# Shower-Based Water Savings

# Flow Rate vs. Duration vs. Volume

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Maximum Performance

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# HOW SHOWERHEAD FLOW RATES IMPACT SHOWER DURATION AND VOLUME

## 1.0 Introduction

Two of the most important residential water demand studies in North America are the 1999 and 2016 Residential End Uses of Water Studies (REUS1999 and REUS2016) completed by Aquacraft, Inc.[1] These two studies data logged water use in a large number of single-family homes[2] across the USA and Canada to quantify the volume associated with each individual water use within the home.

The 1999 report[3] identified an average indoor water demand of 69.3 gallons per capita per day (gpd). By 2016, this demand had fallen to 58.6 gcd – a decline of about 10.7 gcd over 16 years or an average of about 1% per year[4]. What seems remarkable is that a full 90% of this reduction was attributed to only two household use categories - toilet demands declined by 4.3 gcd and clothes washer demands declined by 5.4 gcd (see Figure 1 reproduced from 2016 REUS).

So why so little savings associated with showers?

The 2016 REUS determined that showering currently accounts for about 19% of indoor residential water demands; that people take an average of 0.69 showers per day; and that the average shower duration is about 7.8 minutes long. Of course, many people shower more frequently and many less frequently, and many take longer showers and many take shorter showers – but, on average, we take about 0.69 showers per day with a duration of about 7.8 minutes per shower.

[1] While REUS reports were published in 1999 and 2016, water demand data were collected in the years preceding publication.
[2] 1,187 homes were logged in 1999 and 762 homes were logged in 2016.
[3] Water Research Foundation's 1999 Residential End Uses of Water (Mayer et al. 1999), http://www.waterrf.org/PublicReportLibrary/RFR90781_1999_241A.pdf
[4] Water Research Foundation's 2016 Residential End Uses of Water Study Update – Version 2 (Mayer et al. 2016), http://www.waterrf.org/Pages/Projects.aspx?PID=4309)

While showering accounts for almost one-fifth of indoor residential water demands, there are challenges associated with reducing shower-based water demands that do not exist for toilet-based and clothes washer-based demands – namely, the personal and tactile experience associated with showering, i.e., end-user behavior. Although the primary reason for showering may be to "get clean", many people enjoy the experience of showering – the warmth, the comfort, the feel of the water striking the skin. Showering is a very personal experience and product manufacturers have responded by designing many hundreds of different models of showerheads, each with slightly different spray characteristics. Some showerheads are hand-held, while some are wall-mounted; some are very high-flow, while some are super efficient; some provide high-velocity sprays, while some feel like a gentle rain shower; some offer a number of different spray patterns, while some are strictly utilitarian, etc. In short, people can customize their shower 'experience' almost any way they choose. However, because of the significant impact of personal preference on showerhead selection, in an unfettered marketplace it is likely that many people would choose to install high flow rate showerheads – sacrificing water and energy efficiency for comfort. What's more, showerheads tend to be far less expensive than clothes washers or toilets, and much easier to change-out. That is, homeowners that are not fully satisfied with their "shower experience" (for whatever reason) can easily replace their offending fixture for a more acceptable one.

This 'ease of installation' is the crux of the challenge faced by water utilities and showerhead manufacturers trying to reduce customer water demands and achieve product efficiency. For example, while it is relatively inexpensive for a utility to give away or rebate the purchase of efficient showerheads by their customers, and it is relatively easy for a homeowner to install an efficient showerhead (usually without the need to hire a plumber), it is just as easy for a homeowner to remove the new showerhead if they are not happy with its performance and replace it with a potentially high-flow-rate model, eliminating any expected water or energy savings. Perhaps this is why a quick web search indicates there are far fewer water utilities rebating or giving away efficient showerheads now than there was a decade ago.

