This technical memorandum is a draft working document. It is undergoing agency review and is intended for discussion purposes. The proposed approach and findings have not been endorsed by any agency on the "20X2020 Team". It is expected that the information will be updated as the work progresses. The content of this and other technical memoranda will be used in the preparation of an overall report, and a draft of the overall report will be shared with the public. Please submit comments on this draft technical memorandum by December 5, 2008 to 2020comments@ccp.csus.edu

Public Draft Technical Memorandum

Task 4 – Potential Conservation Savings from Current Actions

November 8, 2008

This Technical Memorandum (TM) assesses the impact of existing plumbing codes, regulatory initiatives, and Best Management Practices on urban water use in the year 2015 and 2020 relative to the base year (2005). It uses a bottoms-up approach and should be read in conjunction with the baseline and targets TMs. This TM is organized as follows:

1 Introduction

2 Estimation Methodology

3 Results

4 Conclusions

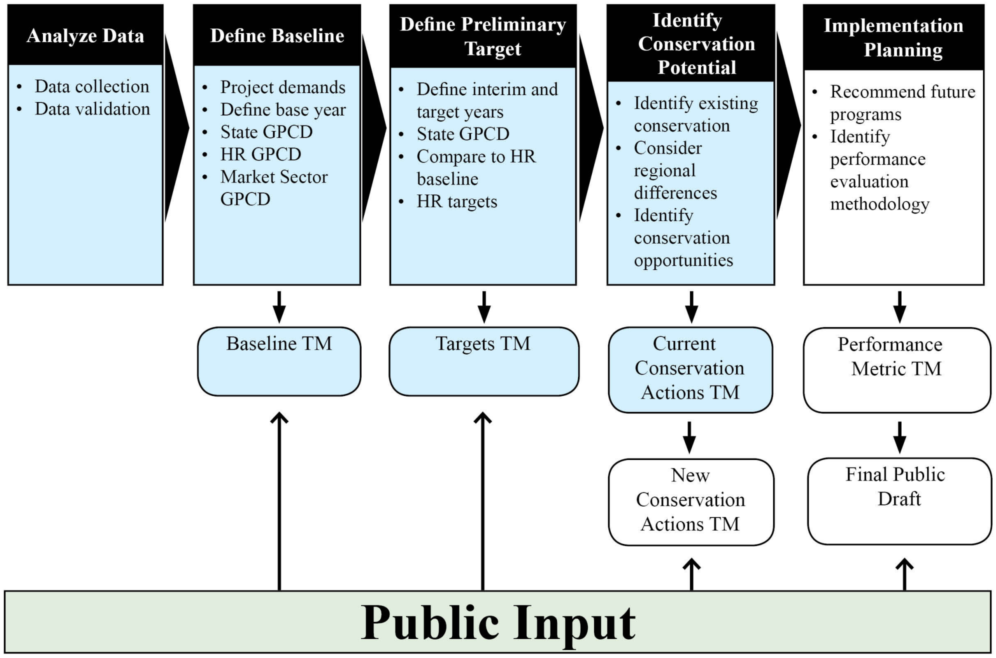
5 References

Appendix A – Data, Assumptions, Methodology, and Measure Savings

Appendix B – Abbreviations and Acronyms

This TM is part of the fourth step of the 20x2020 Program. The overall process of developing the Program is illustrated in Figure 1-1 (completed steps are highlighted).

Figure 1-1: 20x2020 Program Development Process



1 Introduction

Per-capita water use has been steady or dropping for many years since the early 1990s in many parts of California, for several reasons. First, after adopting the California Urban Water Conservation Council's Memorandum of Understanding Regarding Urban Water Conservation (MOU) in 1991, many urban water suppliers started to aggressively undertake water conservation programs identified as Best Management Practices (BMPs) in the MOU. These BMPs are listed in Table 1-1.

