ANALYSIS OF AUSTRALIAN OPPORTUNITIES FOR MORE WATER-EFFICIENT TOILETS

For

The Australian Government Department of the Environment, Water, Heritage and the Arts.

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Please cite this report as: Schlunke, A. Lewis J. & Fane, S, 2008, *Analysis of Australian opportunities for more efficient toilets,* [prepared for the Australian Government Department of the Environment, Water, Heritage and the Arts], Institute for Sustainable Futures, University of Technology, Sydney, February.

Acknowledgements

The authors would like to acknowledge review and input from Dr Kumi Abeysuriya and Professor Stuart White from the Institute for Sustainable Futures and Dr Paul Starr from the Australian Government Department of the Environment, Water, Heritage and the Arts.

Executive Summary

Toilet flushing represents a significant fraction of the total water supplied to Australian cities and towns. This proportion only increases when water restrictions are in force. Toilets in Australia are, however, already relatively water-efficient. The average flush volume of a toilet sold today is about 50% of what it was 25 years ago.

This study explores whether there are opportunities for even more water-efficient flush toilets than the current Water Efficiency Labelling and Standards (WELS) four star rated toilet models sold in Australia. It specifically examines what would be required to introduce WELS five and six star rated toilet models. The study addresses flush toilets solely and therefore excludes vacuum and dry toilets.

The research approach was designed to identify and assess the opportunities for and barriers to more water-efficient flush toilet classes being introduced into Australia. The initial step was a review to identify potential toilet classes. Semi-structured interviews with selected stakeholders were then conducted. Finally a model was developed to estimate the potential water savings from more efficient toilet classes out to 2050 and estimates of the cost effectiveness of savings were made.

The toilets classes included in the study are compared in Table I below.

Table I Comparison of efficient toilet classes included in the study

Toilet class	WELS rating*	Ave flush **	AS inclusion*	Status
Dual flush; 4.5/3L	4 Star	3.1L – 3.5L	Y	Sold in Aus
Basin–integrated; 4.5/3L	5 Star	> 3L	Y	Sold in Aus
Dual flush; 4/2L	(5 or 6 Star)	2.4L - 2.7L	N	Sold in EU
Urine-separating; 4/0.2L or 6/0.2L	(6 Star)	1 L -1.4 L#	N	Sold in EU
Dual flush; 3/2L	(6 Star)	2.2 L	N	R&D needed
Air assisted	(6 Star)	1.5 L	N	Prototype

*Achieving a WELS rating requires inclusion within the Australian standard for Cisterns (AS 1172.2)

** The average flush volume of a dual flush toilet is taken as one full flush and four half flushes

This average flush volume is reliant on various behavior changes regarding toilet usage

The study found that despite the impressive gains in water efficiency to date, the potential for further gains in toilet efficiency are worth considering. There is also almost certainly a ready market for more efficient toilets if performance is maintained and the additional cost is not excessive.

Over time the level of possible savings is not insignificant. In one scenario modelled, for example, in which air assisted flush toilets slowly grew to 50% of the toilet market starting in 2010, the annual estimated water savings in 2050 in Sydney would be 20GL and while in Melbourne it would be 18GL.

The cost effectiveness of the water saved in this scenario would depend on the price differential between current dual-flush toilets and new air assisted flush toilets. It is however unlikely to be less than $1.40 per kilolitre.

The cost effectiveness of introducing 4/2L toilets into the Australian market would, in comparison, be significantly greater as there is no reason to assume a cost differential between dual flush 4/2L and existing dual flush toilets. The cost associated with introducing 4/2L toilets into Australia would principally be in relation to the regulatory compliance and the marketing required to attain market share. This could be in the order of $0.02 to $0.20 per kiloliter saved. Such costs can be compared to the cost of new desalination plants that are currently being installed in cities around Australia. These plants have a unit cost of water which ranges between $1.19 and $2.55 per kilolitre.

The technical issues that will need to be overcome by more efficient toilet classes include their ability to clear waste from the pan (without requiring frequent cleaning or multiple flushing), the interaction of the toilet with the drain (in terms of the ability of the drain to carry waste from the toilet to the main sewer line), and the impact that lower flows will have on the sewer system. Drain and sewer carriage were raised as the largest issues in the eyes of most stakeholders. This is despite wastewater flows from other fixtures in the home or other building being likely to play as significant a role for carriage as actual flush volumes. This reliance on in building wastewater flow then raises its own issues when plumbing is designed for grey water reuse.

On the regulatory front at present, convincing Standards Australia Committees that the performance of new more efficient toilet classes will be adequate remains the largest hurdle for most parties considering the introduction of more efficient toilet classes into the Australian market. In the medium term we propose that studies on what the limits are in terms of the minimum flush volume, in various Australian contexts, have the potential to better define the necessary performance characteristics and help with the introduction of some lower flush classes.

Terminology

In this report, dual flush toilets are described by the full flush volume number, followed by the reduced flush volume number. Thus, for example, a toilet with a full flush volume of four and a half litres and a reduced flush volume of three litres is described as a 4.5/3L toilet.

Under the WELS scheme the average flush volume is defined as the average of one full flush and four reduced flushes. For example, a 4.5/3L toilet has an average flush of 3.3L (4.5 + (4x3) = 16.5 ÷ 5 = 3.3).

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1. INTRODUCTION

The water used in toilets represents a significant fraction of the total water supplied to Australian cities and towns. At least 25% of indoor residential water use is due to toilet flushing and as a proportion this water use increases in drought situations when water restrictions are in place. In the context of many cities and towns in Australia facing increasing water scarcity, all opportunities for increasing the water efficiency of toilets across the country are worth investigating.

The Australian Government Department of the Environment, Water, Heritage and the Arts commissioned the Institute for Sustainable Futures (University of Technology, Sydney) to assess the opportunities for more water-efficient toilets. Specifically this study addresses the potential for introducing more efficient flush toilet classes into Australia than the current 4.5/3L models.

The investigation involved interviewing key stakeholders, modelling possible water savings and analysing the likely technical, regulatory or standards related barriers, and possible solutions to these problems. Key questions were 'how might the toilet market progress in terms of water efficiency into the future?' and 'how can 5 star, 6 star, or even more efficient toilets enter the market?'

1.1. Background to the study

A brief history of water-efficient toilets in Australia

Since the introduction of dual flush toilets in the 1980's the water efficiency of toilets in Australia has increased significantly and the introduction of each new class of toilet has seen a progressive reduction in average flush volume (Snelling *et al.* 2007).

Up until 1982, all toilets in Australia were single flush models. The average flush volume of these toilets was about eleven litres. Dual flush toilets were initially introduced with an 11/5L configuration. In 1989 the 9/4.5L model was introduced. Shortly after 1989 these 9/4.5L toilets where made mandatory. This was only after extensive trials including retrofitting a number of whole communities.

In 1995, again after extensive field testing by Caroma (now GWA Caroma), the 6/3L class was introduced. More recently, in 2005, the 4.5/3L class was introduced, again after field trials by GWA Caroma, which tested their model in this class.

The WELS Scheme

The Department of the Environment, Water, Heritage and the Arts administers the Australian Government's Water Efficiency Labelling and Standards (WELS) Scheme. The Scheme requires toilets and other water using fixtures/appliances to display a WELS water-rating label at the point of sale (second-hand products and products imported into Australia for personal use are excluded from WELS). The label shows a one to six star rating that allows a comparative assessment of the model's water efficiency (the more stars on the label the more water-efficient the product) and a figure showing the water consumption or water flow rate of the product, based on laboratory tests.

WELS covers showers, tap equipment, toilets, urinals, clothes washing machines and dishwashers, with the legal framework for the WELS scheme provided by The *Water Efficiency Labelling and Standards Act 2005.* There is also a WELS Standard, AS/NZS 6400:2005 *Water efficient products-Rating and labelling*, which incorporates most of the Scheme's details. The Scheme is optional for flow controllers.

The WELS Scheme for toilets

Reports prepared for the WELS Scheme predict that toilets could provide 22% of the total water savings produced by the scheme as a whole (Wilkenfeld, 2003). Toilets are star rated under the Scheme with the average flush volumes for star ratings shown in Table 1.

The WELS Scheme also includes a minimum water efficiency requirement for toilets. This requires that the average flush of toilets sold in Australia must not exceed 5.5 litres.

Table 1 WELS star ratings for toilets

Star rating	Average flush volume*	Toilet classes with this rating in WELS data base
1	Not more than 5.5 L	9/4.5L dual flush, 6L single flush**
2	Not more than 4.5 L	*No models available*
3	Not more than 4.0 L	6/3L dual flush, 4L single flush
4	Not more than 3.5 L	4.5/3L dual flush
5	Not more than 3.0 L	4.5/3L dual flush with integrated hand-basin***
6	Not more than 2.5 L	*No models available*

*Average consumption of a dual flush toilet is taken as one full flush and four half flushes.

** These represent 6L single flush models with the flush volumes adjusted down to 5.5L

*** The average flush volume is 3.5 however grey water reuse within the cistern allows the lower flush volume to be claimed

The Australian Toilet Standards

There are currently two Australian Standards that specifically address toilet pans and toilet cisterns (AS 1172.1 and AS 1172.2). These Standards specify various performance tests for toilet models as well as acceptable classes of flush toilets.

For a toilet to be WELS rated, it must also comply with the Australian Standards for toilets (AS 1172.1 and AS 1172.2). In particular, toilet models must be included in Table 4.1 of the Australian Standard for Cisterns (AS 1172.2) to qualify for a WELS star rating. This table gives the acceptable range of average flush volume for different toilet models, and the only toilet classes included in this table are:

- Single flush toilets – 6 litre and 4 litre classes.
- Dual flush toilets – 6/3L and 4.5/3L classes.
- Replacement cisterns to match pre-installed pans only – 9/4.5L.

According to Table 4.1 of AS 1172.2, the acceptable range for the average flush volume of 9/4.5L toilets is 4.5-5.5 litres per flush, but under WELS a 2 star toilet cannot have an average flush volume of more than 4.5L per flush. For this reason, there are no 2 star toilets available. There are also no 6 star toilets available due to the lack of overlap between WELS and AS 1172.2. The range of acceptable flush volumes for 4.5/3L toilets, which are the most efficient toilets included in Table 4.1 of AS 1172.2, is 3.1-3.5 litres per flush, but to achieve a 6 star WELS rating, a toilet must not have an average flush volume of more than 2.5 litres per flush.

Significantly, toilets that meet the flush volumes set out in AS/NZS 6400 (the WELS standard) for a five or six star WELS rating do not currently comply with the requirements of the Australian Standards for flushing toilets. They therefore cannot be registered for WELS and consequently are not available for supply in Australia.

Innovative toilets that re-use grey water by incorporating a hand-basin into the cistern of a 4.5/3L dual flush systems can be registered with a five star WELS rating.

1.2. Research approach

The research approach taken in the study was designed to identify and assess the opportunities for and barriers to more efficient toilet classes being introduced into Australia.

Documentary review

As an initial step, the study included a review of relevant literature and documentation. This covered:

- Information resources and technical specifications for the water-efficient toilet classes currently available in Australia;
- Information resources and technical specifications for water-efficient toilets classes currently not available in Australia;
- Current regulations and codes of practice affecting the manufacture, importation, sale and installation of toilets in Australia ; and
- Current Australian Standards that address the manufacture, importation, sale and installation of toilets in Australia.

A list of the key documents reviewed for the study is found in Appendix A.

Stakeholder interviews

Interviews conducted with selected stakeholders comprised a core component of the study. These interviews were semi-structured. The set of questions addressed technical barriers to more efficient toilet classes, issues related to State and Federal based regulation and the various Australian Standards addressing toilets, as well as market-place and commercial considerations. Representatives of the Department of the Environment, Water, Heritage and the Arts were consulted on both the selection of stakeholders and the questionnaire used for the study.

Where particular interviewees had a specific knowledge set, additional questions were included in order to explore these aspects (for example, the situation in New Zealand or the specific case of Standards Australia). With the consent of the interviewees, all but a couple of interviews were recorded. A majority of the interviews were then transcribed. All interviewees were given the opportunity to provide material both in confidence and on the record.

A list of the stakeholders approached for the study as well as those interviewed is found in Appendix B. In all cases the included quotes have been confirmed by the interviewee.

Modelling of potential water savings

A model of water demand due to toilets in Australia was developed in MS Excel. The model was developed to estimate the potential water savings that could result from the introduction of more efficient toilet classes into Australia out to 2050. The model estimates the water demand for toilets on an Australia-wide basis and is based on expected changes in the stock of toilets over time. In the model, toilet demand is a function of proportion of each toilet class installed in a given year (determined from population projections and assumptions about market share), the existing toilet stock and the 'decay' in stock over time, the total population, number of toilets per household, and toilet usage rate(s).

The model uses Australia-wide average flush volume assumptions.

The existing toilet classes included in the model are:

- Eleven litre single flush toilets;
- Dual flush 11/5L toilets;
- Dual flush 9/4.5L toilets;
- Dual flush 6/3L toilets;
- Dual flush 4.5/3L toilets.

A range of potentially more efficient toilet classes were tested in the model together with varying market uptake rates. The potential toilet classes modelled were:

- Dual flush 4/2L toilets;
- Dual flush 3/2L toilets;
- A urine separating 4/0.2L toilet;
- An 'air assisted' flush toilet with an average flush volume of 1.5 litres.

The mix of these toilet types in the total stock at any time determines the average flush volume and the total toilet water demand for that year. Further key modelling assumptions as well as the results of the modelling are described in Section 6.

Additional to the stock modelling task and water savings projections, estimates of the cost effectiveness of savings were also made and compared to alternative water conservation and urban water supply options.

Research questions

Though the course of the study a number of research questions were identified and then addressed. These questions can be grouped in terms of the technical potential and concerns; the regulatory and standards related barriers and possible solutions; and the market place considerations.

Technical potential and concerns

- Which more efficient toilet classes can be identified?
- What issues are raised in terms of the performance of the actual toilet suite with low flush volumes?
- What issues need to be considered in terms of drain carriage out of homes and buildings?
- Could more efficient toilets cause sewer carriage or waste water treatment problems?
- What are the potential solutions to the technical problems identified?
- How much water saving might be achieved through the introduction of more efficient toilet classes?

Regulatory and standards related barriers

- What instruments regulate toilet installations across Australia?
- What would be required to change the standards and introduce new toilet classes into the existing Australian Standards for toilets?
- What is required to create a new standard for air assisted flush or urine separating toilets?
- What regulatory barriers are perceived by potential entrants to the market?

Market place issues

- Is there a market demand for more water-efficient toilets, taking into account pricing?
- Can poor quality toilets meet the current standard? Could this be an issue for the introduction of more efficient classes?
- What would be the implications of introducing a toilet class that is not appropriate for all installations?
- What are the issues with raising the minimum standard for toilets in Australia?
- How might the toilet market move forward in terms of water efficiency over the next five to ten years?

1.3. The structure of this report

This report is structured with this section, the Introduction, followed by:

- Section 2: Water-efficient toilet classes in Australia;
- Section 3: Technical issues;
- Section 4: Regulatory and standards issues;
- Section 5: Market place considerations;
- Section 6: Potential water savings;
- Section 7: Conclusions and recommendations.

Section 2 draws primarily on the document analysis and review. Sections 3, 4 and 5 draw principally on the interviews, with background provided by the document analysis and review. Section 6 presents the results of the modelling of water demand due to toilets and the potential water savings from introducing more efficient classes.

A discussion of the study's findings together with the conclusions drawn from the implications of the study is provided in Section 6. Recommendations on what action could facilitate the introduction of more efficient toilets into Australia are also made in this final section.

2. WATER-EFFICIENT TOILET CLASSES IN AUSTRALIA

This section answers the question 'Which more efficient toilet classes can be identified?' In doing so it provides descriptions of various low flush toilet classes with a nominal average flush volume below 3.5 litres. This includes a toilet class that is commonly available in the Australian market as well as potential entrants widespread in overseas markets, and classes of toilet that have yet to be fully developed or commercialised.

While most of the technologies described in this section are available currently either in Australia or overseas, others are not yet commercially or technically viable. These are included to provide an idea of what may be available in the future. Lillywhite *et al.* stated in 1987 "it is generally accepted that with good pan design, full flush volumes down to 4 litres do not present a problem in terms of 'normal' drains and sewers being able to dispose of the solid and liquid wastes." Thus, some of the technologies included here push the boundaries of what has been commonly considered possible.

2.1. 4.5/3L dual flush toilets

Dual flush 4.5/3L toilets are the standard models of highly efficient toilets in Australia at present. The average flush volume is nominally 3.3 litres. These toilets meet the 4 star rating under WELS.

Roberts (2005) however reported 4.5/3L toilets in a retrofit field trial having average flush volume of about 4.5 litres. This anomaly may be due, in part, to the fact that these trials were in a retrofit situation and used pre-production toilets. It could also be partly due to the trend towards a lower ratio of half to full flushes with decreasing toilet flush volume that Roberts observed (with the ratio being 54:46 for 11/6L toilets, 45:55 for 9/4.5L toilets and 27:73 for 6/3L toilets).

