Junctions on Grade

It's all connected

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Junctions on grade form an integral component of the sanitary drainage system!

One of the main roles of a plumbing and drainage system is to transport fluids, faecal and other liquid waste from sanitary fixtures, fittings, and appliances safely with no possibility of leakage, cross contamination, and disruption of system functionality (blockages!).

On a day-to-day basis the drainage and ventilation systems must deal with the **unsteady flow** of water from the discharge points to the outfall.

Modern plumbing standards v’s older

WELS Star Rating : WELS 4 Rated, 4.5/3 (3.5L average flush)

Example of a modern day toilet, low flushing volume with 4 star WELS rating

Plumbing & Drainage codes and standards throughout the world have been developed and based on flows from older style fixtures and fittings.

However, due to the onset of modern plumbing fixtures and reduced water volumes being discharged through the sanitary systems issues have arisen due to poorly designed and poorly installed sanitary drainage/plumbing systems which have struggled with the ever-decreasing water volumes running through the drainage systems……

One could say that in some respect the design practices have stood still,

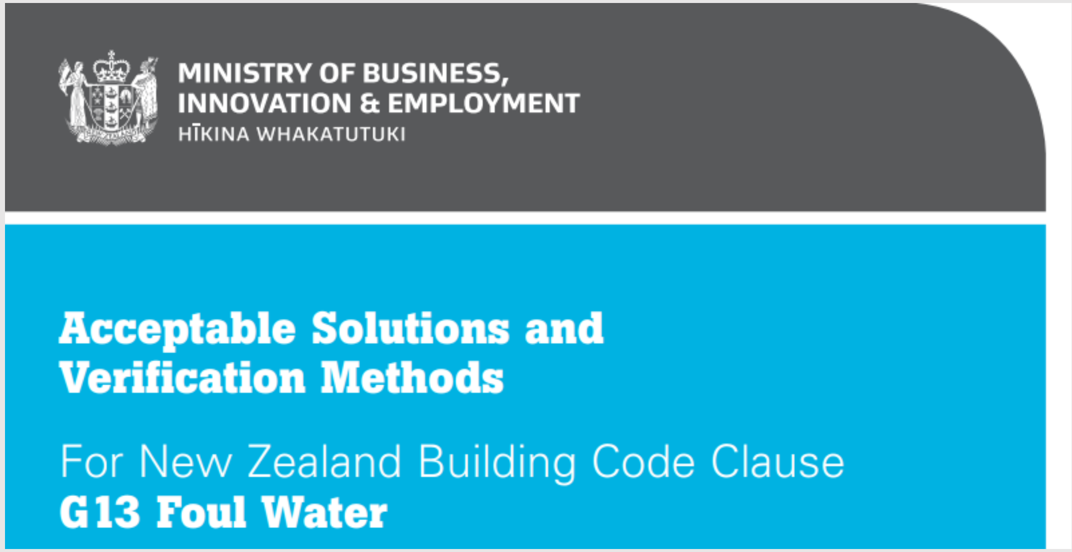
But that cannot be said for fixtures and fittings designs which have continually evolved over time

Correct design & installation is the key to a well performing and functioning sanitary drainage system

What are some characteristics/factors that can impact on discharges?

- Discharge volume (in litres)
- Discharge time (in seconds)
- Discharge length
- Discharge head
- Unwanted solids removal including modern items such as “flushable wipes”
- Kinematic viscosity of water (resistance to flow, simply put how syrupy is the liquid)
- Discharge temperatures
- Pipe roughness (internal bore roughness)

