF) by a "peaking factor", d:

PDWF = d * ADWF

where:

> ***ADWF** is the combined average daily sanitary flow into a sewer from domestic, commercial and industrial sources. Based on empirical evidence, ADWF is deemed to be 180 L/d/EP or 0.0021 L/s/EP.*
>
> *The dry weather peaking factor, **d**, is a function of the gross development area in hectares. Values of d are given in Figure C.1.*

The average dry weather flow in (L/s) is:

ADWF = 0.0021 * EP

Where:

> ***EP** is based on combined residential, commercial and industrial equivalent populations and is known or otherwise calculated in accordance with Appendix B i.e.*

PDWF = d * 0.0021 * EP

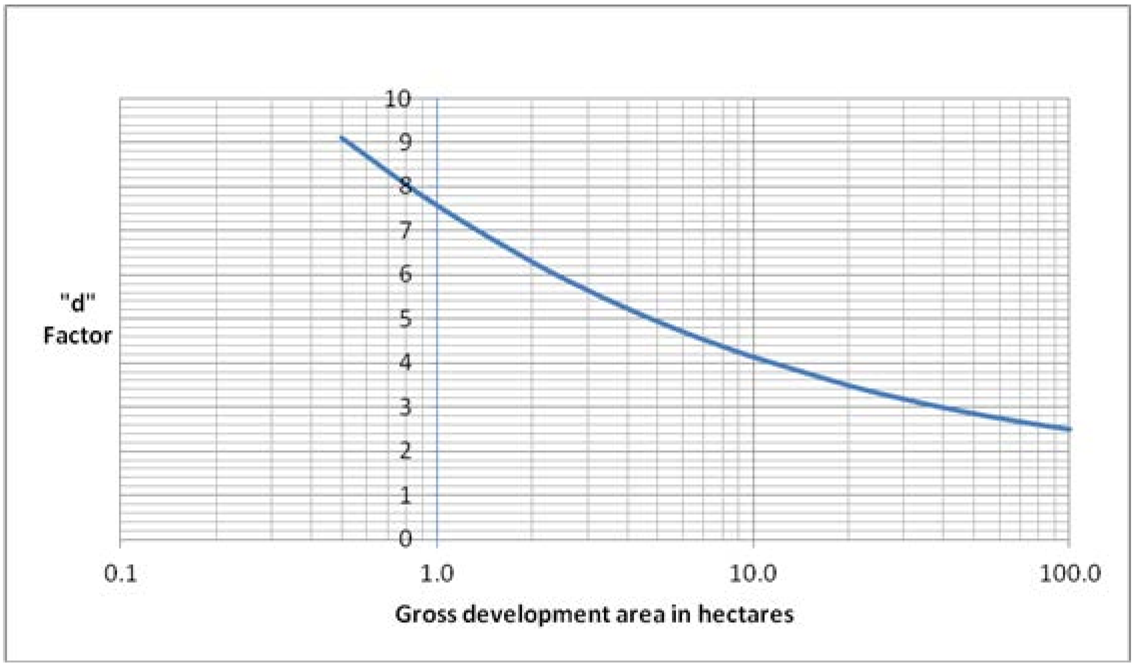


FIGURE C1 "d" FACTOR VERSUS AREA – AREAS <40 Ha

The curve in Figure C1 may be approximated by the following correlation and applied up to gross development areas of 100 000 hectares:

$d = 0.01(\log A)^4 - 0.19(\log A)^3 + 1.4(\log A)^2 - 4.66\log A + 7.57$

where:

A *is gross plan area of the development's catchment, in hectares.*

C3 GWI CALCULATION

Groundwater infiltration (GWI) is caused where the long-term non-rainfall dependent groundwater table or seawater level exceeds pipe inverts and enters the sewer network through pipe wall permeation and defects such as cracks, porosity, corroded and/or eroded areas, ineffective and/or tree root penetrated joints at pipes, fittings and maintenance structures and their displacement.

Where a map of groundwater table levels is not available, areas with fine clays and sandstones should be classified as high groundwater table portions of the catchment, or as otherwise advised by the responsible local agency or technical specialist.