Manufacturers needed to undertake research and development of toilets in this class in order to maximise the shear energy and pan cleaning produced from lower water volumes and streamline the flow of water in toilet pans. GWA Caroma, for example, indicate that, compared to the previous 6/3L class, the flush valves for the 4.5/3L have been re-engineered to maximise the energy generated from less water, and the pan has been redesigned to streamline the flow of water (Caroma 2007).

Several other manufacturers or importers now offer this toilet class within their product range. These include Ifö, Laufen, Parisi, Imperial, Vista, American Standard, Gemini, Johnson Suisse, Pubco, Fowler, and others (Australian Government, 2007). However, some information derived from the interviews with stakeholders indicates that not all models from all manufacturers in this class currently sold in the Australian market have equivalent levels of performance in the field.

Under the current Australian toilet standard, toilets in the 4.5/3L class are the lowest volume flush toilets permissible.

Figure 1. Caroma 4.5/3L 4 star toilet. Sourced from http://www.caroma.com.au

2.2. 4/2L dual flush toilets

Internationally, the markets for what are considered 'low flush' toilets vary considerably and, compared to many countries, Australian toilet classes would be considered as highly efficient. In several markets in Europe, however, dual flush 4/2L toilets are common. Several models of toilet exist in this class.

The manufacturer Ifö, for example, introduced their Cera dual flush 4/2L model into the European market in 1996. This model has since been installed in more than 5 million locations across Europe.

At least one European manufacturer explored the possibility of introducing their 4/2L model into the Australian market. This process has been unsuccessful to date, as this class of toilet is not currently eligible for registration in Australia under the Australian Standards covering toilets (AS 1172.1 and AS 1172.2).

A dual flush 4/2L toilet would have a nominal average flush volume of 2.4 litres. This would give these toilets a WELS star rating of 6 stars. In testing, however, Ifo's Cera model has a flush volume of 4 litres full flush and 2.4 litres reduced flush. This model would, therefore, achieve a WELS star rating of 5 stars, if it could be registered in Australia.

2.3. 3/2L and 2/1L litre dual flush toilets

In Scandinavia, 3/2L dual flush toilets have been in use for some time. Ifö's Cera range, for example, includes a 3/2L model with adjustable flush volume. These toilets are, however, generally installed in holiday homes with rainwater tanks and limited water supplies. These situations commonly involve steeper than average drainage grades.

An internet search on 3/2L toilets reveals that Caroma Inc. Ltd holds Patents for a 3/2L model toilet (wikipatents.com/ca/2456773, freepatentsonline.com/EP1451417). This points to the fact that 3/2L models may well be technically feasible. However whether 3/2L toilets can be developed to the level that could be sold commercially remains to be seen. It is likely to require significant research and development to develop a commercially available 3/2L toilet model. No such developments are currently known to be occurring in Australia and no toilets in this class are currently available in the Australian market.

A dual flush 3/2L toilet would have a nominal average flush volume of 2.2 litres which would translate into toilets a WELS star rating of 6 stars.

2.4. Dual flush toilets with integrated hand basin

Integrated hand basin grey water reuse models reduce water consumption by using the same water for two purposes: hand washing and toilet flushing. A tap and hand basin sit atop the toilet cistern and fresh, potable water used to wash the user's hands is then passed into the cistern to be used for flushing.

In this class, Caroma has developed the Profile™ toilet suite which is a 4.5/3L dual flush toilet with a hand basin integrated. In the Profile™ model the tap flows when the toilet is flushed. Because of the water reuse feature the Profile™ obtains a 5 star rating under WELS. Oz-Aquasaver has also developed a new retrofit basin that can be fitted on to the existing cistern. In this model the tap can be turned on without having to flush.

Figure 2. Caroma 5 star toilet with integrated hand basin
Sourced from http://www.caroma.com.au

Integrated hand basin reuse models are also commercially available overseas. For example, the research team has found anecdotal evidence of integrated hand basins in use in Japan.

2.5. Urine separating toilets

Urine separating or urine diverting toilets have two bowls within the one pan and collect the faeces and urine separately. This also allows very low flush volumes for the reduced or urine flush compared to the full flush. The reduced flush volume for a urine separating toilet is usually around 0.2 of a litre per flush. Full flush volumes for urine diverters are commonly between 4 and 6 litres per flush. This results in an average flush volume of between 1 and 1.4 litres.

Achieving these nominal average flush volumes would, however, require behaviour change from both male and female toilet users. Urine separating models generally require males (as well as females) to sit down during all visits so that the toilet works most effectively. The opportunity for female users to flush toilet paper together with the urine flush is not available with a urine separating toilet.

In some instances urine diversion is also combined with an ultra low flush system for faeces. These tend, however, to be vacuum or 'dry' systems (Swedenviro, 2001) and therefore fall outside the scope of this study.

Figure 3. Urine separating toilet pan
Sourced from http://www.novaquatis.eawag.ch

By 1999, about 3000 urine diverting toilets had been installed in Sweden (Hellström and Johansson, 1999). More recently, two municipalities (Tanum and Norrköping) have mandated urine diverting toilets in new and renovated bathrooms (Cordell, 2006).

The Swedish consultancy Swedenviro compiled a market survey of low flush toilets in 2001. According to the researchers involved, the models and manufacturers supplying the Swedish market remain much the same today. Table 2 summarises the manufacturers and models.

Table 2 Urine separating toilet available in Sweden (adapted from Swedenviro, 2001)

Manufacturer	**Model**	**Full flush**	**Urine flush**
BB Innovation & Co AB	Dubbletten	4 L	0.15 L- 0.2 L
Gustavsberg	Nordic	4 L	2 L
Roediger Vakuum + Haustechnik	Roevac No Mix	6 L	0.2 L
Wost Man Ecology	WM-DS	3.5 L	0 – 0.7 L

In addition to low flush volumes, urine separating toilets could also give the additional benefits in terms of recycling nutrients via the capture and commercial use of urine. Urine separation provides the potential for more efficient nutrient recycling (Berndtsson,

2006) because the urine (with its high phosphorous and nitrogen content) can be stored and reused as fertiliser without further treatment (for further information, see World Health Organization 2007 Guidelines for the safe use of waste water, excreta and grey water). This could also help in preventing nutrient pollution from reaching receiving water bodies (Cordell, 2006).

With urine separating toilets, issues of appropriate infrastructure, engineering experience, municipal support and user motivation and knowledge also need to be considered. For further information about the potential for urine diverting toilets in Australia, see Cordell (2006).

Another potential development is the inclusion of a waterless urinal within a urine separating toilet. This would further reduce the water required for flushing. Research into waterless urinals however indicates that there are potential barriers and issues to overcome in implementing the technology, but that this is possible with careful planning. Issues may include high costs of retro-fitting, the need for appropriate maintenance, altered waste water composition, technical and plumbing design, and psychological resistance by users (Cordell, Chanan and White, 2004).

2.6. Air assisted flush toilets

Propelair is a UK-based company which has designed a new type of toilet with an assisted flush. Because of the pressurised air assistance, the flush volume will be 1.5 litres. The toilet is in a pre-production stage with in situ trials completed.

The toilet works with users required to close the toilet lid before flushing. This forms an air seal. A small amount of water is then passed into the bowl to wash it, followed by displaced air. This air displaces the contents of the bowl, and water is reintroduced to replenish the water trap seal. The flushing cycle takes three seconds (Propelair, 2007). The toilet’s appearance is the same as standard toilets and it can be connected to existing drainage systems. The air displacement requires a small electric motor.

Figure 4. Propelair toilet
Sourced from http://www.propelair.com/technology.html

It should be noted that air assisted flush toilets differ from pressure assisted toilets. The cisterns of pressure assisted toilets contain an inner tank, which is completely sealed. When water is fed from the water line, the air inside the sealed tank gets compressed (so the pressure is created by the water pressure) and when the toilet is flushed, the water is forced out with the pressure of the compressed air. This differs from the Propelair model, which uses an electric motor to displace the air used during flushing.

Although currently at pre-production prototype stage, recent testing has been conducted by the Water Research Centre in the UK of the Propelair model. The tests were against European Standard EN997 which incorporates tests that are also required by the Australian Standard AS1172. This testing revealed low average flush volumes, reduced net energy use (once the embodied energy in the water was accounted for) and good user acceptance. Further testing on a wider scale will soon be undertaken.

The company indicates that there are plans for trials in Australia and that these are being organised with a Sydney council and Australian university (Propelair, 2007). The company also indicates that, given the requisite funding, commercial production of these toilets could begin in less than a year.

3. TECHNICAL ISSUES

This section utilises information, including direct quotes, from the stakeholder interviews to draw attention to the technical issues that arise due to decreasing the volume of flush water. These technical issues can be considered at varying levels. They range from the level of the toilet suite itself, to the level of the house or building, to the wider sewer network and waste water system to which the toilet will be connected.

3.1. Toilet performance

At the level of the toilet suite itself, it is evident from the interviews that all aspects of toilet performance need to be considered, not just its water efficiency. This sub-section addresses the question 'What issues are raised in terms of the performance of the actual toilet suite with low flush volumes?

"*Well, again the reference to more efficient classes is only relevant to the water volume that's actually being used to flush. It's not saying that the product functions…… a product can be water efficient but not functional*." **Tim Fisher, Plumbing Products Industry Group**

"*A possible problem would be a compromising of the effectiveness and health standards. You might not be able to clear the pan as effectively. The water trap seal must be maintained to stop sewer gases entering the room*." **Des Horton, City West Water**

"*…if it doesn't work, then it is not water efficient*." **Industry Spokesperson**

A key to this is the issue of amenity of the toilet pan for the user. The need to keep the pan clean cannot be ignored. Designing toilets for increased water efficiency without maintaining the performance of the flush can potentially lead to the pan being left more frequently marked.

"*Obviously as you reduce the flushing volume there is a higher likelihood that you are going to have a soiled fixture at the end of the event*" **David Cox, Water Services Association of Australia.**

"*Something that has been mentioned to me a couple of times is the design of pans to achieve the low flush volumes reduces the water area of the seal and also the shape of the pan and they're tending to in some instances not be as self cleansing as they possibly could be*." **Stephen Movley, Institute of Plumbing Australia**

The performance issue can impact on customers in terms of amenity and the need for them to manually clean the pan with a brush. It also affects the water saving potential of low flush toilets. A number of interviewees highlighted the potential for people to flush multiple times if pan clearing performance was poor.

"*What we've started to see in some of the toilet design is some modification, so to speak, to try and make things work a little more efficiently when in actual fact what we can finish up with is a situation where the reduced flush volumes may mean multiple flushes to actually clear the pan. That is not the desired outcome.* **Tim Fisher, Plumbing Products Industry Group**

"if further reduced volume is progressed without significant technical assessment …we may find that you could require two or three or maybe even four attempts to flush and clear the

pan which has the potential to defeat the purpose of lower mandated flush volumes" **Tim Fisher, Plumbing Products Industry Group**

"There's a double flushing issue if the technology's not right" **Industry Spokesperson**

As well as the potential mark issue, a narrow throat can also caused other problems with certain user behaviour, associated with toilet paper use in public toilets.

"*The difficulty with reducing the 3 litre 'half' flush is toilet paper performance in the drain. This is particularly the case in some public toilets where users line the toilet seat with paper before they use it and then flush the paper*." **Industry Spokesperson**

"*There could be some concerns expressed by people that there is a limit to how far you should go with reducing flushing volumes for toilets for public use whereas for private use it is probably different*" **David Cox, Water Services Association of Australia**

Toilet blockages are likely to be issues in schools, gaols and hospitals. Hospitals in particular will be an issue because of the heavy loads and the potential for adverse health impacts when toilets block. A couple of interviewees raised the concern that in hospitals toilet blockages are an infection risk issue.

"*In hospitals, low flushers are a problem.*" **Stephen Movley, Institute of Plumbing Australia**

A number of interviewees also indicated that, in their experience, drain line carriage was not dependent solely on flush volume but that toilet design and performance had a significant effect.

"*I can give you a personal case history where I had a 6/3L pan installed in my house. It was on the end of the drain, so there was nothing flushing past to transport the waste down further into the drainage system. It would block … so I took it out and put back a conventional flush toilet and it wasn't an issue. Then when the 4.5/3L was brought out I was asked if I'd want to partake in that trial as well…. I did. I installed it and haven't had an issue with it since. So remarkable!"* **Jeff Clark, SA Water**

Jeff Clark was not alone in indicating that lower flush toilets could, on occasion, out-perform higher flushing models

3.2. Drain carriage

The question of 'What issues need to be considered in terms of carriage out of homes and building with low flush volumes?' is an important one.

It is critical that toilet flushing not only clears waste from the pan, but also transports the waste through the drain to the main sewer line.

The most commonly mentioned technical barrier to introducing more efficient toilet classes into Australia was drain line carriage. The overall message was that the performance of the whole household or building plumbing system needs to be considered, not just the toilet.

"*When there are problems with the plumbing, customers can see the toilet and that it is a low flush toilet, so they decide that the toilet is the problem. Industry knows that it is not* *necessarily the toilet but it can be the drain line system that it is connected to. This has [been] validated […] many, many times."* **Industry Spokesperson**

"I think that's the biggest issue, making sure that the waste can be disposed of totally out of the system and into the main sewerage line. Plumbers tell me that there's an increase in the volume of toilet paper and other things that people use when they go to the toilet these days and so all of those things have issues with making sure that we don't end up with blocked [drains]." **Gary Workman, MPMSAA and Green Plumbers**

Blockages in the drain line joining the outlet of the toilet to the main sewer line can be caused by a number of things. Pipe work can be damaged over time, develop cracks or be invaded by tree roots. Older houses may have terracotta pipes in their plumbing systems. Some plumbing systems use right angle connectors (rather than at a smaller angle, which would reduce the chance of waste flowing the wrong way). These systems may all function properly when the volume of water flowing through them is high, but if the volume is reduced through the use of more efficient fittings and appliances, then problems can start to emerge.

"*It is definitely a factor, but it's not a huge factor. There is a cumulative affect of reduced water flushing, waterless urinals, more improved technology changes, more efficient showers, baths and so on."* **Les Barnard, Sydney Water**

"*We can't just talk about reduced volume flushing without having proven capability of the plumbing drainage systems to be able to cope with those significantly reduced flows*." **Tim Fisher, Plumbing Products Industry Group**

When efficient toilets are positioned on a drain line with no upstream flows, or one that is not used frequently, blockages can also occur. It was mentioned that some builders are experiencing blockages in the pipe work from existing three and four star rated toilets.

"*What they believe is going on is that homes now have more toilets in them and particularly in two stories houses where there's the main bathroom and the en suite upstairs, with a third toilet downstairs. The third toilet tends to be a low use toilet….because the toilet isn't used, the pipes dry out and you get blockages from the toilet paper. Then what sometime later you use the toilet again and flush it, and it's blocked. In new houses, the builder will get phone calls saying 'my toilet's blocked' because the homeowner would imagine that must be a problem. What the builders have found on investigation when they've gone to unblock the toilets, is that it's just dried out and there's nothing wrong with the toilet*." **Housing Industry Representative.**

Reduction of the flow in drain lines will also be caused if there is separation of grey water plumbing within the home to allow collection and reuse.

"…the current trend to separate grey water, to reuse the grey water means that there's even less water in the drainage system for flushing in some cases. This may be a concern with lower and lower flushing of toilets." **Stephen Movley, Institute of Plumbing Australia**

John Brennan (WA Water Corporation), Jean Villani (Plumbers Licensing Board) and Daniel Ellis-Jones (Western Australia Department of Housing) commented that in Western Australia the Department of Housing and Works introduced a minimum standard of 4 stars (equating to 4.5/3L models) for toilet suites in September 2007, as part of the 5 Star Plus Housing Scheme. As part of Stage 2 of that scheme, which will start in 2008, new homes on suitable lots must be plumbed to enable grey water diversion to allow grey water reuse systems to be introduced at a later time.

> "*Poor in-building carriage and reduced effectiveness due to grey water removal is a key concern.*" **Leon English, Department of Water, Western Australia**

Due to concerns that were raised about the effect that the combination of efficient toilets and grey water diversion will have on drainage systems, the Master Plumbers and Gasfitters Association has begun coordinating a number of trials in order to monitor the performance of drainage systems when the grey water is diverted. The outcome of these trials will be considered before combined grey water diversion and 4 star toilets are made mandatory in Stage 2.

3.3. Reduced flows in sewer network

Some people raised potential concerns about flows in the main sewer line as well as the in house or in building drainage and queried 'Would more efficient toilets cause sewer carriage or waste water treatment problems?'.

Others believed that it may become a problem as flows continue to decrease or could possibly emerge as a problem in areas on the edge of the existing system, where all houses are highly water-efficient.

