5
Roof Drainage

This section considers the design of water drainage from the time it hits the roof cladding to the time it enters the downpipe. As the design considerations are similar, this also includes the discharge from gutters and troughs within the roof plane, valleys, internal gutters, and external spouting.

The Roof Drainage section gives guidance for compliance with NZBC Clause E1 Surface Water. It describes how to drain rainwater effectively from roofs and gutters.

5.1
NZBC: Clause E1 — Surface Water

Objective *Safeguard people from injury or illness, and property from damage, caused by surface water*
Functional Requirement *Buildings and sitework shall be constructed in a way that protects people and other property from the adverse effect of Surface Water.*
Performance *Surface water resulting from an event with a 2% probability of occurring annually shall not enter buildings.*

5.2
Types of Gutter

The term "gutters" can be applied to all roof drains, but "spouting" refers specifically to external gutters.

Types of gutter:

- **External gutters** – positioned outside the building envelope.
- **Concealed Fascia-Gutter Systems** – gutters installed directly behind a fascia.
- **Internal Gutters** – formed inside a parapet wall or where two connected gables meet at an internal draining point.
- **Valleys** – where two roof planes meet at an angle of less than 180°.

- **Roof Gutters** – where a penetration obstructs and concentrates the flow of water, often into a single pan.
- **Secret Gutters** – where a roof discharges into a raked barge.

The definition of gutters in the COP includes the troughs of a profile adjacent to an obstruction (such as a penetration) or where a secret gutter is required, i.e., at the barge line of a swiss gable roof.

5.2.1 External Gutters (Spouting)

NZBC clause B2/AS1 requires spouting to have a durability of 5 years. In practice, this is rarely commercially acceptable. However, with sound design and reasonable maintenance, a spouting life of 10 years or more is usually achieved when using the same material as the profiled metal roof.

Spouting that is difficult to access for replacement should be specified in more durable, compatible materials.

5.2.2 Concealed Fascia Gutters

Concealed gutter systems are bespoke or proprietary systems that run inside the fascia.

The concealed gutter design must ensure that water cannot enter the soffit or overflow into the building if the gutter system outlet becomes blocked.

Overflows must be provided for concealed gutter systems within 1 m on either side of the downpipe to discharge through the soffit, immediately behind the fascia, and be capable of discharging the total catchment area served by the downpipe.

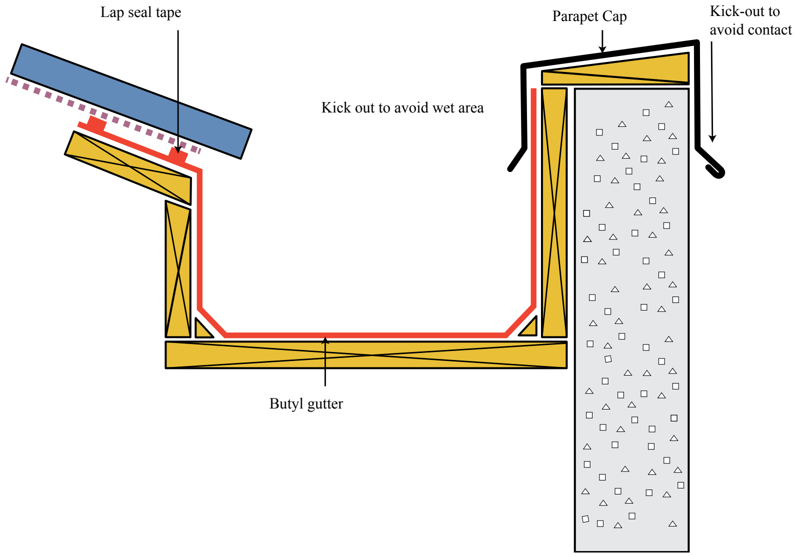
See 5.3.3 Overflows.

5.2.3 Internal Gutters

When internal gutters are difficult to replace and their failure could cause major disruption to the building below, they must be made from materials that will last 50 years to comply with the NZBC; metallic coated steel is not recommended for internal gutters that are difficult to replace.

Common internal gutter materials are butyl or other membranes, fibreglass, or non-ferrous metal. Where butyl gutters are used, the metal and flashings should be separated from wet contact with the butyl rubber.

5.2.3A Separation of Butyl Gutter and Metal Roofing



Suitable non-ferrous metals include 0.9 mm aluminium, 0.6 mm stainless steel, and 0.6 mm copper. Contact between coated metal products and copper or stainless steel must be avoided because it will lead to early corrosion. Splashback or runoff from copper onto coated metal can have the same effect.

5.2.3.1
Internal Gutter Design Features

All internal gutters must have upstands that are hooked or returned. Gutters that return under the eaves are not recommended as this design makes removal for replacement more difficult.

5.2.3.1A Hooks and Returns

To prevent permanent deflection of the gutter, support for the sole of an internal gutter should be provided by either a plywood lining or by close ribbed sheets of roof cladding, separated by a layer of roofing underlay. Internal gutter support must be strong enough to support the weight of water when at capacity, and if over 300 mm wide, be able to support foot traffic.

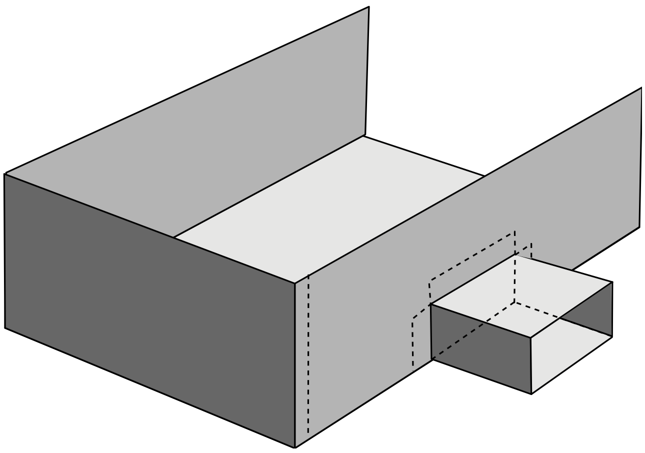
Internal box gutters must have a minimum depth of 50 mm at their lowest point, including freeboard. A width to height ratio of 2:1 plus freeboard gives maximum flow as it minimises wet surface area for a given cross-sectional area.

A sharp direction change in flow of an internal gutter will affect discharge capacity. Where two buildings meet at an angle, each gutter must be drained separately, or a specific discharge capacity calculation must be applied.

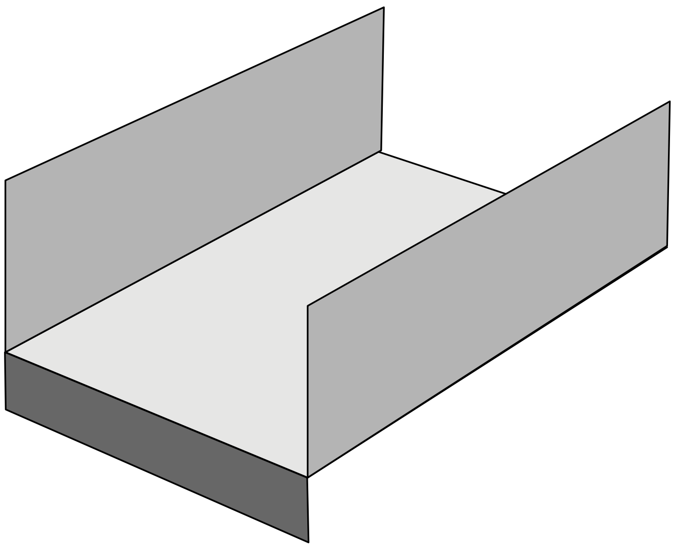
Internal gutters should have an expansion joint at the stop-end.

Outflows from internal gutters may be scuppers or weirs.

