Performance compatibility of water efficient fixtures with drainage systems and plumbing codes.

Dr Steve Cummings
Jeff Clark
Les Barnard

Caroma Dorf
ASFlow Committee Chairman
Sydney Water
Part 1
Regulatory Issues

Jeff Clark    ASFlow Committee Chairman
## Regulatory Issues – ASFlow Committee Members

<table>
<thead>
<tr>
<th>Name</th>
<th>Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr Steve Cummings</td>
<td>Australian Industry Group (Caroma Dorf)</td>
</tr>
<tr>
<td>Jeff Clark</td>
<td>NPRF &amp; NPRF TAC Chair (SA Water)</td>
</tr>
<tr>
<td>John Park</td>
<td>NPRF-TAC; WS-014 (Plumbing Industry Commission)</td>
</tr>
<tr>
<td>Paul Day</td>
<td>NPRF-TAC; WS-014 (ACT Planning and Land Authority)</td>
</tr>
<tr>
<td>Les Barnard</td>
<td>NPRF-TAC; WS-031 (Sydney Water)</td>
</tr>
<tr>
<td>Bruce Kline</td>
<td>NPRF (Department of Building and Housing New Zealand)</td>
</tr>
<tr>
<td>David Cox</td>
<td>Water Services Association Australia</td>
</tr>
<tr>
<td>Tiffany Dickinson</td>
<td>Federal Department of Environment, Heritage and the Arts (WELS)</td>
</tr>
<tr>
<td>Murray Thomas</td>
<td>Master Plumbers Association WA</td>
</tr>
<tr>
<td>Steve Movely</td>
<td>Plumbing Institute of Australia</td>
</tr>
<tr>
<td>Jeff Patchell</td>
<td>Plumbing Connection</td>
</tr>
</tbody>
</table>
Regulatory Issues – ASFlow Project

• Proactive approaches of governments and industry to address our ever increasing water shortages, their initiatives have raised questions in regard to the long term and immediate effects those initiatives will have on our plumbing installations.

• This has instigated the need to conduct investigations on the influences of reduced flushing volumes from toilet pans and urinals, and the reduced flows resulting from the extraction of greywater and blackwater from plumbing and drainage systems.

• These initiatives have led to the need for developing sustainable plumbing solutions and practices as the current approaches have the potential to change the basic function of plumbing and drainage systems that have been operating effectively since the nineteenth century.
Implications of flow reductions in sanitary plumbing and drainage systems

- The development of more efficient sanitary drainline designs by research that will optimise the transportation of waste discharged from sanitary fixtures into the network utility operator's systems.

Reduction in flows impact on black water transportation.

- The potential implications on the transportation of black water within drainline systems where grey water has been separated.

To compare systems internationally.

- Particularly those in Europe and the USA.

Feasibility of ultra low discharge volumes

- The potential implications for lower flush volumes than the current minimum of 4.5/3L have on drainage systems complying with AS/NZS 3500.2.
Regulatory Issues – The ASFlow Project objectives

Analysis Of Australian Opportunities For More Water-Efficient Toilets

Findings

- Potential for further gains in toilet efficiency are worth considering.
- There is a ready market for more efficient toilets if performance is maintained.
- Additional cost is not excessive.
Regulatory Issues – Regulatory requirements for plumbing products in Australia

WaterMark Approval

• The WaterMark is a certification trademark used in relation to water supply, sewerage, plumbing and drainage goods.

• Watermark certified goods comply with present regulatory position and meet required specifications and standards.
Current drought situation is cause for radical initiatives by Governments

- **Queensland** – Proposal to turn off the water to all urinals
- **Western Australia** - Five Star Plus standards

  - **Stage 1:** Mandate 4 Star 4.5/3L toilets, 4 Star tapware (7.5 L/min max)
    - **3 Star Showers** - (9L/min max).

  - **Stage 2:** Alternative Water Supply Systems
    - **Grey Water Capacity**: All shower, bath, laundry trough and washing machine drains must be able to be connected at a later date to an appropriate grey water diversion system without the need to break, or cut into the fabric of the building to run new pipes.
**Regulatory Issues** – Further reductions in fixture discharge

- **Government** - WELS direction to further reduce fixture water usage

- **National Plumbing Regulators and Industry** - Significant concern on the impact of reduced flows on the drainline system and utility infrastructure.