> **"***There is anecdotal evidence right now to suggest that the alarm bells are ringing as people wish to extract more and more water from the system either through demand management or through grey water reuse or a range of other activities such as water mining of sewers*." **David Cox, Water Services Association of Australia.**

> "*As a network utility operator, we are experiencing some difficulty in the reduction of flows in our systems [due to water conservation with restriction]*" **Les Barnard, Sydney Water**

> "*When you reduce the level of liquids to solids in a system, then all sorts of things come into play. The greater the pipes, the greater the sedimentation, due to the solid to liquid ratio. It all has a compounding effect*." **Les Barnard, Sydney Water**

In Sydney, these issues are linked to informal grey water reuse in response to water restrictions which has reduced sewer flows in some areas by 15%. If more efficient toilets did lead to more sewer blockages this would be a concern as blockages cause septic sewers, leading to odour and corrosion problems through sewerage networks.

> **"***I think that people have lost sight of [the fact] that the [sewer] transportation systems that we have, need water to operate effectively … it is on the radar screen to actually start to review the hydraulic design of sewers*" **David Cox, Water Services Association of Australia.**

> "*The major concern at present is that our systems – our waste water systems – are designed on some fairly ageing models as far as flows are concerned*" **Les Barnard, Sydney Water**

> "*Because we've got 50 - 100 year old infrastructure in most of the major cities that have been designed on a certain amount of water running through the pipes, they would essentially become oversized pipes if they've lost a lot of the water coming out of houses. There would also be less water going into treatment plants which have been built at particular sizes. I have*

no idea how big or small the potential ramifications are, but I think it's important if we move further down this track, that the utility providers are in the discussion and that they're saying yes, our system won't fail because it's got no water in it." **Housing Industry Representative.**

"*Reconstructing existing sanitary systems is out of the question "we've got a current drainage system and we've got to see how we can effectively manage that system with reduced flushing volumes*" **David Cox, Water Services Association of Australia.**

It should be noted that the current issues identified in sewers in Sydney were linked to informal grey water reuse in response to water restrictions. These were reported to reduce sewer flows in some areas by 15%. Only the most optimistic scenarios, in terms of the overall efficiency of the toilet stock, modelled in Section 6 below, would result in this level of reduction in waste water flows, and only after 2040.

3.4. What are the potential solutions?

Study "how low can we go?"

Various interviewees indicated that there is a need to better investigate the interaction of very low-flush toilets with drainage systems in the Australian context. To date there has been no systematic study on this in Australia, but internationally there has been some research. McDougall and Wakelin (2007) investigated the effect of flush volume, drainline slope, drain diameter, drain shape (circular or non-circular) and the length of the drain on the performance of the combined toilet and drainline. The ability of a single toilet to transport waste solids to the first pipe junction was analysed. Flush volumes of 9.1L to 4.5L were investigated. By extrapolating the data trends, McDougall and Wakelin suggested that average flush volumes below 4 litres would be feasible if the system and appliance design parameters are considered.

By incrementally reducing toilet flush volumes and studying the impact on the whole system, it should be possible to gauge how low flush volumes can go before carriage becomes a problem.

Jeff Clark from SA Water is chairman of a working group that is organizing such a study. This working group also includes Steve Cummings from Caroma. The study will explore what the limits are in terms of minimizing flush volumes with existing systems. It will also investigate the effect of combining low flush toilets with grey water reuse. In the proposed study the flush volume will be decreased incrementally and the performance of toilets monitored. An initial meeting was held on 29th November 2007 to map out the scope of work. The next meeting will be held in Canberra in early 2008. A number of installations will be needed and the timeframe for the study is that it should start within the first half of 2008.

Such a study may show that we are already close to the limit in terms of the water efficiency of conventional water flush toilets.

"*So simply just looking at volume is a problem and I think where we seem to be at the moment with 4.5/3 litre is about the limitation that certainly for solid movements is about* *the limitation that we have with current technology.*" **Tim Fisher, Plumbing Products Industry Group**

"*Where we are now is at a cross-roads….. what we need to do is an investigation to establish what is possible and what is not possible. We also need a system approach…*" **Industry Spokesperson**

By studying toilets as part of the drainage system, the positioning of toilets could also be considered, and translated into advice on installation (for example, in new buildings there should be other fixtures such as baths or showers upstream from toilets).

Introducing more efficient toilets into new buildings or high rise buildings

As part of the semi-structured interviews, stakeholders were asked about the implications of introducing a more efficient toilet class that could only be installed in new buildings, or in multi-storey buildings. A number of market and regulatory issues were raised with this idea and these are addressed in Sections 4 and 5 below. For many stakeholders this idea was seen as a clear opportunity for introducing more efficient toilets into Australia.

"*Perhaps we could be looking at toilets from the perspective of where they're destined to [go] or the type of dwelling they're destined to be used [in] because you see a lot of single-flush toilets in high-rise building where the conveyance distance is measured in centimetres not in metres…You are virtually guaranteed of a continuous flow down [to] the waste water network. So that's a clear opportunity [for more efficient toilets].*" **Andre Boerema Sydney Water**

Alternative technologies

Air assisted flush toilets (Propelair for example) may be a solution to some drain line carriage issues. Although vacuum toilets were not included in the scope of this study, it was mentioned by a number of interviewees that these are proven, commercialised, low water use (1 litre per flush) options that avoid the drain line carriage issues that higher efficiency traditional flush toilets may cause. It was also suggested that composting and waterless toilets (also not part of the scope of this study) could be an alternative to higher efficiency flush toilets.

Vacuum systems are already being employed in some conventional sewer networks. They are used in areas with sensitive waterways or water charged ground (to prevent contamination) and areas where topography is flat. These systems can be run quite close to the surface. If reduced sewer flows were a problem, the vacuum systems may be a potential solution. Vacuum systems will not, however, work if sewer systems are too 'leaky' to create a pressure gradient and they do require energy to generate the vacuum.

Small bore sewer or STEP (septic tank effluent pump) systems are another alternative. With these systems, sewage from homes or buildings goes straight to a local septic tank were solids are retained. The liquid fraction of the effluent is then pumped to a usually decentralised waste water treatment plant. Sewer carriage is therefore removed as an issue. As with all septic tanks, STEP tanks must be pumped out periodically to remove accumulated solids (sludge).

Use of alternative water sources

Grey water from the hand basin is already used for flushing five star toilet models. Other sources of alternative water supply for toilet flushing were suggested by many stakeholders. Gary Workman of the Master Plumbers and Mechanical Services Association of Australia and Green Plumbers provides some good examples.

> "*If you are looking at saving water for flushing toilets you could look at using non-drinking water for flushing toilets... Other countries use sea water, other countries use recycled water. We don't have to use the best quality drinking water to flush our toilets to begin with. If governments wanted to make a bigger impact, that's where I'd be focusing the regulation*."

> "*Every building could collect enough rainwater for toilet flushing quite easily. If we keep restricting the flow more and more in the toilet technology, you're going to end up with issues at the drainage end and at the sewerage treatment plant end*." **Gary Workman, MPMSAA and Green Plumbers**

As well as being used directly for toilet flushing, stormwater could be introduced into the drains at strategic times and levels to flush the network. This may be a solution to stranding problems in the sewer system. One outcome of the studies in Western Australia into the combination of grey water diversion and efficient toilets may be that only partial diversion of grey water is allowed, so that in-building carriage can be maintained.

Education and changed behaviour

It was suggested by various stakeholders that behavioural change could solve some of the toilet blockage problems.

> *"People have to be careful about putting things down toilets that they shouldn't and I know we all enjoy the comfort of our triple ply toilet papers … but in doing that they required more water to actually get them down the system and into the main drain."* **Jean Villani, Plumbers Licensing Board**

> "*I think there'll be some education for the community involved and perhaps some changes to the way people currently view the sewerage system and the toilets and what you can and can't put down them.*" **Jean Villani, Plumbers Licensing Board**

> *"So we need a bit of public education to let people know that if they're going to have these [extra toilets in their home], they need to use them. Or the other way to adapt, the owners could say that perhaps we don't need a third toilet, [in all new houses]"* **Housing Industry Representative.**

4. REGULATORY AND STANDARDS ISSUES

This section covers what must be done for new, more efficient toilet classes to be given a WELS rating, as well as what is required for compliance with other regulations and standards relating to toilets. As with the previous section it utilises information, including direct quotes and passages from the stakeholder interviews to draw attention to the regulatory and standards related issues.

4.1. What instruments regulate toilet installations across Australia?

The WELS Scheme

The Australian Government's Water Efficiency Labelling and Standards Scheme requires certain new water using fixtures and appliances (WELS products), including toilets, to display a water efficiency star rating label at the point of supply.

The WELS Scheme was enacted via the *Water Efficiency Labelling and Standards Act 2005*. The WELS Standard, which sets out the water efficiency requirements for WELS products, has been determined by the Minister to be AS/NZS 6400:2005: *Water efficient products - Rating and labelling*. This Australian Standard is overseen by a Standards Australia Committee, WS-032. The organisations represented on WS-032 are listed in Appendix C of this report.

The WELS Standard sets out the criteria against which toilets are rated on a scale from 1 to 6 stars. However, to be given a star rating under WELS, toilets must also comply with certain aspects of the toilet standards (AS 1172.1 and AS 1172.2) or relevant Australian Technical Standards for flushing valves and solenoid valves (ATS 5200.020, 5200.021, 5200.030).

Of particular importance, in the context of this study, is Table 4.1 of AS 1172.2, as this sets out the categories of flushing volumes within which toilet models must perform (called 'toilet classes' in this study). If a toilet has a flushing combination (full/reduced) that falls outside the ranges set out in Table 4.1 of AS 1172.2, it cannot be registered for WELS or given a WELS rating.

The WELS Scheme only regulates the supply of toilets. The installation of toilets is controlled separately via plumbing codes, which reference the WaterMark Certification.

The Australian Standards for pans and cisterns (AS 1172.1 and AS 1172.2)

There are two Australian Standards specifically for toilets, AS 1172.1 for pans and AS 1172.2 for cisterns. The Australian Standard AS 1172.2-1999: Water *closet pans of 6/3L capacity or proven equivalent – Cisterns* includes a discharge test. To pass this test, the toilet cistern discharge volumes must be as given in Table 4.1 in the Standard (reproduced below in Table 3). Toilets are included in the standard as particular classes only, with discharge volumes specified by toilet class. It means that toilet classes must fall within the ranges set out in this table in order to meet the Australian standard.

Table 3 Maximum and minimum water flush volumes for allowable toilet classes in AS 1172.2-1999

Toilet Class	Full-flush	Reduced-flush	Average flush
Dual flush 6/3L	5.5L min. 6.5 L max	3.0L min. 3.5L max	3.5L – 4.0L
Dual flush 4.5/3L	4.3L min. 4.7L max.	2.8L min. 3.2L max.	3.1L – 3.5L
Dual flush 9/4.5L	8.0L min. 9.5L max	4.0L min. 4.5L max.	4.5L – 5.5L*
Single-flush 6L	6L max		
Single-flush 4 L	4L max		

* Replacement cisterns only

The Australian Standard AS 1172.1-2005 Water closets (WC) – Pans also includes performance requirements. One of these is the Solids Discharge Test, which includes the requirement that the trailing water volume (the volume of water leaving the pan after the last solid test piece has been expelled) is not less than 2.5L. This solids discharge test is based on the German DIN Standard. If the test remains within the Standard it is unlikely that manufacturers could achieve an average flush volume of less than 2.5 litres, which is the maximum for a 6 star toilet under WELS.

The WaterMark Certification Scheme

The WaterMark Certification Scheme sets the rules for certification of plumbing and drainage products in Australia as prescribed by the Plumbing Code of Australia. In all jurisdictions in Australia, products must obtain WaterMark certification to be legally installed into a plumbing system.

When a plumbing or drainage product has a WaterMark Certificate of Conformity, it demonstrates that the product complies with the applicable Standards.

The WaterMark Scheme draws on the AS 5200 series of standards which are technical specifications for all plumbing and drainage products; and the AS 3500 series of standards which cover plumbing and drainage installation.

There are three types of WaterMark certification: Level 1, Level 2 and New Product Authorization (NPA). Toilets that are included in the toilet standards (AS 1172.1 and AS 1172.2) require Level 1 certification. Toilets that are not included in the toilet standards may be able to apply for an NPA. However, this would not allow the toilet to achieve a WELS rating.

Level 1 WaterMark Certification

The manufacturer or supplier reviews the product to determine if it complies with the relevant standards or specifications listed in Section 5 of the Australian Standard AS 5200.000-2006. Products that do not comply with the relevant standards or specifications listed in Section 5 of AS 5200.000-2006 cannot be certified. If the product is not covered by Section 5 then the procedure for New Product Authorisation must be followed (see following sub-section).

To start the process, the manufacturer or supplier applies to a 'conformity assessment body' (CAB) for WaterMark certification. The product is then assessed on quality assurance and compliance with Australian Standards.

The manufacturer must have a quality assurance system or quality plan, and the assessment body will conduct a quality assurance audit.

To assess compliance with Australian Standards, the product must be tested by a recognised testing laboratory. The assessment body then considers the results of the tests.

If the quality system meets the CAB system requirements and the CAB-recognised testing laboratory test results show that the product complies with Australian Standards then the CAB grants a license to the applicant to use the WaterMark and registers the product on the WaterMark database. Upon granting of the license, the manufacturer applies the mark to the product.

New Product Authorisation

If a product is not covered by Section 5 of AS 5200.000-2006, then the manufacturer or supplier applies to a CAB for a New Product Authorisation. The CAB supplies documents to the manufacturer or supplier to enable them to prepare a draft Australian Technical Specification (ATS). The manufacturer then submits a product list, draft ATS, drawings and Quality Assurance Certificate (if available). The CAB reviews these documents and submits the information to the Standards Australia committee WS-031 (technical procedures for plumbing and drainage products authorisation) to approve or reject the ATS and determine the required WaterMark level of certification.

The WS-031 committee must forward the draft ATS to the Standards Australia committee WS-014 committee (the committee for Plumbing and Drainage, 3500 series) to assess the installation requirements. The WS-031 then reports back to the CAB, which advises the manufacturer on the status of the application. If the manufacturer or supplier decides to continue with the application they must follow the procedures determined by the applicable certification level. Once the ATS has been accepted, it is referred to the appropriate Standards Committee for inclusion in a relevant Australian Standard (new or existing) within 2 years.

Local plumbing codes

New toilet classes would also have to comply with state based or water utility based regulation of what can be connected to a particular plumbing or sewer system. This point of regulation actually dictates what can legally be installed.

> "*At the end of the day it is the state based regulators who determine what can and what can't be used on a particular plumbing or sewerage system.*" **Kevin Enright, Standards Australia.**

However, in all jurisdictions, any product that is being installed in a plumbing installation has to be an approved product. Local Plumbing Codes therefore generally reference the Australian Standards and WaterMark.

"*Anything that comes onto the market within Australia, provided it meets an Australian technical specification that is a watermarked approved product, we would have no dramas in accommodating that into any of the systems*." **Les Barnard, Sydney Water.**

"*So if they can get the reduced flush systems down even further, below three, then that's fine, as long as they're an approved product." "As a network utility operator, we'll manage the system to suit*" **Les Barnard, Sydney Water.**

4.2. What would be required to change the standards and introduce new toilet classes into the Australian Standards?

All Australian Standards have their associated Standards Committees.

"Standards Australia produces Australian standards and it produces standards by the process of forming a committee of experts and key stakeholders and it is that committee then that actually provides the intellectual property to develop an Australian standard." **Kevin Enright, Standards Australia.**

In general, changes to a Standard require consensus on the committee responsible for it.

"It is a consensus process, however, we do have rules whereby if we don't achieve 100 per cent consensus then we will arbitrate and we will allow standards to be published if it is perceived that there are no significant sectors of industry or the community that vote negatively on a standard then we will still publish".

"[But] before a standard is approved it goes through a period of public comment." **Kevin Enright, Standards Australia.**

The Standards Committee that is responsible for the toilet standards (AS 1172.1 and AS 1172.2) is the WS-003 committee. The committee includes toilet manufacturers, regulators from the states, representatives from various water and sewerage authorities around the country and others who have a real interest.

The Standards Committee that is responsible for the Plumbing and Drainage standards (AS 3500 series) is the WS-014 committee. The Committee responsible for the Australian Technical Specifications (AS 5200 series) is the WS-031 committee. These committees also include a variety of stakeholders. The organisations represented on these committees are given in Appendix C.

Various interviewees indicated that the committee membership was in theory aimed at maintaining a balance of interests including regulatory interests, manufacturing interests, community interests, research interests. However, it was noted that while some parties maintained personnel on the committees with long experience on the committees, others, particularly government organisations have had higher turnover rates.

In relation to the WS-03 committee "*I think most of the people that are currently sitting on the Committee are probably only recent participants on that committee*.