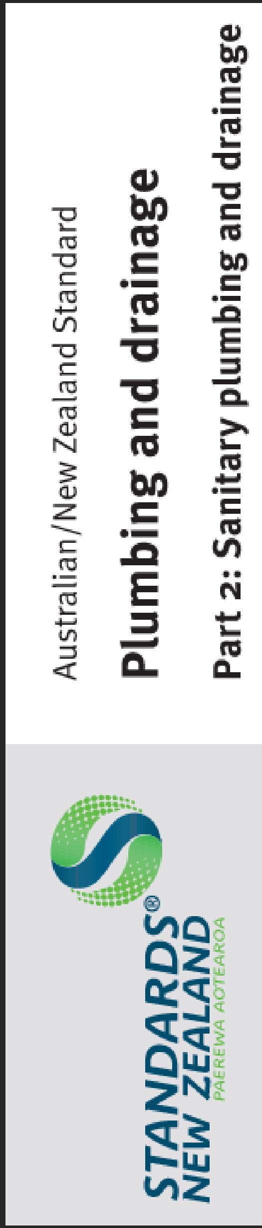
New Zealand Building Code - Junctions



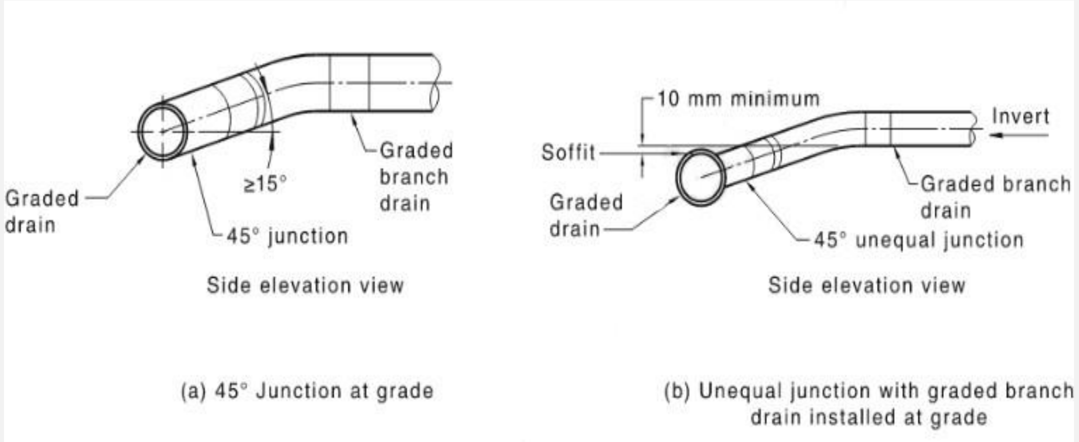
Changes to G13/AS3

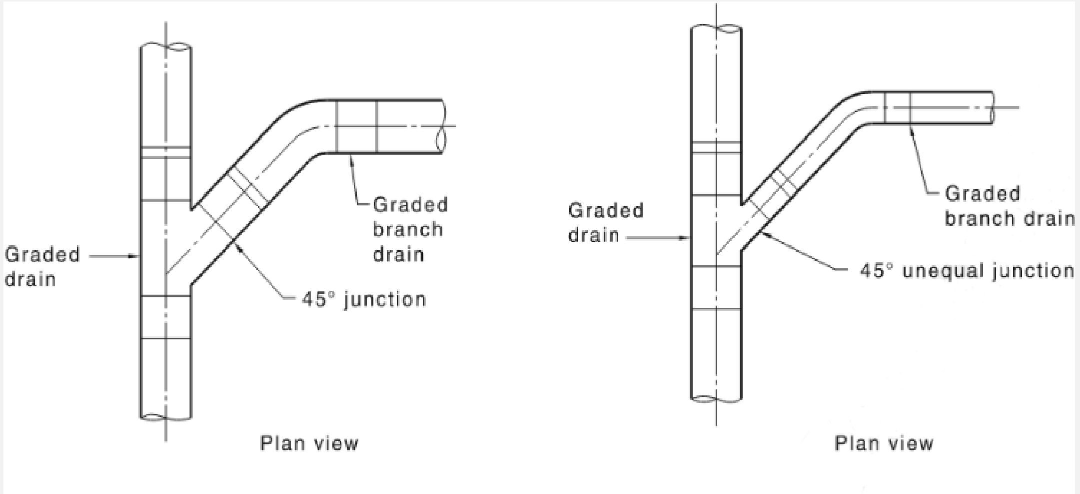
- Reduce the likelihood of drain blockages with the increasing use of water efficient fixtures
- The changes were intended to support updates made to AS/NZS 3500.2:2018, specifically Clause 4.9.1 Junctions installed at grade

(note the 2021 version is in place now)

