Design Manual for Roads and Bridges

Drainage
Design

CD 526
Spacing of road gullies

(formerly HA 102/17)

Revision 3

Summary
This document provides the requirements and advice for determining the length of road that can be drained by grating and kerb outlets.

Application by Overseeing Organisations
Any specific requirements for Overseeing Organisations alternative or supplementary to those given in this document are given in National Application Annexes to this document.

Feedback and Enquiries
Users of this document are encouraged to raise any enquiries and/or provide feedback on the content and usage of this document to the dedicated Highways England team. The email address for all enquiries and feedback is: Standards_Enquiries@highwaysengland.co.uk

This is a controlled document.

Contents

Release notes

Version	Date	Details of amendments
3	Jan 2020	Revision 3 (January 2020) corrects typographical errors in Equation C.7 in Appendix C. Revision 2 (October 2019) corrects typographical errors in Equation 5.14.1N2b, B5 1) in Appendix B and Equation C.7 in Appendix C. Revision 1 (October 2018) corrects a number of equation typographic errors in Section 5, Appendix A and Appendix B. It also rectifies an incorrect unit of measure stated in the Symbols table. Revision 0 (August 2018) CD 526 replaces HA 102/17. This full document has been re-written to make it compliant with the new Highways England drafting rules.

Foreword

Publishing information

This document is published by Highways England.

This document supersedes HA 102/17, which is withdrawn.

Contractual and legal considerations

This document forms part of the works specification. It does not purport to include all the necessary provisions of a contract. Users are responsible for applying all appropriate documents applicable to their contract.

Introduction

Background

This document sets out the requirements and advice for determining the spacing of road grating and kerb inlets for removing surface water from the carriageway within an acceptable width of channel flow. The research upon which the design methodologies described in Appendix B and C are based is detailed in HRW SR 533 [Ref 7.I].

Assumptions made in the preparation of this document

The assumptions made in GG 101 [Ref 4.N] apply to this document.

The limiting factor determining the spacing between road gullies is normally taken to be the inlet capacity of the overlying grating rather than the underlying gully pot or associated pipework. See also Appendix C8.

The hydraulic design method in this document assumes that the gap between the kerb and the first slot(s) of a gully grating is not greater than 50mm.

Road profiling and gradients determine gully locations on roundabouts; refer to CG 501 [Ref 1.N] for further information.

Abbreviations and symbols

Abbreviations

Abbreviation	Definition
HRW	Hydraulics Research Wallingford
TRL	Transport Research Laboratory

Symbol	Definition
A_a	As A_{dr} but for actual rainfall intensity, performance factor and channel roughness (m^2)
A_{dr}	Maximum area which can be drained by a kerb channel for a rainfall intensity of I = 50m m/hr, a performance factor of m = 1.0, and a channel roughness of n = 0.017 (m^2)
A_f	Cross-sectional area of flow in channel just upstream of grating (m^2)
A_g	Area of smallest rectangle with two sides parallel to kerb that contains all the slots in the grating (m^2)
B	Maximum allowable width of flow in channel upstream of grating (m)
C_b	Coefficient for grating bar pattern
G	Grating parameter (s/m^2)
G_d	Design value of G for grating type (s/m^2)
H	Water depth at kerb (m)
I	Design rainfall intensity (mm/h)
k_n	Roughness and grating efficiency factor
k_L	Kerb inlet length factor
L	Length of opening provided by kerb inlet (m)
L_i	Overall length of opening in kerb provided by angled kerb inlet (m)
m	Performance factor
m_{us}	Performance factor for upstream grating
N	Return period of design storm (years)
n	Manning roughness coefficient
p	Waterway area as a percentage of grating area (%)
Q	Flow rate in channel approaching grating (m^3/s)
Q_{us}	Flow rate in channel approaching upstream grating (m^3/s)
R	Hydraulic radius of channel (m)
S_c	Crossfall
S_i	Longitudinal slope at distance Z_i from upstream gully (m)
S_p	Maximum allowable spacing between adjacent gullies (m)
S_L	Longitudinal gradient
T	Critical storm duration (minutes)

(continued)

Symbol	Definition
t_g	Time for water to travel along kerb to gully grating (minutes)
t_s	Time for water to travel from furthest point on road surface to kerb (minutes)
V	Flow velocity along kerb (m/s)
W_e	Effective catchment width draining to channel (m)
η	Flow collection efficiency of grating (%)
η_{us}	Flow collection efficiency of upstream grating (%)
2minM5	Rainfall depth occurring at a location in a period of 2 minutes with an average return period of 5 years (mm)
Z	Distance between adjacent gullies (m)
Z_i	Distance from upstream gully measured in downstream direction (m)

Terms and definitions

Terms

Term	Definition
Critical storm duration	A storm duration equal to the time of concentration.
Frame	For a gully, the fixed part of the gully top that receives and supports the grating.
Grating	The removable part(s) of a gully top that permits the passage of water to the gully.
Gully	An assembly to receive water for discharge into a drainage system.
Gully pot	A device installed below a grating to collect settleable solids and prevent them entering the piped drainage system.
Gully top	That part of a gully which is placed on the gully pot.
Intermediate gullies	Gullies for which some calculated portion of the approaching flow may be permitted to continue past the grating, to be picked up by the next grating downstream.
Kerb channel	The channel formed by the surface of a carriageway and the kerb.
Kerb inlet	Kerb inlets are units that when installed along the line of a kerb provide a series of openings parallel to the direction of flow and through each of which water can be discharged via a gully pot to the below-ground pipe system.
Return period	The average period between successive exceedances of a specified storm event.
Surface water channel	A triangular or other cross-section channel near the edge of the carriageway specially constructed to collect and convey water.
Terminal gullies	Gullies for which no significant portion of the approaching flow may be permitted to pass the grating.
Time of concentration	The sum of the time taken for water to travel from the furthest point on the road surface to the kerb, and then along the kerb to the gully.
Transverse bars	Part of the grating which is at 90º ± 10º to the direction of flow.
Waterway area	The total area of all the slots in a grating through which water can pass.

1. Scope

Aspects covered

1.1 The requirements, advice and design methodologies contained within this document shall apply for determining the spacing of road grating and kerb inlets to the range of longitudinal gradients between 0.33% (1/300) and 6.67% (1/15).

1.1.1 The requirements, advice and design methodologies for determining the spacing of road grating and kerb inlets may be extended to a longitudinal gradient of 8.0% (1/12.5) in accordance with HRW SR 533 [Ref 7.I].

NOTE 1 Flat longitudinal gradients are unavoidable in some situations and road gullies can offer advantages over surface water channels in this situation as the gradient to carry road runoff from a gully to an outfall is not dependent on the gradient of the road.

NOTE 2 For long lengths of flat gradient, grating and kerb outlets do not always provide the optimum drainage solution.

NOTE 3 Further information on the design of gully spacings for the drainage of level or nearly level roads is given in TRL LR602 [Ref 3.I].

NOTE 4 Kerb drainage system having continuous slots or closely-spaced holes that discharge into a longitudinal pipe or channel formed within the kerb unit (combined kerb and drain unit) are outside the scope of this document.

Implementation

1.2 This document shall be implemented forthwith on all schemes involving the use of gully gratings and kerb outlets to remove runoff from the carriageway on the Overseeing Organisations' motorway and all-purpose trunk roads according to the implementation requirements of GG 101 [Ref 4.N].

Use of GG 101

1.3 The requirements contained in GG 101 [Ref 4.N] shall be followed in respect of activities covered by this document.

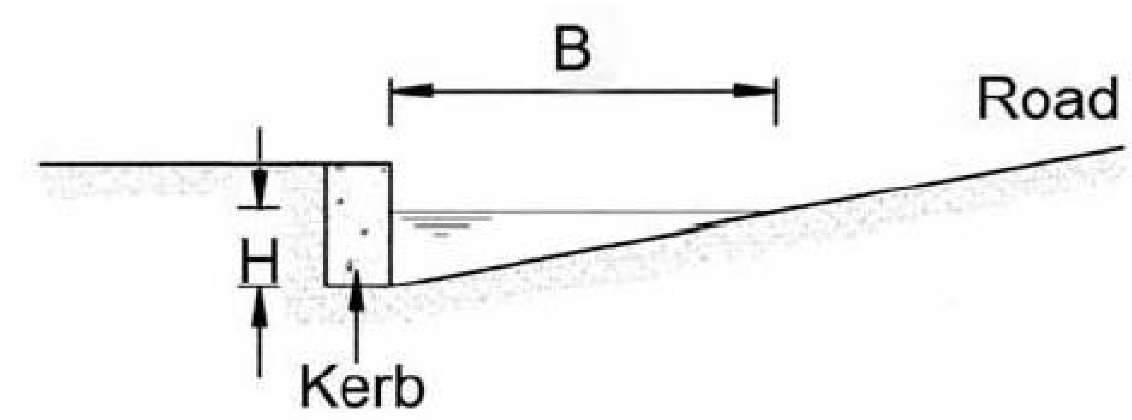
1.4 Safety risk mitigation measures shall follow the ERIC hierarchy - Eliminate, Reduce, Isolate and Control for each identified safety risk.

2. Design principles

2.1 The hydraulic design of road gratings and kerb inlets shall fulfil the requirements set out in this section.

2.2 The flow of water parallel to the kerb shall not exceed an allowable flow width (see reference to B in Figures 2.2 and 2.4).

Figure 2.2 Flow width of water against kerb

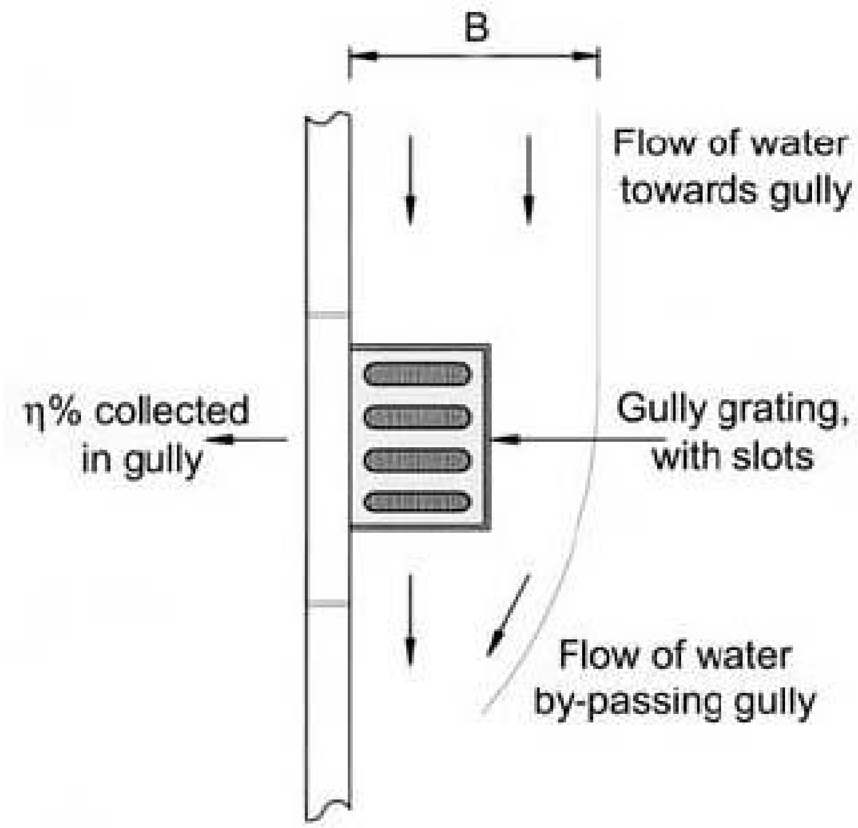


2.3 When checked for a 1 in 5 year storm as described in CG 501 [Ref 1.N] the allowable flow width B shall not exceed 1.5m for the hard shoulder or 1.0m for the hard strip.

NOTE An excessive flow width can be a danger to traffic.

2.4 The grating of the gully or kerb inlet shall collect as much of the approaching flow as possible. Efficiency η (%) is expressed as the water flow down the grating or inlet as a percentage of the approaching flow (Figure 2.4).

Figure 2.4 Flow of water along kerb and by-passing gully grating



NOTE Any water not collected flows past the grating, augmenting the flow in the next downstream section.

2.5 No flow shall bypass a terminal gully.

2.6 The overall hydraulic capacity of a system of road gratings and kerb inlets shall capture any water that by-passes any single grating in the system.

3. Types of gully grating

3.1 Gully gratings shall comply with the requirements outlined in BS EN 124 [Ref 2.N].

NOTE The hydraulic capacity of a gully grating depends on its overall size, the number and orientation of the slots and the total waterway area provided by the slots.