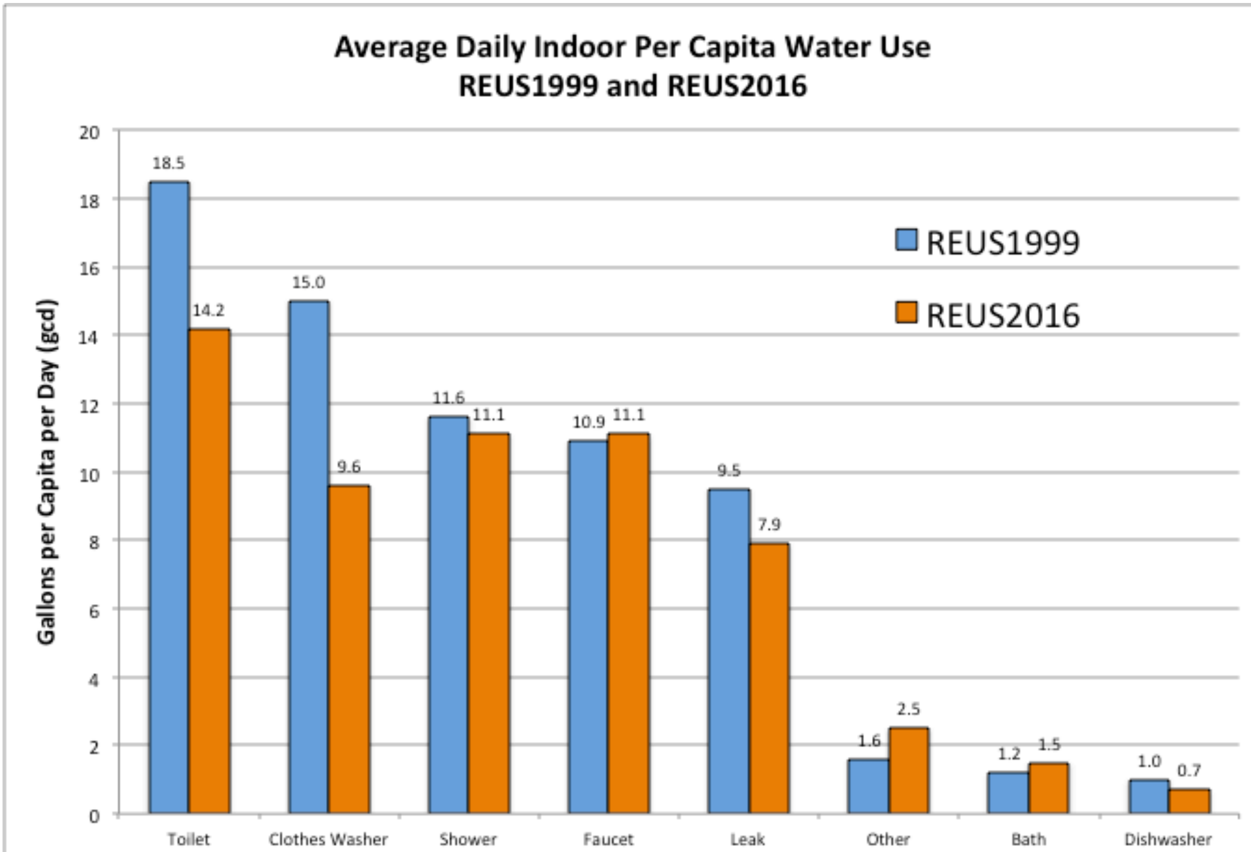


**Figure 1**

As illustrated above, between 1999 and 2016, shower-based water demands declined by only 0.5 gcd! There seems to be two simple possibilities for this low level of savings - either:

a) showerhead technology (and efficiency) did not improve significantly between 1999 and 2016, *OR*
b) as showerheads became more efficient (i.e., with lower flow rates), people compensated by taking longer showers, thus negating the potential water savings associated with those lower flow rates.

But there is also a third possibility – that actual showerhead savings are greater than that indicated in Figure 1, and this possibility is discussed in Section 4.

## 2.0 Average Showerhead Flow Rates – REUS1999 vs. REUS2016

A comprehensive analysis was completed by Gauley/Koeller on shower-based data collected as part of the 1999 and 2016 Residential End Use Studies.[5] The analysis first looked at average showerhead flow rates[6]. Only flow rates between 1.0 and 4.0 gallons per minute (gpm) were considered in the analysis as approximately 97% of the shower-based events identified by the Trace Wizard program used by Aquacraft, Inc. fell within this flow rate range[7] and there was some uncertainty if all events with very high or very low flow rates were truly shower-based events.

The Gauley/Koeller analysis grouped the approximately 42,500 shower events recorded in the REUS1999 and the approximately 15,500 shower events recorded in the REUS2016 into increments of 0.2 gallons per minute (gpm), based on their average flow rate. From this, the percentage of shower events that occurred in each flow rate increment for each of the two studies (Figure 2) was calculated.