Table 1-1: List of Best Management Practices (BMPs)

BMP	Description
BMP 1	Water survey programs for residential customers
BMP 2	Residential plumbing retrofit
BMP 3	System water audits, leak detection and repair
BMP 4	Metering with commodity rates for all new connections and retrofit of existing unmetered connections
BMP 5	Large landscape conservation programs and incentives
BMP 6	High efficiency clothes-washing machine financial incentive program
BMP 7	Public information programs
BMP 8	School education programs
BMP 9	Conservation programs for commercial, industrial, institutional (CII) accounts
BMP 10	Wholesale agency assistance programs
BMP 11	Retail conservation pricing
BMP 12	Conservation coordinator
BMP 13	Water waste prohibition
BMP 14	Residential ultra-low-flush toilet (ULFT) replacement programs

Second, the State also modified its building codes to require the use of efficient water using fixtures. For example, since 1992 only ultra-low-flush toilets and low-flow showerheads have been available for sale in the State of California. More recently, legislation has been adopted (but is not yet in operation) to require efficient clothes washers, and to promote the use of high efficiency toilets and urinals in new construction. All of these plumbing-related state codes have forced the stock of water-using fixtures to become more efficient over time due to natural turnover.

Finally, the state has undertaken several regulatory initiatives to improve water use efficiency. These include: (1) mandating that unmetered connections be metered by 2025; (2) new construction with significant landscaped areas be subjected to plan review to ensure that efficient irrigation systems and low water-using plants are being used (Model Water Efficient Landscape Ordinance); and (3) encourage better coordination between land use and water use planning (SB 221 and SB 610). Not all of these BMPs, regulatory initiatives, or education and outreach activities, have easily quantifiable impacts although the majority of water conservation professionals would acknowledge that each is a valuable component within the larger scheme of things.

It should be of concern, however, that overall per-capita water use trends in California between 1995 and 2005 do not indicate a statistically significant downward trend. This suggests that other factors have been at play counteracting the impact of BMPs, of codes, and of the above-mentioned regulatory initiatives. Assessing these escalating factors is beyond the scope of this study, but is a subject we discuss in TM 3.

In this TM we quantify the impact of the following factors that are expected to continue to reduce per-capita water demand:

1. Code related plumbing and appliance improvements in water use efficiency
    a. Residential low flow showerheads and ultra-low-flush toilets (ULFT)
    b. ULFT in commercial, industrial, institutional (CII) settings
    c. High-efficiency toilets and urinals
2. Conversion of unmetered connections to metered connections
3. Implementation of BMPs (fixtures and appliances; landscape; commercial, industrial, institutional measures; and system water audits and leak repairs) as well as a few new technologies.
4. The impact of expected increases in implementation of BMPs due to the passage in 2007 of AB1420, providing financial incentives to water agencies implementing BMPs by conditioning the receipt of grants and loans to comply with the CUWCC MOU.

2 Estimation Methodology

2.1 Sources of savings considered

We have considered the following codes, active programs, and regulatory activities in quantifying conservation savings.

1. Codes related to plumbing and appliance efficiency
    a. We have quantified the impact of the 1992 state code requiring the sale of efficient showerheads and toilets in California (California Code of Regulations, Title 20, Chapter 2).
    b. We have included the impact of AB 715, the state code that requires only high-efficiency toilets and urinals (HETs and HEUs) to be sold or installed after January 1, 2014. The Federal preemption on regulations pertaining to these devices expired several years ago, which manufacturers of these devices acknowledge.
2. Regulatory activities
    a. We have accounted for unmetered connections served by the Federal Central Valley Project (CVP) being converted to metered connections by 2015, and non-CVP unmetered connections converted by January 1, 2025, as state law requires.
3. Best management practices
    a. We have accounted for active conservation programs aimed at retrofit of inefficient fixtures (BMPs 1, 2, 9 and 14), those aimed at improving outdoor water use efficiency in residential (BMP 1) and large landscape settings (BMP 5), those aimed at improving water use efficiency in CII settings (BMP 9), and those aimed at reducing system leaks (BMP 3). The remaining BMPs have non-quantifiable benefits.
4. New technologies already having an impact
    a. We have accounted for the following two new conservation measures that are already being implemented under the auspices of CII programs. These include: (1) pre-rinse spray valves; (2) steam sterilizers.