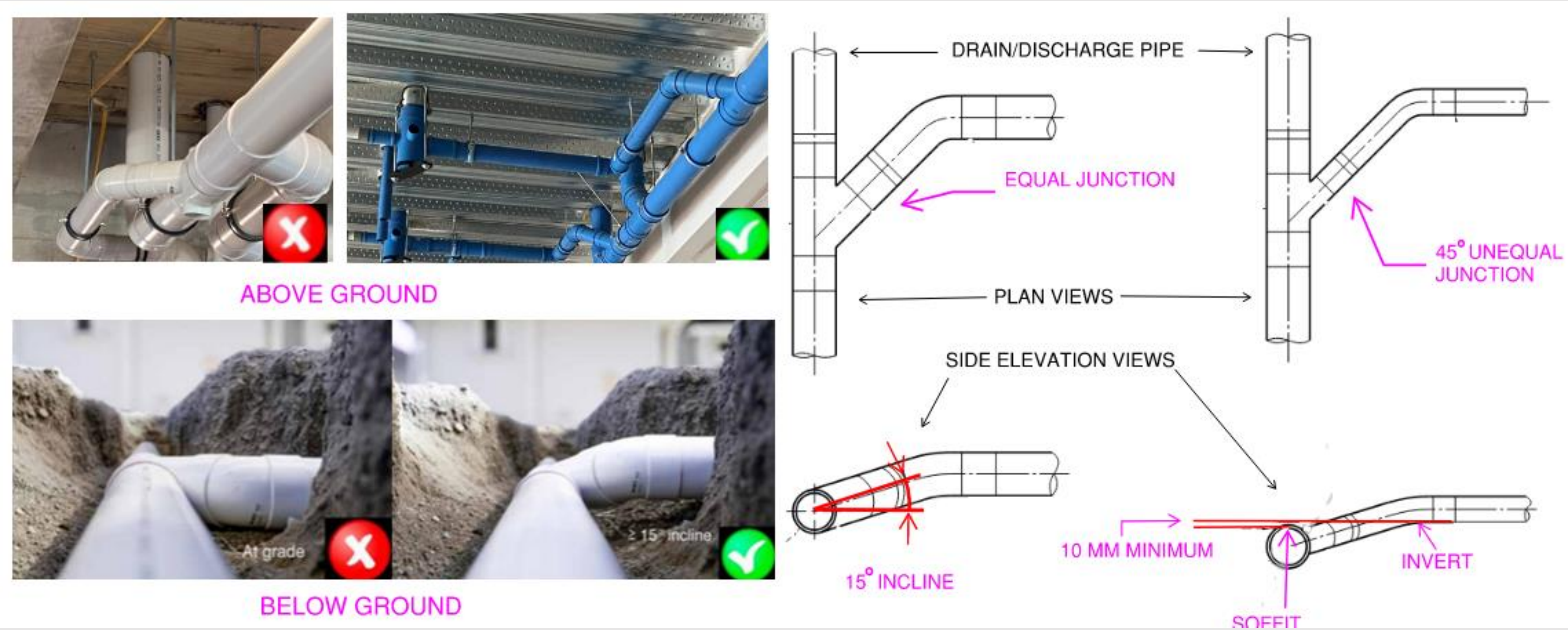


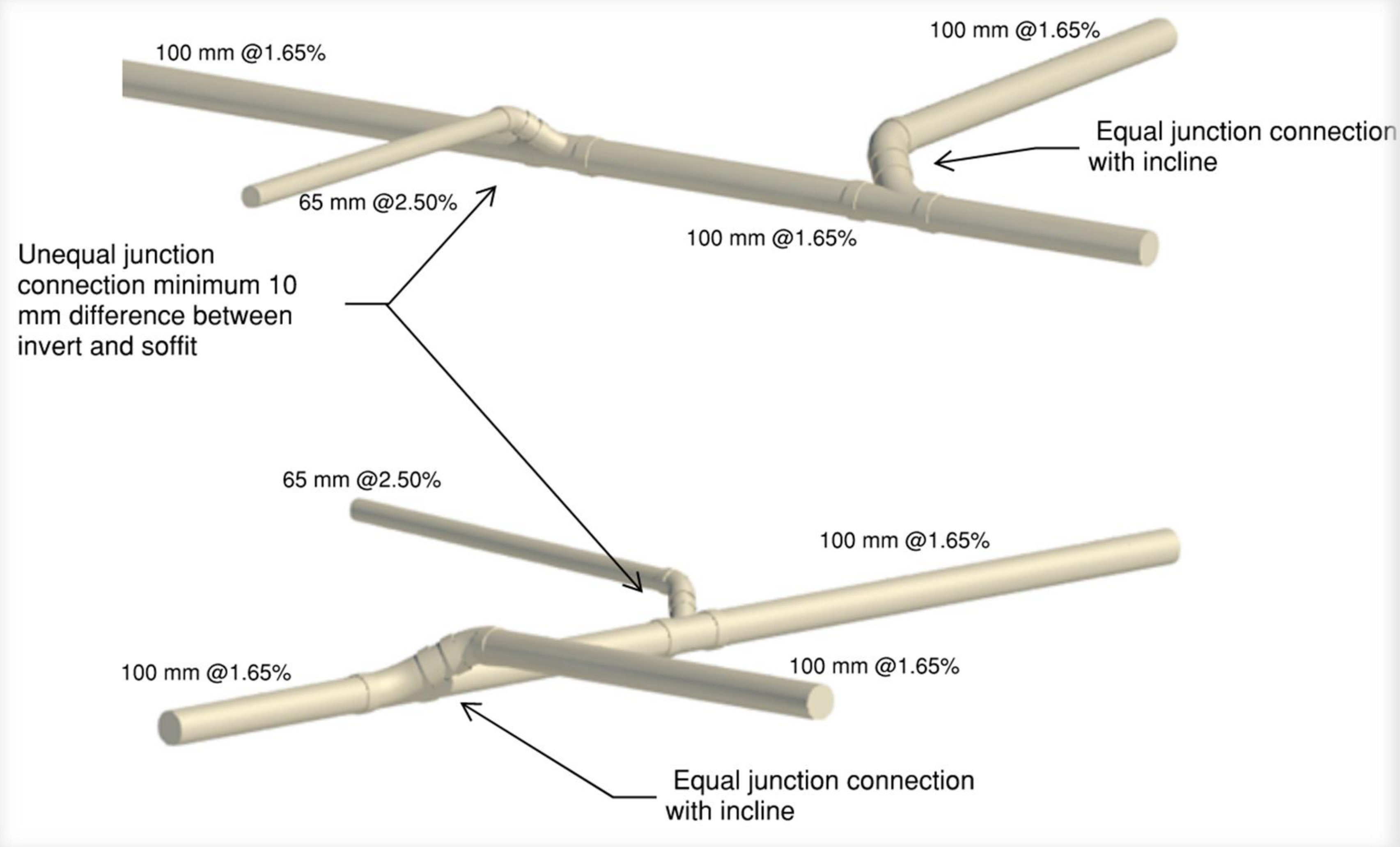
Extracted from the Standard



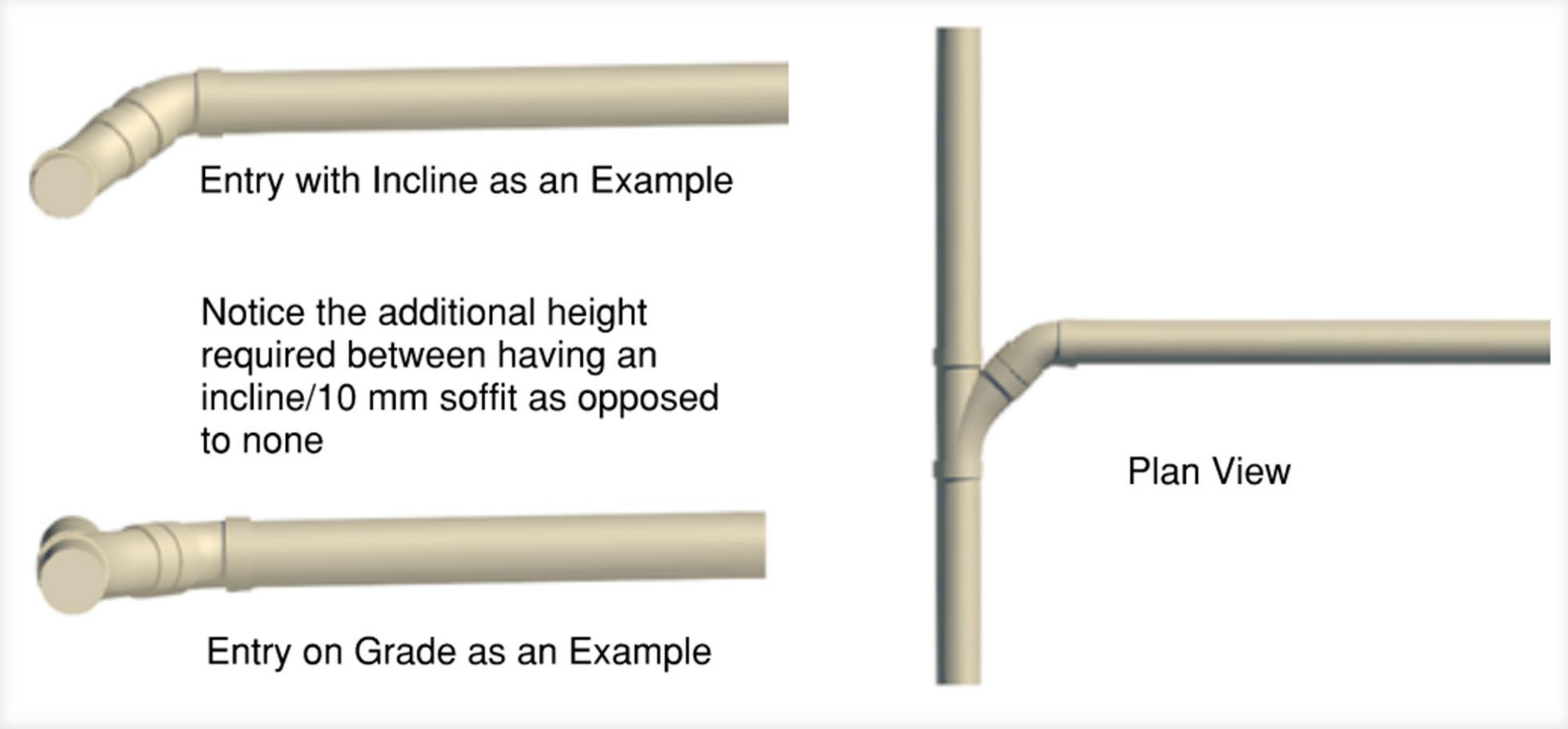


What does it look like?





100 mm @1.65%
100 mm @1.65%
Equal junction connection
with incline
65 mm @2.50%
100 mm @1.65%
Unequal junction
connection minimum 10
mm difference between
invert and soffit
65 mm @2.50%
100 mm @1.65%
100 mm @1.65%
100 mm @1.65%
Equal junction connection
with incline


Entry with Incline as an Example
Notice the additional height required between having an incline/10 mm soffit as opposed to none