3.2 Gully gratings shall be rectangular or triangular with one side adjacent to the kerb.

3.2.1 The kerb face of the frame should be hard against the kerb.

3.2.2 The portion of the total waterway area within 50mm of the kerb should not be less than 45 cm^2, in accordance with BS 7903 [Ref 5.I].

NOTE The hydraulic design method in this document assumes that the gap between the kerb and the first slot(s) of a gully grating is not greater than 50mm.

3.3 Circular gully gratings, and any shapes that are highly asymmetric in a direction transverse to the kerb, shall not be used.

3.4 Grating slots shall be orientated so as not to pose a hazard to cyclists riding over them in the direction of travel.

NOTE BS EN 124 [Ref 2.N] allows grating slots parallel to the kerb which can present a serious hazard to cyclists.

3.5 Classification of gratings shall be determined by the method of calculation in Appendix A, based upon the geometric characteristics of the grating.

NOTE 1 In order to deal with the large number of possible designs that can be produced, Appendix A sets out a method of classifying gratings based on their hydraulic characteristics - Types P, Q, R, S or T in decreasing hydraulic capacity. The advantage of this approach is that a grating type can be specified during design, ensuring the required hydraulic performance whatever type of conforming grating is chosen during construction.

NOTE 2 If a manufacturer wishes to carry out hydraulic tests to determine the classification of a grating, a suitable test procedure is described in HRW SR 533 [Ref 7.I].

3.5.1 Where a gully grating is under performing hydraulically, it may be more cost effective to install a more efficient grating than install an additional gully.

4. Types of kerb inlet

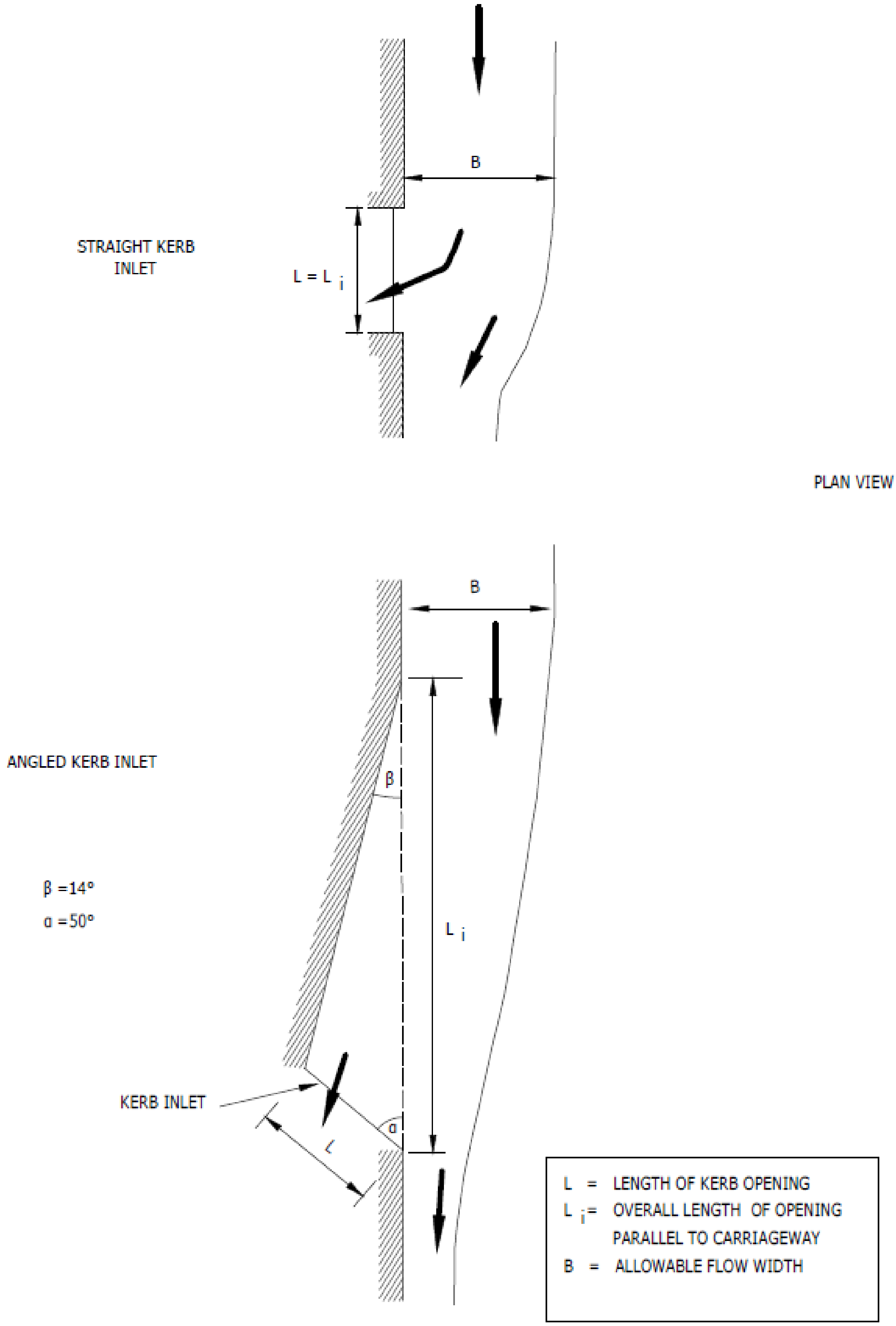
4.1 Kerb inlet covers and frames shall be Class D400 or stronger, in accordance with BS EN 124 [Ref 2.N].

NOTE 1 Kerb inlets tend to have lower flow collection capacity than a gully grating of similar length. This is because the lower velocity of flow along a kerb channel limits the proportion of total flow that is able to turn into the opening provided by the kerb inlet.

NOTE 2 A method of increasing the efficiency of a kerb inlet is to create a longer opening parallel to the direction of flow by recessing the upstream kerb line and setting the kerb inlet at a greater angle to the flow (see Figure 4.1.1).

4.1.1 To prevent flow separating from the recessed section of kerb, the angle β in Figure 4.1.1 should be no greater than 14º, corresponding to an expansion angle of 1:4.

Figure 4.1.1 Layout of kerb inlets



4.2 To minimise the risk to errant vehicles, angled kerb inlets of the type shown in Figure 4.1.1 shall only be used where the direction of water flow is opposite to that of the traffic in the carriageway adjacent to the kerb.

NOTE *Angled kerb inlets can be more prone to blockage. Debris decreases performance and increases the risk of flooding.*

5. Factors affecting hydraulic design

5.1 The hydraulic parameters of channels, gratings and inlets shall be evaluated in accordance with this section before commencing the design procedure.

5.2 An initial assumption about the most suitable grating type (P to T) for a particular scheme shall be made, and upgraded if it does not prove satisfactory.

5.3 The Manning roughness coefficient of the channel (n) shall be taken as no less than 0.017 for an asphalt surface.

NOTE Values for Manning's n for different drainage channel materials are given in Table 5.3N.

Table 5.3N Values of Manning's n

Surface	Condition	n
Concrete	Average	0.013
Concrete	Poor	0.016
Asphalt	Average	0.017
Asphalt	Poor	0.021

5.4 The location of specific gullies shall first be fixed by the requirements and advice given in this section.

5.4.1 The location and spacing for any intermediate gullies may be determined by the design methods given in Appendix B and Appendix C.

5.5 Calculations shall commence at the crests or highest point of the scheme and proceed downhill.

NOTE Design storm return periods are given in CG 501 [Ref 1.N].

Effect of performance reduction

5.6 A performance factor 'm' shall be included to allow for reduced grating efficiency.

NOTE 1 Reduced efficiency can be caused by the accumulation of debris that reduces the hydraulic area and therefore the efficiency.

NOTE 2 The performance factor m has a value of 1.0 for no effect, and decreasing values for increasing levels of risk.

NOTE 3 Values for m are given in Table 5.6N4.

NOTE 4 Site specific characteristics can determine the grating efficiency factor m to be used in the design.

Table 5.6N4 Values of performance factor

Situation	Maintenance factor (m)
Baseline condition	1.0
Roads subject to substantial leaf falls or vehicle spillages (e.g. at sharp roundabouts)	0.8
Sag points on road gradients	0.7

Types of gully

5.7 The type of gully, intermediate or terminal, shall be determined by the distinction between their two modes of hydraulic operation.

NOTE 1 Intermediate gullies are those for which some calculated proportion of the approaching flow can be permitted to continue past the gully, to be picked up by the next gully downstream as shown in Figure 2.4. This is known as by-pass flow.

NOTE 2 Terminal gullies are those for which no significant proportion of the approaching flow is permitted to pass the gully, either because there is no downstream gully or because the passing flow will interfere with traffic.

5.8 Gully design shall allow future maintenance to be carried out safely and effectively.

5.9 Gully design shall not affect the safety of cyclists and other road users and will not impact upon traffic flow.

5.10 Gullies shall be located so as not to pose a hazard to users of pedestrian, cycle or equestrian crossings.

5.11 Gullies shall be located so that there is no standing water at pedestrian, cycle or equestrian crossings.

NOTE 1 A particular problem occurs at sag points in gradients, both because floating debris will tend to accumulate at this point, and because any water not entering a gully at this point cannot pass to another gully.

NOTE 2 Where the crest along a length of road with changing longitudinal gradient is well defined, a gully is not required at this point.

5.11.1 Where there is a slow transition from negative to positive gradient, a gully may be placed at the crest to prevent any ponding of water.

NOTE In cases such as the following it can be beneficial to install an additional upstream gully, designed to act as a terminal gully:

1) *Transitions to superelevations.*
2) *A pedestrian, cycle or equestrian crossing.*
3) *For steeply angled road junctions.*

5.12 Kerb inlets shall not be used as terminal gullies at sag points unless it is in combination with gratings.

Rainfall

5.13 The design rainfall intensity I (mm/h) shall be determined in accordance with the requirements described in CG 501 [Ref 1.N].

5.13.1 Design rainfall intensity may also be determined from the formula given in CD 521 [Ref 3.N], reproduced below:

Equation 5.13.1

$$I = 32.7(N-0.4)^{0.223}\left\{(T-0.4)^{0.565}\frac{2\min M5}{T}\right\}$$

NOTE 1 The term 2minM5 describes the depth of rainfall (in mm) falling at a site over a period of 2 minutes, and with an average return period of 5 years (i.e. an annual exceedance probability of 20%). This is a measure of the rainfall characteristics at any given site and is reproduced in Figure E.1 in Appendix E.

NOTE 2 Design values of the storm return period are given in CG 501 [Ref 1.N].

NOTE 3 Records indicate East Anglia and the South East experience lower Average Annual Rainfall than other parts of the UK. However, these regions experience higher intensity and more frequent short duration storms, particularly during summer months as demonstrated by the 2minM5 values shown in Figure E.1.

NOTE 4 The critical storm duration T (in minutes) is the time of concentration of flow for the area served by the gully.

NOTE 5 The critical storm duration T used for simple modelling purposes is generally recognised as 5 minutes.

NOTE 6 T can be significantly less than 5 minutes for gullies spaced at less than 10m intervals, and with moderate to severe longitudinal gradients (more than 4%).

NOTE 7 *T can be significantly greater than 5 minutes for gullies spaced at greater than 50m intervals, and with flatter longitudinal gradients (less than 0.5%).*

5.14 The value of T shall be checked for the shortest and longest drainage lengths between gullies.

5.14.1 The sum of the time taken for water to travel from the furthest point on the road surface to the kerb, t_s, and then along the kerb to the gully, t_g, should be approximately equal to T, i.e.:

Equation 5.14.1

$$T = t_s + t_g$$

NOTE 1 *A value of ts of 3 minutes is generally recommended. The Wallingford Procedure [Ref 2.I](see section 7.10) provides information on non-standard cases.*

NOTE 2 *For a reasonably uniform gradient, tg (in minutes) can be calculated from the flow velocity, V (in m/s) and gully spacing:*

Equation 5.14.1N2a

$$t_g = \frac{Sp}{60V}$$

Equation 5.14.1N2b

$$V = \frac{2Q}{B^2 Sc}$$

5.14.2 If Equation 5.14.1 shows T to be outside the range 4 to 7 minutes, the design procedure should be repeated using the recalculated value of critical storm duration (T) rounded to the nearest minute.