"*Steve Cummings from Caroma has been actively sitting on the WS-03 Committee probably as long as anyone*" **David Cox, Water Services Association of Australia.**

Some stakeholders commented on the tests within the current Australian Standards for toilets.

"The test [existing 2.5l trailing water volume test] was developed on existing drainline systems. If you are talking about going down to ultralow flush there is a high probability that it won't work in existing drainline systems. If you fail this test it means that you are not transporting solids effectively. The biggest problem is paper performance and we really should have a standard test for paper transportation" **Industry Spokesperson.**

"Simply changing the standard by inserting values without validation appears easy. There's no problem? But all we would be doing then is providing a standard for a fixture that may or may not be able to be easily achieved in R&D or commercially viable. We would not be looking at the linkage with the plumbing system ….it needs to be explicitly understood that simply modifying a standard for a fixture such as a toilet is only a minor part of the overall system to which that is connected, but the product design has be proven as functional and compatible." **Tim Fisher, Plumbing Products Industry Group.**

"How rigorous and how scientific [an Australian standards] test is entirely a matter for the committee." **Kevin Enright, Standards Australia.**

Specifically discussing what could be done if the 2.5L volume after solids tests were removed, Stephen Smith from CSIRO commented that.

"There are some … American based criteria for these products [toilets]: drainage tests, piping lengths and certain falls. These [tests] could be adopted and brought into [the] Australian [Standard] to look at to verify a product length of carry." **Stephen Smith CSIRO.**

Significantly different views were expressed about the need for Australian field trials before introducing more efficient toilet class in the Australian Standard. Stakeholders commented on the need for tests included.

"...realistically they [the Australian Standards] could be changed, but the testing would have to be done to justify the changes." **Jeff Clark, SA Water.**

"It just wasn't a matter of changing the standard to do that - you had to go out and test the product too and the product had to perform before you released the standard." **Jeff Clark, SA Water.**

"Before we went to six/three toilets field testing was set up at a Brisbane sewerage works where a toilet block was fitted out with six/three litre pans and cisterns. The trial was all monitored and using clear pipe, on a daily basis, could see what was actually happening within the system. At the end of the trial there had to be some adjustments made to the pan and cisterns prior to acceptance.

So prior to changing the standards to introduce lesser flush capacities you have to set up all these testing arrangements. Even though the six/three standard covered a reduced 4.5/3 litre pans and cisterns, field testing was still trialled. Caroma did that with Yarra Valley Water over a period of time. It was under a program that if any blockages occurred then Yarra Valley Water could go out and clear the blockage as it was in their catchment area.

But over the period of the trial there was certainly no reported blockages because of the general use of other fixtures, if stranding had occurred, it got washed away". ***John Park, Plumbing Industry Commission.***

"Sometimes even if they have passed the performance based testing as an individual product, how do they perform when they are part of a system? That is always much harder to evaluate because it goes beyond just the confines of a laboratory" **Stephen Smith CSIRO.**

"*Australian trials are needed. It depends on how far outside the current specification [the new class of toilets] is*" **Les Barnard, Sydney Water.**

Geoff Keogh from B&KS raised concerns that the standards would be diminished if they were changed to allow more efficient models and that in these models energy would be required.

4.3. What is required to create a new standard for assisted flush or urine separating toilets?

Most interviewees with a knowledge of the Standards Australia processes indicated that it was highly likely a new Standard or Standards would need to be developed to allow the introduction of assisted flush toilets.

Whether urine separating toilets would also need a separate Standard would depend on the opinion of the WS-003 committee. However, because of the specific plumbing issues related to urine separators and in particular the need for specific piping materials to be used for the urine line, it is likely that a new Standard for urine separating pans at least would be the preferred outcome.

A couple of the stakeholders commented on the problems that can be caused in the urine line due to corrosion and material build-up, unless specific piping materials are utilised and some flushing of the line by upstream fixtures is allowed for.

In either case, the first step would be the development of an Australian technical specification.

"*So with something like an air flush toilet the company making the product would work with somebody like SAI Global to develop a 'technical specification'. Then that specification would be redrafted in to the format of an Australian standard. Then Global would make an assessment of whether this product is suitable and consistent with existing Australian standards.*" **Kevin Enright, Standards Australia.**

"*Global would come to Standards Australia with an application and submit it to a technical committee who are expert in the area. They would make a decision as to the implications of the product being installed on sewerage systems.*" **Kevin Enright, Standards Australia.**

Significantly, if new standards are introduced for either assisted flush or urine separating toilets to allow for these models to be both sold and installed in Australia, it would require revision of the WELS standard (AS 6400), the technical specification standards (AS 5200 series) to allow WaterMark certification and the plumbing and drainage Standards (AS 3500 series).

This would mean that the WS-003 committee (toilets), the WS-032 committee (WELS), the WS-104 committee (drainage) and the WS-031 committee (Technical Specifications – WaterMark) would at least need to be consulted on the new technology and a number of the Standards would require revisions.

As well as addressing, performance of the toilet suite, the possible impacts on in-building plumbing, and any impacts on sewer network, there would also be potential public health implications to consider.

"[For air assisted flush toilets] we have to ensure that the health and safety of not only the people that are in that particular unit but in the surrounding area"

"SARS has certainly brought that home to us, that we'd have to look more closely at those type of systems. It may just be that the hydraulic design of the sanitary plumbing needs to have a larger venting system" **Les Barnard, Sydney Water.**

In all likelihood, local trials of air assisted flush toilets would be necessary before they could receive WaterMark certification or be registered with WELS.

"I'd be very interested in it [air assisted flush toilets] in having a look at that, and seeing if they wanted to trial it in this area ….But we do have to be very careful where you're injecting positive air pressure back onto a sanitary plumbing system" **Les Barnard, Sydney Water.**

While no interviewees believed changing an Australian Standard was effortless, perceptions on how difficult it would be varied.

"The system is not there to lock people out. It is open to innovative and new ways of doing things. But there are a whole bunch of steps that you have to jump through." **Kevin Enright, Standards Australia.**

"If there is an application to change that – in other words, amending the current standards, when that application goes through for an amendment, provided they've got the modelling data to indicate that the systems will work and work efficiently, there shouldn't be any problems with going through and getting that amendment through. Unfortunately, getting amendments to standards does take a little bit of time" **Les Barnard, Sydney Water.**

"There are lots of ways of slowing up the process so you could envisage [that for] anyone trying to make this change there [could be] problems and issues" **David Cox, Water Services Association of Australia.**

"The way Standards Committee's work is that they've assembled a group of people that are supposed to represent the interests of industry groups they represent the community. But in point of fact the people that sit on the committees largely represent individual vested interests and it very easy to white ant any change in the standard" **David Cox, Water Services Association of Australia.**

Case histories offered by interviewee highlight the perceived barrier.

"We asked the regulatory body about changing the standards and they simply asked us to give it up as [that] could only be led by the local manufacturer….they said that it would be very difficult to get it through the standard forums" **Claus Outsrup, Toilet importer.**

Various interviewees pointed to the difficulty of getting a new product through the various standards committees because of the interests represented on the committees.

"That has occurred [before], for example, with waterless urinals. I was chair of the committee that was responsible for the plumbing product authorisation at the time and I just said well we're not going to develop an Australia Standard; we'll just adopt the American Standard~~s~~. So we just called up the ANSI Standard so overnight it could be authorised." **David Cox, Water Services Association of Australia.**

5. MARKET CONSIDERATIONS

This section addresses market and consumer issues that would arise from introducing more efficient toilet classes. It also includes stakeholder responses to the prospect of raising the minimum standard for toilets in Australia. As with Sections 3 and 4, this section incorporates quotes from the stakeholder interviews to draw attention to identified issues and differences of opinion.

5.1. Is there a market demand for more water-efficient toilets?

Many stakeholders commented on the high level of demand for more water-efficient appliances of all types. As Kate Norris from Choice stated:

> *"I think from CHOICE's experience with testing water efficiency for other products like washing machines and dishwashers, consumers do think to want the more efficient models. They are interested in that angle so I think that more efficient toilets could be welcomed on the market"* **Kate Norris, Choice (Australian Consumers Association).**

But Kate Norris also asked the question:

> *"Will it [a more efficient toilet] be competitively priced? People still choose on price even when they have environmental concerns"* **Kate Norris, Choice.**

The question of price competitiveness is very relevant to a novel technology such as air assisted flush toilets, and could also be an issue with more efficient 'conventional flush' toilets. Five and six star toilets may be more expensive, because of the required design features but this is not necessarily the case.

In relation to a pilot program run by Sydney Water in which customers were offered, at a reduced cost, a 4.5/3L or 6/3L toilet to replace an existing single flush model, Andre Boerema from Sydney Water commented:

> *"[Demand for] toilet efficiency is strong - we had an overwhelming response to our pilot replacement program where we targeted single flush toilet owners and offered them a replacement.*
>
> *I don't think scepticism of the efficacy of the technology is a primary barrier at all. There might be to a degree but a bigger barrier is [the expense, the difficulty and the trouble of getting a toilet replaced]. It's a long list of more benign barriers than the technology."* **Andre Boerema, Sydney Water.**

Anecdotal evidence also suggests that for some consumers in the market for water-efficient toilets, the existing situation is confusing. The 6 star WELS labelling system for toilets can be interpreted to mean that 5 and 6 star toilets are available if customers are willing to search for them. This is obviously not the case. In terms of flush volume, the 4 star 4.5/3L dual flush is currently the most efficient flush toilet available in Australia.

> *"On five and six star toilets: [the introduction of models in these classes to the market] would be some relief there because if those things aren't on the market at the moment and they're not available then presumably consumers are out there looking for these products and not being able to find them."* **Kate Norris, Choice.**

Geoff Keogh from B&KS agreed that the market would have to accept the change if more efficient toilet classes were introduced. However, he would not like to see higher efficiency toilets become mandatory. Changing from 6/3L to 4.5/3L models cost B&KS $1 million in new products. It would be hard to justify making the 4.5/3L model obsolete already.

5.2. Poor quality toilets within existing efficient classes

When asked about introducing more efficient toilets classes, a number of stakeholders raised the issue of problems with some, generally imported, models in existing classes or with the creation of hybrid models. Hybrids represent an improper installation rather than a poorly designed model as such.

In discussing the experience of the Western Australian Department of Housing in inspecting five star plus homes that require the installation of 4 star toilets, Daniel Ellis-Jones commented:

> *"The actually toilets themselves [were an issue]…people were actually making hybrid toilets so we have a four star cistern but they're using a normal pan and it's just not working... you need to flush the toilet two or three times to flush away all the soils. "*

> *"Plumbers are picking up various designs and some of them have been labelled or some parts of them have been labelled four star but [the system as a whole is not]. We see it as a labelling and design issue. BOTH the pan and cistern must be labelled, and approved to work with each other. We are encouraged to see that Caroma has redesigned the suite as a whole, but the other manufacturers are playing catch up. Until there is consistency in the market, we will see customers go for the cheaper option, which invariably is a hybrid from overseas. So there are these hybrid toilets being put in that aren't working."*

> *"Until you fix [the poor quality 4star toilets] there's no point going to five star, you know it's going back to a two star because of that extra water flow having to be used in multiple flushes."* **Daniel Ellis-Jones, Western Australian Department of Housing.**

Customers experiencing poorly designed or installed 4 star toilets are unlikely to have a positive attitude to 5 and 6 star toilets if and when these classes become available.

5.3. What would be the implications of introducing a new class of toilets that was not appropriate for all installations?

Most of the stakeholders who discussed the implications of introducing a new class of toilets that was not appropriate for all installations were not overly concerned by the idea.

> *"That's just an education thing. People see that already …certain toilets are going to work better in certain applications than others. I think that message needs to go out clearly to the plumbing industry as well as the consumer."* **Gary Workman, MPMSAA and Green Plumbers.**

Answering a question about the implications of introducing a new class of toilets that where only appropriate for multi-storey installations, Andre Boerema from Sydney Water commented**:**

"I think it's the distribution [approach]. High-rise toilets would be marketed in a very specific way. You end up having a product that's only suitable for high-rise and certain flow dynamics … they're just duplicating a different marketing/ distribution model to that of more versatile toilets. The regulations would sit in the background … saying that these toilets are only useful for these circumstances and have some fairly significant repercussions if they're supplied wrongly or advertised or marketed wrongly. It's about positioning the product to the right market. " **Andre Boerema, Sydney Water**

Jean Villani from the Plumbers Licensing Board in Western Australia raised a note of caution in relation to making assumptions about the plumbing in multi-storey buildings.

"A lot of multi-residential properties have long runs… [and] there's still generally a run from the stack through to the connection to the sewer because these multi-residentials are normally on a larger property … There might need to be a change to building design I would think and potentially the plumbing design as well for those sorts of things." **Jean Villani, Plumbers Licensing Board.**

5.4. What are the issues with raising the minimum standard for toilets in Australia?

Stakeholders were asked what issues could arise from raising the minimum standard for toilets in Australia through the WELS Scheme. Although no policy has been formulated in this area by WELS Regulator two possibilities were suggested to interviewees. These were the removal from sale of replacement 9/4.5L cisterns and the raising of the minimum standard for dual flush 6/3L toilets so that the maximum full flush would be 6 litres and maximum reduced flush would be 3 litres. The range of flushes for 6/3L toilets currently allows flush volumes above the figures of 6/3L (see Table 3 above).

Most stakeholders were positive about the prospect of raising minimum standards as a means of improving the overall efficiency of the toilet stock.

"The Department would be very supportive of raising the minimum standard. …However, before the Commonwealth and before the states will agree to an even higher minimum standard they want to be convinced that there is a net benefit to society of doing it. That is that in terms of water savings principally, and in terms of reducing bills for households." **Hans Wesseling, Department of Water and Energy NSW.**

In relation to the efficient appliance requirements in Western Australia's five star building code, Daniel Ellis-Jones noted:

"A lot of feedback and remarks that we've got back by talking to the community, industry and other government [agencies] is that [people] would prefer to see a lot of this water efficiency and energy efficiency occurring [through] ... the standards being raised so people just can't buy inefficient water and inefficient energy products out there." **Daniel Ellis-Jones Western Australian Department of Housing.**

The situation of small toilet manufactures was raised. John Brennan from WA Water Corporation mentioned that there are a number of small manufacturers who find it difficult to change production runs and therefore can't compete with bigger manufacturers. When the 5 star plus phase 2 building code modifications (requiring 4.5/3L toilets in WA) came into effect in September, a year's grace period was built in to allow local manufacturers to get into the market. These manufacturers used to produce 6/3L models only.

Specifically in relation to the removal of replacement 9/4.5L cisterns from sale, it was noted that this would mean consumers would be required to replace the entire toilet when a cistern broke on either an existing single flush or existing 9/4.5L toilet.

> *"I couldn't see there being anything significant in that. I mean not every toilet is extremely expensive. ….It doesn't take much to replace a system so I couldn't see there being that significant an impact. The only thing is I guess depends on the design of the plumbing system that already exists within that property*." **Jean Villani, Plumbers Licensing Board.**

> "*That means a lot of work for people out there. We estimate there are over 3 million single flush toilets still in the market, let alone 9/4.5 and 6/3 dual flushes. If you took all of them into account there'd be over 7 million – probably closer to 10 million. It depends how you exclude them from the market and what products they've got available to substitute that*." **Gary Workman, MPMSAA and Green Plumbers.**

> *"There is still a fair market for the 9/4.5L cistern, but we are getting close to removing it in the next couple of years*." **Stephen Movley, Institute of Plumbing Australia.**

6. POTENTIAL WATER SAVINGS

The potential water savings that could result from introducing more efficient toilet classes into Australia was investigated with a model of water demand due to toilets. The model projected demand out to 2050 based on the stock of toilets in Australia, total population, number of toilets per household, and toilet usage rate(s).

6.1. The toilet stock models

Central to the model are estimates of the historic, existing, and future stock of toilets in Australia. The toilet stock is characterised in terms of the various toilet classes. The stock model then tracks changes in this stock of toilet classes over time. In the model, toilet demand is therefore a function of proportion of each toilet class that remains in that given year. The installed stock is a function of new installations and the 'decay' in the stock of older installations over time.

The toilet stock

Until 1982, essentially all toilets in Australia were single flush classes with an average flush volume of 11 litres. In 1982, the first dual flush toilets (11/5.5L) were introduced. These were made mandatory in most states of Australia until 1988. In 1989, the 9/4.5L toilet class was introduced, and again made mandatory in most states of Australia. This pattern of introduction has been repeated for subsequent models. During this period the mandating of toilet efficiencies helped locally made toilets to dominate the market, as these were the only ones with sufficient efficiency at the time.

This pattern allows us to make some specific simplifying assumptions within the toilet stock model:

- All toilets are single flush until 1981-82
- All toilet sales between 1982-83 and 1990-91 are dual flush 11/5.5L
- All toilet sales between 1991-92 and 1994-95 are dual flush 9/4. L
- In 1995-96, there is a transition period when sales are 50% dual flush 9/4.5L and 50% dual flush 6/3L
- From 1996-97 to 2004-05, all toilet sales are dual flush 6/3L.