Entry on Grade as an Example
Plan View

Downside - Increased depth is required to accommodate the pipework configuration

Distance from the 45-degree bend to the juncture	Change in depth from the 45-degree bend to the main drain
200 mm	54 mm
300 mm	81 mm
400 mm	108 mm
500 mm	134 mm
600 mm	161 mm
700 mm	188 mm
800 mm	215 mm
900 mm	242 mm
1000 mm	374 mm

Downside

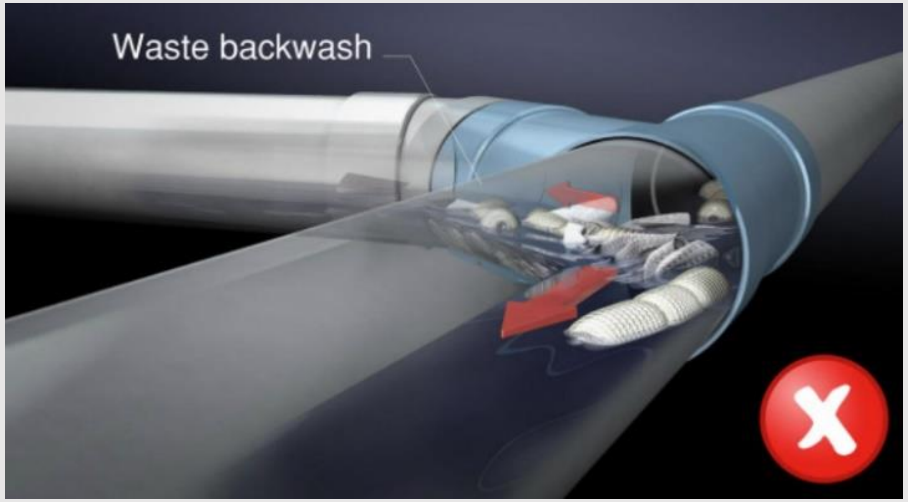
Why bother adding in those inclines??

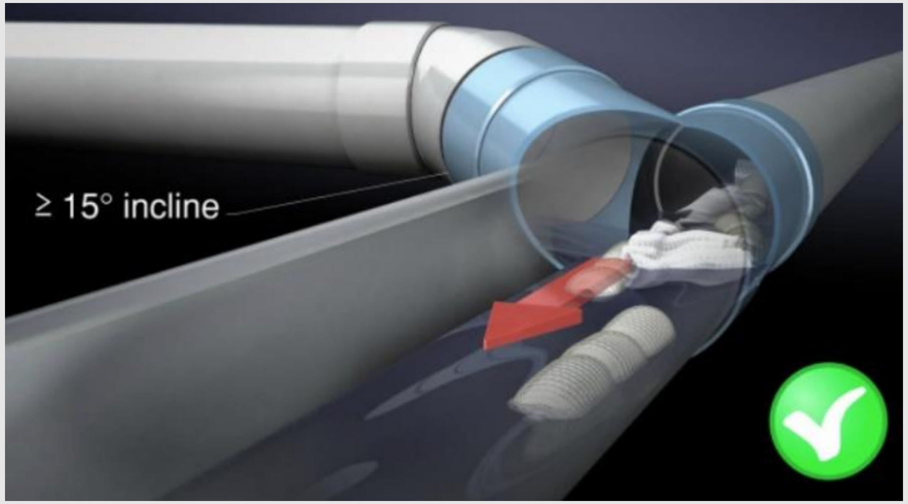
Partial backwash…

Partial backwash…How does it happen?