2.2 Methodology

Geography

We have allocated counties to each hydrologic region (HR) based upon the proportion of each county's population that falls within a HR's boundaries. These proportions were developed by the Department of Water Resources (DWR) for use in the *California Water Plan Update 2005* and the CALFED Bay-Delta Program's *Water Use Efficiency Comprehensive Evaluation*.[1]

Key Data Sources

Data underlying the analyses presented here come from several sources. These are referenced in greater detail in the above cited report (*Water Use Efficiency Comprehensive Evaluation*) and in Appendix A. Table 2-1 only provides an overview. The *Comprehensive Evaluation* was structured to assess the

---

[1] California Department of Water Resources, "California Water Plan Update 2005: A Framework for Action," Bulletin 160-05, December 2005; CALFED Bay-Delta Program Water Use Efficiency Element, "*Water Use Efficiency Comprehensive Evaluation*," August 2006, page 134.

potential for each of the Water Use Efficiency's (WUE's) four main components—agricultural water conservation, urban water conservation, recycling and desalination—to contribute to CALFED goals and objectives. The analyses had two main thrusts: a "look forward" thrust that sought to determine the potential of water use efficiency actions statewide given different levels of investment and policies, and a "look back" thrust that assessed progress to date. The analyses, conducted by California Bay-Delta staff and consultants with input from CALFED Agencies and stakeholders, was intended primarily to help policymakers target future investments in the WUE Element and develop appropriate assurances. Additionally, the projections generated by the Comprehensive Evaluation were expected to—and already do—feed into other studies, such as the California Water Plan Update.

Table 2-1: Sources of data

Data	Source
Population and housing units	California Department of Finance, Decennial Census, 2000
Population per single family and multi family unit	Decennial Census, 2000
Toilets, showerheads, washing machines per household	American Housing Survey
Toilets, urinals in CII settings	Previously published literature cited in Appendix A
Device turnover rates	Previously published literature cited in Appendix A
Unmetered connections	Previously published literature cited in Appendix A
BMP implementation rates	Reports filed with the California Urban Water Conservation Council (CUWCC)
Savings per retrofitted device	Previously published literature cited in Appendix A

Natural device turnover rates

To assess the impact of plumbing codes on the stock of water using fixtures, we have relied on natural turnover estimates that have been used in previously published reports to quantify the impact of plumbing codes. These include the following key parameters:

1. Showerheads have an *average* life of 10 years, implying a device turnover rate of 10% per year (that is, 10% of a given stock is replaced in the first year, 10% of the remaining stock in the second year, and so on).[2] In other words, 10% of a given stock has a life of 1 year, 9% a life of 2

---

[2] If x_0, the number of inefficient devices at the start of the analysis, turns over at rate r, then the number of inefficient devices remaining in year t>0, x_t, is given by

$$x_t = x_0(1-r)^t$$

The number of installed efficient devices in year t>0, y_t, is given by

$$y_t = x_0\left[1-(1-r)^t\right]$$

Thus, assuming the requirements of the 1992 Energy Policy Act became fully binding by 1994 (the federal government was afforded 12 months from the passage of the Act to publish the efficiency labeling standards and years, 8.1% a life of 3 years, and so on. Roughly 35% of the stock would have a life exceeding 10 years. It may not appear intuitive, but it can be mathematically shown that the average of this distribution of lives works out to 10 years.