5.2.3.1B **Scupper**



5.2.3.1C **Weir**



Scupper outlets should be avoided where possible. They are difficult to weatherproof, and they can inhibit expansion. At the outlet end, a weir overflow should discharge into a sump or rainwater head.

5.2.4
Valleys

A valley is a gutter at the internal intersection of two sloping panes of roof cladding.

5.2.4.1
Valley Fixing

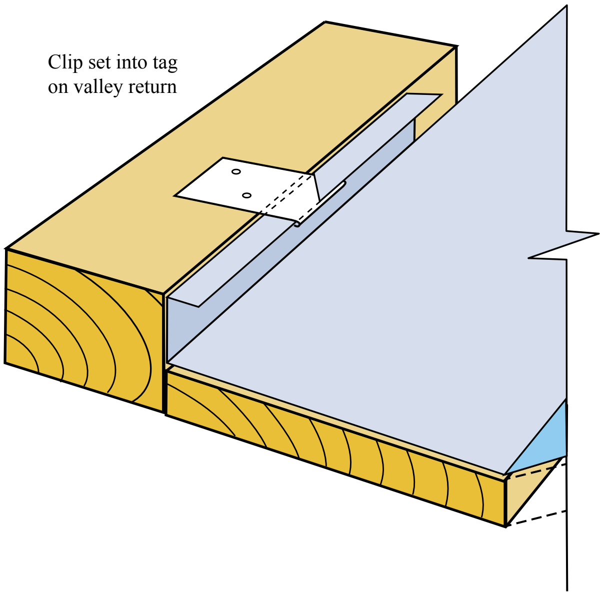
Valleys should not be positively fixed, except at the head, because that

5.2.4.1A **Valley Clip System**

would inhibit expansion and can produce noise.

Alternative means of securing the valley gutter to the substrate include:

- A clip system allows for thermal movement and security.
- A compatible washered nail or screw or a galvanised nail, provided they do not penetrate the sole of the gutter.

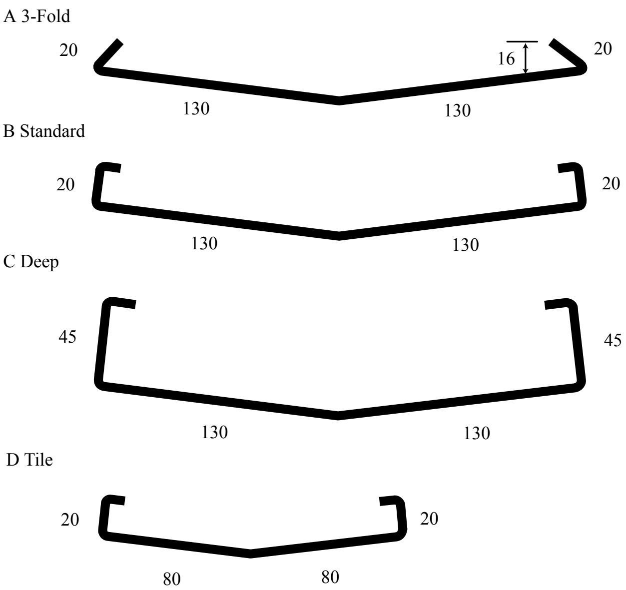


5.2.4.2
Valley Design

Valley gutters must discharge into a rainwater head, sump, or an eaves gutter. The discharge point must be within 2 m of a downpipe if the catchment area exceeds 50 m².

When the roof pitch is less than 12°, the valley should be made in one piece or the joints must be sealed. To ensure snug fitting, the valley angle should be matched to the pitch of the valley support. Having the valley too open will result in a diminished capacity, and too sharp an angle will make installation difficult.

5.2.4.2A Common Valley Shapes



5.2.4.2B Internal Valley Angle

Roof Pitch	Internal Angle
3°	176°
5°	173°
10°	166°
15°	159°
20°	152°
25°	145°
30°	139°
35°	132°
40°	126°
45°	120°
50°	114°
60°	104°

5.2.4.2C Maximum Valley Catchment in m² for Areas Having a 50-year Rainfall Intensity <150 mm/h

Roof Pitch	3°	5°	8°	10°	12.5°	15	20°	25°	30°
A 3-fold			12	18	29	41	70	106	146
B standard			25	34	47	63	99	140	184
C Deep	60	86	152	180	215	251	321	389	452
D Tile					17	22	33	45	57

Free Board: 15 mm for pitches 8° and above
20 mm for pitches below 8°

For other pitches, rainfall intensity, and valley shapes refer to the 5.7 Capacity Calculations tool.

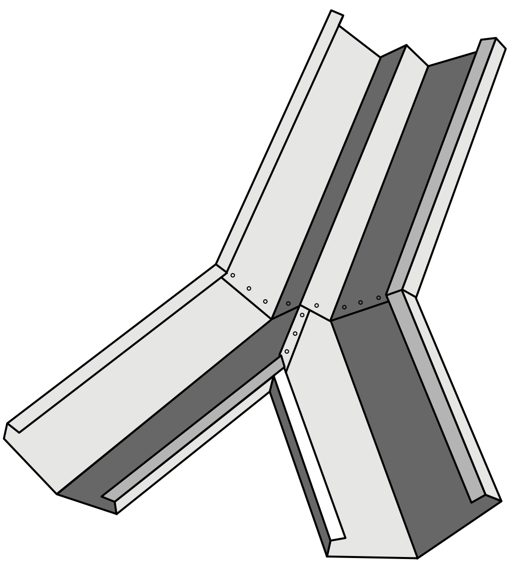
5.2.4.3
Internal Corners

When the back of a gutter is cut down to allow the valley to discharge into it, the gutter capacity is affected. In these cases, gutter calculations should allow for 20 mm less water height, and a min 3 mm spacer should be attached to the back of the gutter (or fascia) at the internal corner to maintain the clearance between the gutter and the fascia.

5.2.4.4
Bifurcated Valleys

The maximum recommended catchment area for a bifurcated valley is 10 m².

5.2.4.4A Ridge Meets a Valley in line with the Valley



5.2.4.5
Changing Angles in Valleys

A change of roof pitch in a valley run will usually result in the change of angle in plan view. The change is acceptable, but the freeboard of the lower valley must be at least 20 mm to allow for turbulence.

5.2.4.6
Asymmetrical Valleys

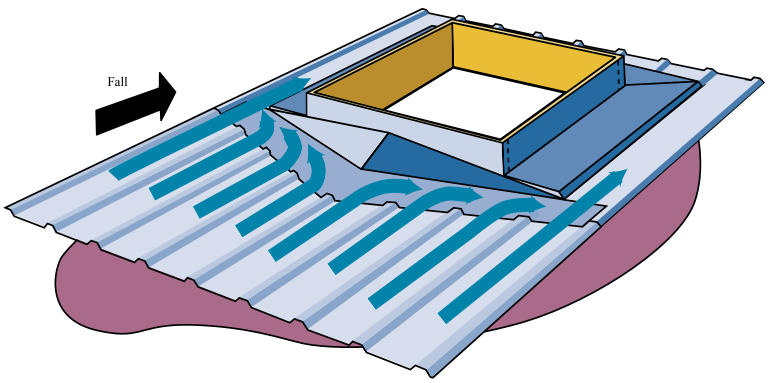
Where opposing roofs of different pitches discharge into a valley an asymmetrical valley is required. They may be designed so the side under the flatter roof is at the same height as the steeper side and 20 mm freeboard is required

5.2.5
Roof Gutters

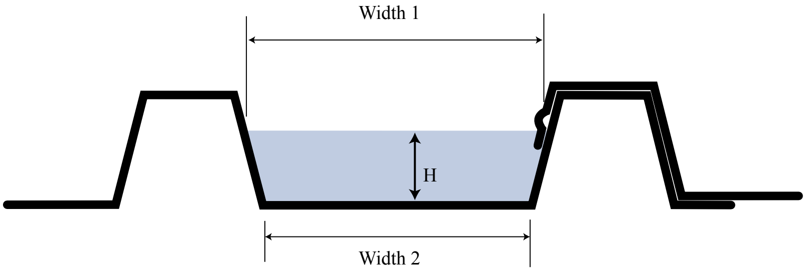
Roof gutters may be secret gutters where a barge or a wall is at an acute angle to the roof.