Different Configuration.

Partial backwash…






What is wrong here?

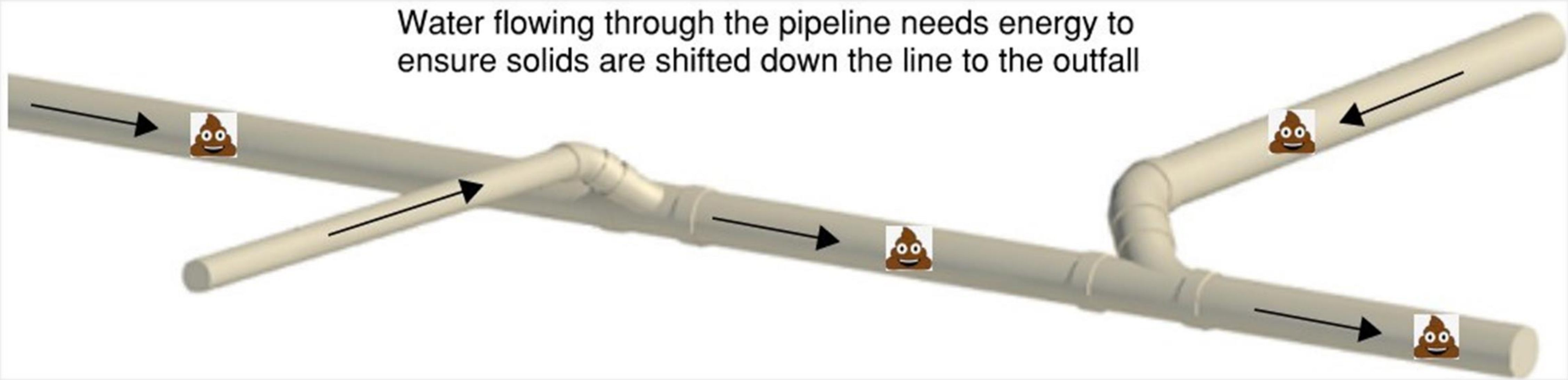
Not Again!

All pipework is fully encased in structural concrete.
You only get one shot to get this right during installation!

Self Cleansing Velocities

- Pipe grades enable self-cleansing flows which is known as velocity.
- Self-cleansing velocity - the velocity of water flowing through the pipe with enough momentum/ force to self-cleanse as it flows through the drainage system.
- There is nothing within AS/NZS 3500.2 or the NZBC that specifically states a minimum self- cleansing velocity number.
- The 2021 edition of AS/NZS 3500.2 provides a definition:

"Velocity of a flowing liquid in a pipe or channel, necessary to prevent the deposition of solids in suspension"



Hydraulic modelling demonstrates that wastewater can travel anywhere between 5 - 50 metres in a drainage system before it runs out of steam…………many factors come into play here.

Simulation Results for 6 Litre Flush		
Pipe Diameter (mm)	Pipe Gradient	Max Travelling Distance (m)
100	1:40 (2.50%)	56
100	1:60 (1.65%)	44
100	1:100 (1.00%)	19
Simulation Results for 4 Litre Flush		
Pipe Diameter (mm)	Pipe Gradient	Max Travelling Distance (m)
100	1:40 (2.50%)	40
100	1:60 (1.65%)	25
100	1:100 (1.00%)	10

How solid matter is transported via the flushing water:

- Grade is 1.65% (1:60)

Why all this extra information on flushing volumes, self-cleansing velocities etc?

What has this got to do with junctions & 15° inclines anyway?

Very good question!

Pipe installation rules like the 15° incline, 10 mm soffit/invert rule, restricted zones, connections at the base of a stack, vent sizes, minimum grades and the list goes on, are not made to make the installers life hard but are there for a reason

- When properly installed to the standard, the sanitary drainage system will function and perform to ensure good safe movement of the solids/liquids through the pipeline to the outfall and good ventilation throughout the system.

The 15° incline and 10mm rule are just two installations rules (out of many) that assist in a correctly functioning sanitary drainage system.

The additional height that these rules provide aid in the elimination of partial backwash, aid in the continuation of self-cleansing flows and in the ventilation of the system.

Let's start connecting

Low Flow Fixtures and Water Services…….mmmmm

With the onset of water sustainable type fixtures, not only means less water going down the sanitary drainage system but also reduces the demand of water to the fixtures and fittings.

As Hydraulic engineer I need to provide….

- the required volume of water,
- undue delays for hot water delivery (without the waste of heat energy)
- satisfactory pressures to all outlets
- water with suitable bacteriological, chemical, and physical characteristics
- satisfactory probable simultaneous flows extending through peak periods of use.
- ensure no wasteful excess in pipe sizes, equipment capacity, installation or system running costs.

Water pipe sizing methods used in New Zealand.

There are a multitude of pipe sizing methods used by engineers daily, however the peak flow rate (also known as peak demand) is the main factor when designing the water pipe system, basically ensuring when most fixtures are being used simultaneously the water delivery is still adequate at the outlets being used. This calculated value is then used to determine the sizes of not only the pipes but also equipment such as booter pumps and plumbing fittings.