Catchment width

5.15 All paved areas draining to the kerb shall be included in the catchment width.

NOTE *Paved areas can include hard shoulders, paved central reserves, footways, emergency refuge areas and maintenance hard-standing. Roof drainage from buildings can also be included where it discharges to road gullies.*

5.15.1 The effective catchment width draining to the kerb channel, W_e (in m), may be determined from a plan area of the site.

5.16 If the unpaved area exceeds the paved area then the methodology outlined in CD 521 [Ref 3.N] shall be used to determine the effective catchment width draining to the kerb channel.

5.16.1 Where the unpaved area does not exceed the paved area, it may be accepted that runoff contribution from unpaved areas equates to 20% that of an equivalent paved area.

6. Normative references

The following documents, in whole or in part, are normative references for this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

Ref 1.N	Highways England. CG 501, 'Design of highway drainage systems'
Ref 2.N	BSI. BS EN 124, 'Gully tops and manhole tops for vehicular and pedestrian areas. Definitions, classification, general principles of design, performance requirements and test methods'
Ref 3.N	Highways England. CD 521, 'Hydraulic design of road edge surface water channels and outlets'
Ref 4.N	Highways England. GG 101, 'Introduction to the Design Manual for Roads and Bridges'

7. Informative references

The following documents are informative references for this document and provide supporting information.

Ref 1.I	British Standards Institution. BS 6367, 'Code of practice for drainage of roofs and paved areas'
Ref 2.I	National Water Council. The Wallingford Procedure, 'Design and analysis of urban storm drainage – Volume 1, Principles, methods and practice'
Ref 3.I	Transport and Road Research Laboratory. Whiffin, A.C. and Young, C.P.. TRL LR602, 'Drainage of level or nearly level roads'
Ref 4.I	British Standards Institute. BS EN 12056, 'Gravity drainage systems inside buildings. Roof drainage, layout and calculation'
Ref 5.I	BSI. BS 7903, 'Guide to selection and use of gully tops and manhole covers for installation within the highway'
Ref 6.I	HR Wallingford. Forty, E.J.. HRW SR 508, 'Performance of gully pots for road drainage'
Ref 7.I	HR Wallingford. Spaliviero, F., May, R.W.P. and Escarameia, M.. HRW SR 533, 'Spacing of road gullies: Hydraulic performance of BS EN 124 gully gratings and kerb inlets'

Appendix A. Determining the grating type

A1 Introduction

When determining the grating type, the following three geometrical properties are determined first.

1) The area A_g (in m^2) of the smallest rectangle parallel to the kerb that just includes all the slots.
2) The waterway area as a percentage (p) of the grating area A_g.
3) The coefficient C_b determined from Table A1 below.

Bars more than 10mm below the surface of the grating are treated as part of the waterway area when calculating the value of p. If a grating has a combination of bar alignments, the number of transverse slots and the number of slots with other alignments are calculated. If there are more transverse slots than other slots, C_b is be taken as 1.75; otherwise C_b is taken as 1.5.

Table A.1 Grating bar pattern

Grating bar pattern	C_b
Transverse bars	1.75
Other bar alignments - (i.e. longitudinal, diagonal and bars curved in plan)	1.5

The category into which a grating falls may then be determined from the value of the grating parameter G (in s/m^2):

Equation A.1

$$G = \frac{69C_b}{\left(A_g^{0.75}\right)\sqrt{p}}$$

The grating type and the corresponding design value G_d of the grating parameter is then determined from Table A2. The value of G_d should be used to calculate the maximum spacing between gullies, rather than the actual value of G from Equation (A.1).

Table A.2 Determination of grating type

Grating type	P	Q	R	S	T
Range of G ($s/m^{2)}$)	<30	30.1 - 45	45.1 - 60	60.1 - 80	80.1 - 110
Design value G_d (s/m^2)	30	45	60	80	110

Appendix B. Use of tables for determining flow capacity of gullies

B1 Introduction

A series of design tables is given in Appendix D of this document. These can be used, subject to the limitations indicated, to determine gully spacings with the minimum of calculation.

Alternatively the equations on which they are based are given in Appendix C of this document, and these equations can be used directly.

It should be noted that the tables refer to spacing of intermediate gullies. The design of terminal gullies is described at the end of this appendix.

B2 Hydraulic parameters

The following parameters are required:

1) Values of the longitudinal gradient, S_L, at points along the length of the scheme (expressed as fractions in the design tables and calculations). For an individual length drained by a gully, S_L should be taken as the average gradient over a 3m distance upstream of the gully.
2) The cross-fall, S_c, also expressed as a fraction in the tables and calculations. It is measured 0.5m upstream of the leading edge of the gully and for the maximum permissible width of flow.
3) The Manning roughness coefficient, n.
4) The maximum allowable flow width against the kerb (B in m, see Figure 2.2).
5) The grating type (P, Q, R, S or T), or the size and angle of kerb inlet.

Table D1 in Appendix D can be used to determine the discharge at the kerb immediately upstream of the grating if required. For intermediate values of cross-fall and gradient, the flow may be either interpolated or taken as the nearest higher value. For values of n other than 0.017, the flow should be multiplied by 0.017/n.

B3 Maximum spacings for gully gratings

Tables D2 to D6 in Appendix D give the area of road that may be drained (A_{dr} in m^2) by an intermediate gully for a rainfall intensity of 50mm/h, performance factor m = 1.0, and n = 0.017. Each of tables D2 to D6 corresponds to one of grating types P to T. The actual area (A_a) that can be drained is then given by:

Equation B.1

$$A_a = A_{dr}\left(\frac{50}{I}\right)mk_n$$

It is sufficiently accurate, where the grating efficiency η at n = 0.017 is more than about 80%, to set k_n to 0.017/n. The exact solution is:

Equation B.2

$$k_n = \left(\frac{\left(\frac{0.017}{n}\right) - \left(\left(1-\left(\frac{\eta}{100}\right)\right)\left(\left(\frac{0.017}{n}\right)^2\right)\right)}{\frac{\eta}{100}}\right)$$

The maximum design spacing between adjacent intermediate gratings (Sp in m) is then given by:

Equation B.3

$$Sp = \frac{A_a}{W_e}$$

where:

W_e Effective catchment width

These tables also give the flow collection efficiency η of the grating in % (in brackets). If η is below about 60%, the grating is not very efficient, and the design should be reconsidered (see Appendix C). The design method is intended to be applied over a range of η between 100 and 50%. Below 50%, it becomes increasingly conservative.

Tables D2 to D6 are for intermediate gullies on a uniform gradient, and become inaccurate for gradients which vary greatly over short distances. As a general guide, errors become significant if the gradients between adjacent gullies change by more than two of the increments in the tables, and also if the grating efficiency η is less than 80%. A more accurate calculation for this case is given in Appendix C.

B4 Maximum spacings for kerb inlets

Values of the catchment area (A_{dr} in m^2) that can be drained by 0.5m long and 1.5m long inlets installed in the line of the kerb are given in tables D7 and D8 respectively. Table D9 applies to the case of a 0.5m long inlet installed at angles α=50º and β=14º as shown in Figure 4.1.1; this arrangement is equivalent in performance to an in-line inlet providing a 1.85m long opening in the kerb. The values of A_{dr} given in the tables assume a rainfall intensity of I = 50 mm/h, a performance factor of m = 1.0 and a channel roughness of n = 0.017. If other values of I or m apply, the actual area, A_a , that can be drained will be different from A_{dr} and may be calculated from Equation (B.1). If tables D7 to D9 show that the flow collection efficiency, η, would be less than 60%, the use of either a longer kerb inlet or a suitable gully grating is recommended. For a given length, a gully grating will usually be more efficient than a kerb inlet.

The maximum allowable spacing between intermediate kerb inlets, Sp (in m), is calculated from Equation (B.3) using the value of Aa (in m^2) and the effective catchment width, We (in m).

The effect on the allowable drained area and spacing of assuming a different value of channel roughness, n, may be estimated approximately by setting k_n in Equation (B.1) to 0.017/n, provided the flow collection efficiency given for n = 0.017 in the appropriate tables D7 to D9 exceeds η = 80%. If the efficiency is lower the more accurate formula given in Equation (B.2) should be used.

The drained areas and spacings for other lengths of kerb inlet may be determined by applying an appropriate factor k_L to the values obtained from tables D7 to D9. Firstly the table for which the inlet length, Li1 (in m), is closest to the required length, Li2 (in m) should be chosen. From the table, the flow collection efficiency, η, corresponding to the length Li1 should be found, and the value of the factor k_L calculated from the formula:

Equation B.4

$$k_L = \frac{1.0 - \left(\left(1.0 - \left(\frac{\eta}{100}\right)\right)\left(\frac{L_{i1}}{L_{i2}}\right)\right)}{\frac{\eta}{100}}$$

k_L =The actual drained area (A_a) and the maximum spacing distance (Sp) corresponding to the inlet length L_{i1} should then be multiplied by the factor k_L to find the corresponding values for the required inlet length L_{i2}.

B5 Terminal gullies

The procedure for designing different arrangements of terminal gullies is as follows:

1) Single gully at sag point. There will be flow into the gully from both directions. Table D1 or Equation (C.4) are used to determine which direction gives the greater flow. This flow is then doubled, and Equation (C.5) or (C.8) is used to determine the flow collection efficiency η. For effective drainage this is greater than 95%. The maximum allowable spacings upstream of the gully is then checked using Equation (C.6) or (C.7).
2) Twin gullies at sag point (the more efficient arrangement, possibly requiring fewer gullies upstream). Use the tables or equations to determine the design spacing and η for each gully. η will be greater than 95% for both gullies.
3) Other terminal gullies (where it is not desirable for the flow to bypass the grating) The design spacing upstream of the gully should be determined from the tables or equations. To avoid excessive flow past the gully, η should be greater than 95%.

Appendix C. Use of equations for determining the flow capacity of gullies

C1 Introduction

Appendix C describes the equations used in the design procedure described in this document. They were used in compiling the design tables in Appendix D, and may also be used for direct calculation of gully spacings. These equations may readily be programmed, and in this form are very easy to use for exploring the effects of changing the drainage parameters.

C2 Flow capacity of kerb channel

The water depth against the kerb (H, in m) as shown in Figure 2.2 is given by:

Equation C.1

$$H = BS_c$$

The cross-sectional area of flow, A_f (in m^2), just upstream of the grating is given by:

Equation C.2

$$A_f = \frac{BH}{2}$$

The hydraulic radius of the channel, R (in m), is given by:

Equation C.3

$$R = \frac{A_f}{H + \sqrt{B^2 + H^2}}$$

The flow rate, Q (in m^3/s) approaching the grating is calculated from Manning's equation:

Equation C.4

$$Q = \frac{A_f R^{\frac{2}{3}} S_L^{\frac{1}{2}}}{n}$$

C3 Flow collection efficiency of gully grating

The flow collection efficiency, η (in %) is given by:

Equation C.5

$$\eta = 100 - G_d\left(\frac{Q}{H}\right)$$

G_d is the grating parameter and its value is determined by the grating type - see Appendix A.

The acceptable range of values for η is discussed in Appendix B3.

C4 Maximum design spacing of gully gratings

For intermediate gratings along a uniform longitudinal gradient, the maximum allowable spacing between adjacent gratings (Sp) may be calculated from the equation:

Equation C.6

$$S_p = \frac{\left(3.6 \cdot 10^6 Q \frac{m\eta}{100}\right)}{W_e I}$$

For non-uniform gradients, the grating spacings are calculated going downstream for each pair of gratings, and Equation (C.6) is replaced by:

Equation C.7

$$S_p = \frac{3.6 \cdot 10^6 \left[Q - Q_{us}\left(1 - \frac{m_{us}\eta_{us}}{100}\right)\right]}{W_e I}$$

where Q_{us}, m_{us} and η_{us} refer to the upstream grating. Calculations using this equation should commence at the upstream end. If the upstream end is at the top of a crest with no gully, Q_{us} becomes zero.

C5 Flow collection efficiency of kerb inlet

The flow collection efficiency (η in %) is given by:

Equation C.8

$$\eta = 100 - \frac{36.1Q}{L_i H^{1.5}}$$

Q is the flow rate (in m^3/s) in the kerb channel just upstream of the gully and is calculated using Equation C.4. H is the corresponding water depth (in m) at the kerb. L_i is the length (in m) of the opening in the line of the kerb provided by the inlet. Note that in the case of an angled kerb inlet (see Figure 4.1.1), L_i is greater than the length L of the kerb unit itself. For the particular kerb angles shown in Figure 4.1.1, L_i = 3.7 L.

If Equation (C.8) shows that the flow collection efficiency, η, would be less than 60%, the use of either a longer kerb inlet or a suitable gully grating is recommended as described in Appendix B.