Penetrations concentrate water flow from numerous troughs to a single trough. These troughs can be considered as roof gutters and designed to accommodate the required water flow.

5.2.5A **Penetration Gutters**



5.2.5B **Trough Capacity**

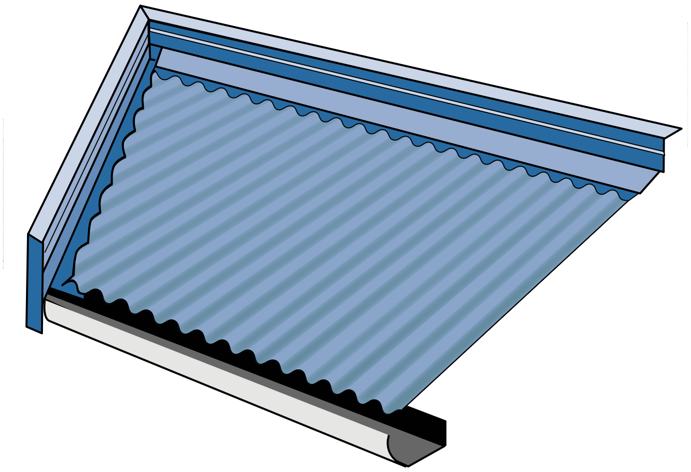


Effective cross section area of a trapezoidal profile is calculated by the width of the trough and depth to the bottom of the capillary groove

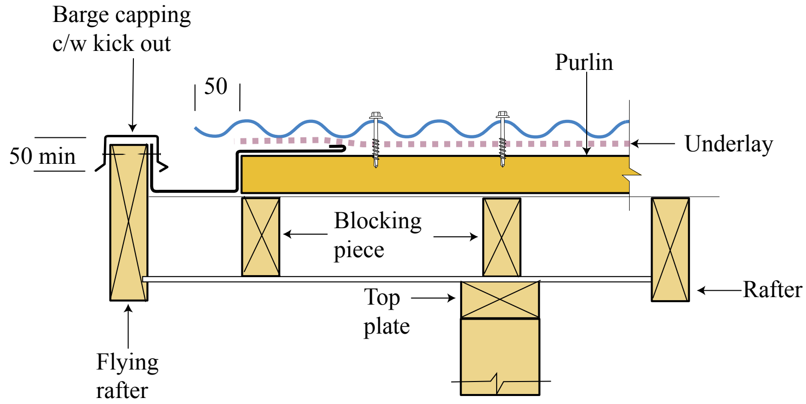
5.2.6
Secret Gutters

A secret gutter is used where the roof edge runs at an angle of less than 90° to a wall, barge, or parapet.

5.2.6A Secret Gutters Behind Barge



5.2.6B Secret Gutter Detail



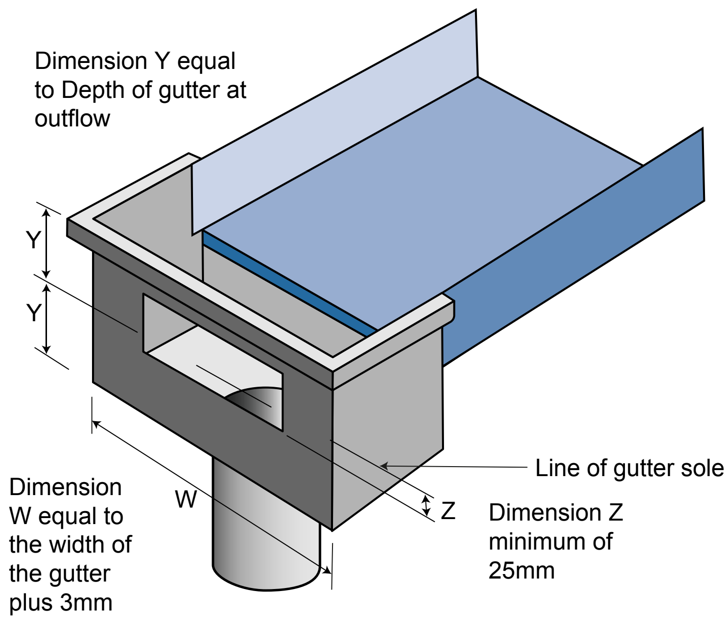
Secret gutters should be wide enough to allow for cleaning and must be designed in accordance with 5.2.3.1 Internal Gutter Design Features.

5.3
Rainwater Heads, Sumps, and Overflows

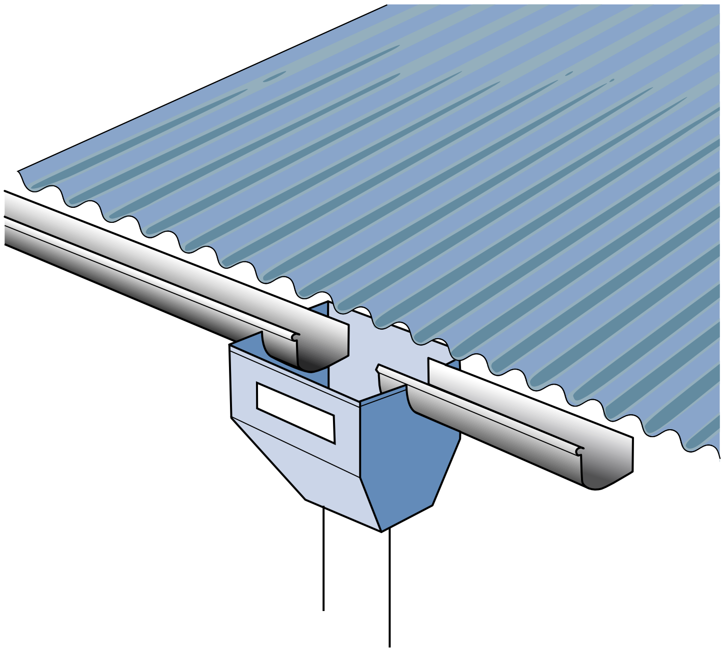
Rainwater heads are situated outside the building envelope and sumps are internally located.

They both serve to increase the head of water entering a downpipe, and to provide an overflow capacity to safely discharge water when downpipe capacity is compromised or exceeded. The overflow should be obvious so discharging water warns the occupant that downpipe capacity has been exceeded or the primary downpipe is blocked.

5.3A Internal Gutter Discharging into a Rainwater Head



5.3B External Gutter Discharging into a Rainwater Head



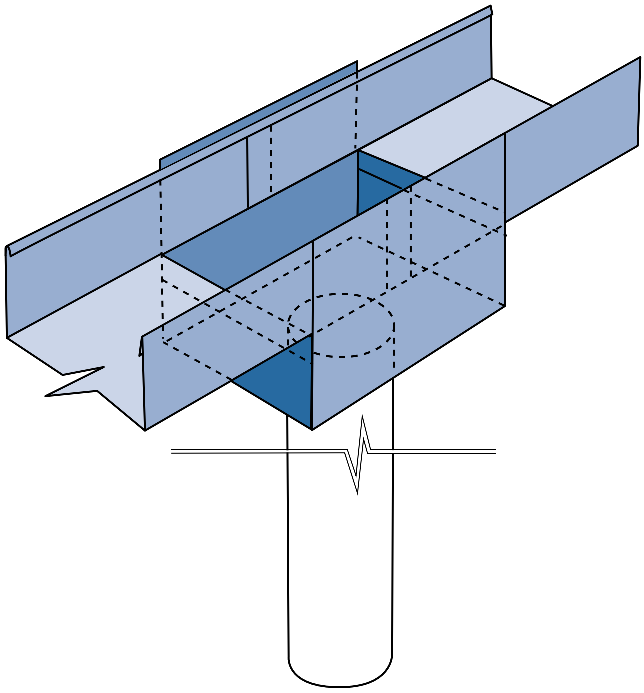
5.3.1
Rainwater Heads

Rainwater heads must be at least as wide as the gutter and have an overflow (normally a weir type). The cross-sectional area of the overflow must be at least equal to that of the required downpipe size for the catchment being served. The lower edge of the overflow must be at least 25 mm below the sole of the gutter, and the upper edge must be at least 25 mm below the upper edge of the gutter.