The allowance for GWI assumes that good quality materials and workmanship have been used for sewer system construction and that ongoing condition assessment, inspection and maintenance is performed. The allowance for GWI should taken to be:

$GWI = 0.025 * A * Portion_{Wet}$

where:

GWI *is groundwater ingress in L/s.*

A *is gross plan area of the development's catchment, in hectares.*

$\textbf{Portion}_{Wet}$ *is the portion of the planned pipe network estimated to have groundwater table levels in excess of pipe inverts. For example if 70% of the sewer system is below groundwater table levels, then* $Portion_{Wet} = 0.7$

C4 RDI CALCULATION

RDI is the peak (rainfall dependent) inflow and infiltration that may enter the sewer network as inflow via localised flooding of yard gully traps, illegal stormwater connections and as rainfall infiltration through pipe and maintenance structure defects. RDI is affected by factors such as soil type, the condition of pipes, fittings, joints (including customer sanitary drains), maintenance structures, surface covers and community awareness and attitudes regarding the impact of sanitary drains and illegal stormwater connections. Control of RDI requires the Water Agency to deploy programmed monitoring, condition assessment, inspection, testing and maintenance of the sewer network and to cultivate community awareness to improve the level of compliance of customer sanitary drains.

RDI is calculated in L/s by using a model similar to the National "Rational Method" for stormwater flow calculation using the formula:

$RDI = 0.028 * A_{Eff} * C * I$

where:

A_{Eff} *is the effective area capable of contributing rainfall dependent infiltration. Calculation of* A_{Eff} *depends on the type e.g. residential or industrial, gross planned area and density i.e. EP per hectare of development.*

For residential developments:

A_{Eff} *is a function of the development density, as follows:*

$A_{Eff} = A \times (Density/150)^{0.5}$ *for Density <150 EP/Ha*

$A_{Eff} = A$ *for Density >150 EP/Ha*

where:

A *is gross plan area of the development's catchment, in hectares.*

Density *is the development's EP density per gross hectare.*

For commercial and industrial developments:

A_{Eff} *is a function of the expected portion of the catchment to be covered with impervious structures, such as building roofs, sealed roads and car parks, which will discharge rain-runoff to stormwater drains.*

$A_{Eff} = A \times (1 - 0.75\ Portion_{Impervious})$

where:

A *is gross plan area of the development's catchment, in hectares.*

$Portion_{Impervious}$ *is the portion of the gross plan area likely to be covered by impervious structures that drain directly to the stormwater system e.g. if a development has 20% coverage by such structures, then* $Portion_{Impervious} = 0.2$.

C *is the IIF leakage severity coefficient (similar to the stormwater "run-off coefficient"). It defines the contribution of rainfall run-off to sewer flows via IIF. C comprises the sum of the contributions from a "soil movement" aspect e.g. highest contribution for expansive clays and a "defects aspect" including the effectiveness of the Water Agency's long-term strategy for maintenance and managing the impact of sanitary sewers. With reference to Table C1, C will lie in the range from 0.4 to 1.6.*

The Water Agency should nominate values of C to be adopted for design, taking account of the likely impact of factors outlined above.

TABLE C1

LEAKAGE SEVERITY COEFFICIENT (C)

Influencing aspect	Low impact	High impact
Soil aspect, S_{aspect}	0.2	0.8
Network defects and inflow aspect, N_{aspect}	0.2	0.8
C = S_{aspect} + N_{aspect}	Minimum = 0.4	Maximum = 1.6

I *is a function of rainfall intensity at the development's geographic location, catchment area size and required sewer system containment standard. These influencing factors are related by:*

$$I = I_{1,2} \times Factor_{Size} \times Factor_{Containment}$$

where:

$I_{1,2}$ *is the 1 hour duration rainfall intensity at the location, for an average recurrence interval of 2 years.*

Rainfall intensities for particular locations may be determined from the Bureau of Meteorology at http://www.bom.gov.au/hydro/has/cdirswebx/cdirswebx.shtml*.*

Coordinates for particular locations for use in the Bureau of Meteorology's site may be found at http://www.ga.gov.au/place-name/*.*

Approximate values for a selection of Australian cities are presented in Table C2.

The Water Agency should nominate values of $I_{1,2}$ to be used.

TABLE C2

APPROXIMATE VALUES OF $I_{(1,2)}$ FOR VARIOUS LOCATIONS

City	Approx. Value of $I_{(1,2)}$
Adelaide	16.5
Alice Springs	20.9
Ballarat	19.1
Brisbane	47.0
Broome	46.7
Cairns	59.5
Canberra	21.4
Darwin	60.2
Dubbo	25.9
Geelong	17.4
Gold Coast	50.6
Gosford	37.3
Hobart	13.9
Melbourne	18.4

City	Approx. Value of $I_{(1,2)}$
Newcastle	34.5
Perth	20.5
Port Hedland	35.3
Sydney	40.5
Whyalla	14.5

Factor

$\textbf{Factor}_{\textbf{Size}}$ accounts for the fact that II flow concentration times are faster for smaller catchments, calculated as:

$\text{Factor}_{\text{Size}} = (40/A)^{0.12}$

where:

$\textbf{A}$ is gross plan area of the development's catchment, in hectares.