**ASFlow Committee** - Formed to study the implications of flow reductions in sanitary plumbing and drainage systems
Regulatory Issues – Further reductions in fixture discharge – High WELS Star Ratings
Committee - Australasian Scientific Review of Reduction of Flows on Plumbing and Drainage Systems

Objectives:

• To evaluate reductions in flushing volumes of toilet suites and the effects on plumbing/drainage systems - WELS.

• To determine the effects and solutions to introduce amendments to current AS/NZS 3500 if required.

• To examine the performance of the drainage system with particular reference to the upper end of the system that is connected directly to the WC.

• To compare systems internationally.

• To determine the effects on the plumbing and drainage systems if grey water is removed from main stream plumbing system and if reduced flushing volumes are adopted.
Regulatory Issues – Investigation into reductions in fixture discharge – ASFlow Committee

National Plumbing Regulation Forum – ASFlow Committee
- two studies that have resulted in code changes

• Non water using urinals

• Drainline transportation performance of low-flow water closets
Part 2
Waterless Urinal Research

Les Barnard  ASFlow Sydney Water
Waterless Urinal Research – Drainline system evaluation

- Drainline: 40mm Glass Pipes
- Urinal A: With Drainline Connection to Wash Basin
- Urinal B: Without Basin Connection to Drainline
- Wash Basin: With Drainline Connection to Leda Urinal

Caroma H2zero Urinal: Not Used in Trial, No Connection to Drainline, Not in Use

Electronic Counter Recording Urinal Usage
Electronic Counter Recording Basin Usage

Wetherill Park Mensroom
URINAL A
With Shared Drainline Connection to Basin

An Electronic Counter records the Urinal usage

Sensor

Drainline 40mm Glass Pipe

Waterless Urinal
No FLUSHING Water

An Electronic Counter records the Basin usage

Sensor

Wash Basin
650mL / USE

Basin Tap Discharge
650mL / USE
(based on average hand wash time of 12s)
Waterless Urinal Research – Drainline system evaluation

**URINAL B**
With No Drainline Connection to Basin

An Electronic Counter records the Urinal usage

Sensor

Drainline 40mm Glass Pipe

Waterless Urinal
No FLUSHING Water
Waterless Urinal Research – Drainline system evaluation

**URINAL A**
With Shared Drainline Connection to Basin

**URINAL B**
With No Drainline Connection to Basin

---

**CAUTION**
GLASS TUBING
DO NOT KNOCK

Urinal A

Urinal B

Gradient: 1.67% or 1:60
**Drain-line Evaluation – Discharge Comparison Table**

<table>
<thead>
<tr>
<th></th>
<th>URINAL A (Total Usage 9985)</th>
<th>WASH BASIN</th>
<th>URINAL B (Total Usage 21897)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ave Daily Usage</td>
<td>11</td>
<td>49</td>
<td>26</td>
</tr>
<tr>
<td>Estimated Daily Discharge Volume (Litres) *</td>
<td>32L per Day</td>
<td></td>
<td>0L</td>
</tr>
</tbody>
</table>

*Based on an average hand wash of 650mL over 12 seconds.
Waterless Urinal Research – Drainline system evaluation

Urinal A
- drainline connection to lavatory
Waterless Urinal Research – Drainline system evaluation

Inspection Locations

A

B

C
Study 2 – Comparative urinal drainline evaluation 6000 uses

<table>
<thead>
<tr>
<th>URINAL A</th>
<th>22 MONTHS</th>
</tr>
</thead>
<tbody>
<tr>
<td>With Basin Connection</td>
<td></td>
</tr>
<tr>
<td>Drainline Distance</td>
<td></td>
</tr>
<tr>
<td>2 Metres</td>
<td>4 Metres</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>URINAL B</th>
<th>16 MONTHS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without Basin Connection</td>
<td></td>
</tr>
<tr>
<td>Drainline Distance</td>
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<td>4 Metres</td>
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Study 2 – Comparative urinal drainline evaluation 10000 uses