2. Residential toilets have an *average* life of 25 years implying a device turnover rate of 4%.
3. Residential clothes-washers have an *average* life of slightly over 14 years implying a device turnover rate of 7%.
4. CII toilets have an *average* life of roughly 20 years implying a device turnover rate of 5%.

Savings estimation scenarios

A number of uncertainties exist in estimating savings from state codes and regulations related to plumbing and appliances, from active programs being pursued by water suppliers, and from regulatory actions. For example, we can only estimate the impact of existing codes and of new code initiatives that are just over the horizon, but not those that are beyond the foreseeable future. Similarly, while device turnover rates mentioned above appear reasonable, and are supported in part by previously published studies, even small errors in turnover rates can accumulate into large discrepancies due to compounding. Only statewide device saturation studies conducted every few years can prove the veracity of these parameters. Finally, active conservation programs undertaken by water suppliers may fall below or exceed the MOU's coverage requirements, and over time additional suppliers may become MOU signatories, a factor difficult to take into account. Finally, the water savings impacts of important previous regulatory initiatives, such as, the Model Water Efficient Landscape Ordinance, or improved coordination between land use and water use policies (SB 221 and SB 610) have never been evaluated, thus remain difficult to quantify.

Here we quantify the level of savings likely to result from code driven efficiencies, and from BMP implementation up to a point that is locally cost-effective (this latter constraint is relaxed and evaluated in TM 5). These two estimates are derived as follows:

1. Code related savings only. Savings include those from code and regulation driven retrofits, and from conversion of unmetered accounts to metered accounts. Codes bring about increased efficiency in two ways. They ensure that fixtures and appliances in new construction are of the most efficient kind. And they ensure that when old fixtures and appliances in existing construction turn over, they are replaced by the more efficient kind.
2. Code related savings plus regionally cost-effective BMP implementation savings. Savings include all of the above plus those that result from BMP implementation up to a point that is regionally cost effective. The impact of regionally cost-effective retrofit of pre-rinse spray valves and commercial dishwashers, steam sterilizers, CII process water, and efficient residential dishwashers is also included in these estimates. The regionally cost-effective estimates of savings potential come from CALFED's *Water Use Efficiency Comprehensive Evaluation*, which provides a complete description of the underlying data, methodology, and models used to develop these estimates.[3] Key points to keep in mind regarding the estimates of cost-effectiveness savings potential are as follows:
    a. Cost-effectiveness is evaluated from the perspective of the water supplier in terms of a regional estimate of avoided water supply costs. Regional marginal water supply costs

---

manufacturers were afforded 12 months from the date of publication to comply with them), a 10% replacement rate implies that by Year 2000, 47% of non-LF showerheads existing in 1994 would have converted to LF showerheads; by 2008 the share would have increased to 77%; and by 2020 it would have increased to 94%.

[3] Appendix A also discusses key assumptions and data used to develop these estimates.

are based on a representative sample of water suppliers from each hydrologic region. Marginal water supply costs include avoided costs of transport, treatment, and distribution and are from the perspective of a retail water supplier. Marginal supply costs used by the *Comprehensive Evaluation* are averages for large regions and therefore may mask important intraregional cost differences. Appendix A includes these estimates.

b. The analysis incorporates all urban water use in a region, without regard to whether water is delivered by an MOU signatory or not. This modeling framework overstates achieved conservation. On the other hand, data reported by MOU signatories about their conservation programs also remain unreliable. Basing estimates of achieved conservation solely upon self-reported data would most likely understate achieved conservation. Our approach here is to take the optimistic model-generated estimates and then adjust them downward to instill greater realism.

c. In the case of BMPs, the level of annual investment is constrained by each BMP's remaining coverage requirement for the region. In the case of non-BMPs, the level of annual investment was capped at ten percent of the estimated technical savings potential for the region. This cap is a way to model logistical and cost constraints that force water suppliers to spread conservation programs over several years instead of trying to realize the full technical potential in a single year of program activity, which is practically impossible.

d. The estimates of regionally cost-effective savings are based on planning models developed for the CALFED Bay-Delta Program, not empirically measured rates of implementation, and therefore may over- or understate actual regional trends in BMP implementation. The methodology, key assumptions, and data used to implement these models are presented in Appendix A.