C6 Maximum design spacing for kerb inlets

The maximum allowable spacing between intermediate kerb inlets can be determined from Equations (C.6) and (C.7).

C7 Effect of longitudinally varying gradient

If the longitudinal gradient of a kerb channel increases significantly with distance in the direction of flow, it is necessary to check that the channel has sufficient flow capacity at all points along its length. If the distance between two adjacent gullies is Z and the gradient at the downstream gully is S_L as described in Appendix B, then at any intermediate distance Z_i from the upstream gully the local gradient S_i should satisfy the following requirement:

Equation C.9

$$S_i > S_L \left(\frac{Z_i}{Z}\right)^2$$

If the limit is not satisfied, an additional gully should be located at the point where the kerb channel has insufficient capacity.

Note that the limit only needs to be checked if S_i increases with Z_i, the opposite of what might be expected. The above requirement is independent of whether gratings or kerb inlets are used.

C8 Flow capacity of gully pots

On steeper sections of road, the maximum allowable spacing between gullies may not be determined by the collection efficiency of the grating but by the flow capacity of the gully pot beneath it. Experimental tests in HRW SR 508 [Ref 6.I] indicate that the maximum flow rate that can be accepted by a gully pot without surcharge is about 10 litres/s if the outlet pipe has a diameter of 100mm, and 15 litres/s if it has a diameter of 150mm. Table D1 in Appendix D gives estimated discharges at the kerb, under a rainfall intensity of 50 mm/h, for combinations of flow width, crossfall and longitudinal gradient.

C9 Redesign

The design gully spacings determined from the design tables in Appendix C or by calculation are the maximum spacings: good practice would aim to reduce this distance. If the design shows the gully spacing or grating efficiency to be inadequate for the scheme, then redesign using one or more of the following options.

1) If the grating efficiency η is less than about 80% for an intermediate gully, the most effective solution is likely to be redesign with an improved grating type.
2) If the grating efficiency η of a terminal grating is less than 95%, redesign is essential. The first step should be to redesign with an improved grating type. If the required efficiency is still not achieved, the permitted width of kerb flow B should be replaced by a lesser design width. This will have the effect of reducing the design flow approaching the grating and increasing the grating efficiency, but may require the use of additional intermediate gullies.

Alternatively it may be more practical to adjust other parameters , e.g. changes in the road profile or the catchment width.

Appendix D. Design tables

The following tables are derived from research, see HRW SR 533 [Ref 7.I].

Table D.1 Discharge at the kerb in litres/s

Crossfall %(S_c)	Gradient %(S_L)	Flow width (B in m)			
		0.5	0.75	1	1.5
1.67%(1/60)	0.33% (1/300)	0.18	0.53	1.15	3.39
	0.67% (1/150)	0.26	0.76	1.63	4.80
	1.0% (1/100)	0.31	0.93	1.99	5.87
	1.33% (1/80)	0.35	1.03	2.23	6.57
	1.67% (1/60)	0.41	1.19	2.57	7.58
	2.0% (1/50)	0.44	1.31	2.82	8.31
	2.5% (1/40)	0.50	1.46	3.15	9.29
	3.33% (1/30)	0.57	1.69	3.64	10.73
	5.0% (1/20)	0.70	2.07	4.46	13.14
	6.67% (1/15)	0.81	2.39	5.14	15.17
2.0%(1/50)	0.33% (1/300)	0.24	0.72	1.56	4.59
	0.67% (1/150)	0.35	1.02	2.20	6.49
	1.0% (1/100)	0.42	1.25	2.69	7.94
	1.33% (1/80)	0.47	1.40	3.01	8.88
	1.67% (1/60)	0.55	1.62	3.48	10.25
	2.0% (1/50)	0.60	1.77	3.81	11.23
	2.5% (1/40)	0.67	1.98	4.26	12.56
	3.33% (1/30)	0.77	2.28	4.92	14.50
	5.0% (1/20)	0.95	2.80	6.02	17.76
	6.67% (1/15)	1.10	3.23	6.96	20.51
2.5%(1/40)	0.33% (1/300)	0.35	1.04	2.25	6.63
	0.67% (1/150)	0.50	1.48	3.18	9.38
	1.0% (1/100)	0.61	1.81	3.89	11.48
	1.33% (1/80)	0.69	2.02	4.35	12.84
	1.67% (1/60)	0.79	2.33	5.03	14.83
	2.0% (1/50)	0.87	2.56	5.51	16.24
	2.5% (1/40)	0.97	2.86	6.16	18.16
	3.33% (1/30)	1.12	3.30	7.11	20.97
	5.0% (1/20)	1.37	4.04	8.71	25.68
	6.67% (1/15)	1.58	4.67	10.06	29.65

Table D.1 Discharge at the kerb in litres/s (continued)

Crossfall %(S_c)	Gradient %(S_L)	Flow width (B in m)			
		0.5	**0.75**	**1**	**1.5**
3.33%(1/30)	0.33% (1/300)	0.57	1.68	3.61	10.65
	0.67% (1/150)	0.80	2.37	5.11	15.06
	1.0% (1/100)	0.99	2.91	6.26	18.45
	1.33% (1/80)	1.10	3.25	6.99	20.62
	1.67% (1/60)	1.27	3.75	8.08	23.81
	2.0% (1/50)	1.39	4.11	8.85	26.09
	2.5% (1/40)	1.56	4.59	9.89	29.17
	3.33% (1/30)	1.80	5.30	11.42	33.68
	5.0% (1/20)	2.20	6.50	13.99	41.25
	6.67% (1/15)	2.54	7.50	16.15	47.63
4.0%(1/25)	0.33% (1/300)	0.77	2.26	4.87	14.37
	0.67% (1/150)	1.09	3.20	6.89	20.32
	1.0% (1/100)	1.33	3.92	8.44	24.88
	1.33% (1/80)	1.49	4.38	9.44	27.82
	1.67% (1/60)	1.72	5.06	10.90	32.13
	2.0% (1/50)	1.88	5.54	11.94	35.19
	2.5% (1/40)	2.10	6.20	13.35	39.35
	3.33% (1/30)	2.43	7.16	15.41	45.43
	5.0% (1/20)	2.97	8.76	18.87	55.64
	6.67% (1/15)	3.43	10.12	21.79	64.25
5.0%(1/20)	0.33% (1/300)	1.11	3.26	7.02	20.70
	0.67% (1/150)	1.56	4.61	9.93	29.28
	1.0% (1/100)	1.92	5.65	12.16	35.86
	1.33% (1/80)	2.14	6.31	13.60	40.09
	1.67% (1/60)	2.47	7.29	15.70	46.29
	2.0% (1/50)	2.71	7.99	17.20	50.71
	2.5% (1/40)	3.03	8.93	19.23	56.69
	3.33% (1/30)	3.50	10.31	22.20	65.46
	5.0% (1/20)	4.28	12.63	27.19	80.18
	6.67% (1/15)	4.95	14.58	31.40	92.58

Table D.1 Discharge at the kerb in litres/s (continued)

Crossfall %(S_c)	Gradient %(S_L)	Flow width (B in m)			
		0.5	0.75	1	1.5
6.67%(1/15)	0.33% (1/300)	1.77	5.21	11.22	33.07
	0.67% (1/150)	2.50	7.37	15.86	46.77
	1.0% (1/100)	3.06	9.02	19.43	57.28
	1.33% (1/80)	3.42	10.09	21.72	64.04
	1.67% (1/60)	3.95	11.65	25.08	73.94
	2.0% (1/50)	4.33	12.76	27.47	81.00
	2.5% (1/40)	4.84	14.26	30.72	90.56
	3.33% (1/30)	5.59	16.47	35.47	104.57
	5.0% (1/20)	6.84	20.17	43.44	128.07
	6.67% (1/15)	7.90	23.29	50.16	147.89

Manning's coefficient is n = 0.017.

For other values of Manning's n, multiply the discharge by (0.017/n)

Table D.2 Type P

Crossfall (S_c)	Gradient % (S_L)	Flow width (B in m)							
		0.5		0.75		1.0		1.5	
1.67%(1/60)	0.33%(1/300)	13	(99)	38	(99)	81	(98)	234	(96)
	0.67%(1/150)	18	(99)	53	(98)	114	(97)	325	(94)
	1.0% (1/100)	22	(99)	65	(98)	138	(96)	393	(93)
	1.33%(1/80)	25	(99)	73	(98)	154	(96)	436	(92)
	1.67%(1/60)	29	(99)	84	(97)	177	(95)	496	(91)
	2.0%(1/50)	31	(98)	91	(97)	193	(95)	539	(90)
	2.5%(1/40)	35	(98)	102	(96)	214	(94)	594	(94)
	3.33%(1/30)	40	(98)	117	(96)	245	(93)	673	(87)
	5.0%(1/20)	49	(97)	142	(95)	295	(92)	797	(84)
	6.67%(1/15)	57	(97)	162	(94)	336	(91)	893	(82)
2.0%(1/50)	0.33%(1/300)	18	(99)	51	(99)	109	(98)	315	(95)
	0.67%(1/150)	25	(99)	72	(98)	153	(97)	437	(94)
	1.0%(1/100)	30	(99)	88	(97)	186	(96)	526	(92)
	1.33%(1/80)	34	(99)	98	(97)	207	(95)	583	(91)
	1.67%(1/60)	39	(98)	113	(97)	237	(95)	663	(90)
	2.0%(1/50)	42	(98)	123	(96)	259	(94)	718	(89)
	2.5%(1/40)	47	(98)	137	(96)	287	(94)	791	(87)(
	3.33%(1/30)	54	(98)	157	(95)	328	(93)	893	85)
	5.0%(1/20)	66	(97)	190	(94)	395	(91)	1052	(82)
	6.67%(1/15)	76	(97)	218	(94)	449	(90)	1174	(79)
2.5%(1/40)	0.33%(1/300)	25	(99)	74	(98)	158	(97)	452	(95)
	0.67% (1/150)	36	(99)	104	(98)	220	(96)	624	(92)
	1.0% (1/100)	44	(99)	126	(97)	267	(95)	751	(91)
	1.33% (1/80)	49	(98)	141	(97)	297	(95)	829	(90)
	1.67% (1/60)	56	(98)	162	(96)	340	(94)	941	(88)
	2.0% (1/50)	61	(98)	177	(96)	370	(93)	1017	(87)
	2.5% (1/40)	68	(98)	196	(95)	411	(93)	1117	(85)
	3.33% (1/30)	78	(97)	225	(95)	468	(91)	1256	(83)
	5.0% (1/20)	96	(97)	272	(94)	562	(90)	1469	(79)
	6.67%(1/15)	110	(96)	311	(93)	637	(88)	1628	(76)

Table D.2 Type P (continued)

Crossfall (S_c)	Gradient % (S_L)	Flow width (B in m)							
		0.5		0.75		1.0		1.5	
3.33%(1/30)	0.33% (1/300)	41	(99)	118	(98)	252	(97)	718	(94)
	0.67% (1/150)	57	(99)	166	(97)	351	(95)	986	(91)
	1.0% (1/100)	70	(98)	202	(97)	425	(94)	1181	(89)
	1.33% (1/80)	78	(98)	225	(96)	472	(94)	1301	(88)
	1.67% (1/60)	89	(98)	258	(95)	539	(93)	1470	(86)
	2.0% (1/50)	98	(97)	281	(95)	586	(92)	1584	(84)
	2.5% (1/40)	109	(97)	312	(94)	649	(91)	1732	(83)
	3.33% (1/30)	125	(97)	358	(94)	738	(90)	1935	(80)
	5.0% (1/20)	152	(96)	431	(92)	880	(87)	2235	(75)
	6.67% (1/15)	175	(95)	491	(91)	994	(85)	2449	(71)
4.0%(1/25)	0.33% (1/300)	55	(99)	159	(98)	338	(96)	960	(93)
	0.67% (1/150)	77	(98)	223	(97)	471	(95)	1314	(90)
	1.0% (1/100)	94	(98)	271	(96)	569	(94)	1569	(88)
	1.33% (1/80)	105	(98)	302	(96)	631	(93)	1725	(86)
	1.67% (1/60)	120	(97)	346	(95)	720	(92)	1942	(84)
	2.0% (1/50)	132	(97)	377	(94)	782	(91)	2088	(82)
	2.5% (1/40)	147	(97)	419	(94)	865	(90)	2276	(80)
	3.33% (1/30)	168	(96)	478	(93)	981	(88)	2528	(77)
	5.0% (1/20)	204	(96)	576	(91)	1167	(86)	2892	(72)
	6.67% (1/15)	234	(95)	655	(90)	1313	(84)	3140	(68)
5.0%(1/20)	0.33% (1/300)	79	(99)	229	(97)	484	(96)	1367	(92)
	0.67% 1/150)	110	(98)	320	(96)	672	(94)	1861	(88)
	1.0% (1/100)	135	(98)	388	(95)	812	(93)	2211	(86)
	1.33% (1/80)	150	(97)	432	(95)	899	(92)	2423	(84)
	1.67% (1/60)	173	(97)	494	(94)	1024	(91)	2716	(81)
	2.0% (1/50)	189	(97)	538	(94)	1111	(90)	2910	(80)
	2.5% (1/40)	210	(96)	597	(93)	1225	(88)	3156	(77)
	3.33% (1/30)	241	(96)	681	(92)	1386	(87)	3479	(74)
	5.0% (1/20)	293	(95)	817	(90)	1638	(84)	3921	(68)
	6.67% (1/15)	335	(94)	927	(88)	1835	(81)	4197	(63)