In 2005, the 4.5/3L toilet model entered the market, but was not made mandatory. An assumption about the sales breakdown between 6/3L and 4.5/3L is therefore necessary. According to Geoff Keogh, B&KS sells 60% 4.5/3L toilets and 40% 6/3L toilets. However, B&KS sell mainly to builders, and so he expects that retailers selling to home renovators would sell many more 6/3L models. Caroma (with the major market share in Australia) sell both 4.5/3L and 6/3L toilets.

It is possible then that sales of 4.5/3L are higher than sales of 6/3L models and that over time there will be an increase in sales of 4.5/3L toilets at the expense of 6/3L toilets. However, the issue of reduced drain line flows, especially with increasing levels of grey water reuse, may have an effect on the sales of 4.5/3L toilets.

Due to these complexities, a simplifying assumption has been made that sales will be divided equally between dual flush 6/3L and dual flush 4.5/3L from 2005-06 onwards.

Decay of toilets over time

The ABS provides data on the proportions of residential single flush and dual flush toilets (ABS 2004a). This means that we can readily model the total number of single flush toilets as a proportion of the total number of households. However, ABS does not provide data on the proportion of each type of dual flush toilet. To model the stock of each type of dual flush toilet, we start with the assumptions listed above and the observation that the stock of any type of dual flush toilet during its mandatory sale period can be calculated by subtracting the single flush stock and the sum of the dual flush stock remaining from previous years from the total toilet stock.

Next, we need to make some assumptions about the rate at which toilets are replaced over time. The toilet model uses a lifetime distribution model to estimate the probability of replacement of a toilet over time. It should be noted that the replacement of toilets occurs for many reasons, not only due to the end of a toilet's useful life, but also replacement due to renovations and alterations and additions. The lifetime distribution model can be any probability density function defined over the modelling period. The corresponding cumulative density function gives the proportion of the entire population of each toilet stock type replaced by a given year. A lognormal distribution function was found to be the best predictor of the decline in single flush ownership.

The final step in modelling the stock of each type of dual flush toilet is to assume that the decay of each type of dual flush toilet can be modelled using the same probability function identified for single flush toilets. This allows progressive calculation of the stock of each toilet type as it is introduced.

Flush volume by classes included in the model

The toilet demand model requires data on the average flush volume and number of flushes per day for each of the included toilet types. The average flush volumes used in the model are given in Table 4 and were taken from Roberts (2005), with the exception of the 4.5/3L flush, which is calculated based on the assumed ratio of 66.5% full flush to 33.5% half flush. Roberts (2005) also observed that the flush volume of single flush toilets is lower than the 11L rating (10.1L).

Table 4 Flush volumes for toilet classes incorporated in the toilet demand model

Toilet class	Flush volumes	Ratio of half to full flushes
Eleven litre single flush	10.1L Measured	-
Dual flush 11/5.5L	7.8L Measured	54:46 Measured
Dual flush 9/4.5L	7.1L Measured	45:55 Measured
Dual flush 6/3L	5.8L Measured	27:63 Measured
Dual flush 4.5/3L	4.0L Imputed	33.5:66.5 Assumed

Average flush volume in a given year

The average flush volume of a toilet is an important predictor of demand. It depends on the percentage mix of toilet types within the stock. That is, the average flush volume for all toilets is the weighted average of the flush volumes of all toilet types. For example, as the percentage of more efficient toilets increases in Australia, the average flush volume will decrease.

The toilet stock model predicts the percentage share of each toilet type. This is expected to be different for the residential and non-residential sectors and so each was modelled separately.

Percentage share of toilet classes

The stock of single flush toilets is the product of the percentage share of single flush toilets and the total stock of toilets, where the percentage share is a decay function that evaluates the proportion of the entire population of single flush toilets replaced by the year. The development of the decay function is described later in this section.

In 1982, the first dual flush toilet (DF 11/6L) was introduced, and was mandatory through until 1988. Therefore, for the period between 1982 and 1988 (the mandatory sale period), the stock of the DF 11/6L becomes the total stock of toilets minus the stock of single flush toilets.

In 1989, the DF 9/4.5L toilet was introduced, and made mandatory shortly thereafter. Thus, the stock of DF 11/6L begins to decay and is replaced by the DF 9/4.5L. The stock of DF 9/4.5L in each year during the mandatory sale period (that is between 1989 and 1992), becomes the residual stock.

The stock of DF 11/6L toilets is similarly the product of the percentage of DF 11/6L and the total stock of toilets.

In general, for all types of toilets during their respective mandatory sale period, the stock is the residual of the total stock, the single flush stock and the sum of the stock remaining from previous years.

As 6/3L toilets and 4.5/3L toilets are both being sold currently, when the 4.5/3L model was introduced it was only allocated 50% of toilet sales, with the remaining 50% assigned to the 6/3L model.

Toilet decay function

The toilet model uses a lifetime distribution model to determine the decay functions for single and dual flush toilets. This model predicts the probability that a toilet unit will be replaced over time.

The ABS report *Environment Issues: People's Views and Practices* (ABS, 2004) published the percentage of households in Australia with a dual flush toilet in 1998, 2001 and 2004. These percentages are used to determine the lifetime distribution model for single flush toilets in Australia.

A lifetime distribution model can be any probability density function defined over the range of time. The corresponding cumulative density function gives the proportion of the entire population of each toilet stock type replaced by the year. The real percentages (ABS, 2004) were used for calibration. A least squares difference analysis determined that a lognormal distribution function with a median lifetime of 34.6 years and a shape parameter of 0.09 gave the best fit with the actual ownership data. Based on this fit, the predicted proportion of single flush toilets for 2007 was 21%, which compared well with the value from the *Environment Issues: People's Views and Practices* ABS report for 2007 (19.1%). A recalibrating of the model using the extra data point made a negligible difference to the modelling results.

The predicted residential toilet stock from 1990 to 2050 is shown in Figure 5. The total number of toilets increases with the number of households. By 2050 there is predicted to be an equal number of 6/3L and 4.5/3L toilets. This is the case because an assumption of the model is that after the introduction of the 4.5/3L model, sales of these two models (6/3L and 4.5/3L) are equal (rather than all new toilets sold being 4.5/3L, because we know this is not the case now). When enough time has passed for all of the 6/3L models that were part of the toilet stock when the 4.5/3L was introduced to have been replaced, there will be equal fractions of each model in the toilet stock.

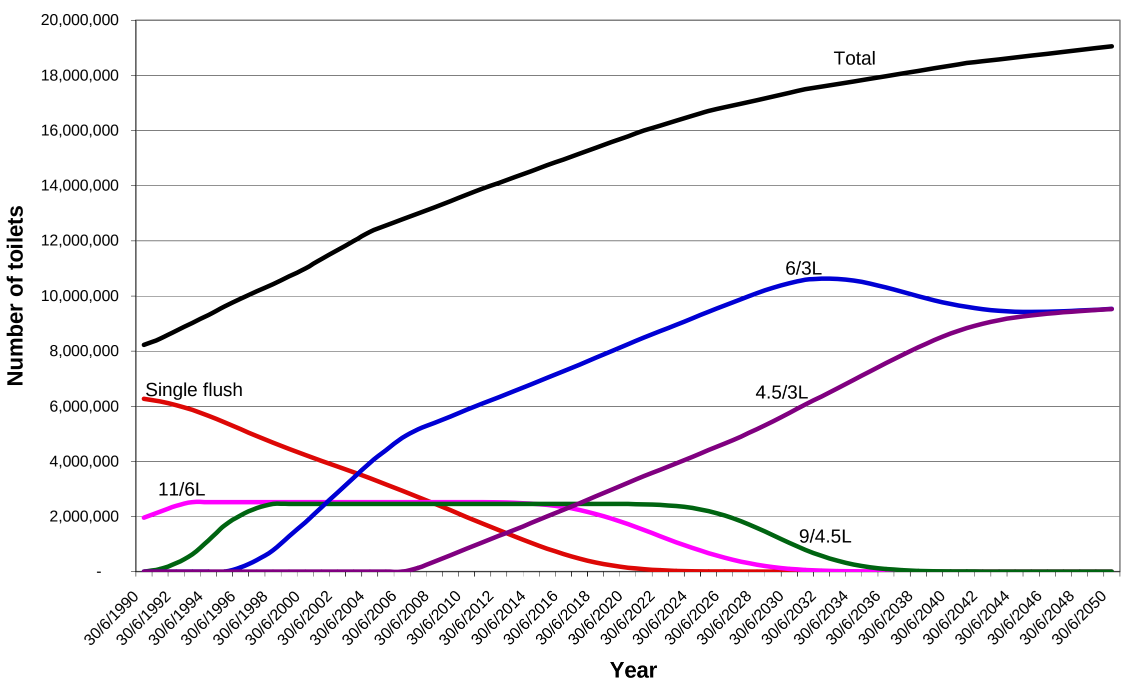

Figure 5. Base case predicted residential toilet stock.

Figure 6 shows the predicted percentage of each toilet type in use over time. The rate of decrease in the fraction of single flush toilets has been fitted to reflect the trend in ABS data on dual flush versus single flush residential toilets.

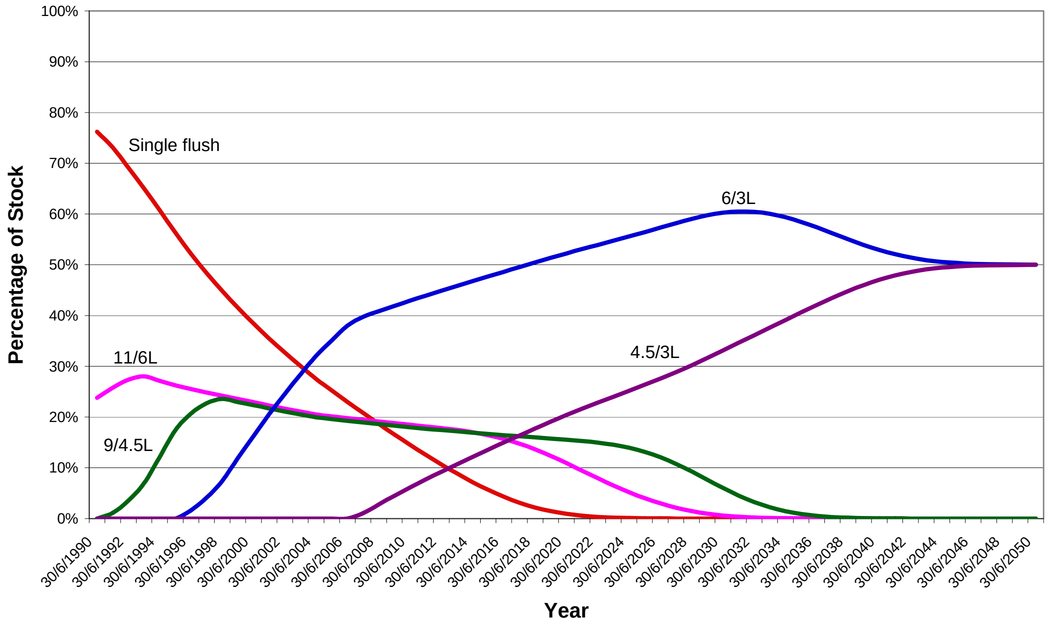

Figure 6. Base case residential stock breakdown.

Figure 7 shows the predicted average flush volume over the period 1990 to 2050. It can be seen that the average volume of water used per flush decreases by more than 4 litres over this time, stabilizing at 4.9L per flush (when the only remaining models are 6/3L and 4.5/3L, in equal proportions).

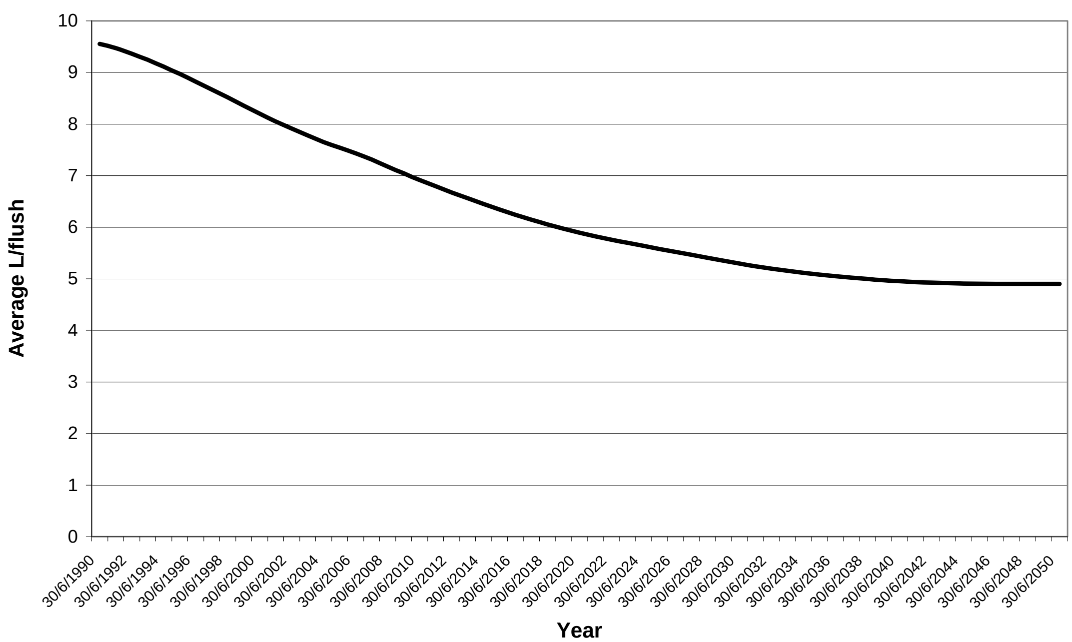

Figure 7. Base case predicted residential average flush volume.

The residential toilet stock model

Toilet water demand

Toilet demand for each year in the future depends on the total number people (population), the average number of times each person flushes a toilet in a year (usage) and the average volume of water used to flush a toilet (average flush volume).

Population

The residential toilet demand model requires time series data on the population of Australia and the average occupancy of households. These data were available in Australian Bureau of Statistics (ABS) publications for Australia. Historical population data were taken from Census figures (ABS 2006). Future projections were taken from ABS (2005). The number of households was derived from Australian Bureau of Statistics (ABS) (2004b) *Household and Family Projections, Australia, 2001 to 2026*, 3236.0 and (ABS 2001).

The same demographic data was used for the non-residential model. It was assumed that non-residential toilet flushes would grow at the same rate as residential toilet flushes (both at the same rate as the population).

Usage

The number of times toilets flush in each household per year (usage) is calculated from the average number of flushes per person per day. A set number of toilet flushes per person per day was chosen (7) and these were divided between the residential and non-residential models (3.8 flushes per person per day in the residential model, according to Roberts (2005) and 3.2 flushes per person per day in the non-residential model).

Toilet per household

The total stock of residential toilets for each year in Australia (stock) depends on the average number of toilets per household and the total number of households.

The average number of toilets per household increased from 1.4 (RMRC, 1993) in 1993 to 1.6 (Roberts, 2004) toilets per household in 2001. The ISF model assumes a conservatively low value of 1.6 toilets per household for future years.

Within the total stock of toilets, the toilet demand model identifies five different toilet types within Australia. Each type differs by the volume of water used for flushing. The next section will describe the method used to determine the percentage of each toilet type within the total stock of toilets.

The non-residential toilet stock model

In the absence of data on the number or type of non-residential toilets in Australia, the residential stock model was used as a starting point. It was assumed that growth in non-residential toilets would occur at the rate of population growth.

The non-residential toilet stock is believed to be on-average less efficient than residential toilet stock. To take this into account, the median lifetime of non-residential toilets was increased to 50 years. This means that the older, less efficient models remain in use for longer, and therefore the average flush volume of non-residential toilets is higher than for residential toilets.

As no data was available a number of factors were not included in the model. These include the installation of single flush toilets, commonly of the 6 litre class. Single flush toilets are known to exist in the non-residential toilet stock in some minor proportion. Many of these toilets are imported and their sources in the market place are varied. As no sales data could be sourced these toilets have not been included in the model.

The predicted non-residential toilet stock with time is shown in Figure 8. It can be seen from this figure that single flush toilets are predicted to remain as part of the toilet stock for a longer time than for the residential model (as are the less efficient dual flush models).