<table>
<thead>
<tr>
<th>URINAL A</th>
<th>With Basin Connection</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 Metres</td>
<td>4 Metres</td>
</tr>
<tr>
<td>7.5 Metres</td>
<td>0mm</td>
</tr>
<tr>
<td>Drainline Distance</td>
<td></td>
</tr>
<tr>
<td>39 MONTHS</td>
<td></td>
</tr>
</tbody>
</table>

<table>
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<tr>
<th>URINAL B</th>
<th>Without Basin Connection</th>
</tr>
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<tbody>
<tr>
<td>2 Metres</td>
<td>4 Metres</td>
</tr>
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<td>7.5 Metres</td>
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<tr>
<td>Drainline Distance</td>
<td></td>
</tr>
<tr>
<td>22 MONTHS</td>
<td></td>
</tr>
</tbody>
</table>

URIC-SCALE BUILD-UP
MINOR URIC-SCALE / SOAP DEPOSIT BUILD-UP

- Study 2 compares the performance of urinal drainlines after 10,000 uses.
- URINAL A has a basin connection and shows minimal build-up after 39 months.
- URINAL B does not have a basin connection and shows more significant build-up after 22 months.
Waterless Urinal Research – Drainline system evaluation

**URINAL B**
**DRAINLINE BLOCKAGE**
14th August 2008

- Drainline 40mm Glass Pipe
- Sedimentary Urine deposit completely Blocking Pipe.

- Liquid unable to pass through urinal

**Urinal B**
**WITHOUT BASIN CONNECTION**

**USES -21842**
**39 MONTHS**
Waterless Urinal Research – Drainline system evaluation

URINAL B - 21842 USES
Without Basin Connection

Drainline Distance

1 Metre

URIC SCALE BUILD-UP
MINOR URIC-SCALE / SOAP DEPOSIT BUILD-UP
Waterless Urinal Research – Drainline system evaluation

URINAL A
Plumbing Connection - Plumbing Inspection

**Inspection Point 2**
40mm PVC DWV Plumbing Connectors

**40mm Glass Pipe**

**Rubber Pipe Connectors**

**Flow of Urine**

**Mixture of Water and Urine**

**Inspection Point 1**
40mm PVC DWV Plumbing Connectors

**Waterless Cartridge**

**Flow of Urine**

**Water From Wash Basin**

**Detail of Urinal A Plumbing Connection**

**USES - 9985**
**40 MONTHS**
Waterless Urinal Research – Drainline system evaluation

**URINAL A**
Plumbing Connection - Plumbing Inspection

**Inspection Point 2**

Flow of Urine

Flow of Water from Basin

Flow of Urine / Water Solution

Section Detail of Inspection Point 2
Waterless Urinal Research – Drainline system evaluation

URINAL B
Plumbing Connection - Plumbing Inspection

Inspection Point 1
40mm Glass Pipe

40mm Glass Pipe

Flow of Urine

Waterless Cartridge

Urinal B

Detail of Urinal Plumbing Connection

USES - 21897
40 MONTHS
URINAL B
Plumbing Connection - Plumbing Inspection

Section Detail of Urinal Plumbing Connection

- Urine Deposit Build up
- 22mm

Inspection Point 1
40mm Glass Pipe
Waterless Urinal Research – Drainline system evaluation

**URINAL B**
Plumbing Connection - Plumbing Inspection

**Inspection Point 1**
40mm Glass Pipe

**Section Detail of Urinal Plumbing Connection**
Consistent Urine deposit build up through out entire length of Drainline
Water Pressure: 20,000 psi (138000 kPa)
Part 3

Water Closet Drainline Transportation Research

Dr Steve Cummings  ASFlow Caroma Dorf
WC Drainline Transportation Evaluation

Three studies:

1. WC transportation - Flush volumes and varying test media
2. Sweep Junctions affect on drainline transportation
3. Horizontal Sweep Junctions affect on drainline transportation.
WC Drainline Transportation Evaluation – Flush volumes and varying test media

60m testing rig
WC Drainline Transportation Evaluation – Flush volumes and varying test media

1.67% Grade on drainline
WC Drainline Transportation Evaluation – Flush volumes and varying test media