5.3.2
Sumps

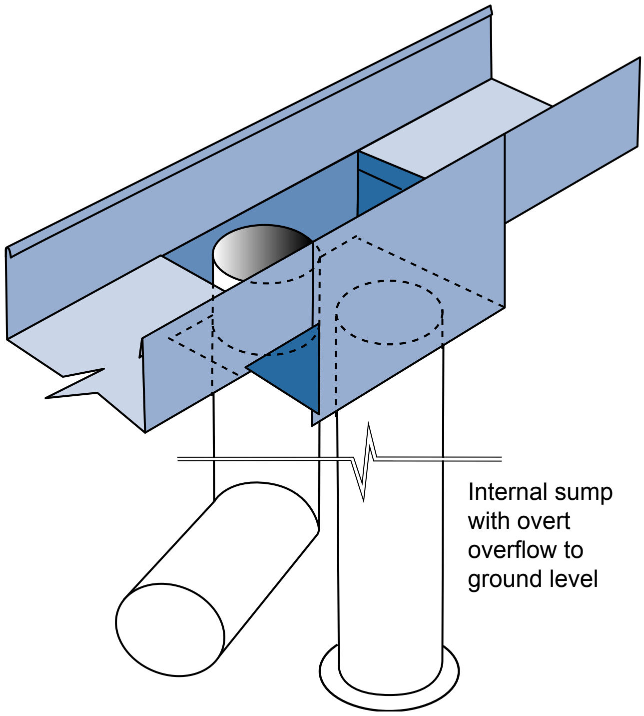
Sumps must be at least the same width as the gutter and have an outlet positioned below the sole of the gutter to increase the head of water at the outlet.

5.3.2A Sump – same Width as Gutter



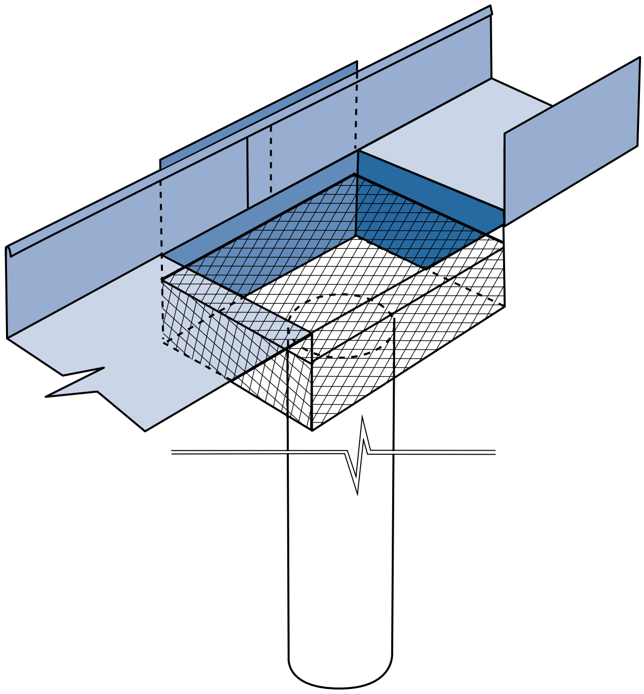
Internal sumps must have overflows. These are often a secondary pipe overflow with the outlet height positioned above the level of the primary outlet.

5.3.2B Sump with Obvious Overflow



An internal sump should have a guard that prevents debris from blocking the outlet. A removable aluminium expanded-metal box can be fitted at a minimum of 40 mm below the sole of the gutter. Because the top is flat, it is unlikely that the entire surface area of the outlet can become blocked, so it is preferable to balloon-type guards. A leaf guard should have a horizontal surface area of at least four times the size of the downpipe outlet area and should be installed at roughly mid-height of the sump depth. Gratings can cause sump blockage, and this can reduce the outlet capacity.

5.3.2C Sump with a Leaf Guard



Gratings or guards should be designed so that any debris will float, and hail, or obstructions, such as a tennis ball, will not wedge and block the guard. Gratings or guards should be cleared of accumulated debris regularly as part of normal maintenance.

5.3.3
Overflows

Overflows must discharge clear of the building to clearly show that downpipe capacity has been exceeded; it should be an obvious indication that the gutters need maintenance.

The overflow opening of a rainwater head from an external gutter must have a cross-sectional area equal to that of the downpipe. The bottom of the overflow must be no higher than 25 mm below the bottom of the spouting.

Where the position of an outlet of a parapet wall gutter is on an outside wall, any scupper outflow should discharge into a rainwater head.

5.4
Outlets and Downpipes

A gutter’s discharge capacity increases with the depth of water over the outlet. The best way to increase the head is to discharge the open end of the gutter into a rainwater head or sump. Swirl at the outlet reduces its performance, so positioning of the outlet is important.

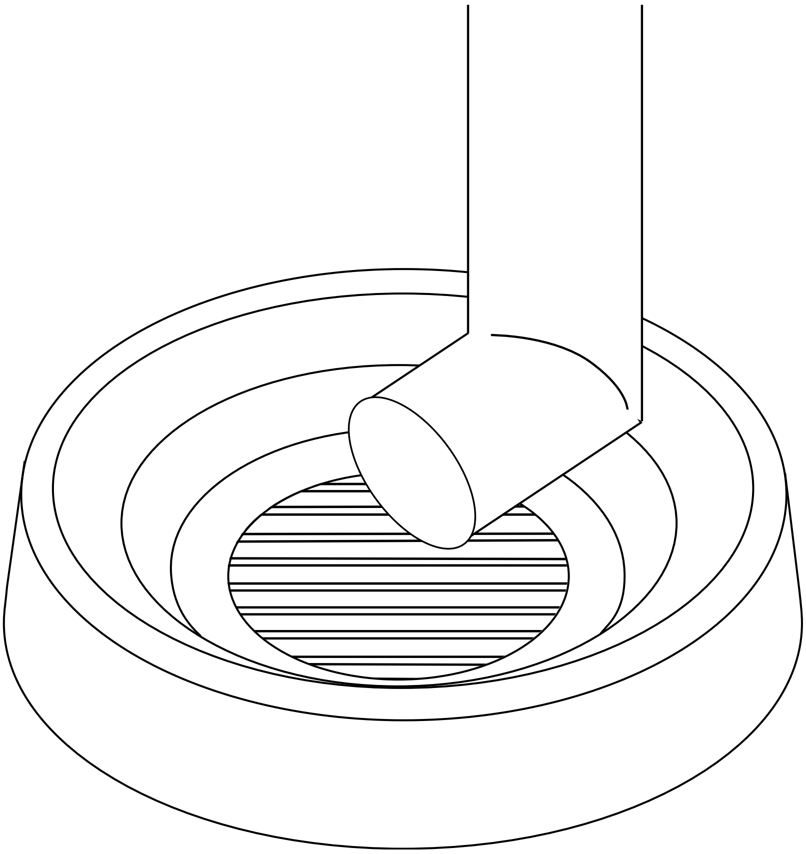
Outlets must be placed at a distance less than or equal to the outlet diameter from the nearest vertical side of the sump.