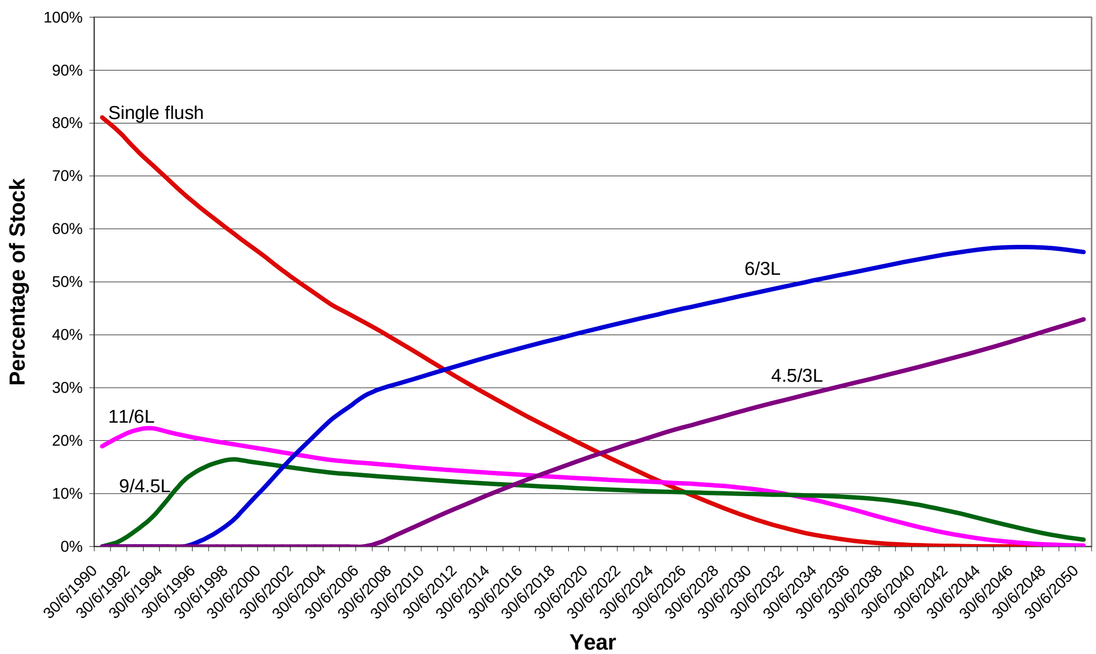

Figure 8. Base case non-residential toilet stock breakdown.

The predicted non-residential average flush volume over time is shown in Figure 9. As for the residential model, the non-residential average flush volume decreases with time as less efficient toilet classes are replaced.

Projected base case demand

A projection for total demand for water due to toilet flushing in Australia without further increases in toilet efficiencies is given in Figure 9. This demand represents the base case for the savings estimates below.

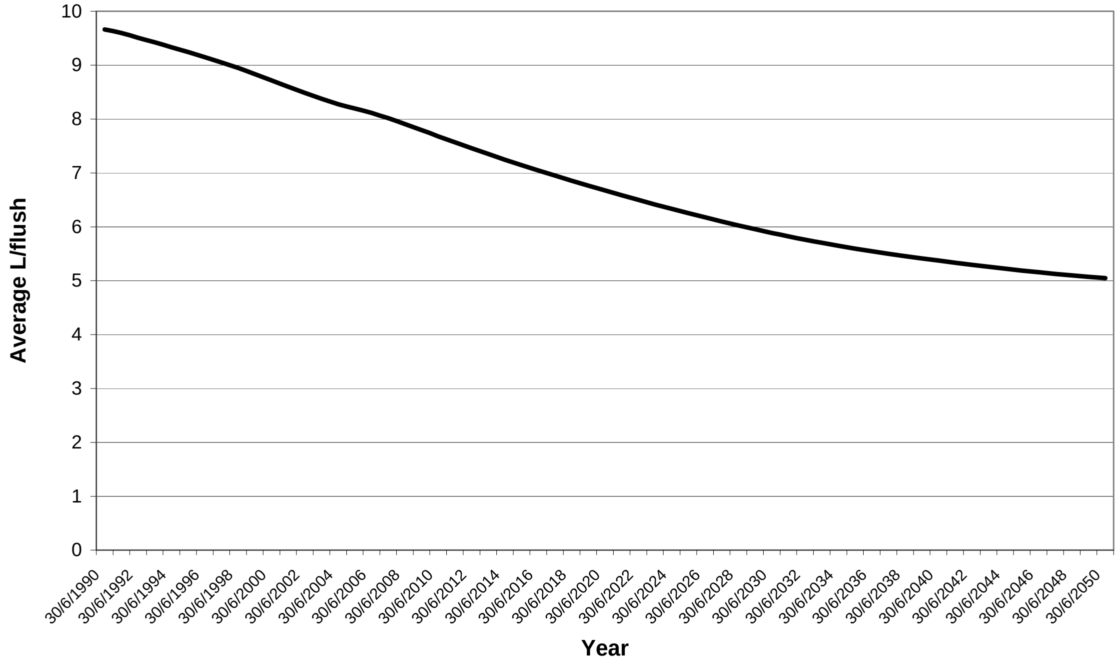

Figure 9. Base case predicted non residential average flush volume.

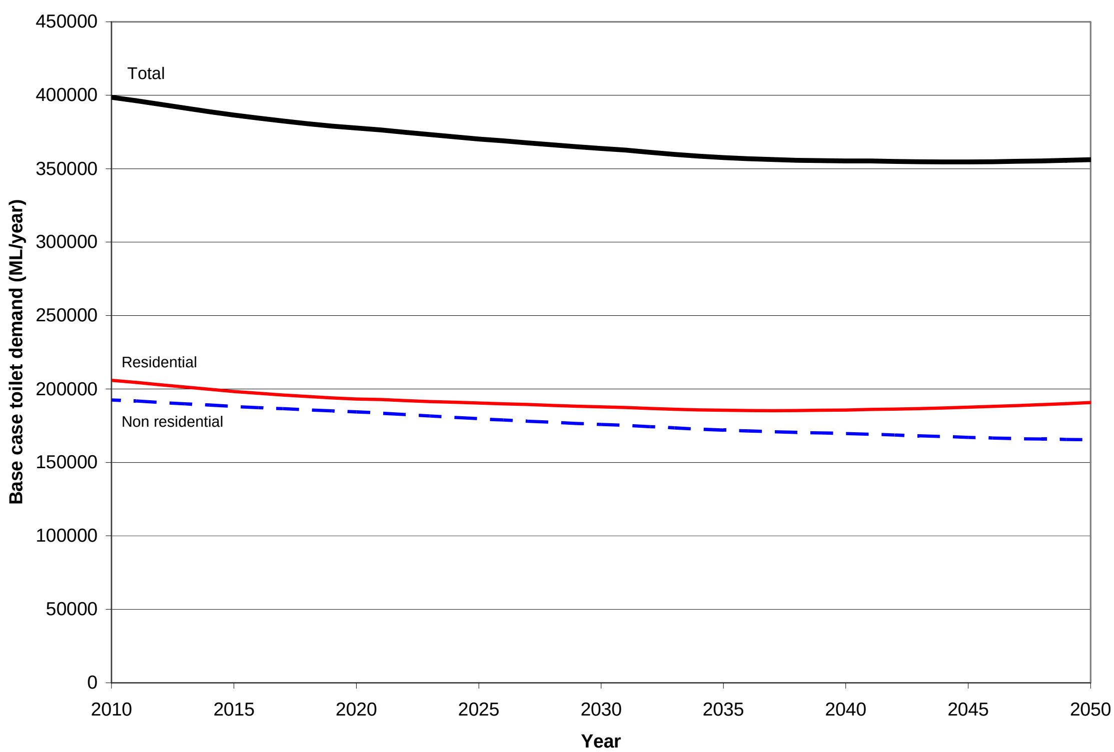

Figure 10. Base case projection of total water demand due to toilet flushing in Australia

6.2. Scenarios considered

The effect of the introduction of four new toilet classes was investigated using the toilet stock model. The possible classes modeled were air assisted flush: 4/2L dual flush, 3/2L dual flush, and urine separating toilets, with each scenario concerning the introduction of one of these classes.

Different years of introduction (ranging from 2010 to 2020) were investigated, as were different market shares. The models were given their market share gradually (20% of the eventual market share in the first year and an additional 20% in each subsequent year until the total assigned market share was reached). For example, a toilet model introduced in 2010 and assigned a market share of 50% was given 10% of the market in 2010, 20% in 2011, 30% in 2012, 40% in 2013, and 50% in 2014 and later years. The scenarios used for each toilet model are described below.

In general, optimistic market shares were investigated. This was to investigate the potential for water savings. More realistic water savings can be calculated from these savings by reducing the saving proportionally to the reduction in market share.

Air assisted flush

Of all the toilet classes investigated, the 'air assisted flush' (AAF) has the smallest flush volume with the Propelair model being the only design currently in that class. It is possible to install air assisted flush in the widest range of buildings (new and existing, residential and non-residential). However, it should be noted that air assisted flush toilets use energy as well as water for flushing (500J per flush or around 0.3 kg CO_2 per person per year, which is two orders of magnitude smaller than per person emissions for residential lighting).

Propelair air assisted flush toilets have a flush volume of 1.5 litres. Three market shares were investigated. Firstly, to see the maximum impact that this model could have on water use, the scenario where air assisted flush toilets eventually took 100% of the market was investigated. Three introduction dates were investigated for this market share – 2010, 2015 and 2020. As Propelair toilets are still in the prototype stage it may be optimistic to assume that they would be available for sale in large quantities in 2010.

The second air assisted flush toilets scenario investigated was where air assisted flush toilets took 50% of the toilet market, leaving 25% of the market for 4.5/3L and 25% for 6/3L. Introduction dates of 2010 and 2015 were investigated.

Finally, air assisted flush toilets replaced 6/3L, and so air assisted flush toilets and 4.5/3L were each given 50% of the market. Introduction dates of 2010 and 2015 were investigated.

4/2L dual flush

Some 4/2L models are already being used overseas and pass the various Australian Standards tests. The barrier to installation of this model in Australia is the inclusion of this class within the relevant standard. As discussed in section 5 above, this may well require Australian trials.

The average flush volume chosen for the 4/2L model was based on 66.5% of flushes being full and 33.5% being half (the same ratio of full to half flushes as was assumed for the 4.5/3L model), resulting in an average volume of 3.33 litres.

Two market share scenarios were investigated for this model. The first was that the 4/2L model replaced 6/3L models (and the sales of 4.5/3L models did not change). This was investigated for start years of 2010 and 2015.

The second market share scenario investigated was where the 4/2L model could only be installed in new buildings. This scenario was chosen because of concerns over the impact of reduced flows on existing plumbing. By only installing this model in new buildings, the pipe work could be designed to work with lower flows. This scenario was modelled by assigning the sales due to growth in the number of toilets to the 4/2L model and by sharing the other toilet sales equally between the 6/3L and 4.5/3L models. Start years of 2010 and 2015 were investigated.

3/2L dual flush

Like 4/2L toilets, some 3/2L models are already being used overseas. The barrier to installation of this model in Australia is the inclusion of it in the relevant standards, and this is assumed to be more significant for the 3/2L model than the 4/2L model because the flush volume is so low that it would be difficult for it to pass tests such as the solids discharge test in AS 1172.1.

The average flush volume chosen for the 3/2L model was based on 66.5% of flushes being full and 33.5% being half (the same ratio of full to half flushes as was assumed for the 4.5/3L model), resulting in an average flush volume of 2.67 litres.

The same market scenarios as for the 4/2L model were investigated, but start years of 2015 and 2020 were used instead of 2010 and 2015. This was to reflect the difference in readiness between the two models. There are already 4/2L models available that pass the tests required by the Australian Standards (1172 series), but 3/2L models may require more development to pass the same tests (if not actual revision of the Australian Standards).

Urine separating toilets

The average flush volume for urine separating toilets was based on a model with a large flush of 4L and a small (urine) flush of 0.2L. It was assumed that 50% of the population (males) using this toilet would use one large flush for every four small flushes but that the other half of the population (females) would always use the large flush (due to the tendency to flush paper following urination). This resulted in an average flush volume of 2.56 litres. Due to the assumption that females will always need to flush paper, and paper cannot be flushed using the small flush, this model of toilet only has water saving advantages over the 4.5/3L model when used by males. For this reason, the installation of urine separating toilets in the non-residential market was not investigated because a combination of 4.5/3L toilets and waterless urinals would have the same water saving potential.

The scenarios investigated for urine separating toilets were that they took all of the existing residential market share from 6/3L toilets or that they took half of this market share. Start dates investigated for the two scenarios were 2010 and 2015.

6.3. The results: How much water saving might be saved through the introduction of more efficient toilet classes?

The results for all of the toilet models and market share scenarios are summarized in Table 5. These give the cumulative water savings for each model compared are to the Base case are given for 2020 and 2050. As would be expected, delaying the introduction of each toilet model decreases the cumulative water savings for 2020 and 2050 (indeed models introduced in 2020 only accumulated a year of savings by the end of 2020).

The modelling results show for example if air assisted flush toilets were to start a process of replacing 50% of conventional flush toilets sales in the Australian market from 2010 that the resulting cumulative water savings could be 2244 GL by 2050. This would be roughly equivalent to 4.5 sydharbs[1] of water saved over a 40 year period. Such a scenario is however based on air assisted flush toilets being available and competitively priced by 2010 and capturing 50% of the Australian toilet market from 2020.

Table 5. Summary of cumulative water savings

	Cumulative savings (GL)	
	2020	2050
AAF, 100% market, 2010	267	4487
AAF, 100% market, 2015	65	3481
AAF, 100% market, 2020	1.2	2567
AAF, 50% market, 2010	134	2244
AAF, 50% market, 2015	32	1740
AAF, replaces 6/3, 2010	169	2837
AAF, replaces 6/3, 2015	41	2201
4/2 replaces 6/3, 2010	97	1630
4/2 replaces 6/3, 2015	20	1235
4/2 not existing buildings, 2010	60	762
4/2 not existing buildings, 2015	14	521
3/2 replaces 6/3, 2015	23	1551
3/2 replaces 6/3, 2020	0.5	1182
3/2 not existing buildings, 2015	20	740
3/2 not existing buildings, 2020	0.0	413
Urine sep. replaces 6/3 2010	74	1312
Urine sep. replaces 6/3 2015	18	1042
Urine sep. 25% market, 2010	37	656
Urine sep. 25% market, 2015	9	521

[1] One sydharb is the volume of one Sydney Harbour, which is approximately 500GL (2006 Australian Water Directory).

One scenario for each new toilet class has been compared in Figure 7 (showing average flush volumes for the residential market) and Figure 8 (showing average flush volumes for the non-residential market), Figure 9 (showing yearly water saving for the residential market) and Figure 10 (showing yearly water saving for the non-residential market). In these scenarios, all models are introduced in 2015. The 'air assisted flush toilets' scenario shown is the one where air assisted flush toilets take 50% of the toilet market (4.5/3L and 6/3L share the other half of the market equally). The 4/2L and 3/2L scenarios included are those where these models are only installed in new buildings. The urine separating scenario chosen is the one where this model takes half of the 6/3L sales (6/3L takes 25% of the market and 4.5/3L takes 50%).

It can be seen from Figure 7 that the introduction of air assisted flush toilets has the greatest impact on the average flush volume, reducing the average flush volume in the residential market by around 1.6L per flush by 2050. The corresponding predicted reduction in average flush volume for the other models investigated was around 0.5L/flush.

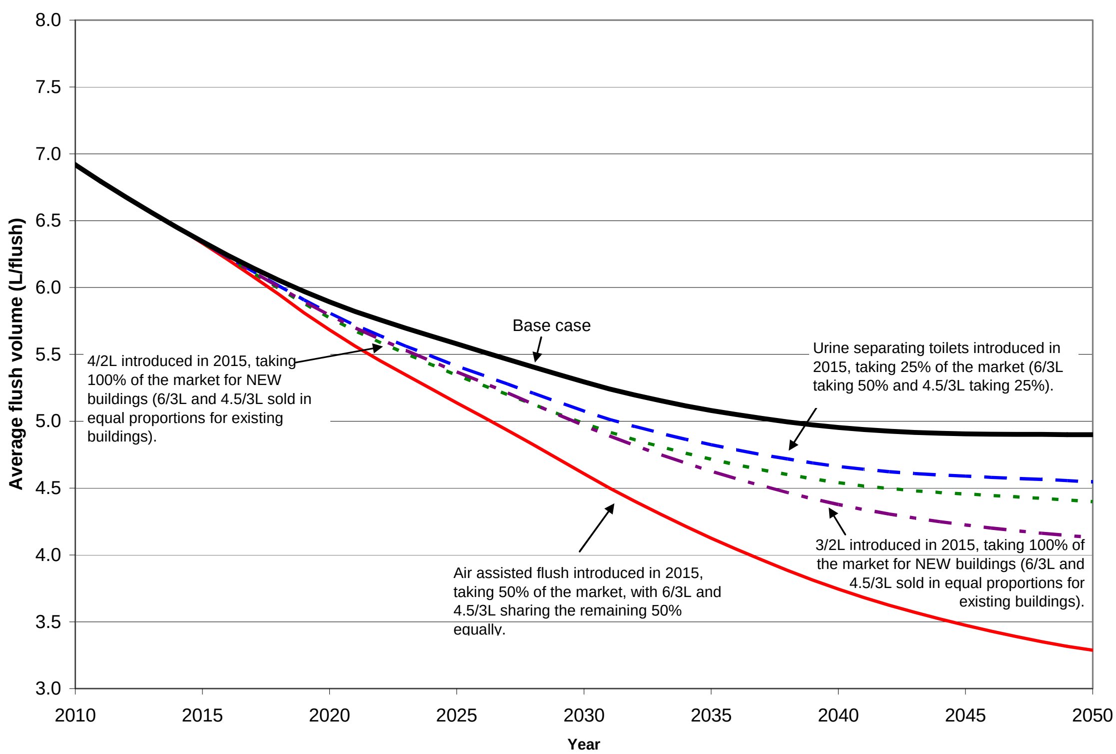

Figure 7. Comparing predicted average residential toilet flush volumes for different toilet scenarios.