The analysis clearly shows a trend towards lower flow rate showerheads between 1999 and 2016. For example, the 1999 data identified that only 44% of installed showerheads had flow rates of 2.0 gpm (the maximum flow rate for a WaterSense® labeled showerhead) or less while by 2016 this rate had increased to 56%. Note that if only showerheads with flow rates of 2.0 gpm or less are considered "efficient", then (at least as of 2016) approximately 44% of installed showerheads continue to operate inefficiently.

The results of this analysis indicate that showerhead technology (at least insofar as flow rates are concerned) has improved between 1999 and 2016. So why did the REU studies identify so

[5] Shower-based data from the Residential End Uses of Water studies were provided by Co-Principal Investigator, Peter Mayer, P.E.

[6] The REUS studies recorded actual flow rates, not rated flow rates.

[7] Water demand data collected as part of the 1999 and 2016 REUS are analyzed using the Trace Wizard software program. This program uses the flow rate and flow duration of each recorded water use event to assign the event to the appropriate household fixture or appliance. While the accuracy of the Trace Wizard analysis is considered very high, it is not considered perfect. For a full description of the Trace Wizard program please see http://www.aquacraft.com/downloads/trace-wizard-description/

little shower-based water savings between 1999 and 2016? The low level of savings could be explained if people do, on average, compensate for lower flow rates by taking longer duration showers. But is this really the case?