Where they are connected directly to the drain, all internal downpipes must be sealed to internal sumps by a compression ring, or similar fitting, and must have access for cleaning at the base. All sump downpipes must be able to withstand a water pressure test with an applied head of 1.5 m of water without leakage.

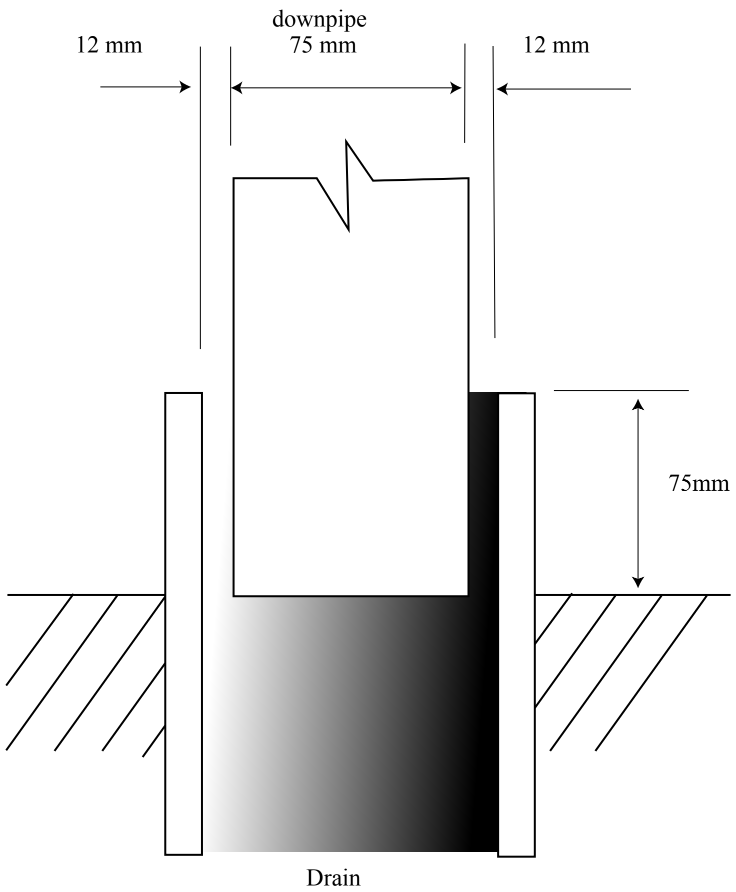
To avoid any water back-up if the drain capacity is overloaded or obstructed, an air-break should be provided for all downpipes to ensure that water does not back up the downpipe.

All exterior downpipes must discharge freely over a grated gully trap or into an oversize pipe which must be a minimum of 50 mm above the adjacent ground level.

5.4A Downpipe Draining into a Grated Gully Trap



5.4B Downpipe Draining into a an Oversized Pipe



Downpipes fixed at an included angle of less than 105° must have a cross-sectional area equal to that of the gutter or be sized by calculation.

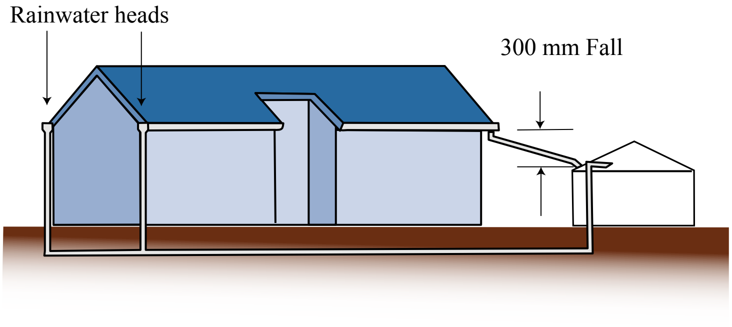
Downpipes must be compatible with the roof and gutter material and must comply with the 15-year durability requirement of the NZBC.

Discharging water off an inert surface onto unpainted galvanised rainwater goods can cause corrosion. See 4.12B Inert Catchment.

Horizontally run PVC downpipes and gutters require a greater provision for expansion than metal, particularly if they are painted a dark colour. Horizontally run PVC downpipes and gutters should have a maximum length of 9 m.

When rainwater is collected into a water tank, there is often not enough distance to obtain adequate fall for one downpipe outlet. In such cases, or whenever the roof design pre-empts a continuous spouting to the tank, it is possible to have several sealed downpipes (some of which can run underground) to discharge into the tank. The outlet discharging into such pipes should be a rainwater head to avoid flooding.

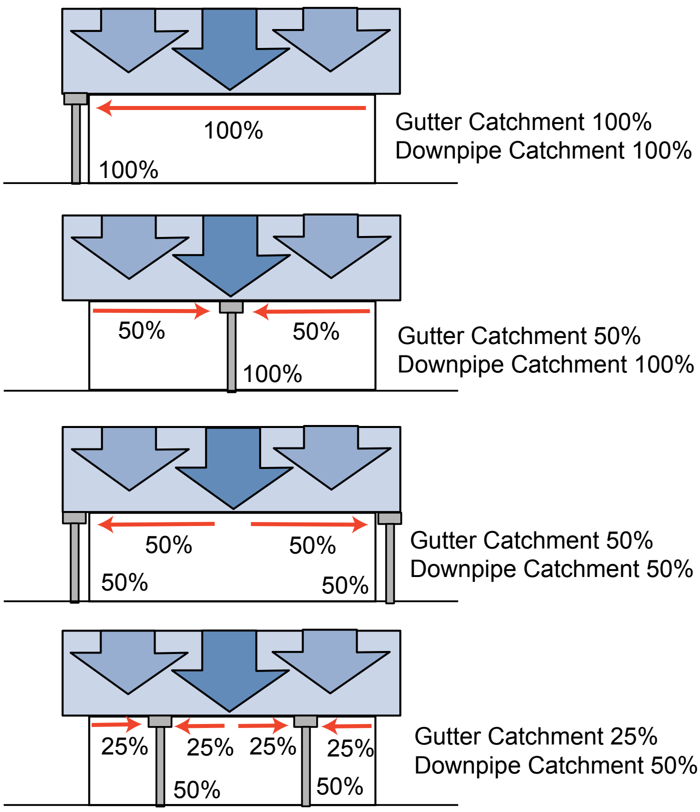
5.4C Collecting Rainwater in Tanks



5.4.1
Placement of Downpipes

Placement of downpipes significantly affects gutter and downpipe calculations.

5.4.1A Downpipe Placement



5.4.2
Capacity Table for Common Size Downpipes

Use this table to select the correct internal dimensions of common downpipe sizes for use in the online calculator at 5.7 Capacity Calculations.

5.4.2A Downpipe Capacity Table

Material	Size	Nominal Diameter (mm)	Internal Dimension (mm)	x-Section Area (mm²)
PVC	65 x 50		65 x 52	3380
	100 x 50		102 x 51	5171
		65	63	3138
		80	76	4537
		110	98	7626
		160	143	16157
		200	178	25157
		250	224	39840
		280	253	50823
		315	274	59610
Steel		75	75	4466
		100	100	7940
		90x50	90 x 50	4400

5.5 Gutters

External gutters must be installed with the back lower than the fascia board or cladding.

External and internal gutters must have a cross-sectional area in accordance with 5.3.2.1A Cross-sectional Area of Gutter, and sumps, rainwater heads and downpipes must not restrict the flow from the gutter.

For design purposes, gutters are assumed to be level. It is not recommended to obtain fall by tapering, as it reduces the cross-sectional area of the gutter.

With the limited fall available it is not always possible to ensure that all internal or external gutters will remain dry without ponding and so, to avoid premature corrosion, consideration should be given to using non-ferrous metals. See 5.5.8 Fall.