- Australian Test Media
- US MaP Test Media (latex covered)
- US MaP Test Media (Uncased)
- US MaP Test Media (Modified Case)
- ASME Polypropylene Ball Test Media
- Paper Test Media
**WC Drainline Transportation Evaluation** – Flush volumes and varying test media

- Reductions in flush volume – **exponential reduction** in solid waste drainline carry performance

<table>
<thead>
<tr>
<th>Flush Volume</th>
<th>Flow Rate</th>
<th>Drainline Carry (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6L</td>
<td>2.1 L/sec</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.5 L/sec</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 L/sec</td>
<td></td>
</tr>
<tr>
<td>4.8L</td>
<td>2.1 L/sec</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.5 L/sec</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 L/sec</td>
<td></td>
</tr>
<tr>
<td>3L</td>
<td>2.1 L/sec</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.5 L/sec</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 L/sec</td>
<td></td>
</tr>
<tr>
<td>2L</td>
<td>2.1 L/sec</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.5 L/sec</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 L/sec</td>
<td></td>
</tr>
<tr>
<td>1L</td>
<td>2.1 L/sec</td>
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</tr>
<tr>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>1 L/sec</td>
<td></td>
</tr>
</tbody>
</table>

**US MaP Test Media**
- **(Modified Case)**
- **(latex covered)**
- **(Uncased)**

**Australian Test Media**

**Images:**
- Australian Test Media
- US MaP Test Media (latex covered)
- US MaP Test Media (Uncased)
- US MaP Test Media (Modified Case)
WC Drainline Transportation Research – Sweep junctions affect on drainline transportation

- Significant **rectification costs** to due to system incompatibility
WC Drainline Transportation Research – Sweep junctions affect on drainline transportation

Note: 90° Sweep Junctions
90 degree Sweep Junction
WC Drainline Transportation Research – Sweep junctions affect on drainline transportation

90 degree Sweep Junction
WC Drainline Transportation Research – Sweep junctions affect on drainline transportation

90 degree Sweep Junction
WC Drainline Transportation Research – Sweep junctions affect on drainline transportation

45 degree Sweep Junction
WC Drainline Transportation Research – Sweep junctions affect on drainline transportation

45 degree Sweep Junction
WC Drainline Transportation Research – Sweep junctions affect on drainline transportation

45 degree Sweep Junction
Plumbing and drainage Part 2: Junctions installed on a vertical line - amendment

4.9.3 Junction installed on a vertical line (part 2)

Junctions installed in a vertical plane shall not be used for connection of stacks. Sweep and 45° junctions may be laid in the vertical plane for the connection of a single discharge pipe or a drain, provided:

a) A 45° junction shall only be used for the connection of a water closet pan.
WC Drainline Transportation Evaluation – Horizontal sweep junctions affect on drainline transportation performance incomparability - system is stressed with a drainline design complying to AS/NZS 3500 and a toilet complying AS1172 not operating effectively.

Domestic Western Australian installation failure
WC Drainline Transportation Evaluation – Horizontal sweep junctions affect on drainline transportation

Canberra Institute of Technology simulation test rig
WC Drainline Transportation Evaluation – Horizontal sweep junctions affect on drainline transportation

1st Junction – 4m
2nd Junction – 4.4m
3rd Junction – 5.1m
4th Junction – 6.1m
### WC Drainline Transportation Evaluation – Horizontal sweep junctions affect on drainline transportation