Water savings accounting in the presence of efficiency codes

In the case of toilets, showerheads, and potentially clothes washers, water savings can be the consequence of efficiency codes or water supplier programs. The enactment of efficiency codes for these devices would eventually result in their conversion to the codified efficiency standard through the process of natural replacement. At the same time, water supplier programs can accelerate the rate at which this conversion occurs. Water savings estimation requires accounting for both processes and must be done in a way that avoids double counting of water savings. The approach taken by the *Water Use Efficiency Comprehensive Evaluation* and used here is illustrated in Table 2-2. This example assumes that 100 toilets are replaced as a result of a water supplier program in year 1. In the absence of the water supplier program, the efficiency code would have replaced these toilets through the process of natural replacement. At an annual natural replacement rate of 4%, the column labeled "ULFTs Credited to Code" shows the number of toilets credited to the code requirement in each year even though the 100 toilets were initially retrofitted due to a water supplier program. The column labeled "ULFTs Credited to Water Supplier" shows the number of toilets credited to the water supplier's replacement program in each year. Key aspects of the accounting include the following assumptions:

1. Physical water savings do not decay over time. Replacing 100 toilets this year will generate water savings from 100 toilets each year thereafter. Only the division of credit for the savings between the code and the water supplier program changes over time.
2. Credit for water savings assigned to the code increases over time while credit assigned to the water supplier decreases. This is because it is assumed that the toilets would eventually have turned over had there been no water supplier program. By the end of 10 years approximately 31 toilets would have turned over as a result of natural replacement under the assumptions described above. Thus, the code receives credit for approximately 31 toilet replacements in year 10 for

every 100 toilets retrofitted in year 1 due to water supplier programs. The residual of 69 toilets remains credited to the water supplier program in year 10.

3. The credit accounting impacts the calculation of program cost-effectiveness from the perspective of the water supplier but it does not impact the calculation of physical water savings resulting from the replacement of 100 toilets.

Table 2-2: How 100 ULFTs Retrofitted by Water Supplier in Year 1 Are Allocated to Code Over Time

Year	ULFTs credited to code	ULFTs credited to Water Supplier
1	0	100
2	4	96
3	8	92
4	12	88
~	~	~
10	31	69

Note that Table 2-2 is only accounting for water savings associated with water supplier replacement programs. Total water savings from conversion of toilets or showerheads is the sum of conversions realized through both the code and water supplier programs. The share of total savings coming from water supplier programs versus the code depends on the scale of supplier programs relative to natural replacement.

Suppose for example there are a total of 10,000 non-ULFT toilets at the beginning of year 1, and an agency retrofits 100 ULFTs per year through an active conservation program. At the end of year 1, 400 toilets would have turned over due to natural replacement, and another 100 due to the water supplier program (Table 2-3). By year 10, a total of 3190 ULFTs would have been installed due to natural turnover and another 1000 due to the active program. A straightforward accounting may conclude that 23.9% (1000 ÷ (3190+1000) of water saved by ULFT retrofits should be counted towards active conservation programs. But as discussed earlier, by year ten 31 ULFTs of the 100 retrofitted in year 1 would have been captured through natural turnover, 28 of the 100 retrofitted in year 2, and so on. Of the total 1000 ULFTs retrofitted via active conservation programs, 162 would have been captured via natural turnover. When this fact is accounted for, the contribution of the active conservation program drops to 20% ((1000-162) ÷ (3190+1000)). And when new construction is factored in, the contribution of active conservation drops further still, since by definition increased saturation of ULFTs caused by new construction is allocated to code. Historically, the scale of water supplier toilet replacement programs has been small relative to natural replacement in most parts of California.[4] Thus the summary tables presented later show most water savings from toilets coming from code requirements.