Unpainted galvanised steel is not guaranteed for spouting and gutters.

Because dirt retains moisture and causes corrosion, ponding voids warranties.

All AZ coated steel spouting and gutters must be maintained to prevent ponding due to the collection of debris or dirt as required in 16 Maintenance .

Where their renewal within 15 years would be difficult, AZ-coated or pre-painted steel must not be used for internal gutters.

All gutters are subject to expansion and, therefore, there is a maximum recommended length before an expansion joint is needed. The maximum length is determined by the metal, its thickness and colour. It is similar to the limit recommendations for roof cladding but should not exceed 12 m. See 7.3.2 Roof Cladding Expansion Provisions. N.B. A sump or spouting angle provides sufficient movement for expansion.

Where a spouting or gutter can move freely and independently the increase in length should be according to the specifications in A Sliding Washers .

Sliding washers and the spouting or gutter should be of a cross-sectional dimension capable of resisting expansion forces. Copper or aluminium spouting or guttering that has been softened by brazing is not suitable for an extended length.

Outlets are only required at twice the length module because an expansion joint can be either a sump, rainwater head or a saddle flashing. See 5.3.2.3G Gutter Capacity.

5.5 Gutter Installation and Maintenance

Spouting should be installed with the back lower than the fascia board or cladding to allow for draining of overflow water through the gap between the gutter back and the fascia.

A 2 mm gap between the back of the gutter and the fascia will give a discharge area equal to the diameter of a 75 mm downpipe for every 2.2 m of gutter run.

This gap is only totally effective if the spouting is correctly maintained and the gap is free of debris. A designed outlet is preferred, either a gutter bracket creating a minimum 6 mm space stop end weir, a raised outlet above the spouting sole, a slotted front or a low fronted gutter.

A weir stop-end, or an outlet with a top edge above the sole of the gutter, can be used to increase outlet capacity.

5.5.1 Maximum Gutter Length

All gutters are subject to expansion. Maximum gutter-length is determined by the type of metal and its colour. Where gutters have an allowance for expansion (such as an external gutter on a typical gutter bracket or an internal gutter with sliding clips), lengths should be restricted to 25 m in steel and 12 m for copper or aluminium.

An expansion joint can be either a sump, rainwater head or a saddle flashing. Gutters that are directly through-fastened to the fascia or eaves purlin will not be free to move and should be restricted to a maximum of 12 m. Through-fastened gutters are not recommended as they are difficult to replace.

5.5.2
Gutter Support Systems

The spouting bracket system must withstand the potential weight of a gutter full of water. In snow load areas, spouting may be fitted with snow straps and brackets at a maximum of 600 mm centres to withstand the additional potential weight of any snow build-up.

Brackets should be made using compatible material or non-ferrous metal. Brackets for pre-painted external gutters should be painted or powder coated before installation.

Brackets for external gutters should be located close to all stop-ends, at both ends of sumps and rain-heads at a maximum of 750 mm spacing for gutters less than 180 mm wide, and at 600 mm for gutters 180 – 300 mm wide. Brackets must be installed to provide a 1:500 (2 mm per metre) minimum gutter gradient towards the outlets.

5.5.3
Gutter Maintenance

Gutter or spouting blockages can cause flooding because of the build-up of debris. Regular inscpection and maintenance must be carried out to ensure that gutters are free draining, overflow outlets can also prevent damage.

The COP does not recommend permanent gutter leaf guards. Although they do prevent large pieces of debris from obstructing the outlets, they allow finer particles to collect on the sole of the guttering. Without regular maintenance, the prolonged wetting of the interface between any debris and the metal can lead to early corrosion of the roof or gutter. The decay of organic matter such as leaves can produce organic acids, which will also accelerate corrosion.

The build-up of matter on the upper surface of the leaf guard can also form a poultice, which increases the time of wetness and acidity and can accelerate corrosion of the roof sheet ends.

5.6
Roof Drainage Design

The objective of roof drainage systems is to maintain a weatherproof building, to minimise the risk of injury or inconvenience due to flooding, and to avoid potential monetary loss and property damage — including to the contents of buildings.

Roof drainage design requires consideration of:

- *Type of gutter (external, internal, valley, or roof gutter),,*
- *rainfall intensity,*
- *catchment area,*
- *gutter fall,*
- *gutter-cross-sectional area and wetted surface area, and*
- *outlet and downpipe capacity.*

This section details specific requirements for the sizing of all drainage components.

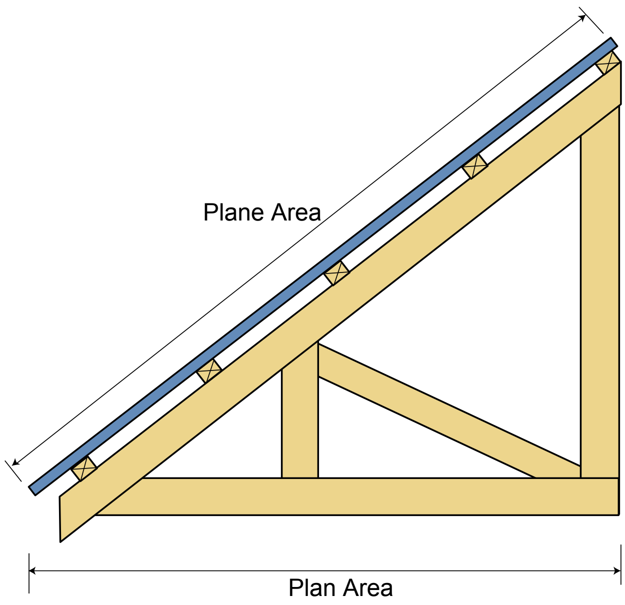
5.6.1
Catchment Area

The effective catchment area for a gutter is determined not only by the plane area of the roof itself but also by the walls adjacent to the roof. When a wall is discharging on to a roof, half the surface area of that wall (up to a maximum height of 10 m), must be added to the catchment calculation.

5.6.1.1
Roof Pitch

The COP calculations are based on the **plane area** of the roof (which is the sloping surface area of the roof), not the **plan area** (which is the area covered by the roof).

5.6.1.1A Plane Area v.s. Plan Area

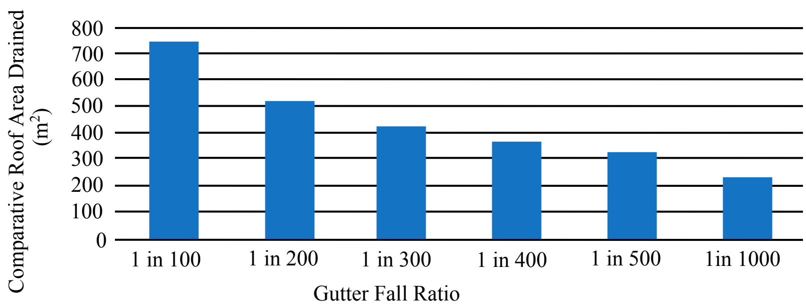


Wind action can influence effective catchment area, and the COP assumes the worst case scenario, i.e., rain striking the roof at an angle perpendicular to the roof plane.

5.6.2
Gutter Fall

All gutters must have a minimum fall of 1:500 (2 mm in 1 m), the COP recommends 1:200 (5 mm in 1 m), as it will improve drainage and self-cleaning.