From Figure 8 it can also be seen that air assisted flush toilets have the largest impact on average flush volumes in the non-residential case. The predicted reduction in flush volumes by 2050 due to the new toilet models is lower in the non-residential case than in the residential case and this is because the toilet life in the non-residential model is larger, and so it takes longer to replace the same fraction of toilets.

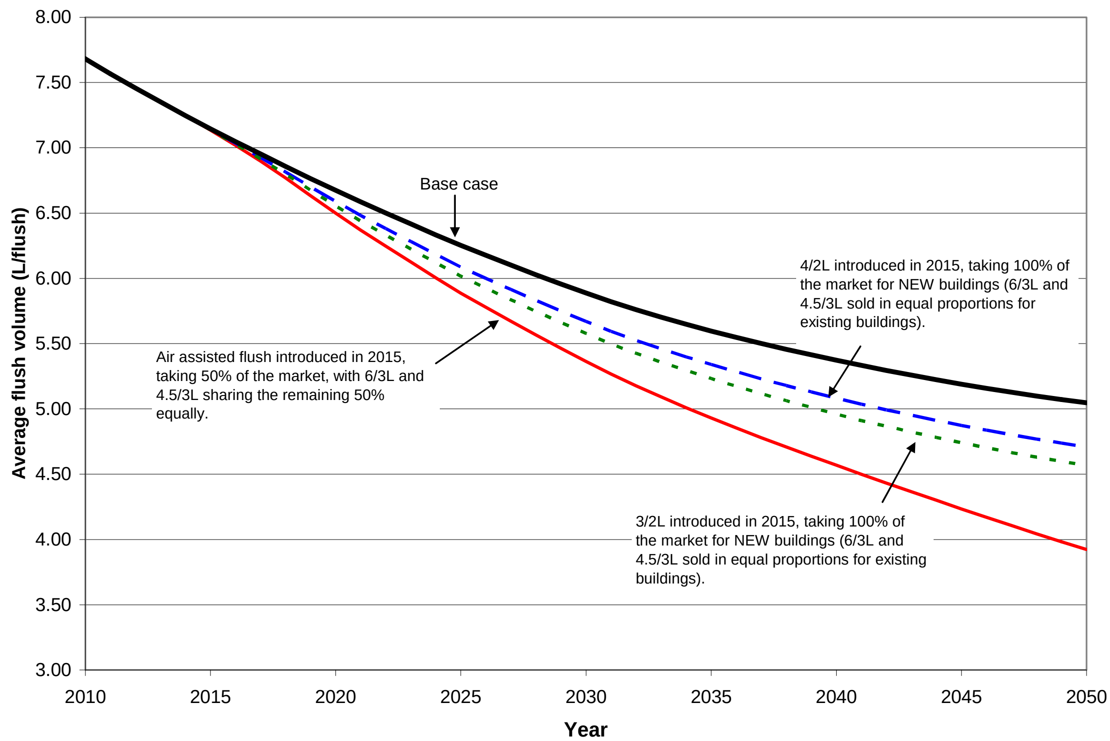

Figure 8. Comparing predicted average non-residential toilet flush volumes for different toilet scenarios.

Figure 9 and Figure 10 translate the predicted effect on average flush volume into water savings for the same toilet models and scenarios. In Figure 9 it can be seen that by 2030, savings ranging from 8 to 25 GL per year are predicted for the toilet models in the residential market, while Figure 10 shows that the predicted savings in 2030 range from around 7 to 15 GL per year (note that the urine separating model is not included in the non-residential modelling).

The predicted savings shown in Figure 9 and Figure 10 depend on the assumptions made about uptake rate and on the assumed flush volumes. However, by considering the suitability of the toilet models for existing plumbing systems and markets, and by considering the relative flush volumes, it would be possible to come up with the same ranking of models in terms of predicted savings without having to put numbers to average flush volumes and market share.

The impact of the projected water savings on the total water demand due to toilets in Australia is shown in figure 11. This is the combined both residential and non-residential demand projections.

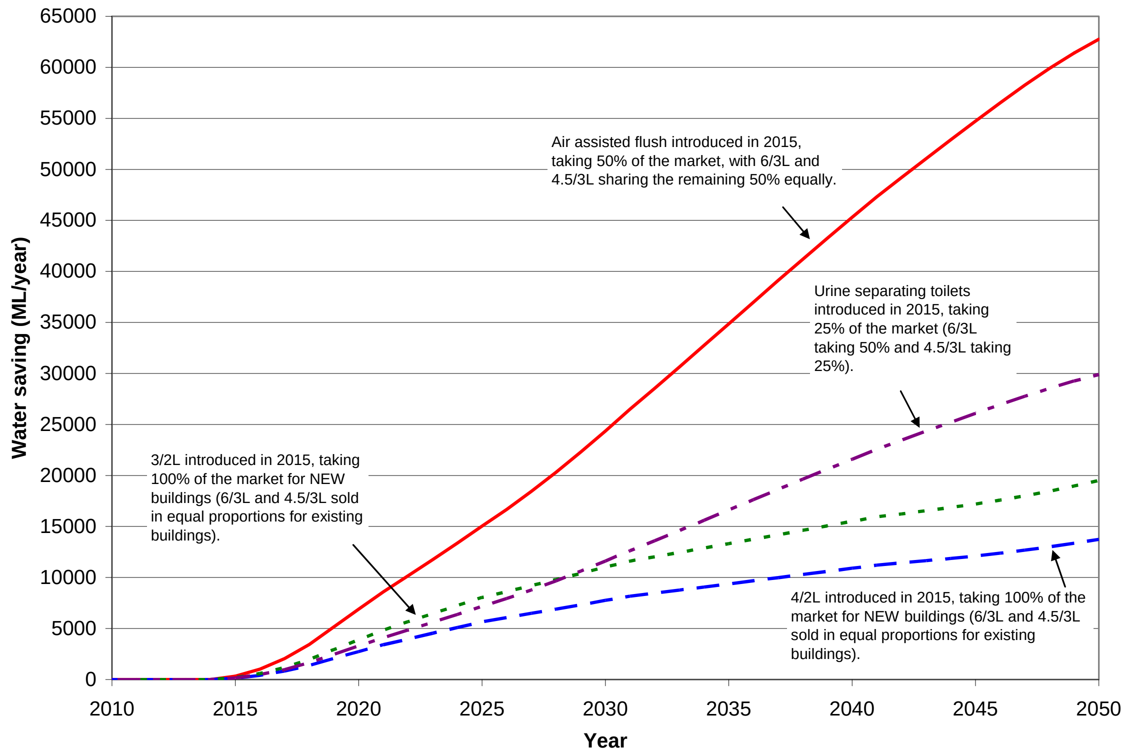

Figure 9. Comparing predicted residential water savings for different toilet scenarios.

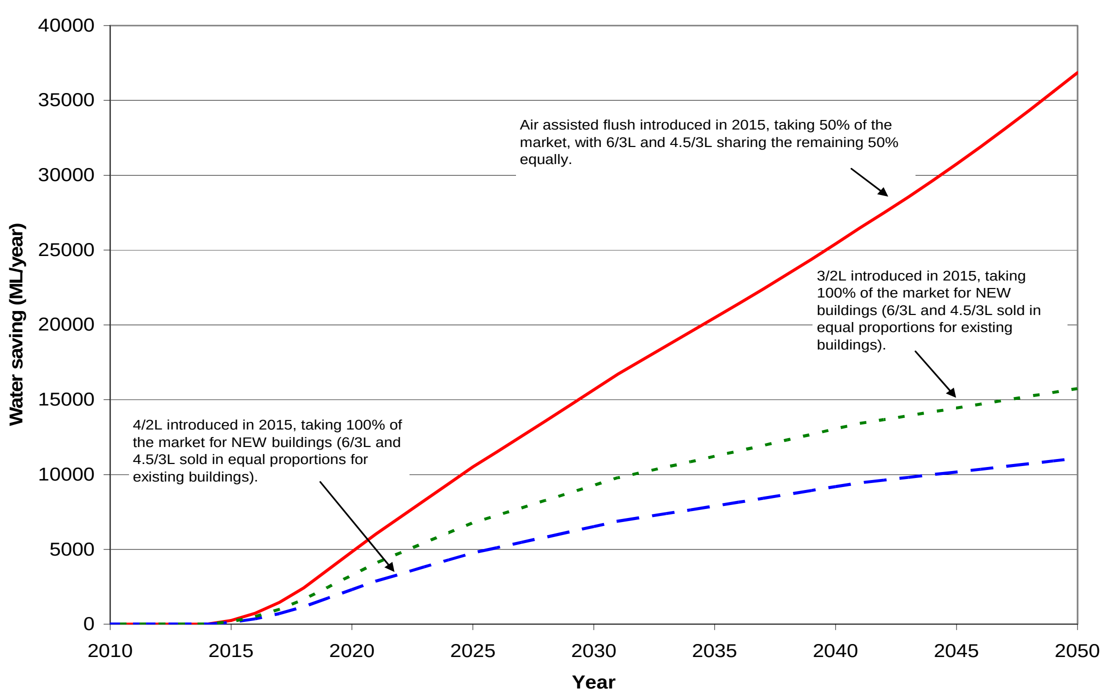

Figure 10. Comparing predicted non-residential water savings for different toilet scenarios.

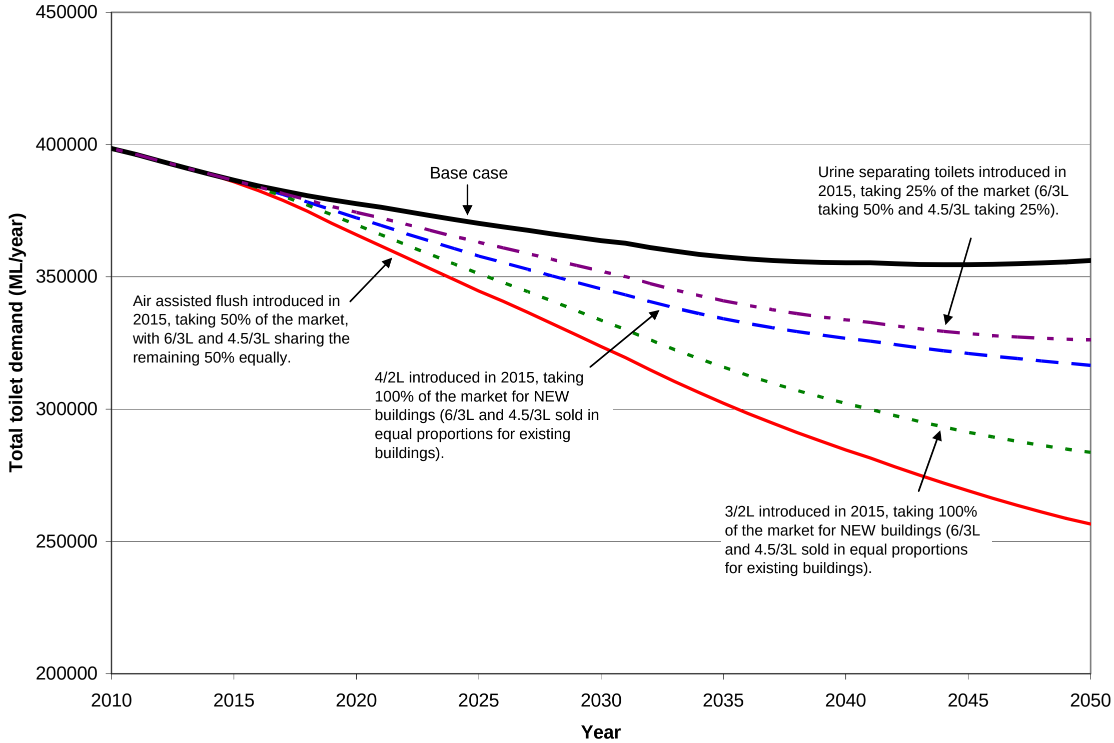

Figure 11. Comparing projected total demand from the various scenarios.

Projected water savings by region

Tables 6 and 7 shows how the projected water savings for the selected scenarios could expect to be allocated within the metropolitan regions across Australia.

Table 5. Projected water savings in 2020 by region

	Saving (ML/year)			
City	AAF	4/2L	3/2L	Urine sep.
Sydney	2395	1032	1465	671
Melbourne	2089	900	1279	585
Brisbane	1186	511	726	332
Adelaide	587	253	359	164
Perth	927	400	567	260
Hobart	106	46	65	30
Darwin	70	30	43	20

Table 7. Projected water savings in 2050 by region

	Saving (ML/year)			
City	AAF	4/2L	3/2L	Urine sep.
Sydney	19823	4941	7018	5951
Melbourne	17831	4444	6313	5353
Brisbane	11854	2955	4197	3559
Adelaide	4283	1068	1516	1286
Perth	8667	2160	3068	2602
Hobart	797	199	282	239
Darwin	797	199	282	239

Factors impinging on modelling results

A number of assumptions were required in the modelling so that potential water savings estimates were possible. The ratio of toilets to people was assumed to remain constant at 2004 levels until 2050, toilet leakage was not taken into account in the model, and for the base case, new toilet sales were assumed to be equally distributed between 4.5/3L and 6/3L models. For the non-residential model it was assumed that the percentage growth in toilets would be the same as for the residential market, and the toilet lifetime was 15 years longer on average than for the residential market (this thereby made the predicted average flush volume for the non-residential toilet stock higher than that of the residential toilet stock, which matches observations). It was also assumed that females would use urine separating toilets in a manner very similar to conventional toilets and therefore the full potential water savings would not be achieved.

The model currently assumes a constant ratio of toilets to people. Increases in the number of toilets per person in new residences will affect the toilet stock, increasing the number of new toilets sold in a particular year. This will then act to decrease the average predicted flush volume of the toilet stock as a whole. However, as toilet sales are around 3% of the total toilet stock each year, this slight difference between the assumed and actual toilet sale would have negligible impact on the predicted average flush volume for the toilet stock.

Leakage from toilets makes a significant contribution to total household leaks, but this was not taken into account in the modelling. Leakage would only affect the predicted water savings if the new toilet models leaked at different rates to the existing toilet models. No evidence for this exists either way.

The assumed market share of 4.5/3L and 6/3L toilets that was used in the model will affect the base case predicted water consumption and therefore the prediction of potential savings. If the future sales of 4.5/3L toilets are higher than 50%, then the estimated water savings for some scenarios may be somewhat over estimated.

If growth in the number of toilets in the non-residential market is not proportional to the rate in the residential market then this will have an impact on the predicted average flush volume for the non-residential market. However, for this impact to be at all significant, the growth rates would have to be much larger than predicted rates (which are around 3%). If the assumed non-residential toilet lifetime of 50 years was found to be significantly incorrect, this would have a larger impact on the predicted average flush volume, and consequently on the predicted savings. The predicted savings would increase as the average toilet life decreased (due to the faster turnover rate of toilets meaning that a higher proportion of existing toilets would be replaced with more efficient models).

Finally, it was assumed that females will use urine separating toilets in the same manner as conventional toilets, so that the urine flush will be accompanied by flushing of paper (requiring a full flush). If the paper was disposed of differently (put in a bin for example) then when urine was flushed, there would not need to be a full flush and the savings due to urine separating toilets would be higher than predicted by the model.

Energy use

Air assisted flush toilets has the smallest flush volume of all the toilet models investigated, but also require energy in their operation. The significance of this amount of energy depends on the source of water for toilet flushing (potable, rainwater, grey water), and how much energy is used to provide it to the consumer (treatment and pumping energy).

Were the carbon intensity of Australia's electricity sector to remain at current levels until 2050 this would result in cumulative carbon dioxide emission of 120 thousand tonnes for the 100% market share scenario (when introduced in 2015). This is based on Australia's average carbon intensity of generation of 841 g CO_2/kWhr (UNFCCC, 2007).

Critically however this does not account for the energy and related carbon emissions savings that would result from the water savings themselves. Water supplied to residential and non-residential customers involves energy use in treatment and transport.