$\textbf{Factor}_{\textbf{Containment}}$ reflects local environmental aspects and regulations on wet weather sewage containment (overflow frequency). The design should incorporate the ARI of sewage overflows, specified by the Water Agency. Given the specified ARI, $\text{Factor}_{\text{Containment}}$ may be either taken from Table C3, or calculated from:

$$\textit{Factor}_{\textit{Containment}} = 0.77 \times \frac{10^{0.43X}}{10^{0.14X^2}}$$

where:

$\textbf{X}$ = Log_{10}(ARI) and ARI is the specified containment frequency in years.

TABLE C3

CONTAINMENT FACTOR VERSUS ARI

ARI	1 month	3 months	6 months	1 year	2 years	5 years	10 years
$\text{Factor}_{\text{Containment}}$	0.2	0.4	0.6	0.8	1.0	1.3	1.5

C5 WORKED EXAMPLE FOR A RESIDENTIAL DEVELOPMENT

C5.1 *Description*

A low density development on a greenfields site with gross area of 50 hectares and an average lot size of 500 m^2 is proposed for North Adelaide.

C5.2 *Peak dry weather flow (PDWF)*

From Table B1, the EP per gross hectare for 500 m^2 single occupancy lots is 50.

Calculate the design EP: = 50 x 50 (Ha) = 2500 EP

Estimate design ADWF: = 0.0021 x EP = 0.0021 x 2500 = 5.25 L/s

Determine the "d" factor: From the formula under Figure C.1, d has been calculated = 2.85

Determine PDWF: = d x ADWF = 2.85 x 5.25 = 15.0 L/s

C5.3 Ground water infiltration (GWI)

It is known that the local "perennial" groundwater table levels are such that half of the proposed sewer routes will be subject to high groundwater table levels. The GWI flow allowance is then calculated as:

GWI = 0.025 x A x $Portion_{Wet}$

For $Portion_{Wet}$ = 0.5, GWI = 0.025 x 50 x 0.5 = 0.625, say 0.6 L/s

C5.4 Rainwater dependent inflow and infiltration (RDI)

RDI calculation is as noted in C4:

RDI = 0.028 x C x I x A_{Eff}

To determine C:

Sandy loam soils (low soil movement and good drainage) are prevalent in the route of the sewer. Assuming that the Water Agency has a program to reduce illegal stormwater connections and has a reasonable condition assessment, inspection and maintenance program in place, with reference to Table C1, a "C" value of 0.6 is adopted i.e. assume S_{aspect} = 0.2 and N_{aspect} = 0.4)

To determine $I_{1,2}$:

Determining North Adelaide's coordinates from http://www.ga.gov.au/place-name/ to be Lat. -34° 54', Long. 138° 36' enables $I_{1,2}$ to be determined as 16.1 from http://www.bom.gov.au/hydro/has/cdirswebx/cdirswebx.shtml

To determine $Factor_{Size}$:

= $(40/A)^{0.12}$ = $(40/50)^{0.12}$ = 0.97

To determine $Factor_{Containment:}$

Regional environmental regulations for sewage spill frequency permit a 2 year ARI containment standard. Using Table C3 this gives $Factor_{Containment}$ = 1.0.

To determine I:

I = $I_{1,2}$ x $Factor_{Size}$ x $Factor_{Containment}$ = 16.0 x 0.97 x 1.00 = 15.5

To determine A_{Eff}:

A_{Eff} = A x $(Density / 150)^{0.5}$

A_{Eff} = 50 x $(50 / 150)^{0.5}$ = 28.9 Ha

To determine RDI:

RDI = 0.028 x C x I x A_{Eff} = *0.028 x 0.6 x 15.5 x 28.9 = 7.5 L/s*

C5.5 Design flow

Design flow calculation is as follows:

Design flow = PDWF + GWI + RDI = 14.9 + 0.6 + 7.5 = 23.0 L/s, which, for this example, is equivalent to 1.5*PDWF.

Note: For a given development, the ratio of Design flow:PDWF may significantly vary with variables such as C, $I_{1,2}$ and $Factor_{Containment}$.