Table D.2 Type P (continued)

Crossfall (S_c)	Gradient % (S_L)	Flow width (B in m)							
		0.5		0.75		1.0		1.5	
6.67%(1/15)	0.33% (1/300)	125	(98)	363	(97)	767	(95)	2145	(90)
	0.67% (1/150)	176	(98)	507	(96)	1061	(93)	2895	(86)
	1.0% (1/100)	214	(97)	614	(95)	1276	(91)	3415	(83)
	1.33% (1/80)	239	(97)	682	(94)	1411	(90)	3725	(81)
	1.67% (1/60)	274	(96)	780	(93)	1602	(89)	4143	(78)
	2.0% (1/50)	299	(96)	848	(92)	1734	(88)	4415	(76)
	2.5% (1/40)	333	(96)	939	(91)	1906	(86)	4749	(73)
	3.33% (1/30)	382	(95)	1069	(90)	2146	(84)	5167	(69)
	5.0% (1/20)	462	(94)	1276	(88)	2516	(80)	5678	(62)
	6.67% (1/15)	528	(93)	1443	(86)	2796	(77)	5924	(56)

Drained area of road in m^2 under a rainfall intensity of 50mm/h and collection efficiency in % (in brackets)

Manning's coefficient is n = 0.017.

For others values of rainfall intensity I, multiply the area by (50/I).

Table D.3 Type Q

Crossfall (S_c)	Gradient % (SL)	Flow width (B in m)							
		0.5		0.75		1.0		1.5	
1.67% (1/60)	0.33%(1/300)	13	(99)	38	(98)	80	(97)	229	(94)
	0.67% (1/150)	18	(99)	53	(97)	112	(96)	316	(91)
	1.0% (1/100)	22	(98)	64	(97)	136	(95)	378	(89)
	1.33% (1/80)	25	(98)	72	(96)	151	(94)	417	(88)
	1.67% (1/60)	29	(98)	82	(96)	172	(93)	472	(86)
	2.0% (1/50)	31	(98)	90	(95)	187	(92)	509	(85)
	2.5% (1/40)	35	(97)	100	(95)	208	(91)	557	(83)
	3.33% (1/30)	40	(97)	114	(94)	236	(90)	623	(81)
	5.0% (1/20)	49	(96)	138	(93)	282	(88)	722	(76)
	6.67% (1/15)	56	(96)	157	(91)	319	(86)	794	(73)
2.0%(1/50)	0.33% (1/300)	17	(99)	51	(98)	108	(97)	307	(93)
	0.67% (1/150)	25	(98)	71	(97)	151	(95)	422	(90)
	1.0% (1/100)	30	(98)	87	(96)	182	(94)	504	(88)
	1.33% (1/80)	33	(98)	96	(96)	202	(93)	554	(87)
	1.67% (1/60)	38	(98)	111	(95)	231	(92)	625	(85)
	2.0% (1/50)	42	(97)	121	(95)	251	(91)	673	(83)
	2.5% (1/40)	47	(97)	134	(94)	277	(90)	734	(81)
	3.33% (1/30)	54	(97)	153	(93)	315	(89)	817	(78)
	5.0% (1/20)	65	(96)	185	(92)	375	(86)	938	(73)
	6.67% (1/15)	75	(95)	210	(90)	422	(84)	1022	(69)
2.5%(1/40)	0.33%(1/300)	25	(99)	73	(97)	155	(96)	439	(92)
	0.67% (1/150)	35	(98)	103	(96)	216	(94)	599	(89)
	1.0% (1/100)	43	(98)	125	(96)	261	(93)	713	(86)
	1.33% (1/80)	48	(98)	139	(95)	289	(92)	782	(85)
	1.67% (1/60)	55	(97)	159	(94)	329	(91)	878	(82)
	2.0% (1/50)	61	(97)	173	(94)	357	(90)	941	(81)
	2.5% (1/40)	67	(97)	192	(93)	394	(89)	1022	(78)
	3.33% (1/30)	77	(96)	219	(92)	446	(87)	1130	(75)
	5.0% (1/20)	94	(95)	263	(90)	529	(84)	1279	(69)
	6.67% (1/15)	108	(94)	299	(89)	593	(82)	1375	(64)

Table D.3 Type Q (continued)

Crossfall (S_c)	**Gradient % (SL)**	**Flow width (B in m)**							
		0.5		**0.75**		**1.0**		**1.5**	
3.33%(1/30)	0.33%(1/300)	40	(98)	117	(97)	247	(95)	693	(90)
	0.67% (1/150)	57	(98)	163	(96)	342	(93)	937	(86)
	1.0% (1/100)	69	(97)	198	(95)	412	(92)	1108	(83)
	1.33% (1/80)	77	(97)	220	(94)	456	(91)	1209	(81)
	1.67% (1/60)	88	(97)	252	(93)	518	(89)	1347	(79)
	2.0% (1/50)	97	(96)	274	(93)	561	(88)	1437	(77)
	2.5% (1/40)	107	(96)	303	(92)	617	(87)	1549	(74)
	3.33% (1/30)	123	(95)	345	(90)	696	(85)	1690	(70)
	5.0% (1/20)	149	(94)	413	(88)	817	(81)	1867	(63)
	6.67% (1/15)	171	(93)	467	(86)	909	(78)	1959	(57)
4.0%(1/25)	0.33%(1/300)	54	(98)	157	(97)	332	(95)	923	(89)
	0.67% (1/150)	76	(98)	219	(95)	458	(92)	1240	(85)
	1.0% (1/100)	93	(97)	266	(94)	550	(91)	1457	(81)
	1.33% (1/80)	103	(97)	295	(93)	607	(89)	1585	(79)
	1.67% (1/60)	119	(96)	337	(92)	688	(88)	1756	(76)
	2.0% (1/50)	130	(96)	366	(92)	744	(87)	1865	(74)
	2.5% (1/40)	144	(95)	405	(91)	817	(85)	1997	(70)
	3.33% (1/30)	165	(95)	460	(89)	917	(83)	2157	(66)
	5.0% (1/20)	200	(93)	548	(87)	1070	(79)	2334	(58)
	6.67% (1/15)	228	(92)	618	(85)	1184	(75)	2397	(52)
5.0%(1/20)	0.33% (1/300)	78	(98)	226	(96)	474	(94)	1305	(88)
	0.67% (1/150)	109	(97)	314	(94)	651	(91)	1738	(82)
	1.0% (1/100)	133	(97)	379	(93)	780	(89)	2026	(78)
	1.33% (1/80)	148	(96)	420	(92)	859	(88)	2192	(76)
	1.67% (1/60)	170	(96)	479	(91)	971	(86)	2407	(72)
	2.0% (1/50)	186	(95)	520	(90)	1047	(85)	2540	(70)
	2.5% (1/40)	206	(95)	574	(89)	1145	(83)	2693	(66)
	3.33% (1/30)	236	(94)	650	(88)	1279	(80)	2862	(61)
	5.0% (1/20)	285	(92)	771	(85)	1479	(76)	2996	(52)
	6.67% (1/15)	324	(91)	866	(83)	1622	(72)	Not eff.	(44)

Table D.3 Type Q (continued)

Crossfall (S_c)	Gradient % (SL)	Flow width (B in m)							
		0.5		0.75		1.0		1.5	
6.67%(1/15)	0.33% (1/300)	124	(98)	357	(95)	746	(92)	2027	(85)
	0.67%(1/150)	174	(97)	496	(93)	1020	(89)	2659	(79)
	1.0% (1/100)	211	(96)	597	(92)	1215	(87)	3061	(74)
	1.33% (1/80)	235	(95)	660	(91)	1335	(85)	3282	(71)
	1.67% (1/60)	269	(95)	751	(90)	1500	(83)	3552	(67)
	2.0% (1/50)	293	(94)	813	(89)	1611	(81)	3706	(64)
	2.5% (1/40)	326	(93)	895	(87)	1753	(79)	3863	(59)
	3.33% (1/30)	372	(92)	1010	(85)	1942	(76)	3986	(53)
	5.0% (1/20)	447	(91)	1189	(82)	2211	(71)	Not eff.	(42)
	6.67% (1/15)	508	(89)	1325	(79)	2389	(66)		

Drained area of road in m^2 under a rainfall intensity of 50mm/h and collection efficiency in % (in brackets)

Manning's coefficient is n = 0.017.

For others values of rainfall intensity I, multiply the area by (50/I).

Table D.4 Type R

Crossfall (S_C)	Gradient (S_L)	Flow width (B in m)						
		0.5	0.75		1.0		1.5	
1.67%(1/60)	0.33% (1/300)	13	37	(97)	79	(96)	224	(92)
	0.67%(1/150)	18	52	(96)	110	(94)	306	(88)
	1.0% (1/100)	22	64	(96)	133	(93)	363	(86)
	1.33% (1/80)	25	71	(95)	148	(92)	398	(84)
	1.67% (1/60)	28	81	(94)	168	(91)	447	(82)
	2.0% (1/50)	31	88	(94)	182	(90)	479	(80)
	2.5% (1/40)	34	98	(93)	201	(89)	520	(78)
	3.33% (1/30)	40	112	(92)	228	(87)	573	(74)
	5.0% (1/20)	48	134	(90)	269	(84)	648	(68)
	6.67% (1/15)	55	152	(89)	302	(81)	695	(64)
2.0%(1/50)	0.33% (1/300)	17	51	(97)	107	(95)	300	(91)
	0.67% (1/150)	24	71	(96)	148	(93)	406	(87)
	1.0% (1/100)	30	86	(95)	178	(92)	481	(84)
	1.33% (1/80)	33	95	(94)	197	(91)	526	(82)
	1.67% (1/60)	38	109	(94)	224	(90)	587	(79)
	2.0% (1/50)	42	118	(93)	243	(89)	627	(78)
	2.5% (1/40)	46	131	(92)	268	(87)	677	(75)
	3.33% (1/30)	53	149	(91)	302	(85)	741	(71)
	5.0% (1/20)	64	179	(89)	355	(82)	825	(64)
	6.67% (1/15)	74	203	(87)	396	(79)	871	(59)
2.5%(1/40)	0.33% (1/300)	25	73	(97)	153	(95)	427	(89)
	0.67% (1/150)	35	101	(95)	211	(92)	574	(85)
	1.0% (1/100)	43	123	(94)	254	(91)	675	(82)
	1.33% (1/80)	48	136	(94)	281	(90)	735	(79)
	1.67% (1/60)	55	156	(93)	318	(88)	814	(76)
	2.0% (1/50)	60	169	(92)	344	(87)	865	(74)
	2.5% (1/40)	67	187	(91)	378	(85)	928	(71)
	3.33% (1/30)	76	213	(89)	425	(83)	1003	(66)
	5.0% (1/20)	92	253	(87)	496	(79)	1089	(59)
	6.67% (1/15)	105	286	(85)	549	(76)	1122	(53)

Table D.4 Type R (continued)