5.6.2A Effect of Gutter Fall on Drainage Capacity



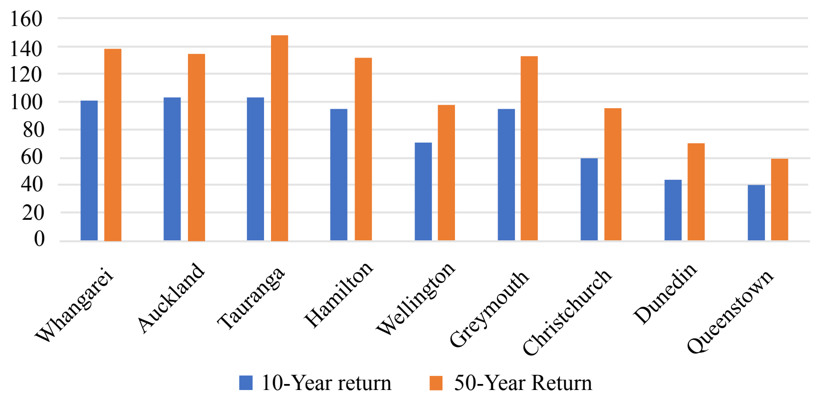
5.6.3

Rainfall Intensity

Rainfall intensity can be taken off the maps for 50-year average return intervals (ARI). When the co-ordinates of a site are known, site-specific values can be obtained using NIWA's HIRDS tool at https://hirds.niwa.co.nz/

As NZBC E1 requires that rainwater from events having 2% likelihood of occurring annually shall not enter buildings, the COP uses figures for 50-year Average Return Interval, rather than the 10% probability figures published in E1/AS1.

5.6.3A Comparison of 10-year and 50-year Rainfall Intensities

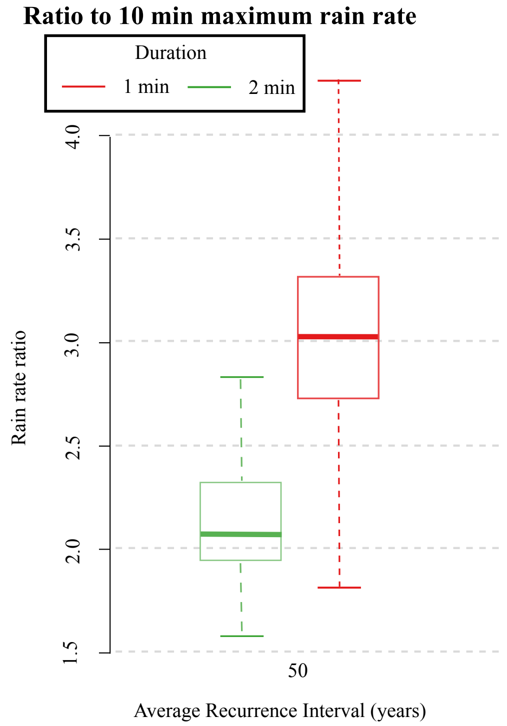


5.6.3.1
Duration

Rainfall intensity figures quoted on the NIWA site are for maximum intensity over a ten-minute duration. Intensity may vary within this period, and roof drains can overflow quickly when demand exceeds capacity. A 1-minute rainfall intensity can be as much as 4.2 times higher than the 10-minute intensity.

To account for short-term rainfall intensity, various factors should be applied to internal and external gutters, and to drains depending on their location and consequence of overflow. See 5.6.3.2A Short-Term Intensity Multiplication Factors.

5.6.3.1A Comparison of 10-Minute Published Intensity with 1-Minute and 2-Minute Intensities



5.6.3.2
Allowance for Short-Term Intensities

The COP drainage calculator multiplies the ten-minute maximum intensity by a factor to allow for short-term fluctuations. This minimum factor varies by gutter location as follows.

5.6.3.2A Short-Term Intensity Multiplication Factors

Application	Gutter Multiplier	Downpipe Multiplier	
		With Overflow	No Overflow
Valleys	3.1	n/a	n/a
Penetrations	3.1	n/a	n/a
Internal Gutters Residential	3.1	1.6	3.1
Internal Gutters Commercial	2.2	1.1	2.5
External Gutters — no Overflow	2.5	1.3	2.5
External Gutters — with Overflow	1	1	1

5.6.3.2B Short-term Intensity Factor Explanation

These are minimum factors; higher factors may be applied at the designer’s discretion.

- Valleys, Penetrations, and Internal Gutters Residential have a minimum factor of 3.1 because failure of these gutters is likely to cause damage to internal elements. Where a 2% probability of flooding is unacceptable, a higher figure should be used.
- Internal Gutters Commercial have a minimum factor of 2.2 as failure of these gutters is less likely to cause severe damage and water run time may be longer. Short runs and steep pitches will reduce run time. (At 250 mm/hr intensity and 3 degrees pitch, rain will take 2 minutes to travel 15 metres). For short runs, steeper pitches and where the probability of flooding of 2% is unacceptable, a higher figure should be used.
- External gutters no overflow have a minimum factor of 2.5, providing the building has a soffit. Otherwise, they should be treated as an internal gutter.
- External Gutters with overflow have a minimum factor of 1.5 as occasional overflow is not likely to cause damage. To qualify as drained, the back of the gutter must be below the fascia height and it must have a gap of at least 3 mm between the gutter and the fascia or cladding.

For convenience, ARI maps are included in the calculation section which includes tables for gutter and valley capacity for different rainfall intensities.

5.6.4
Minimum Freeboard Values

In gutters where overflow can enter the structure, it is necessary to have freeboard to allow for wave action, obstructions, and other unforeseen circumstances. 5.7 Capacity Calculationsallow the thse minimum freeboard values.

5.6.4 Minimum Freeboard Values

5.6.4A Minimum Freeboard Values

Gutter Type	Freeboard
Internal gutters	20 mm
Secret gutters	
Valleys with a pitch less than 8°	
External gutters with no overflow	15 mm
Valleys with a pitch of 8° or more	
External Gutters with Overflow	No freeboard required

5.7
Capacity Calculations

Calculating drainage capacities of gutters, downpipes, and valleys involve various factors such as rainfall intensity, roof pitch, gutter size, downpipe size, valley angle, etc. The NZMRM COP provides online calculators to derive the maximum allowable roof area drained under various scenarios.

Site Address

(Enter Site Address to Display)

Note that this site address is used only for convenience if printing calculations to attach to documentation.
*This address is **not** factored into calculations - you must determine intensity from Rainfall Intensity Maps or NIWA's HIRDS tool.*
The address is not recorded or shared with any other parties.

Calculations for Gutter

Rainfall Intensity - I (10 Min Duration, 50 Year Return Period)	100	mm/hr

Options

Type of Building: ○ Commercial ○ Residential

Type of Gutter: ○ External ○ Internal

Overflow along Gutter: ○ No ○ Yes

Overflow at Downpipe: ○ No ○ Yes

Short-Term Intensity Multiplication Factor	3.1

Minimum 3.1 for current selections

Select Gutter Information Source

◉ **Rectangular Gutter** ○ Manufacturer's Data

Gutter Fall

1:500 = 2 mm per metre

90 Degree Bends	2	bends
Gutter Length served by outlet	7	m
Gutter Width (Entire Width)	100	mm
Gutter Upstand - D	80	mm
Freeboard	20	mm

Minimum 20 for current selections

Rectangular Gutter Illustration

Illustration is for explanatory purposes only and is not to scale.