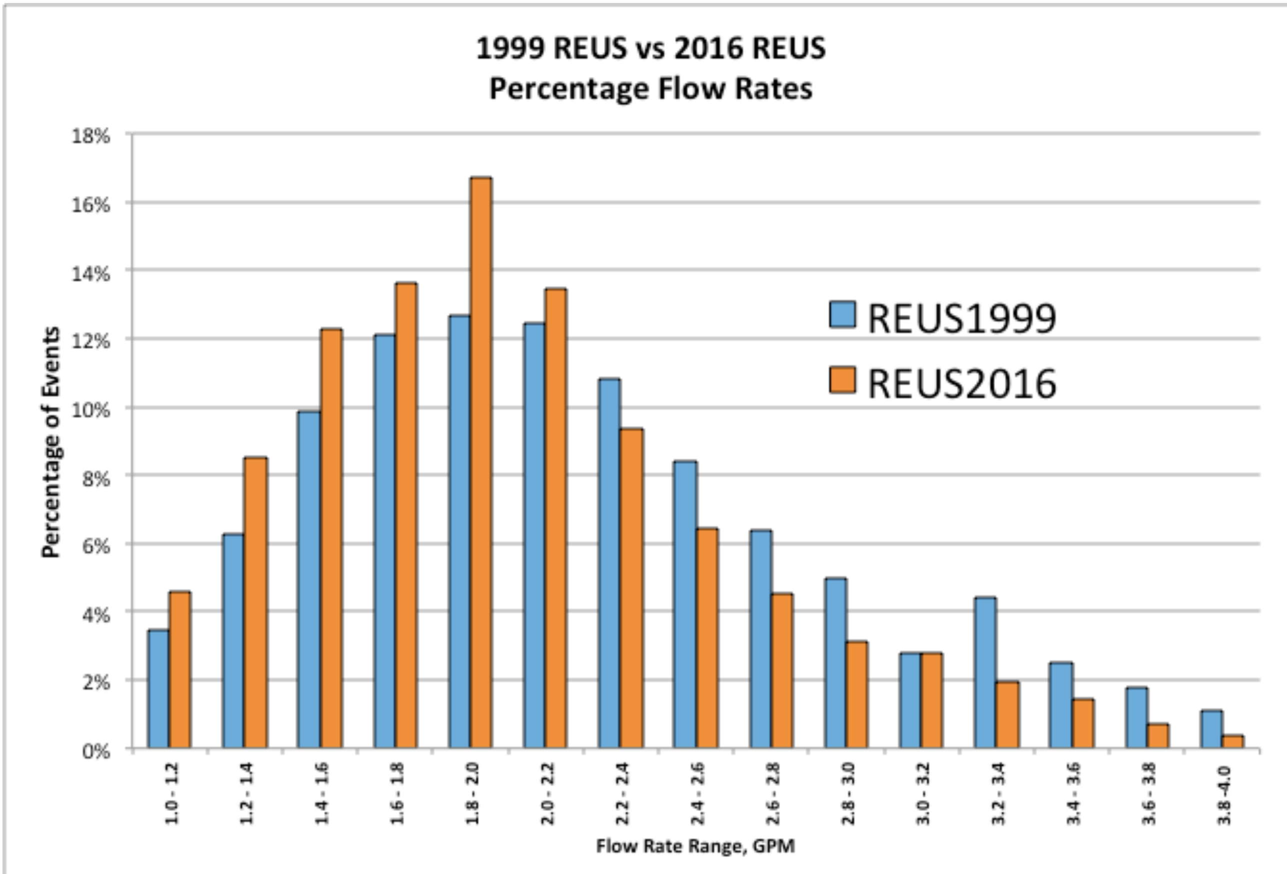


Figure 2

## 3.0 Shower Flow Rate vs. Duration vs. Volume

The primary purpose of this study was to verify if there is a tendency for shower durations to increase as flow rates decrease, possibly resulting in little or no water savings associated with the use of lower flow rate showerheads. An analysis was completed on the 1999 and 2016 REUS data to determine the relationship between shower flow rate and duration (note that flow rate multiplied by duration equals shower volume).

For reasons stated earlier, only flow rates between 1.0 and 4.0 gallons per minute (gpm) were included in the analysis[8]. For similar reasons, only shower durations between 2.0 and 20.0 minutes were included in the analysis[9].