Crossfall (S_c)	Gradient (S_L)	Flow width (B in m)						
		0.5	0.75		1.0		1.5	
3.33%(1/30)	0.33% (1/300)	40	16	(96)	243	(93)	669	(87)
	0.67% (1/150)	56	161	(94)	334	(91)	888	(82)
	1.0% (1/100)	68	195	(93)	400	(89)	1034	(78)
	1.33% (1/80)	76	216	(92)	440	(87)	1117	(75)
	1.67% (1/60)	87	246	(91)	497	(85)	1225	(71)
	2.0% (1/50)	95	267	(90)	536	(84)	1290	(69)
	2.5% (1/40)	106	294	(89)	585	(82)	1365	(65
	3.33% (1/30)	121	333	(87)	653	(79)	1445	(60)
	5.0% (1/20)	146	395	(84)	754	(75)	1500	(51)
	6.67% (1/15)	166	443	(82)	825	(71)	Not eff.	(43)
4.0%(1/25)	0.33% (1/300)	4	156	(95)	325	(93)	886	(86)
	0.67% (1/150)	76	216	(94)	445	(90)	1166	(80)
	1.0% (1/100)	92	260	(92)	531	(87)	1346	(75)
	1.33% (1/80)	102	288	(91)	583	(86)	1446	(72)
	1.67% (1/60)	117	327	(90)	656	(84)	1570	(68)
	2.0% (1/50)	128	355	(89)	706	(82)	1642	(65)
	2.5% (1/40)	142	391	(88)	769	(80)	1718	(61)
	3.33% (1/30)	162	441	(86)	853	(77)	1785	(55)
	5.0% (1/20)	195	520	(82)	974	(72)	Not eff.	(44)
	6.67% (1/15)	222	581	(80)	1056	(67)		
5.0%(1/20)	0.33%(1/300)	78	222	(95)	463	(92)	1244	(83)
	0.67% (1/150)	108	307	(93)	630	(88)	1614	(77)
	1.0% (1/100)	132	370	(91)	748	(85)	1841	(71)
	1.33% (1/80)	146	409	(90)	819	(84)	1961	(68)
	1.67% (1/60)	167	464	(88)	917	(81)	2099	(63)
	2.0% (1/50)	182	502	(87)	983	(79)	2170	(59)
	2.5% (1/40)	202	551	(86)	1065	(77)	2231	(55)
	3.33% (1/30)	231	620	(84)	1173	(73)	Not eff.	(48)
	5.0% (1/20)	277	725	(80)	1319	(67)		
	6.67% (1/15)	314	805	(77)	1409	(62)		

Table D.4 Type R (continued)

Crossfall (S_C)	Gradient (S_L)	Flow width (B in m)						
		0.5	0.75		1.0		1.5	
6.67%(1/15)	0.33% (1/300)	123	352	(94)	726	(90)	1909	
	0.33%(1/300)	172	483	(91)	979	(86)	2422	
	0.67% (1/150)	208	579	(89)	1154	(83)	2707	(80)
	1.0% (1/100)	231	638	(88)	1258	(80)	2839	(72)
	1.33% (1/80)	264	721	(86)	1398	(77)	2962	(66)
	1.67% (1/60)	287	778	(85)	1489	(75)	2998	(62)
	2.0% (1/50)	318	851	(83)	1600	(72)	Not eff.	(56)
	2.5% (1/40)	362	951	(80)	1739	(68)		(51)
	3.33% (1/30)	432	1101	(76)	1905	(61)		(46)
	5.0% (1/20)	488	1208	(72)	1981	(55)		
	6.67% (1/15)							

Drained area of road in m^2 under a rainfall intensity of 50mm/h and collection efficiency in % (in brackets)

Manning's coefficient is n = 0.017.

For others values of rainfall intensity I, multiply the area by (50/I).

Table D.5 Type S

Crossfall (S_c)	Gradient (S_L)	Flow width (B in m)							
		0.5		0.75		1.0		1.5	
1.67% (1/60)	0.33%(1/300)	13	(98)	37	(97)	78	(94)	218	(89)
	0.67%(1/150)	18	(98)	52	(95)	108	(92)	292	(85)
	1.0% (1/100)	22	(97)	63	(94)	130	(90)	343	(81)
	1.33% (1/80)	24	(97)	70	(93)	143	(89)	374	(79)
	1.67% (1/60)	28	(96)	79	(92)	162	(88)	414	(76)
	2.0% (1/50)	31	(96)	86	(92)	175	(86)	439	(73)
	2.5% (1/40)	34	(95)	95	(91)	193	(85)	470	(70)
	3.33% (1/30)	39	(94)	108	(89)	216	(83)	507	(66)
	5.0% (1/20)	47	(93)	129	(87)	252	(79)	548	(58)
	6.67% (1/15)	54	(92)	146	(85)	279	(75)	562	(51)
2.0%2.0%(150)	0.33%(1/300)	17	(98)	50	(96)	105	(94)	290	(88)
	0.67% (1/150)	24	(97)	70	(95)	144	(91)	386	(83)
	1.0% (1/100)	30	(97)	84	(93)	173	(89)	451	(79)
	1.33% (1/80)	33	(96)	93	(93)	191	(88)	488	(76)
	1.67% (1/60)	38	(96)	106	(91)	216	(86)	536	(73)
	2.0% (1/50)	41	(95)	115	(91)	233	(85)	567	(70)
	2.5% (1/40)	46	(95)	127	(89)	254	(83)	601	(67)
	3.33% (1/30)	52	(94)	144	(88)	284	(80)	640	(61)
	5.0% (1/20)	63	(92)	171	(85)	329	(76)	673	(53)
	6.67% (1/15)	72	(91)	193	(83)	361	(72)	Not eff.	(45)
2.5%(1/40)	0.33%(1/300)	25	(98)	72	(96)	150	(93)	410	(86)
	0.67% (1/150)	35	(97)	100	(94)	206	(90)	540	(80)
	1.0% (1/100)	42	(96)	120	(92)	245	(88)	624	(76)
	1.33% (1/80)	47	(96)	133	(91)	270	(86)	671	(73)
	1.67% (1/60)	54	(95)	151	(90)	304	(84)	730	(68)
	2.0% (1/50)	59	(94)	164	(89)	327	(82)	764	(65)
	2.5% (1/40)	65	(94)	181	(88)	356	(80)	801	(61)
	3.33% (1/30)	75	(93)	204	(86)	395	(77)	834	(55)
	5.0% (1/20)	90	(91)	241	(83)	452	(72)	Not eff.	(45)
	6.67% (1/15)	102	(90)	269	(80)	491	(68)		

Table D.5 Type S (continued)

Crossfall (S_c)	Gradient (S_L)	Flow width (B in m) 0.5		0.75		1.0		1.5	
3.33%(1/30)	0.33% (1/300)	40	(97)	114	(95)	238	(91)	636	(83)
	0.67% (1/150)	56	(96)	158	(92)	323	(88)	823	(76)
	1.0% (1/100)	68	(95)	190	(91)	383	(85)	936	(70)
	1.33% (1/80)	75	(95)	210	(90)	419	(83)	995	(67)
	1.67% (1/60)	86	(94)	238	(88)	469	(81)	1061	(62)
	2.0% (1/50)	94	(93)	257	(87)	502	(79)	1094	(58)
	2.5% (1/40)	104	(93)	282	(85)	543	(76)	1120	(53)
	3.33% (1/30)	118	(91)	317	(83)	597	(73)	Not eff.	(46)
	5.0% (1/20)	142	(89)	370	(79)	669	(66)		
	6.67% (1/15)	161	(88)	410	(76)	712	(61)		
4.0%(1/25)	0.33% (1/300)	54	(97)	153	(94)	317	(90)	836	(81)
	0.67% (1/150)	75	(96)	211	(91)	428	(86)	1067	(73)
	1.0% (1/100)	91	(95)	253	(90)	505	(83)	1197	(67)
	1.33% (1/80)	101	(94)	279	(88)	551	(81)	1260	(63)
	1.67% (1/60)	115	(93)	315	(87)	614	(78)	1322	(57)
	2.0% (1/50)	125	(92)	340	(85)	654	(76)	1345	(53)
	2.5% (1/40)	139	(92)	372	(83)	704	(73)	Not eff.	(48)
	3.33% (1/30)	158	(90)	417	(81)	768	(69)		
	5.0% (1/20)	189	(88)	484	(77)	846	(62)		
	6.67% (1/15)	213	(86)	532	(73)	885	(56)		
5.0%(1/20)	0.33% (1/300)	77	(96)	218	(93)	449	(89)	1161	(78)
	0.67% (1/150)	107	(95)	299	(90)	601	(84)	1450	(69)
	1.0% (1/100)	129	(94)	358	(88)	705	(81)	1594	(62)
	1.33% (1/80)	144	(93)	393	(87)	766	(78)	1652	(57)
	1.67% (1/60)	164	(92)	443	(84)	846	(75)	1687	(51)
	2.0% (1/50)	178	(91)	477	(83)	898	(72)	Not eff.	(46)
	2.5% (1/40)	197	(90)	520	(81)	959	(69)		
	3.33% (1/30)	224	(89)	579	(78)	1031	(64)		
	5.0% (1/20)	266	(86)	664	(73)	1106	(56)		
	6.67% (1/15)	300	(84)	723	(69)	Not eff.	(50)		

Table D.5 Type S (continued)

Crossfall (S_c)	Gradient (S_L)	Flow width (B in m)							
		0.5		0.75		1.0		1.5	
6.67%(1/15)	0.33% (1/300)	122	(96)	344	(92)	699	(87)	1751	(74)
	0.67% (1/150)	169	(94)	468	(88)	925	(81)	2107	(63)
	1.0% (1/100)	204	(93)	556	(86)	1073	(77)	2234	(54)
	1.33% (1/80)	226	(92)	609	(84)	1156	(74)	Not eff.	(49)
	1.67% (1/60)	257	(91)	682	(81)	1262	(70)		
	2.0% (1/50)	279	(90)	731	(80)	1326	(67)		
	2.5% (1/40)	308	(88)	793	(77)	1396	(63)		
	3.33% (1/30)	348	(87)	873	(74)	1467	(57)		
	5.0% (1/20)	412	(84)	984	(68)	Not eff.	(48)		
	6.67% (1/15)	461	(81)	1052	(63)				

Drained area of road in m^2 under a rainfall intensity of 50mm/h and collection efficiency in % (in brackets)

Manning's coefficient is n = 0.017.

For others values of rainfall intensity I, multiply the area by (50/I).

Table D.6 Type T

Cross fall (S_c)	Gradient (S_L)	Flow width (B in m) 0.5		0.75		1.0		1.5	
1.67% (1/60)	0.33%(1/300)	13	(98)	37	(95)	77	(92)	208	(85)
	0.67% (1/150)	18	(97)	51	(93)	105	(89)	272	(79)
	1.0% (1/100)	22	(96)	61	(92)	125	(87)	314	(74)
	1.33% (1/80)	24	(95)	68	(91)	137	(85)	336	(71)
	1.67% (1/60)	28	(95)	77	(89)	154	(83)	364	(67)
	2.0% (1/50)	30	(94)	83	(88)	165	(81)	380	(63)
	2.5% (1/40)	33	(93)	92	(87)	180	(79)	395	(59)
	3.33% (1/30)	38	(92)	104	(85)	199	(76)	408	(53)
	5.0% (1/20)	46	(91)	122	(82)	226	(71)	Not eff.	(42)
	6.67% (1/15)	52	(89)	136	(79)	245	(66)		
2.0%2.0%(1/50)	0.33%(1/300)	17	(97)	49	(95)	102	(91)	275	(83)
	0.67% (1/150)	24	(96)	68	(93)	139	(88)	356	(76)
	1.0% (1/100)	29	(95)	82	(91)	165	(85)	405	(71)
	1.33% (1/80)	32	(95)	90	(90)	181	(83)	431	(67)
	1.67% (1/60)	37	(94)	103	(88)	203	(81)	461	(62)
	2.0% (1/50)	40	(93)	111	(87)	217	(79)	476	(59)
	2.5% (1/40)	45	(93)	122	(85)	235	(77)	488	(54)
	3.33% (1/30)	51	(91)	137	(83)	258	(73)	Not eff.	(47)
	5.0% (1/20)	61	(90)	160	(79)	290	(67)		
	6.67% (1/15)	69	(88)	177	(76)	309	(62)		
2.5%(1/40)	0.33%(1/300)	25	(97)	71	(94)	146	(90)	385	(81)
	0.67% (1/150)	34	(96)	97	(91)	197	(86)	489	(72)
	1.0% (1/100)	42	(95)	116	(89)	232	(83)	548	(66)
	1.33% (1/80)	46	(94)	128	(88)	253	(81)	576	(62)
	1.67% (1/60)	53	(93)	145	(86)	282	(78)	603	(57)
	2.0% (1/50)	58	(92)	157	(85)	300	(76)	612	(52)
	2.5% (1/40)	64	(91)	171	(83)	323	(73)	Not eff.	(47)
	3.33% (1/30)	73	(90)	192	(81)	352	(69)		
	5.0% (1/20)	87	(88)	222	(76)	387	(62)		
	6.67% (1/15)	98	(86)	244	(73)	404	(56)		