Within New Zealand typically Hydraulic consultants will use AS/NZS 3500.1 as the basis for water pipe sizing, however the tables are based on a max velocity of 3 m/s which is far too high in respect to water services within a building, typically the accepted velocities are based on the below parameters.

Accepted Velocities	
Cold water	1.5m/s
Circulatory Hot water Flow (60° and greater)	0.9m/s
Hot Water Return (60° and greater)	0.7m/s
Non-Circulatory Flow Hot Water Flow (less than 60°)	1.5m/s
Non-Circulatory Flow Hot Water Flow (60° and greater)	1.2m/s

Peak Flow Rates within Buildings & Probability of Use (Water)

Simply put, peak flow (or alternatively know as peak demand) is the predicted number of fixtures/appliances that will be running simultaneously at the same time; therefore, the water services pipework is sized for this peak demand as opposed to the total sum of fixtures.

Applying principles of probability to the design of the plumbing system was first introduced by Roy B. Hunter in a 1923 National Bureau of Standards publication, *"Recommended Minimum Requirements for Plumbing in Dwellings and Similar Buildings"*

He recognised that for each specific fixture/appliance the flow rates and probability of use was varied, thus created a weighted system called "fixture units" what we know as "loading units if referencing AS/NZS 3500.1 or "fixture units" if we are referencing AS/NZS 3500.2.

TABLE 3.2.1

FLOW RATES AND LOADING UNITS

Fixture/appliance	Flow rate L/s	Flow rate L/min	Loading units
Water closet cistern	0.10	6	2
Bath	0.30	18	8
Basin (standard outlet)	0.10	6	1
Spray tap	0.03	1.8	0.5
Shower	0.10	6	2
Sink (standard tap)	0.12	7	3
Sink (aerated tap)	0.10	6	2
Laundry trough	0.12	7	3
Washing machine/dishwasher	0.20	12	3
Mains pressure water heater	0.20	12	8
Hose tap (20 nom. size)	0.30	18	8
Hose tap (15 nom. size)	0.20	12	4

AS/NZS 3500.1

Water Services

TABLE 6.3(A)

FIXTURE UNIT RATINGS

Fixture	Fixture abbreviations	Min. size of trap outlet and fixture discharge pipe DN		Fixture unit rating
			NZ (only)	
Autopsy table	AT	50		3
Bain-marie	BM	40		1
Basin	B	40	32	1
Bath (with or without shower) (Note 1)	Bath	40		4
Bath (foot)	Bath (foot)	40		3
Bath (baby)	Bath (baby)	40		3
Bath (shower)	Bath (shr)	40		4
Bedpan sterilizer	BPS	50		4
Bedpan washer	BPW	80		6 (F. valve) 4 (Cist.)
Bedpan washer	BPW	100		6 (F. valve) 4 (Cist.)
Bedpan washer/sterilizer	BPWS	80		6 (F. valve) 4 (Cist.)
Bedpan washer/sterilizer	BPWS	100		6 (F. valve) 4 (Cist.)
Bidet, bidette	Bid	40	32	1
Circular wash fountain	CWF	50		4

AS/NZS 3500.1

Plumbing and Drainage

Water Saving

**Requirements have crept in over many years and in most countries……….
there is some form of regulation attached to this.**

Water Saving

5.2.11 Water Conservation

All sanitary fittings and fixtures are to be specified by the Architect. Plumbing contractor to check and confirm all sanitary fixtures/fittings are suitable for installation and carry the Watermark approval as a minimum.

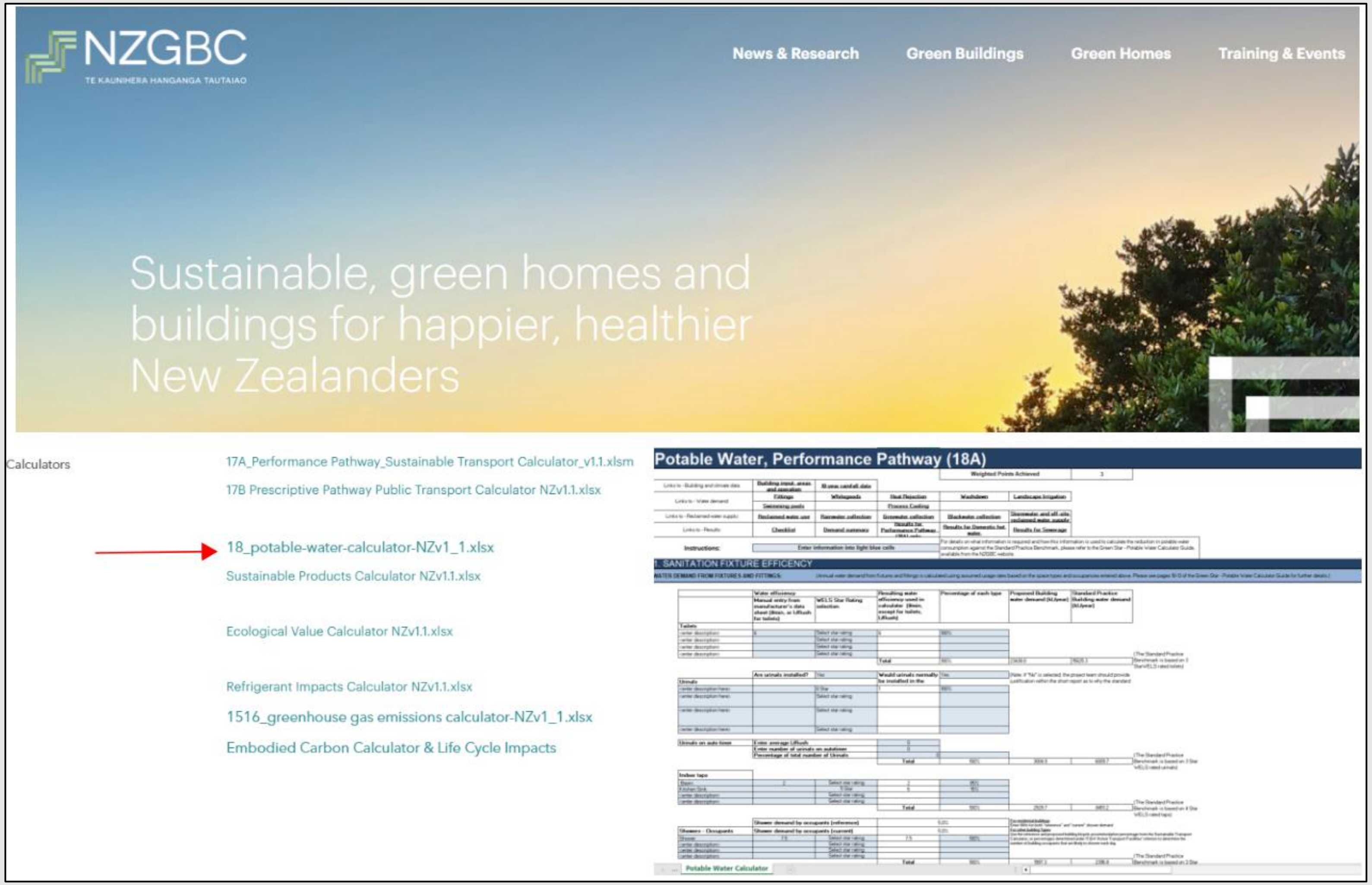
During the selection process water sustainability is to be considered with an aim for a minimum of all fittings and fixtures to have a WELL's accreditation suggested in purple highlighted below.