---

[4] The South Coast region, where water suppliers have invested substantial resources in the replacement of toilets, is an exception.

Table 2-3 Example: Relative Contribution of Natural Turnover and Active Conservation

Year	Non-ULFT stock at beginning of year	ULFTs retrofitted due to natural turnover during the year	ULFTs retrofitted due to supplier programs during the year	Supplier induced retrofits credited to code in year 10
1	10000	400	100	31
2	9500	380	100	28
3	9020	361	100	25
4	8559	342	100	22
5	8117	325	100	18
6	7692	308	100	15
7	7284	291	100	12
8	6893	276	100	8
9	6517	261	100	4
10	6157	246	100	0
Total		3190	1000	162

Code driven savings dominating active BMP savings should not be interpreted to mean that active BMP programs are of less importance. California's supply/demand imbalance is imminent, not far out into the future. Were we trying to reach a conservation goal far into the future, say, in 2050 instead of 2015 or 2020, perhaps reliance on codes over active BMPs could be justified. But as matters stand, urban water use needs to be ratcheted down quickly, and this can only be achieved if water suppliers redouble their efforts at implementing BMPs, preferably exceeding cost-effective BMP coverage goals.

3 Results

Tables 3-1 and 3-2 show the level of likely savings from the codes and regulations considered in our analyses. These include the 1992 code requiring ULFTs and LF showerheads, AB 715 that requires HETs and HEUs starting in 2014, and conversion of unmetered connections to metered connections. Code related savings, computed relative to the base year (2005), are projected to be significant. For example, by 2015 indoor residential use is expected to be lower by anywhere between 3 and 5 GPCD depending upon the hydrologic region. By 2020, indoor residential use is expected to drop by 4 to 8 GPCD. As a percentage of baseline use, code related savings in 2020 can be expected to be between a low of 2% for Colorado River Region to a high of 7% for Sacramento and San Joaquin River Regions.

What explains these fairly significant code-related savings even though several years have elapsed since the 1992 state code relating to plumbing fixtures went into effect? First, since our benchmark year is 2005, code-related efficiencies are derived over 10 and 15 year periods for the 2015 and 2020 scenarios. Of the projected indoor savings through 2020, roughly 4-5 GPCD are obtained from toilet turnover and 1 GPCD from showerhead turnover. Sacramento River and San Joaquin River experience an additional decline because of the conversion of unmetered accounts to metered accounts. Do these estimates appear reasonable? Should not most of the old inefficient showerheads and toilets have turned over by 2005? Well, not quite, according to our modeling parameters.

For example, we have used a 10% natural turnover rate for low-flow showerheads, implying an average life of 10 years. In thirteen years between 1992 and 2005, the saturation of low flow showerheads can be expected to have reached 75% ($1\text{-}0.9^{13}$) due to natural turnover, although we assume that saturation was 79% in 2005 because of the massive showerhead distribution programs undertaken in prior years. This modified estimate is based upon the results of two saturation studies, one performed in Orange County, the other in Santa Clara. By 2020, low-flow showerhead saturation is projected to reach 97%. Since low flow showerheads are estimated to save roughly 4.5 GPCD, 18% (97% - 79%) of the savings potential that still remains to be captured translates roughly into 1 GPCD (0.18 x 4.5).

Similarly, ULFT saturation by natural turnover at a rate of 4% could be projected to have reached roughly 41% ($1\text{-}0.96^{13}$) by 2005. In actuality, ULFT penetration had reached higher levels in several regions because of agency retrofit programs (we assume 54% in 2005 based upon data collected through the Orange County and Santa Clara saturation studies)[5]. As a ULFT retrofit is projected to save roughly 16 GPCD depending upon the mix of single and multi-family housing[6], this implies that going from 54% saturation rate in 2005 to roughly a projected rate of 81% by 2020 ought to save roughly an additional 4-5 GPCD (0.27 x 16). Further factoring in the effect of high efficiency toilets raises our estimate to roughly 5 GPCD.