Table D.6 Type T (continued)

3.33%(1/30)	0.33%(1/300)	39	(96)	112	(93)	229	(88)	587	(77)
	0.67% (1/150)	55	(95)	153	(90)	306	(83)	725	(67)
	1.0% (1/100)	66	(93)	182	(87)	357	(79)	789	(59)
	1.33% (1/80)	74	(93)	200	(86)	387	(77)	811	(55)
	1.67% (1/60)	84	(92)	225	(83)	427	(73)	Not eff.	(48)
	2.0% (1/50)	91	(91)	242	(82)	451	(71)		
	2.5% (1/40)	101	(90)	264	(80)	480	(67)		
	3.33% (1/30)	114	(88)	293	(77)	512	(62)		
	5.0% (1/20)	136	(85)	334	(71)	542	(54)		
	6.67% (1/15)	152	(83)	362	(67)	Not eff.	(47)		
4.0%(1/25)	0.33%(1/300)	53	(96)	149	(92)	304	(87)	762	(74)
	0.67% (1/150)	73	(94)	203	(88)	402	(81)	918	(63)
	1.0% (1/100)	89	(93)	242	(86)	467	(77)	974	(54)
	1.33% (1/80)	98	(92)	265	(84)	503	(74)	Not eff.	(49)
	1.67% (1/60)	112	(91)	297	(81)	549	(70)		
	2.0% (1/50)	121	(90)	318	(80)	577	(67)		
	2.5% (1/40)	134	(88)	345	(77)	608	(63)		
	3.33% (1/30)	151	(87)	380	(74)	639	(58)		
	5.0% (1/20)	179	(84)	428	(68)	Not eff.	(48)		
	6.67% (1/15)	200	(81)	458	(63)				
5.0%(1/20)	0.33%(1/300)	76	(95)	212	(90)	427	(85)	1038	(70)
	0.67% (1/150)	105	(93)	287	(86)	559	(78)	1203	(57)
	1.0% (1/100)	126	(92)	339	(83)	641	(73)	Not eff.	(47)
	1.33% (1/80)	140	(91)	370	(81)	686	(70)		
	1.67% (1/60)	159	(89)	413	(79)	740	(65)		
	2.0% (1/50)	172	(88)	440	(77)	770	(62)		
	2.5% (1/40)	189	(87)	474	(74)	799	(58)		
	3.33% (1/30)	213	(85)	518	(70)	818	(51)		
	5.0% (1/20)	250	(81)	572	(63)	Not eff.	(40)		
	6.67% (1/15)	279	(78)	601	(57)				

Table D.6 Type T (continued)

6.67%(1/15)	0.33%(1/300)	120	(94)	332	(89)	658	(81)	1515	(64)
	0.67% (1/150)	165	(92)	444	(84)	843	(74)	Not eff.	(49)
	1.0% (1/100)	198	(90)	521	(80)	950	(68)		
	1.33% (1/80)	218	(89)	565	(78)	1003	(64)		
	1.67% (1/60)	247	(87)	624	(74)	1058	(59)		
	2.0% (1/50)	267	(86)	661	(72)	1081	(55)		
	2.5% (1/40)	293	(84)	705	(69)	Not eff.	(49)		
	3.33% (1/30)	328	(82)	756	(64)				
	5.0% (1/20)	381	(77)	808	(56)				
	6.67% (1/15)	420	(74)	Not eff.	(49)				

Drained area of road in m^2 under a rainfall intensity of 50mm/h and collection efficiency in % (in brackets)

Manning's coefficient is n = 0.017.

For others values of rainfall intensity I, multiply the area by (50/I).

Table D.7 Kerb inlet with opening length equal to 0.5m

Cross fall (S_c)	Gradient (S_L)	Flow width (B in m)					
		0.5		0.75		1.0	
1.67% (1/60)	0.33%(1/300)	11	(83)	28	(72)	51	(61)
	0.67% (1/150)	14	(76)	33	(61)	Not eff.	(45)
	1.0% (1/100)	16	(70)	35	(52)		
	1.33% (1/80)	17	(67)	Not eff.	(46)		
	1.67% (1/60)	18	(62)				
	2.0% (1/50)	18	(58)				
	2.5% (1/40)	19	(53)				
	3.33% (1/30)	Not eff.	(46)				
	5.0% (1/20)						
	6.67% (1/15)						
2.0%2.0%(1/50)	0.33%(1/300)	15	(82)	38	(72)	68	(60)
	0.67% (1/150)	19	(75)	44	(60)	Not eff.	(44)
	1.0% (1/100)	21	(69)	46	(51)		
	1.33% (1/80)	22	(66)	Not eff.	(45)		
	1.67% (1/60)	24	(60)				
	2.0% (1/50)	24	(57)				
	2.5% (1/40)	25	(52)				
	3.33% (1/30)	Not eff.	(44)				
	5.0% (1/20)						
	6.67% (1/15)						
2.5%(1/40)	0.33%(1/300)	21	(82)	53	(71)	95	(59)
	0.67% (1/150)	27	(74)	62	(58)	Not eff.	(42)
	1.0% (1/100)	30	(68)	Not eff.	(49)		
	1.33% (1/80)	32	(64)				
	1.67% (1/60)	34	(59)				
	2.0% (1/50)	34	(55)				
	2.5% (1/40)	35	(50)				
	3.33% (1/30)	Not eff.	(42)				
	5.0% (1/20)						

Table D.7 Kerb inlet with opening length equal to 0.5m (continued)

3.33%(1/30)	0.33%(1/300)	33	(81)	84	(69)	149	(57)
	0.67% (1/150)	42	(73)	97	(57)	Not eff.	(39)
	1.0% (1/100)	47	(67)	Not eff.	(47)		
	1.33% (1/80)	50	(63)				
	1.67% (1/60)	52	(57)				
	2.0% (1/50)	54	(52)				
	2.5% (1/40)	Not eff.	(47)				
	3.33% (1/30)						
	5.0% (1/20)						
	6.67% (1/15)						
4.0%(1/25)	0.33%(1/300)	44	(80)	112	(68)	196	(56)
	0.67% (1/150)	56	(72)	128	(56)	Not eff.	(38)
	1.0% (1/100)	63	(66)	Not eff.	(46)		
	1.33% (1/80)	66	(62)				
	1.67% (1/60)	69	(56)				
	2.0% (1/50)	70	(52)				
	2.5% (1/40)	Not eff.	(46)				
	3.33% (1/30)						
	5.0% (1/20)						
	6.67% (1/15)						
5.0%(1/20)	0.33%(1/300)	64	(80)	159	(68)	276	(55)
	0.67% (1/150)	80	(71)	180	(54)	Not eff.	(36)
	1.0% (1/100)	90	(65)	Not eff.	(44)		
	1.33% (1/80)	94	(61)				
	1.67% (1/60)	98	(55)				
	2.0% (1/50)	98	(50)				
	2.5% (1/40)	Not eff.	(45)				
	3.33% (1/30)						
	5.0% (1/20)						
	6.67% (1/15)						

Table D.7 Kerb inlet with opening length equal to 0.5m (continued)

6.67%(1/15)	0.33%(1/300)	100	(79)	249278	(66)	427	(53)
	0.67% (1/150)	126	(70)	Not eff.	(52)	Not eff.	(33)
	1.0% (1/100)	140	(64)		(42)		
	1.33% (1/80)	146	(59)				
	1.67% (1/60)	151	(53)				
	2.0% (1/50)	Not eff.	(49)				
	2.5% (1/40)						
	3.33% (1/30)						
	5.0% (1/20)						
	6.67% (1/15)						

Drained area of road in m^2 under a rainfall intensity of 50mm/h and collection efficiency in % (in brackets)

Manning's coefficient is n = 0.017.

For others values of rainfall intensity I, multiply the area by (50/I).

Table D.8 Kerb inlet with opening length equal to 1.5m

Cross fall (S_c)	Gradient (S_L)	Flow width (B in m)							
		0.5		0.75		1.0		1.5	
1.67% (1/60)	0.33%(1/300)	12	(94)	35	(91)	72	(87)	194	(79)
	0.67%(1/150)	17	(92)	47	(87)	96	(82)	244	(71)
	1.0% (1/100)	20	(90)	56	(84)	111	(78)	272	(64)
	1.33% (1/80)	22	(89)	61	(82)	121	(75)	284	(60)
	1.67% (1/60)	25	(87)	68	(79)	132	(71)	294	(54)
	2.0% (1/50)	27	(86)	73	(77)	139	(68)	Not eff.	(49)
	2.5% (1/40)	30	(84)	79	(75)	147	(65)		
	3.33% (1/30)	34	(82)	86	(71)	155	(59)		
	5.0% (1/20)	39	(78)	96	(64)	161	(50)		
	6.67% (1/15)	43	(74)	101	(59)	Not eff.	(42)		
2.0%2.0%(1/50)	0.33% (1/300)	17	(94)	47	(90)	97	(87)	260	(79)
	0.67% (1/150)	23	(92)	64	(87)	129	(81)	326	(70)
	1.0% (1/100)	27	(90)	75	(84)	149	(77)	361	(63)
	1.33% (1/80)	30	(89)	82	(82)	161	(74)	376	(58)
	1.67% (1/60)	34	(87)	92	(79)	176	(70)	387	(52)
	2.0% (1/50)	37	(86)	98	(77)	185	(68)	Not eff.	(48)
	2.5% (1/40)	40	(84)	105	(74)	195	(64)		
	3.33% (1/30)	45	(81)	115	(70)	206	(58)		
	5.0% (1/20)	53	(77)	128	(63)	Not eff.	(49)		
	6.67% (1/15)	58	(74)	134	(58)				
2.5%(1/40)	0.33%(1/300)	24	(94)	68	(90)	140	(86)	32	(78)
	0.67% (1/150)	33	(91)	92	(86)	185	(81)	465	(69)
	1.0% (1/100)	40	(89)	108	(83)	214	(76)	512	(62)
	1.33% (1/80)	44	(88)	118	(81)	230	(73)	531	(57)
	1.67% (1/60)	49	(86)	131	(78)	251	(69)	540	(51)
	2.0% (1/50)	53	(85)	140	(76)	263	(66)	Not eff.	(46)
	2.5% (1/40)	58	(83)	150	(73)	277	(62)		
	3.33% (1/30)	66	(81)	164	(69)	291	(57)		
	5.0% (1/20)	75	(76)	181	(62)	Not eff.	(47)		
	6.67% (1/15)	83	(73)	189	(56)				

Table D.8 Kerb inlet with opening length equal to 1.5m (continued)

Cross fall (S_c)	Gradient (S_L)	Flow width (B in m)							
		0.5		0.75		1.0		1.5	
3.33%(1/30)	0.33%(1/300)	38	(93)	108	(89)	223	(86)	591	(77)
	0.67% (1/150)	53	(91)	146	(86)	293	(80)	732	(68)
	1.0% (1/100)	63	(89)	172	(82)	339	(79)	800	(60)
	1.33% (1/80)	70	(88)	187	(80)	364	(72)	825	(56)
	1.67% (1/60)	78	(86)	208	(77)	396	(68)	Not eff.	(49)
	2.0% (1/50)	85	(84)	222	(75)	414	(65)		
	2.5% (1/40)	93	(82)	238	(72)	433	(61)		
	3.33% (1/30)	103	(80)	258	(68)	450	(55)		
	5.0% (1/20)	120	(75)	283	(60)	Not eff.	(45)		
	6.67% (1/15)	131	(72)	293	(54)				
4.0%(1/25)	0.33%(1/300)	51	(93)	146	(90)	300	(85)	791	(76)
	0.67% (1/150)	71	(91)	196	(85)	393	(79)	976	(67)
	1.0% (1/100)	85	(89)	231	(82)	453	(74)	1061	(59)
	1.33% (1/80)	93	(87)	251	(80)	486	(72)	1090	(54)
	1.67% (1/60)	106	(85)	279	(76)	529	(67)	Not eff	(47)
	2.0% (1/50)	114	(84)	296	(74)	550	(64)		
	2.5% (1/40)	124	(82)	318	(70)	575	(60)		
	3.33% (1/30)	138	(79)	344	(67)	595	(54)		
	5.0% (1/20)	158	(74)	375	(59)	Not eff.	(43)		
	6.67% (1/15)	175	(71)	387	(53)				
5.0%(1/20)	0.33%(1/300)	74	(93)	209	(89)	429	(85)	1129	(76)
	0.67% (1/150)	102	(90)	281	(85)	562	(79)	1384	(66)
	1.0% (1/100)	122	(88)	330	(81)	646	(74)	1496	(58)
	1.33% (1/80)	134	(87)	359	(79)	692	(71)	1529	(53)
	1.67% (1/60)	151	(85)	398	(76)	748	(66)	Not eff.	(46)
	2.0% (1/50)	163	(83)	422	(74)	779	(63)		
	2.5% (1/40)	178	(82)	452	(70)	811	(59)		
	3.33% (1/30)	198	(79)	488	(66)	834	(52)		
	5.0% (1/20)	228	(74)	528	(58)	Not eff.	(41)		
	6.67% (1/15)	249	(70)	542	(52)				

Table D.8 Kerb inlet with opening length equal to 1.5m (continued)

Cross fall (S_c)	Gradient (S_L)	Flow width (B in m)							
		0.5		0.75		1.0		1.5	
6.67%(1/15)	0.33%(1/300)	118	(93)	333	(89)	681	(84)	1781	(75)
	0.67% (1/150)	162	(90)	446	(84)	888	(77)	2168	(64)
	1.0% (1/100)	194	(88)	523	(81)	1018	(72)	2324	(56)
	1.33% (1/80)	213	(86)	568	(78)	1088	(68)	2361	(51)
	1.67% (1/60)	240	(84)	628	(75)	1171	(63)	Not eff.	(44)
	2.0% (1/50)	240	(83)	666	(72)	1261	(55)		
	2.5% (1/40)	282	(81)	711	(69)	1286	(50)		
	3.33% (1/30)	313	(78)	765	(64)	Not eff.	(39)		
	5.0% (1/20)	359	(73)	821	(56)				
	6.67% (1/15)	391	(69)	Not eff.	(49)				

Drained area of road in m^2 under a rainfall intensity of 50mm/h and collection efficiency in % (in brackets)

Manning's coefficient is n = 0.017.