Table 5.4: Star Ratings

Recommended Star ratings

Fixture	3 Stars	4 Stars	5 Stars	6 Stars
Shower	7.5 – 9 L/min	N/A	N/A	N/A
Toilet	Average flush no more than 4.0 litres	4.5L/3L Dual Flush with an average flush of no more than 3.5 litres	Average flush no more than 3.0 litres	Average flush no more than 2.5 litres
WHB	7.5 – 9 L/min	6-7.5 L/min	4.5 – 6 L/min	3 - 4.5 L/min
Sink	7.5 – 9 L/min	6 - 7.5 L/min	4.5 – 6 L/min	No more than 4.5L/min
Dishwasher	Max 17 litres per wash	Max 13 litres per wash	Max 11.5 litres per wash	Max 9.5 litres per wash

New Zealand Green Building Council



Net Zero by 2050

Transforming Operational Efficiency

New Zealand has a target to achieve net zero carbon emissions by 2050, this also includes the building and construction sector, according to the Ministry of Business Employment and Innovation (MBIE) the construction sector accounts for approximately 20% of New Zealand's carbon emissions via energy and material used in construction overall.

MBIE have set out targets and strategies for the reduction of water use as part of their transforming operational efficiency plans, the targets are shown below, note the target for 2035!

	Initial Cap	Intermediate Cap	Final Cap (2035)
Water Use litres per person per day	145	110	75

The targets above not only reduce water consumption but also reduce carbon emissions.

MOTT MACDONALD

Current Water use Example

Fixture	Usage Assumptions	Comments	Total Litres
Standard Toilet (6/3) flush	4 x flushes per day	Allow 2 x full flush 2 x half flush	18
Shower (restricted to 6 l/m, with 4-star shower head)	1 x 5-minute shower	Most will shower in the morning only	30
Basin (6 star rated, 3.5 l/m)	Hard to estimate, allow for handwashing, brushing teeth.	Used 10 – 20 seconds per use, allow 8 uses.	1
Kitchen Sink (6 star rated, 5.5 l/m)	2 x lots of dishes per day + rinsing	Use 1 x 20 litre bowl (allow 18 l per wash + rinse water)	40
DW	2 x cycle per day	Uses approx. 10 litres per cycle	20
Tub (6 star rated)	Intermittent use only.	Hardy used, allow a nominal volume	1
WM (6 kg front loader)	1 x cycle per day	Uses approx. 60 litres per cycle	50
		Total	**160**

On the previous slide, the target by 2035 is 75 litres per person per day.

That is half of what is being used now and that already is with water saving features!

How does that affect the pipe sizing??

If you are using less water means less flow through the pipelines, which equals less velocity and lower internal pipe bore cleaning.

Let's briefly look at a real-life example that I have recently been involved with where legionella presented itself within the water system, there were numerous factors at play however it did highlight the mismatch with pipe sizing, Green Star requirements and final fixture selections.

It all added up to the perfect storm!

Example - cont

The pipework was sized based on the required flow rates to the fixture as provided in Table 3 of Acceptable Solution G13/AS1, for a basin the flow rate delivered is to be a minimum of 0.1 l/s @ 45C.

This is also identical to Table 3.2.2 AS/NZS 3500.1 which is also used for sizing water pipes.

Table 3: Acceptable Flow Rates to Sanitary Fixtures
Paragraph 5.3.1

Sanitary fixture	Flow rate and temperature l/s and °C	How measured
Bath	0.3 at 45°C	Mix hot and cold water to achieve 45°C
Sink	0.2 at 60°C* (hot) and 0.2 (cold)	Flow rates required at both hot and cold taps but not simultaneously
Laundry tub	0.2 at 60°C* (hot) and 0.2 (cold)	Flow rates required at both hot and cold taps but not simultaneously
Basin	0.1 at 45°C	Mix hot and cold water to achieve 45°C
Shower	0.1 at 42°C	Mix hot and cold water to achieve 42°C

* The temperatures in this table relate to the temperature of the water used by people in the daily use of the *fixture*.