---

[5] The *Orange County Saturation Study* collected field data in 2000 and found that low flow showerheads and ultra low flush toilets had reached a saturation level of 64.7% and 48.7% respectively in the pre-1992 housing stock. The *Santa Clara County Residential Water Use Baseline Survey* published in 2004 found that by 2002 42% of toilets in single family residences constructed prior to 1992 were ULFTs. In multi-family residences, the figure was 31%. The same study found that 59% of the showerheads in pre-1992 single family residences were low flow. In multi family residences the figure was 51%. These saturation levels are broadly consistent with the turnover rate assumptions used for this analysis.

[6] The 16 GPCD decline associated with ULFT retrofits is based upon savings documented in the MOU, which in turn came from a very large evaluation conducted in Los Angeles. Other studies such as the "*Residential End Uses of Water*" have generated lower estimates, but we have no particular reason to favor these lower estimates. Assuming individuals flush 5 times per day (as per the end use study), and that ULFTs use 1.6 gallons per flush, a 16 GPCD decline translates into an average pre-1992 toilet capacity of around 4.8 gallons per flush, hardly unreasonable.

Code related savings for residential outdoor are driven by conversion of unmetered accounts to metered accounts, impacting the Sacramento River and San Joaquin River regions primarily, and to a lesser extent Tulare Lake which also has many unmetered accounts.

Savings from code related retrofit of toilets and urinals in the CII sector are included in the CII/Landscape account. Code-related indoor savings in the CII sector are much smaller than residential indoor savings because the stock of toilets in the CII sector is much smaller than the stock of residential toilets.

Turning to Tables 3-3 and 3-4, most of the savings increases over and above code-driven efficiencies come from the CII/Landscape programs, and water loss control programs (BMP 3). Indoor savings increase somewhat because of agency-driven toilet retrofits, but not by much. As discussed earlier, natural turnover influences the entire stock of toilets, dwarfing the impact of agency-driven toilet retrofits. And over time the impact of supplier-driven retrofits is increasingly allocated to code because of the way savings are credited (Tables 2-2 and 2-3). Important drivers behind the estimate of BMP-driven CII/Landscape savings is the implementation of large landscape programs (BMP 5), and CII programs (BMP 9)

Table 3-4 suggests that including the effect of code driven efficiencies and BMP implementation up to the regionally cost-effective level, water consumption in 2020 relative to the baseline could drop by a low of 5.0% in the case of Tulare Lake to a high of 15% in the case of Colorado River region. It may appear puzzling that regions such as Sacramento River and San Joaquin River with high water use do not exhibit greater savings potential, but this is largely a result of how the analyses are structured. Within the existing voluntary BMP framework, agencies are required to only implement programs that are cost-effective from their perspective. Given that our analyses assume a lower marginal cost of water in regions such as Sacramento River ($44 in 2020) relative to say South Coast ($696 in 2020), many programs in the former are not cost-effective (see Appendix A for regional estimates of marginal cost that are embedded in our analyses).

There are four important caveats to these estimates.

First, the cost-effectiveness estimates assume MOU signatories and non-signatories alike implement all BMPs and other measures deemed regionally cost-effective by the analyses. This level of implementation exceeds what water suppliers have achieved historically via the MOU process. On the other hand, BMP implementation data filed by MOU signatories is also of uneven quality, and does not capture conservation by non-signatories. Relying solely on these implementation reports will likely understate achieved conservation. Keeping in mind these data problems, and that only approximately 60% of California's population was being served by MOU signatories as of 2006, perhaps only half of the additional savings over and above what has been attributed to efficiency codes, is likely to be realized if business continues as usual. On the other hand, passage of AB 1420 in 2007 is widely expected to spur water suppliers to redouble their efforts in complying with BMPs. What this translates into is as follows: By 2020, efficiency codes are expected to lower statewide water use by 4% and regionally cost-effective programs by an additional 7% points for a total reduction of 11%. *While it is not reasonable to assume that all suppliers will be in compliance with the MOU by 2020, certainly the passage of AB 1420 in 2007 can be expected to improve compliance in the future relative to what it has been in the past. Assuming that AB 1420 raises compliance to roughly 80%, 2020 consumption can be expected to be roughly 9-10% (4% plus eight-tenths of 7%) below the baseline.*