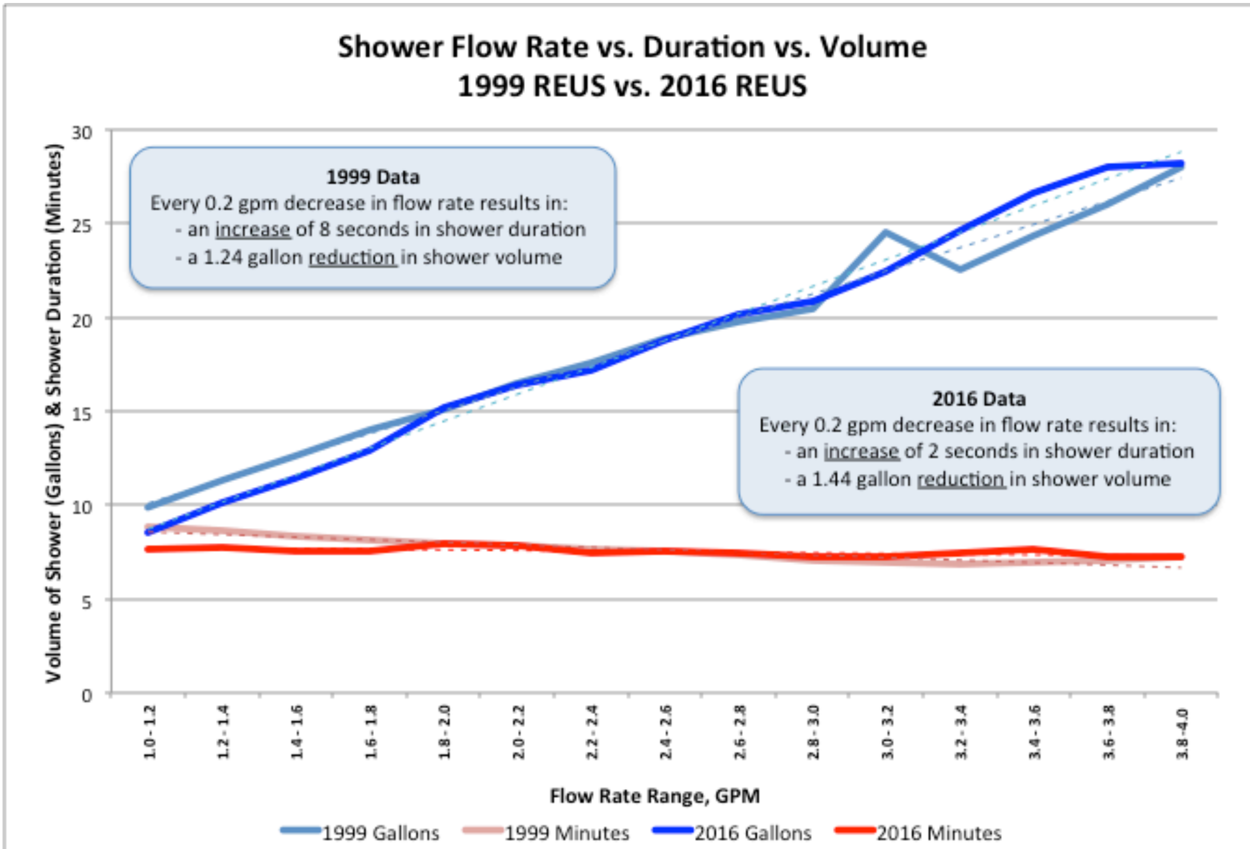


Figure 3

While water demand data for the two REU studies were collected more than 15 years apart and there was some variation in the participating communities, the results of the flow rate vs. duration analysis proved to be remarkably similar for the two data sets. For example, Figure 3 illustrates the relationship between shower flow rate vs. shower duration vs. shower volume. Note that shower duration increases only minimally as flow rates decrease for both the 1999 and 2016 data sets, at least for flow rates between 1.0 and 4.0 gallons per minute. For every

[8] While some people may purposely choose to install very low flow rate showerheads, it is probable that the low flow rates recorded in some of the participating homes were the result of low water pressures and/or excessive mineral buildup in the water supply piping or showerhead, rather than as a consequence of showerhead design.

[9] This range included 96% of all shower events and excluded events that may have been misidentified as showers by the Trace Wizard software, e.g., events with durations as low as 10 seconds or as high as 173 minutes.

0.2 gallon per minute decrease in flow rate, the average shower duration increases by only 8 seconds based on 1999 data and by only 2 seconds based on 2016 data. Both sets of data also show a decrease in shower volume as the flow rate decreases. For every 0.2 gallon per minute decrease in flow rate, the average shower volume decreases by 1.24 gallons based on 1999 data and by 1.44 gallons based on the 2016 data.

Figure 3 clearly illustrates that, on average:

- people do not compensate for lower flow rates by commensurately increasing the duration of their shower, and
- lower flow rate showerheads do result in a lower overall shower volume.

While some people take longer showers and some take shorter showers, the data shows, in general, people tend to follow their own unique routine for showering regardless of the flow rate of the showerhead. In fact, it is possible that the few extra seconds spent showering at lower flow rates may be primarily related to washing and rinsing hair.

So why were the shower-based savings identified in the 2016 REUS so low? Part of the answer may be in how the results are presented. While, for simplicity sake, tables in the 2016 REUS report identify average per capita per shower water demands of 11.6 gallons for 1999 and of 11.1 gallons for 2016, these values, by themselves, do not articulate the margin of error associated with their calculation. Figure 4 (reproduced from Figure 6.13 in REUS2016) shows the average daily per capita demands for each indoor use as well as the margin of error at the 95% confidence level. As such, while average shower-based demands in 1999 are identified as 11.6 gcd, the value (at the 95% confidence level) could actually range from as little as about 11.2 gcd to as high as 12.0 gcd, while 2016 shower-based demands could range from about 10.5 to 11.7 gcd. Based on this analysis, average daily per-shower demands could actually be as much as 0.5 gallons higher in 2016 or as much as 1.5 gallons lower in 2016.