For the same scenario, using an average energy intensity of water supply of 400 kWh/ML, the resultant reduction in emissions arising from water savings would be approximately 1.2 million tonnes up to 2050. These savings in the energy used in water supply are an order of magnitude greater that the energy used by the toilets.

It is also worth noting that Australian generation capacity is likely to be transformed by 2050 to have a significantly reduced carbon intensity compared to the present.

Estimates of the cost effectiveness of water savings

In estimating the cost effectiveness of water savings from introducing more efficient toilet classes various costs need to be considered. These costs will vary between classes and include both regulatory compliance cost and any additional costs of manufacturing or installing particular models of efficient toilets. The costings below represent rough estimates only.

<u>Air assisted flush</u>

Air assisted flush toilets currently exist in a pre-production state only. The Propelair company estimates that once production begins the cost of their unit will cost more than conventional toilets in the UK. This will also be more than the cost of a current dual-flush toilet in Australia. While the price differential between current dual-flush toilets and air assisted flush toilets could be expected to narrow over time, a substantive difference is likely to remain.

Considering only the price differential per unit and assuming that this is $300 between an air assisted flush toilet and a new dual-flush 4.5/3L dual flush toilet, then the levelised[2] unit cost of the water saved in a standard residential setting (with 1.6 people per toilet) would be around $3.90 per kilolitre. As is illustrated in table 8 below, such water savings would not be considered particularly cost effective. If the cost differential between an air assisted flush and a dual-flush 4.5/3L toilet were only $150 then the levelised unit cost of the water saved would drop to about a $2.00 per kilolitre in the average residential setting.

As well as this additional cost per unit, as described in section 4.3, Australian trials would almost certainly be required before air assisted flush toilets could be introduced into Australia. Also as described in section 4.3, a number of regulatory and standards related requirements would need to be met. There is likely to be a significant upfront cost for Australian trials, the development of a new air assisted flush toilet Australian standard, revision of existing standards (the WELS standard [AS 6400], the technical specification standards [AS 5200 series] for WaterMark, and drainage Standards [AS 3500 series]), and subsequent registration under the WELS and WaterMark schemes. The impact of these upfront costs on cost effectiveness would vary depending on the number of air assisted flush toilets sold in Australia. If a significant market share is assumed (as in the scenarios modeled above) then the impact of the upfront cost would be in the order of a few cents per kilolitre overall.

<u>4/2L dual flush</u>

There is no reason to assume any cost differential between a new dual-flush 4.5/3L dual flush toilet and a new dual-flush 4/2L dual flush toilet. The cost associated with introducing 4/2L toilets into Australia would therefore principally be in relation to having existing models from overseas accredited under the WELS and the Watermark schemes (as described in section 4.2 above) and the marketing required to attain market share.

Considering only a compliance cost of several million dollars for introducing 4/2L toilets, the cost effectiveness of water savings for the scenario were 4/2L are introduced into new buildings from 2010 would be around 2 cents per kilolitre. If costs for compliance and marketing ran to several tens of millions, the levelised cost of water saved for the scenario might be in the order of $0.20 per kilolitre.

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[2] The levelised unit cost of water ($/kl) is calculated as the net present value of additional costs over the net present value of the water saved. Calculation is over the life time of the toilet or to 2050 and a discount rate of 7% has been applied.

3/2L dual flush

Estimating the cost effectiveness for water saved by a 3/2L dual flush toilet is premature. If such a model is technically feasible a significant research and development efforts would be required to develop a commercially viable toilet model in this class.

Urine Separating toilets

There may well be a cost differential between a new dual-flush 4.5/3L dual flush toilet and a urine separating toilet because of the additional requirements of the urine separating bowl. Further, the cost of plumbing urine separating toilets is expected to be higher than for existing toilet models, due to the extra work involved in plumbing an extra line from the toilet to the drain (one line is required for the full flush and one for the urine flush).

If the total price differential were approximately $50 then in a standard residential setting (with 1.6 people per toilet) the cost levelised unit cost of the water saved would be around $1.30 per kilolitre. This figure would not include any compliance and marketing costs.

Comparison of cost effectiveness

Table 8 compares the cost effectiveness of more efficient toilet models to other water saving measures as well as water supply alternatives.

The table shows that the introduction of 4/2L toilets has the potential for highly cost effective water savings if it were introduced into all new buildings.

The table shows that the cost effectiveness of the residential installation of air assisted flush, in particular, does not compare very favourably with the other water savings options. It also shows that the installing urine separating instead of 4.5/3L toilets may be cost effective but would not be as cost effective some other water savings initiatives.

However, it must be remembered that average residential toilet usage has been assumed for the cost effectiveness calculation of air assisted flush and urine separating toilets. The cost effectiveness of these toilet classes would be higher if they were used only in those residential installations where heavy utilisation was anticipated (it is common that one or two toilets in a household will receive the majority of usage). Also, if used in non-residential buildings, the usage per toilet may be orders of magnitude higher than the average residential situation (due to a higher number of people accessing them). In either of these situations the cost effectiveness of installation of air assisted flush and urine separating toilets could be expected to increase proportionally with the increased usage.

Table 8. Cost effectiveness estimates for water supply and conservation options.

Options	Approx. levelised unit cost ($/kL)
Scenario - introducing 4/2L toilets for new buildings	$0.02 -$0.20
Outdoor water efficiency [a]	$0.10 – $0.20
Indoor water efficiency (shower head exchanges, rebates, and retrofits) [a]	$0.50 – $0.60
Installing urine separating instead of 4.5/3L (in the average residential setting)	$1.00-$2.00
Scenario - air assisted flush replace 6/3L in the Australian market	$1.40-$2.80
Desalination [c]	$1.19-$2.55
New storage [b]	$1.26-$3.58
Installing air assisted flush instead of 4.5/3L (in the average residential setting)	$2.00-$4.00
New recycling schemes in Sydney [d]	$1.00 – $5.50
Residential Raintank [a, b]	$3.00 - $4.00

a Estimate from Review of the Metropolitan Water Plan (2006).

b Estimate from Review of Water Supply-Demand Options for South East Queensland (2007).

c Minimum from WA Water Corporation desalination media release (The Perth Seawater Desalination Plant, April 2005) and maximum from Review of Water Supply-Demand Options for South East Queensland (2007).

d Committed and approved recycling schemes in the review of the Sydney Metropolitan Water Plan (2006).

7. CONCLUSIONS AND RECOMMENDATIONS

Since the introduction of dual flush in the early 1980's, the water efficiency of toilets in Australia has increased massively. The average flush volume of a toilet sold today is about half of what it was 25 years ago. Even without the introduction of more efficient toilet classes, the average flush volume of toilets in Australia can be expected to decrease over time for many years to come.

Despite the impressive gains in water efficiency to date, the potential for further gains is worth considering. In one scenario modelled in which air assisted flush toilets grew to 50% of the market, for example, the annual estimated water saving in 2050 was 20GL in Sydney and 18GL in Melbourne. There is also almost certainly a ready market for more efficient toilets in Australia as long as the cost differential of new model is not to high in comparison to current models.

While some opportunity certainly exists for more efficient toilet classes, one of the overarching themes of the conversations with stakeholders was that for a toilet to be truly efficient, it must not only have a low flush volume, it must also work properly. This means that all aspects of a toilets performance need to be considered, not solely carriage but also user interactions, including aesthetics.

A second theme in of many conversations with stakeholders was the need to take a 'systems' perspective on the operation of low flush toilets. This means extending the consideration beyond the cistern and pan and considering the issue of the drain line configuration and also taking into account the user and ancillary factors (e.g. paper use, paper type).

It is significant that all the more efficient toilet classes identified and considered in this study would require at least minor behaviour change from a proportion of users if water savings are to be maximised. Introducing certain new toilet classes would also require a change in practice from plumbers.

Urine separating toilets would require the most change, with the behaviour of both male and female toilet users affected, if water savings are to be optimised. For these toilets to work effectively it is desirable that male users sit down for all visits. Likewise, the water savings from a urine separating toilet are maximised if female users were to use a bin for disposing of toilet paper after urinating (noting that such behaviour change was not assumed in the modelling in section 5). Plumbers would also need to change their practice as only certain piping materials can be used when plumbing in the urine line from a urine separating toilet.

It was indicated by one manufacturer that the 3L 'half' flush is necessary because of certain user behaviour (large volumes of toilet paper used in some public toilets). A 4/2L toilet class would face this issue and may not be suitable for public toilet installations. Alternatively education about the level of toilet paper usage and type of paper used may be needed. Air assisted flush toilets also rely on (minor) behaviour change with users required to always close the lid before flushing. It is worth noting, however, that the move from single to dual flush toilets also required behaviour change from users so such change is not unprecedented.

Drain and sewer carriage were raised as possible issues by many stakeholders. However, carriage is affected as much by wastewater flows from other fixtures as the toilet flush volume. The proposed study by Jeff Clark from SA Water that will explore what the limits are in terms of minimising flush volumes could provide useful data on this issue. The way the toilet market moves forward in terms of water efficiency over the next five to ten years is likely to be affected by the outcome of such studies. If the results of this and other studies suggest that lower flush volumes are possible then this will assist the market move towards lower water use models.

7.1. Recommendations:

Recommendations in relation to the WELS scheme:

1) Straightforward information about the actual requirements of registering a toilet under WELS should be easily accessible. In particular, the flow-on implications of having to meet WaterMark certification and Australian toilet standard (AS 1172.1 and AS 1172.2) requirements should be stated explicitly.

2) Consideration needs to be given to providing accessible and straightforward information about the various Standards and their interrelationships. This includes the WELS standard (AS/NZS 6400:2005), the toilet standards (AS 1172.1 and AS 1172.2), the Plumbing and Drainage standards (AS 3500 series) and the Australian Technical Specifications (AS 5200 series) which incorporate WaterMark certification requirements.

3) The creation of hybrid toilets with water-efficient cisterns but inappropriate pans has a number of negative effects. These include: poor customer satisfaction due to poor performance, increased water use through multiple flushing, and a damaging impact on the reputation of water-efficient toilets.

Some stakeholders recommended that low flushing toilets models, including current 4.5/3L models, should be sold as complete suites only. This could be achieved by restricting the WELS rating of toilet pans, so that pans not sold as part of a whole toilet suite can not get a WELS rating. This would ensure that new hybrid toilets were not created and installed.

Whether replacement cisterns might still be WELS rated and thereby be sold separately would need to be considered.

4) The proposal to increase the minimum standard for toilets, particularly the removal of the 9/4.5L class, was on balance positively received by stakeholders. It is recommended that this proposal be taken further and the cost and benefits be assessed.

5) The current formula for calculating the average flush volume for toilets should be reconsidered in the light of studies such as Roberts (2005) which show significantly different ratios of full flush to reduced flush than the currently used 1:4 ratio. An analysis of the flush ratio should be a part of any federally funded trial of existing or more efficient toilet classes.

6) It is recommended that a study address the question of opportunities and barriers to alternative toilet technologies (dry and composting toilets and vacuum systems) that were outside the scope of this study. It is possible, particularly in the mid to long term, that these may become a more significant component of the toilet market in Australia.

As non-renewable resources are depleted globally it is possible that moves to nutrient capture and reuse may drive such as change.

Recommendations in relation to the Australian Standards applying to toilets:

7) To facilitate the introduction of more efficient flush toilets, the Australian Standards for toilets and their installation should look at moving to a more 'systems approach'. This might mean that certain types of toilets could mean the standard but only be installed in certain situations with their installation meeting particular criteria on drain line slope and length. It might also involve specifying different requirements for various types of very low flush toilets and reflecting this within both the technical standards and the plumbing standards.

8) The WS-032 and WS-003 committees should also consider changing the structure of the toilet standards to include technical based maximum, minimum and average flush volumes for toilets, so that rather than including toilets in AS 1172.2 according to class, they are included according to a greater number of more specific performance criteria (as occurs in some international toilet related Standards).

9) That there be a greater level of transparency in relation to the membership, recruitment of members, and operation of the Standards Committees. This should include a contact email address for current members
(for example, ABCB_WS-032@standards.org.au).

10) The provision of Federal Government grants for partially funding of studies of what the limits are in terms of minimising flush volumes for toilets, and for trials of new classes of water saving equipment (including toilets) in Australia.

11) A review of the tests included in the Australian toilet standards to ensure that these are excluding inadequately designed toilets with poor performance within existing classes. Various stakeholders provided anecdotal evidence to the effect that not all low flow toilets models were performing to the same standard in the field.

12). Documentation be developed of what was done in the past to add new toilet models to the toilet standard (and any other relevant standards changes that were made). Details should be given on the way trials were conducted. This will help manufacturers of new models provide the required evidence of adequate performance.

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APPENDIX A: KEY REGULATION AND STANDARDS

AS/NZS 6400:2005: *Water efficient products-Rating and labelling*

AS 1172.1-2005: *Water closets (WC) – Pans*

AS 1172.2-1999: *Water closet pans of 6/3 L capacity or proven equivalent – Cisterns*

AS 5200.000-2006: *Technical specification for plumbing and drainage products - Procedures for certification of plumbing and drainage products*

ATS 5200.020-2004: *Technical Specification for plumbing and drainage products - Flushing valves for water closets and urinals - for use with mains supply*

ATS 5200.021-2004: *Technical Specification for plumbing and drainage products - Flushing valves for water closets and urinals - for use with break tank supply*

ATS 5200.030: *Technical Specification for plumbing and drainage products - Solenoid valves*

AS/NZS 3500.2:2003: *Plumbing and drainage – Sanitary Plumbing and drainage*

APPENDIX B: ORGANISATIONS REPRESENTED ON RELEVANT STANDARDS AUSTRALIA COMMITTEES

The organisations currently (December 2007) represented on the WS-032 committee responsible for the WELS standard (AS/NZS 6400:2005) are:

Australian Building Codes Board

Australian Electrical and Electronic Manufacturers Association

Australian Industry Group

BRANZ

Building Officials Institute of New Zealand

CSIRO Manufacturing & Materials Technology

Co-opted Member

Consumer Electronics Suppliers Association

Consumers' Federation of Australia

Department of Land and Water Conservation NSW

Department of Natural Resources and Water (Qld)

Department of Sustainability and Environment (Victoria)

Department of the Environment, Water, Heritage and the Arts (Federal)

Joint Accreditation System of Australia and New Zealand

Master Plumbers Association of NSW

Master Plumbers Australia

Master Plumbers, Gasfitters and Drainlayers New Zealand

Ministry for the Environment New Zealand

National Association of Testing Authorities Australia

National Plumbing Regulators Forum

New Zealand Engineering Federation

New Zealand Water & Waste Association

Plumbing Products Industry Group

Property Council of Australia

Queensland Brassware Industry Advisory Panel

South Australian Water Corporation

Victorian Water Industry Association

Water Services Association of Australia

The organisations currently (December 2007) represented on the WS-003 committee responsible for the toilet standards (AS 1172.1 and AS 1172.2):

- Association of Accredited Certification Bodies
- Australian Chamber of Commerce and Industry
- Australian Industry Group
- Brisbane Water
- Local Government New Zealand
- Plastics and Chemicals Industries Association Incorporated
- Plumbing Products Industry Group
- Testing Interests (Australia)
- The Institute of Plumbing Australia
- Water Corporation Western Australia

The organisations currently (December 2007) represented on the WS-014 committee responsible for the Plumbing and Drainage standards (AS 3500 series):

- Association of Accredited Certification Bodies
- Association of Hydraulic Services Consultants Australia
- Australian Industry Group
- Building Officials Institute of New Zealand
- Department of Justice (Tasmania)
- Department of Planning and Infrastructure (NT)
- Master Plumbers, Gasfitters and Drainlayers New Zealand
- National Association Sanitary Plumbing and Drainage Contractors
- Plastics Industry Pipe Association of Australia
- Plastics New Zealand
- Plumbers, Gasfitters & Drainlayers Board
- Plumbing Industry Commission

- South Australian Water Corporation
- Sydney Water Corporation
- Water Services Association of Australia

The Standards Committee that is responsible for the Australian Technical Specifications (AS 5200 series) is the WS-031 committee. The membership of this committee is:

- Association of Accredited Certification Bodies
- Australian Electrical and Electronic Manufacturers Association
- Australian Industry Group
- Australian Stainless Steel Development Association
- BRANZ
- Building Officials Institute of New Zealand
- CSIRO Manufacturing & MaterialsTechnology
- Certification Interests (Australia)
- Chair WS-014
- Consumer Electronics Suppliers Association
- Copper Development Centre - Australia
- Gas Appliances and Services Association
- Independent Chairperson
- Master Plumbers Australia
- Master Plumbers and Mechanical Services Association of Australia
- Master Plumbers, Gasfitters and Drainlayers New Zealand
- National Fire Industry Association
- National Plumbing Regulators Forum
- New Zealand Water & Waste Association
- Plastics Industry Pipe Association of Australia
- Plumbing Industry Commission
- Plumbing Products Industry Group
- South Australian Water Corporation
- Water Services Association of Australia