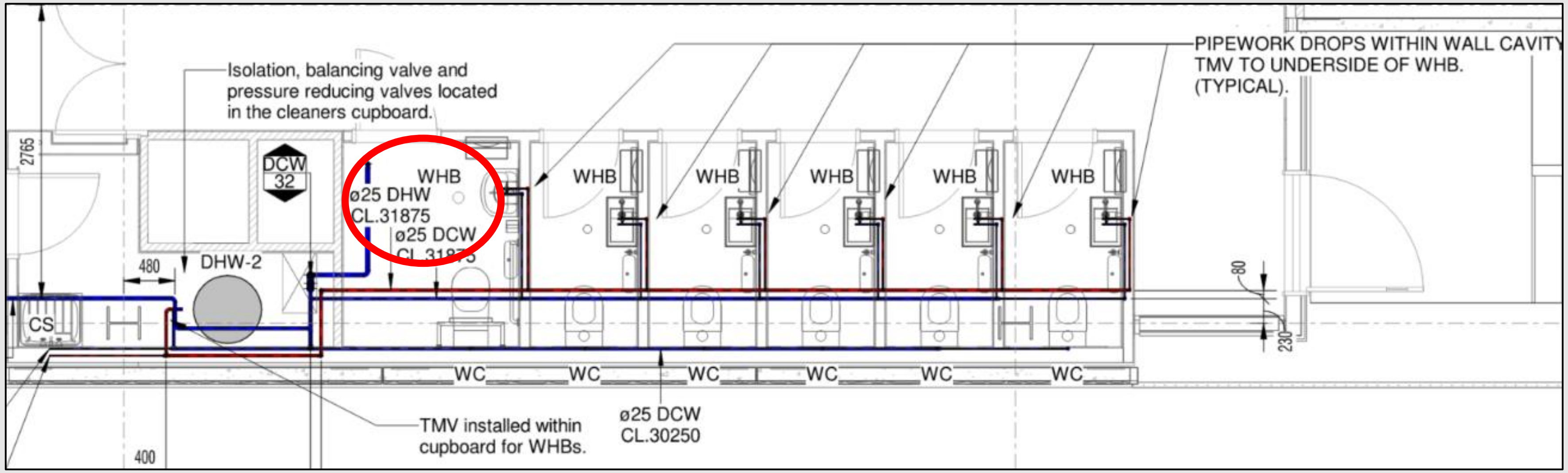
Note:
The flow rates required by Table 3 shall be capable of being delivered simultaneously to the kitchen sink and one other *fixture*.

TABLE 3.2.1
FLOW RATES AND LOADING UNITS

Fixture/appliance	Flow rate L/s	Flow rate L/min	Loading units
Water closet cistern	0.10	6	2
Bath	0.30	18	8
Basin (standard outlet)	0.10	6	1

Example - cont

With reference to the as-builts the main hot water pipe indicated a 25 mm main run, as depicted below.



Example - cont

Below provides a volume calculation with different pipe sizes (based on PEX), of the volume of water and the wait time over an assume main run of 10 m (excludes the 15 mm dropper down the wall) to the furthest fixture from the HWC.

Volume of water is determined by:

Volume = Length (m) x Internal area of the pipe (m^2)

Time is then calculated by:

Wait time = Pipe volume (l) ÷ Fixture flow rate (l/sec)

Pipe size	Assumed main run length	Volume of water	Approx Wait Time
25 mm (19 mm ID)	10 metres	2.836 litres	28 seconds
20 mm (14.4 mm ID)	10 metres	1.629 litres	16 seconds
15 mm (11.6 mm ID)	10 metres	1.057 litres	10 seconds

Example - cont

As it turned out, the tapware itself was ultimately changed to suit the green star requirements for this project, unfortunately the pipe sizing was never revisited.

That leaves the installed pipe sizes oversized for the application.

If all WHB's were activated exactly at the same time and ran for the exact same amount of time, then the demand would be 0.35 litres a second.

This in reality never happens within an office environment, at best 2 x basins maybe operating at the same time but not the same length of time, which equates to 0.11 litres per second.

Based on that and keeping the velocities of hot and cold to 1.5 m/s then **15 mm pipe would have been more than sufficient to deliver an adequate water supply to the low flow tapware for <u>both hot and cold supplies</u>.**

With the move to water saving tapware there is a well-known mismatch in respect to the pipe sizing standards, which at their core are still based on higher flows.

Yet, Engineering consultancies will continue to base their pipe sizing on documented standards, (usually with an in-house safety factor percentage!!) to prevent any litigation post completion.

Sooooo lets start adding

Low flow tapware

↓

Unintended consequences

↓

Creates low flows down the sanitary plumbing and drainage system (grades suitable??)

↓

Creates a greater probability of OPP's forming due to oversized water pipes

Summary

Plumbing & Drainage codes and standards throughout the world have been developed and based on flows from older style fixtures and fittings, quite simply they had large flows of water going through them, whether that was waste or water systems, times have now changed.

With the onset of new technologies, water conservation and the ever pressures on reducing carbon emissions our standards have not developed a fast as the change in water usage.

Plumbing standards are trying to adapt to the change; however, they are doing so in a piecemeal approach instead of a full holistic review across the board. This may happen in the future however I must design to best practice with what we know.

Junctions are just a small part of the sanitary plumbing and drainage system, all fittings, fixtures (including water services) are all inherently linked, each with their own unique nuances however all must work in union to ensure a safe and sanitary Hydraulic system.

Thank you!

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