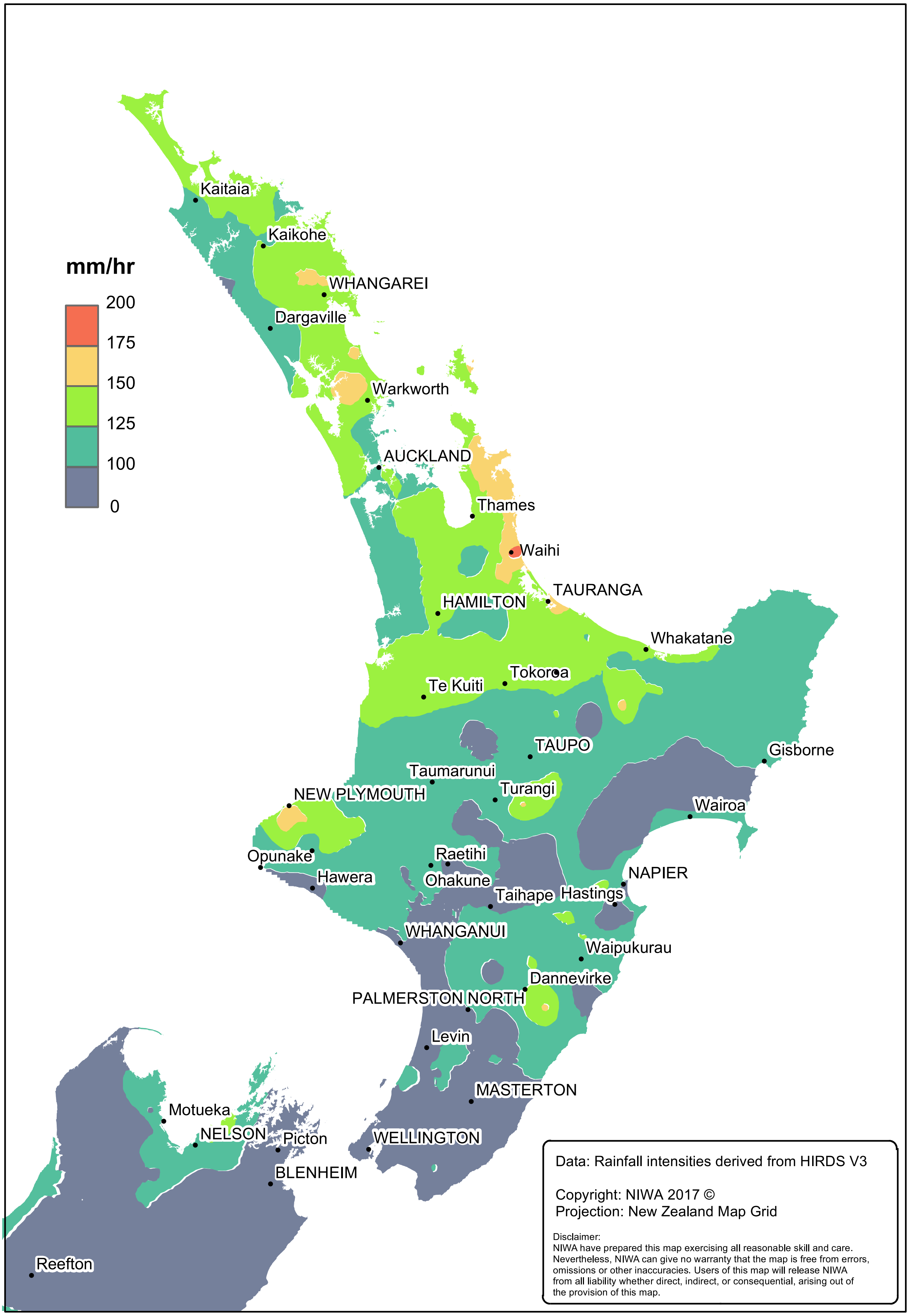
Max Capacity Roof Area - $A_{Roof\ Max}$ **15.89m²**

Conditions and assumptions for flat gutters:

1. Mannings n assumed to be 0.014 to represent long term friction conditions.
2. Equations valid for gutters with min gradient 1:500, max gradient 1:100.
3. Bends are accounted for by local loss coefficients (0.5 for each 90° bend).

5.7.1
North Island 50-year ARI, 10-minute Rainfall Intensity Map

5.7.1A 10 Minute Rainfall Intensity: 50 Year ARI

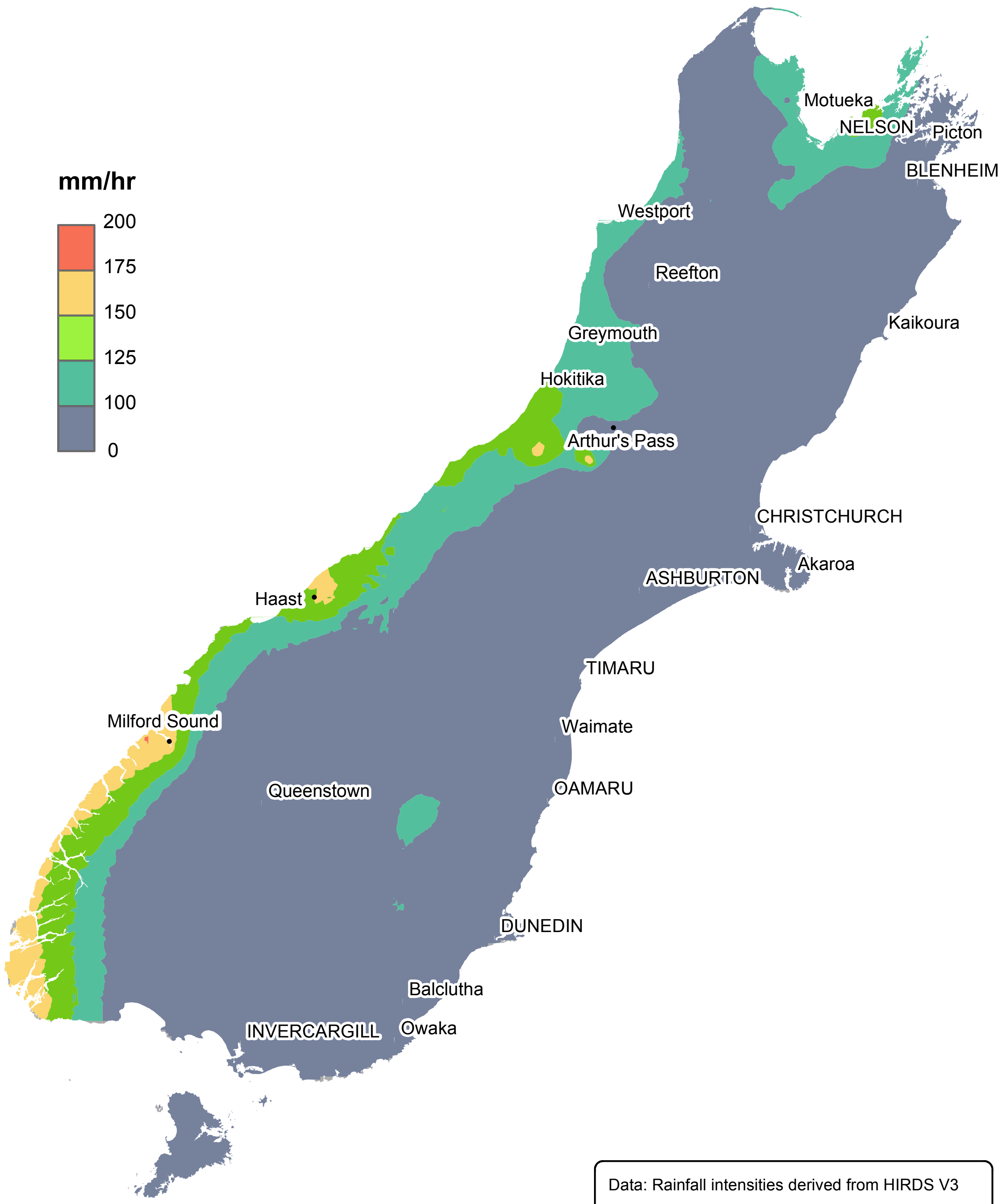


Data: Rainfall intensities derived from HIRDS V3

Projection: New Zealand Map Grid

5.7.2
South Island 50-year ARI, 10-minute Rainfall Intensity Map

5.7.2A 10 Minute Duration Rainfall Intensity: 50-year ARI



Data: Rainfall intensities derived from HIRDS V3

Projection: New Zealand Map Grid