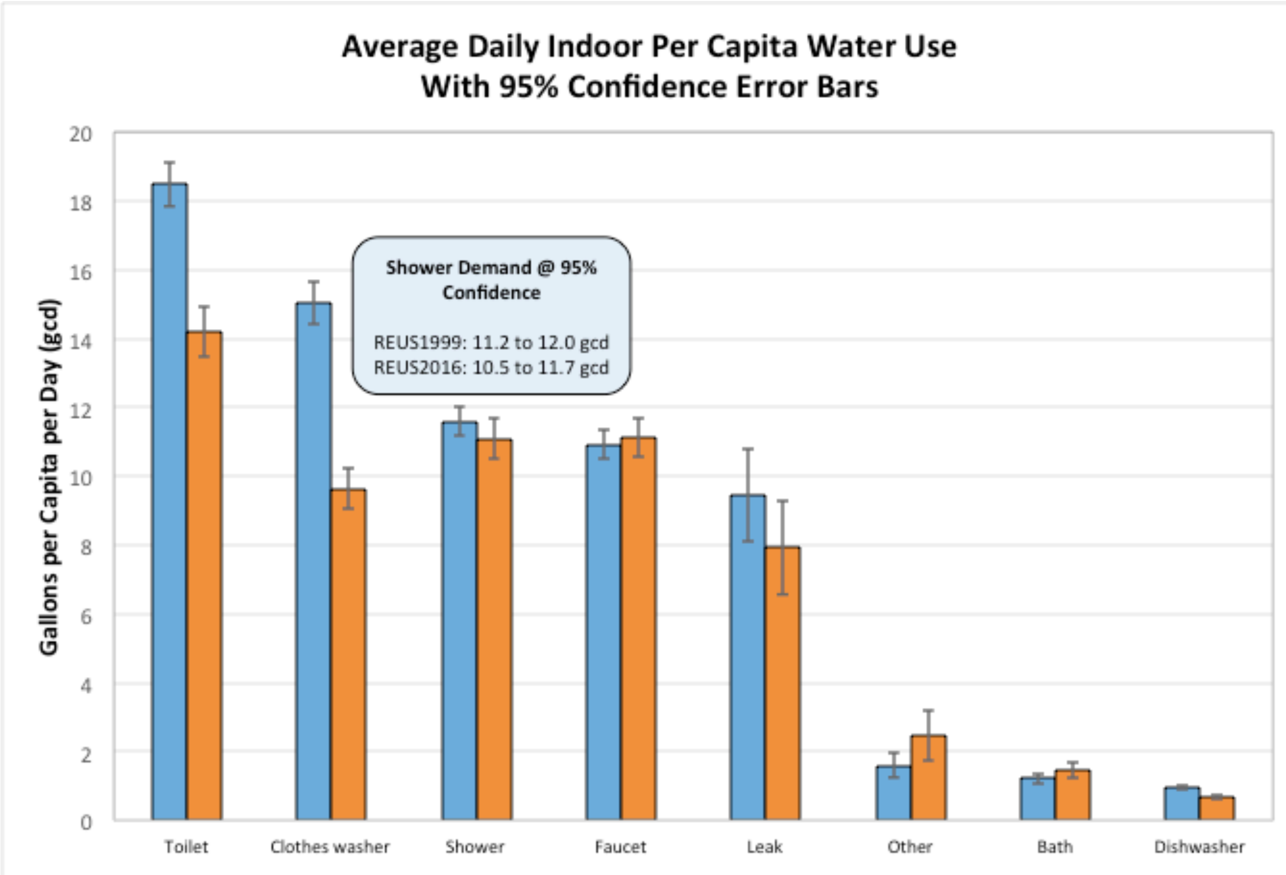
Average Daily Indoor Per Capita Water Use
With 95% Confidence Error Bars
Gallons per Capita per Day (gcd)
20
18
16
14
12
10
8
6
4
2
0
Shower Demand @ 95% Confidence
REUS1999: 11.2 to 12.0 gcd
REUS2016: 10.5 to 11.7 gcd
Toilet
Clothes washer
Shower
Faucet
Leak
Other
Bath
Dishwasher

**Figure 4**

## 4.0 Summary and Conclusion

The flow rate analysis (results illustrated in Figure 2) identified a higher percentage of installed low flow rate showerheads in 2016 than in 1999.

The flow rate vs. duration analysis indicated that people tend to only marginally increase the duration of their shower to compensate for lower flow rates.

Based on applying a 95% confidence interval to per capita shower-based demands, it is possible that the average 0.5 gallons per capita per day shower savings between 1999 and 2016 (as identified in the 2016 REUS report), may be somewhat under-reported and may actually be as high as 1.5 gallons per capita per day.

While studies have shown that people tend to prefer higher flow rate showerheads[10], the results of this analysis clearly show that water savings can be achieved by using lower flow rate showerheads. As such, it appears that low flow rate showerheads that meet customers' expectation for performance will provide the best opportunity to maximize water savings.

Water utilities interested in achieving higher levels of water savings should be encouraged to consider (or re-consider) promoting or rebating high-performance low flow rate showerheads.

Please send any questions you may have regarding the content of this report to the authors:

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[10] High-Efficiency Showerhead Performance Study, 2009, Gauley, Robinson, Elton. Report can be found at: http://www.map-testing.com/assets/files/Veritec-Waterloo%20Final%20Report%20Dec%202009%20copy.pdf

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