- Drainline Junctions – **reduction** in solid waste drainline carry performance

<table>
<thead>
<tr>
<th>Flush V.</th>
<th>Drainline / Test Media</th>
<th>Drainline Carry (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6L</td>
<td>Straight-line – Aus 250g</td>
<td>![Bar Chart]</td>
</tr>
<tr>
<td></td>
<td>4 Junction – Aus 250g</td>
<td>![Bar Chart]</td>
</tr>
<tr>
<td></td>
<td>Straight-line – MaP 250g</td>
<td>![Bar Chart]</td>
</tr>
<tr>
<td></td>
<td>4 Junction – MaP 250g</td>
<td>![Bar Chart]</td>
</tr>
<tr>
<td>4.5L</td>
<td>Straight-line – Aus 250g</td>
<td>![Bar Chart]</td>
</tr>
<tr>
<td></td>
<td>4 Junction – Aus 250g</td>
<td>![Bar Chart]</td>
</tr>
<tr>
<td></td>
<td>Straight-line – MaP 250g</td>
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<tr>
<td></td>
<td>4 Junction – MaP 250g</td>
<td>![Bar Chart]</td>
</tr>
<tr>
<td>3L</td>
<td>Straight-line – Aus 250g</td>
<td>![Bar Chart]</td>
</tr>
<tr>
<td></td>
<td>4 Junction – Aus 250g</td>
<td>![Bar Chart]</td>
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<tr>
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<td>Straight-line – MaP 250g</td>
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</tr>
<tr>
<td></td>
<td>4 Junction – MaP 250g</td>
<td>![Bar Chart]</td>
</tr>
</tbody>
</table>

- Not Tested

![Legend](Straight-line drainline carry)

![Legend](4 Junction drainline carry)
WC Drainline Transportation Evaluation – Horizontal sweep junctions affect on drainline transportation

Identified cause of Western Australian installation failure
WC Drainline Transportation Evaluation – Horizontal sweep junctions affect on drainline transportation
WC Drainline Transportation Evaluation – Horizontal sweep junctions affect on drainline transportation

- Drainline Junctions – waste back flow volumes captured and recorded during flush action.
WC Drainline Transportation Evaluation – Horizontal sweep junctions affect on drainline transportation

- Drainline Junctions – reduction in drainline water carry through waste back flow.

<table>
<thead>
<tr>
<th>Flush V.</th>
<th>Test Media</th>
<th>Waste Back Flow (ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6L</td>
<td>Aus 250g</td>
<td><img src="image1" alt="Diagram" /></td>
</tr>
<tr>
<td></td>
<td>MaP 250g</td>
<td><img src="image2" alt="Diagram" /></td>
</tr>
<tr>
<td>4.5L</td>
<td>Aus 250g</td>
<td><img src="image3" alt="Diagram" /></td>
</tr>
<tr>
<td></td>
<td>MaP 250g</td>
<td><img src="image4" alt="Diagram" /></td>
</tr>
<tr>
<td>3L</td>
<td>Aus 250g</td>
<td><img src="image5" alt="Diagram" /></td>
</tr>
<tr>
<td></td>
<td>MaP 250g</td>
<td>Not Tested</td>
</tr>
</tbody>
</table>

0mls 250ml 500ml 750ml 1000ml 1250ml

1st Junction 2nd Junction 3rd Junction 4th Junction
WC Drainline Transportation Evaluation – Horizontal sweep junctions affect on drainline transportation

• Drainline junctions – Significantly reduce the flush flow volume in the drainline.

<table>
<thead>
<tr>
<th>Flush V.</th>
<th>Test Media</th>
<th>Junction Back Flow (ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.5L</td>
<td>Aus 250g</td>
<td>0mls 250ml 500ml 750ml 1000ml 1250ml</td>
</tr>
</tbody>
</table>

- 872ml of a 4.5L flush volume was lost to junction backflow reducing drainline transportation by 30%.

<table>
<thead>
<tr>
<th>Flush V.</th>
<th>Drainline / Test Media</th>
<th>Drainline Carry (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.5L</td>
<td>0 Junction – Aus 250g</td>
<td>0m 2m 4m 6m 8m</td>
</tr>
<tr>
<td></td>
<td>4 Junction – Aus 250g</td>
<td></td>
</tr>
</tbody>
</table>
WC Drainline Transportation Evaluation – Horizontal Sweep Junctions affect on drainline transportation
WC Drainline Transportation Evaluation – Horizontal Sweep Junctions affect on drainline transportation
4.9 AS/NZS 3500:2 JUNCTIONS IN DRAINS

4.9.1 Drains installed on a grade

Amendment proposal to be determined.
Results show that the design of current drainline systems and fitting configurations will need to be adapted to match the performance of future ultra low flow wcs.

Changes to standards and codes are necessary to provide more efficient drainline system performance.
The results of this project will provide the future criteria for the design of sustainable sanitary plumbing systems.
Thank you

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Les Barnard     les.barnard@sydneywater.com.au