For others values of rainfall intensity I, multiply the area by (50/I).

Table D.9 Kerb inlet with opening length equal to 1.85m

Cross fall (S_c)	Gradient (S_L)	Flow width (B in m)							
		0.5		0.75		1.0		1.5	
1.67%(1/60)	0.33%(1/300	12	(95)	36	(92)	74	(90)	203	(83)
	0.67%(1/150)	17	(93)	49	(89)	100	(85)	264	(76)
	1.0% (1/100)	21	(92)	58	(87)	118	(82)	300	(71)
	1.33% (1/80)	23	(91)	64	(86)	128	(80)	319	(68)
	1.67% (1/60)	26	(90)	72	(83)	142	(77)	341	(62)
	2.0% (1/50)	28	(89)	77	(82)	151	(74)	353	(59)
	2.5% (1/40)	32	(87)	84	(80)	162	(71)	362	(54)
	3.33% (1/30)	35	(85)	93	(76)	175	(67)	Noteff.	(47)
	5.0% (1/20)	41	(82)	106	(71)	191	(60)		
	6.67% (1/15)	46	(79)	115	(67)	197	(53)		
2.0%(1/50)	0.33% (1/300)	17	(95)	48	(92)	100	(89)	273	(83)
	0.67% (1/150)	23	(93)	66	(89)	134	(85)	353	(76)
	1.0% (1/100)	28	(92)	78	(87)	158	(81)	402	(70)
	1.33% (1/80)	31	(91)	85	(86)	172	(79)	426	(67)
	1.67% (1/60)	35	(89)	96	(83)	190	(76)	454	(61)
	2.0% (1/50)	38	(88)	103	(81)	202	(74)	467	(58)
	2.5% (1/40)	42	(87)	112	(79)	216	(70)	477	(53)
	3.33% (1/30)	47	(85)	124	(76)	234	(66)	Noteff.	(45)
	5.0% (1/20)	56	(81)	142	(70)	253	(58)		
	6.67% (1/15)	62	(79)	153	(66)	260	(52)		
2.5%(1/40)	0.33% (1/300)	24	(95)	69	(92)	144	(89)	392	(82)
	0.67% (1/150)	34	(93)	94	(89)	193	(84)	505	(75)
	1.0% (1/100)	40	(91)	112	(86)	226	(81)	571	(69)
	1.33% (1/80)	45	(90)	123	(85)	246	(78)	605	(65)
	1.67% (1/60)	51	(89)	138	(82)	272	(75)	642	(60)
	2.0% (1/50)	55	(88)	148	(80)	289	(73)	658	(56)
	2.5% (1/40)	60	(86)	161	(78)	308	(70)	668	(51)
	3.33% (1/30)	68	(84)	178	(75)	332	(65)	Not eff.	(44)
	5.0% (1/20)	80	(81)	202	(69)	357	(60)		
	6.67% (1/15)	89	(78)	217	(64)	364	(50)		

Table D.9 Kerb inlet with opening length equal to 1.85m (continued)

Cross fall (S_c)	Gradient (S_L)	Flow width (B in m)							
		0.5		0.75		1.0		1.5	
3.33%(1/30)	0.33%(1/300)	39	(95)	111	(91)	230	(88)	624	(81)
	0.67% (1/150)	54	(93)	151	(88)	308	(84)	799	(74)
	1.0% (1/100)	65	(91)	179	(86)	360	(80)	900	(68)
	1.33% (1/80)	71	(90)	196	(84)	390	(76)	950	(64)
	1.67% (1/60)	81	(88)	220	(81)	431	(74)	1001	(58)
	2.0% (1/50)	88	(87)	236	(80)	456	(72)	1022	(54)
	2.5% (1/40)	96	(86)	256	(77)	486	(68)	Not eff.	(49)
	3.33% (1/30)	108	(84)	282	(74)	521	(63)		
	5.0% (1/20)	127	(80)	318	(68)	555	(55)		
	6.67% (1/15)	141	(77)	340	(63)	Not eff.	(48)		
4.0%(1/25)	0.33%(1/300)	52	(95)	149	(92)	309	(88)	837	(81)
	0.67% (1/150)	72	(92)	203	(88)	413	(83)	1068	(73)
	1.0% (1/100)	87	(90)	241	(85)	482	(79)	1199	(67)
	1.33% (1/80)	96	(90)	264	(84)	523	(77)	1263	(63)
	1.67% (1/60)	109	(88)	295	(81)	576	(73)	1326	(57)
	2.0% (1/50)	118	(87)	316	(79)	609	(71)	1349	(53)
	2.5% (1/40)	129	(85)	342	(77)	648	(67)	Not eff	(48)
	3.33% (1/30)	145	(83)	377	(73)	692	(62)		
	5.0% (1/20)	170	(79)	423	(67)	732	(54)		
	6.67% (1/15)	188	(76)	451	(62)	Not eff	(47)		
5.0%(1/20)	0.33%(1/300)	75	(95)	215	(91)	444	(88)	1197	(80)
	0.67% (1/150)	104	(92)	291	(88)	591	(83)	1521	(72)
	1.0% (1/100)	125	(90)	345	(85)	690	(79)	1701	(66)
	1.33% (1/80)	138	(89)	377	(83)	746	(76)	1786	(62)
	1.67% (1/60)	156	(88)	422	(80)	820	(72)	1866	(56)
	2.0% (1/50)	169	(87)	452	(78)	866	(70)	1890	(52)
	2.5% (1/40)	185	(85)	488	(76)	919	(66)	Not eff	(46)
	3.33% (1/30)	208	(83)	536	(72)	979	(61)		
	5.0% (1/20)	243	(79)	600	(66)	1028	(52)		
	6.67% (1/15)	269	(76)	638	(61)	Not eff	(45)		

Table D.9 Kerb inlet with opening length equal to 1.85m (continued)

Cross fall (S_c)	Gradient (S_L)	Flow width (B in m)							
		0.5		0.75		1.0		1.5	
6.67%(1/15)	0.33%(1/300)	120	(94)	341	(91)	705	(87)	1895	(80)
	0.67% (1/150)	165	(92)	462	(87)	936	(82)	2395	(71)
	1.0% (1/100)	199	(90)	547	(84)	1090	(78)	2665	(65)
	1.33% (1/80)	219	(89)	598	(82)	1178	(75)	2787	(60)
	1.67% (1/60)	248	(87)	668	(80)	1292	(72)	2893	(54)
	2.0% (1/50)	268	(86)	714	(78)	1441	(65)	Not eff	(44)
	2.5% (1/40)	294	(84)	771	(75)	1526	(60)		
	3.33% (1/30)	330	(82)	845	(71)	1586	(51)		
	5.0% (1/20)	384	(78)	941	(65)	Not eff	(43)		
	6.67% (1/15)	424	(75)	995	(59)				

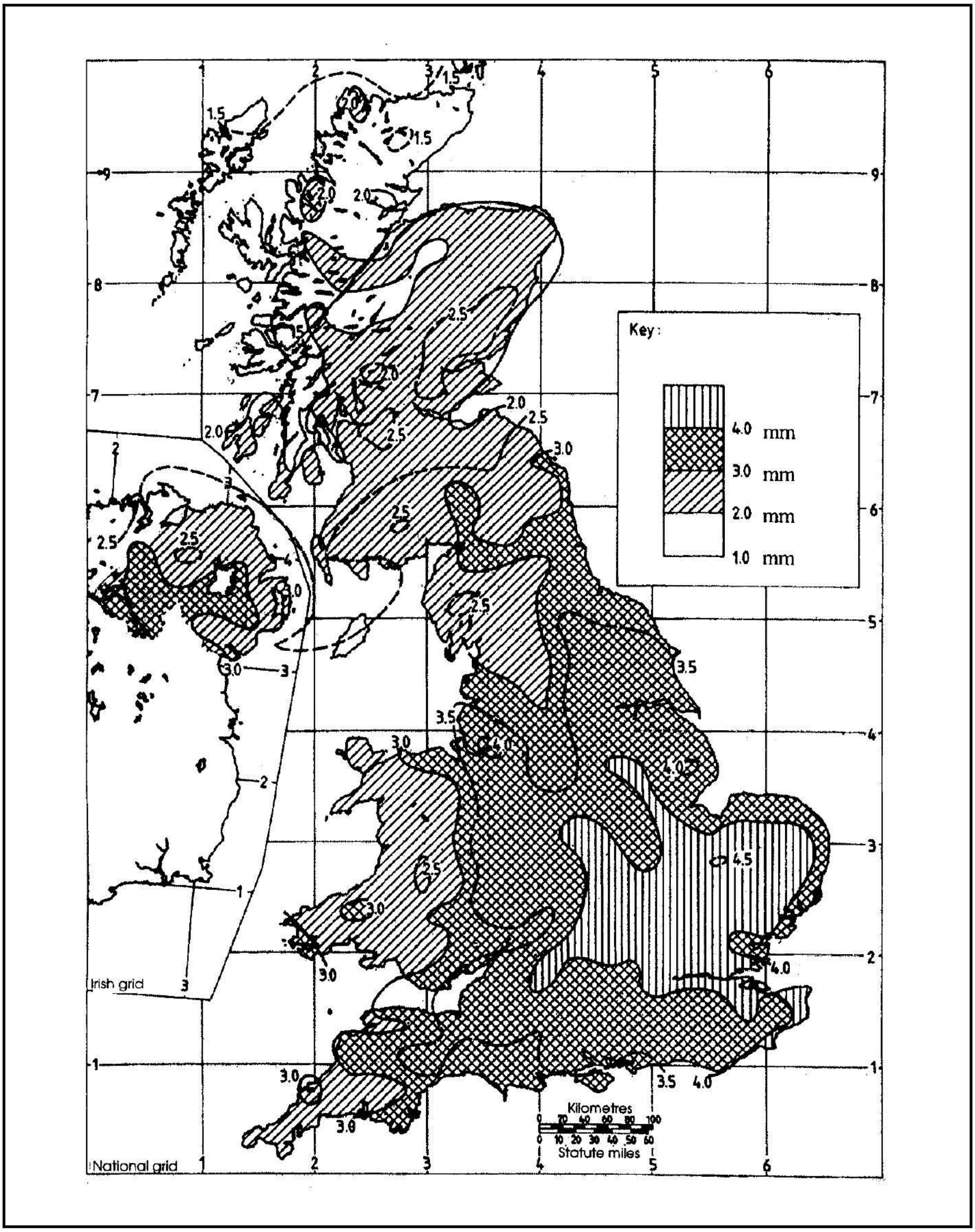
Drained area of road in m^2 under a rainfall intensity of 50mm/h and collection efficiency in % (in brackets)

Manning's coefficient is n = 0.017.

For others values of rainfall intensity I, multiply the area by (50/I).

Appendix E. Rainfall depth

Figure E.1 Values of 2MinM5 rainfall depth for the UK



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