Second, estimation of baseline consumption itself involves several uncertainties, which if properly accounted for, could further lower the above reported percent savings estimates. Because water production data for any given year includes missing and inconsistent elements, we pooled several years of production data (1995 through 2005) to derive a more stable average estimate. Surprisingly, however, no trend over the 11-year period could be observed in these annual data, suggesting either that the data are bad, or that other factors have effectively countered the impact of code- and BMP-driven conservation, such as, the level and composition of economic growth, location and characteristics of new housing, per-capita income, water rates, weather, and so on. Only a model of per-capita water use that includes the impact of conservation along with the impact of these additional factors can shed light on their relative strengths. If such a model were to indicate that factors driving up water use over the past several years have been as strong as the impact of codes, regulations, and BMPs, and that these escalating factors are expected to persist in the absence of corrective public policies, then little reduction ought to be expected in future per-capita use, consistent with the recent experience. Although too pessimistic a scenario, it is one that needs to be rigorously examined. We have not attempted to build a multi-factor model of per-capita water use as part of the present effort due to time and resource constraints. Instead, what we have chosen to do is to use 2005 (the last year for which statewide water production data are available) as the starting point for estimating remaining savings potential through 2015 and 2020, on the ground that these lower estimates are more realistic than the ones based upon using 2000 (midpoint of the water production history) as the base year.

Third, code driven savings associated with toilets and showerheads are computed using unverified saturation estimates. Small errors in baseline saturation estimates can have significant impacts. For example, if actual ULFT saturation in the base year turns out to be 10 percentage points higher than our model estimate, our code related savings potential estimate would be roughly 1.6 GPCD (0.1 x 16 GPCD) too high. The error could just as easily go the other way, however. For example, the California Energy Commission while reviewing an earlier draft of our analyses stated that our showerhead natural turnover rates appeared too high, suggesting that we may be understating the remaining savings potential. Their conclusion was based upon a visit to a hardware store in 2000, where they discovered several showerheads for sale that were illegal and had been illegal for a long time. On the other hand, we have taken our data cues from saturation studies that physically measured showerhead flow rates. Without a comprehensive research program it is next to impossible to adjudicate these differing opinions. As we discuss in other technical memoranda (TMs 3 and 6), several data uncertainties exist that would need to be remedied as part of the comprehensive 20x2020 approach.

Finally, the regional marginal water supply cost estimates upon which the cost-effectiveness analyses are based are somewhat dated and may not capture changes in the State's water supply situation, particularly as it pertains to the Delta, that have driven up water supply costs in recent years. Economic incentives to invest locally in water use efficiency measures may now be greater than assumed for these analyses.

Table 3-1: 2015 Efficiency Code Water Savings – GPCD

HR Number ->	1	2	3	4	5	6	7	8	9	10
HR Name ->	North Coast	SF Bay	Central Coast	South Coast	Sacramento River	San Joaquin	Tulare Lake	North Lahontan	South Lahontan	Colorado River*
Residential - Indoor	4	4	3	3	5	5	4	4	4	3
Residential - Outdoor	0	0	0	0	7	8	3	0	0	0
CII/Landscape	1	1	1	1	1	1	1	1	1	1
Water loss control (BMP 3)	0	0	0	0	0	0	0	0	0	0
Total	5	5	4	4	13	14	8	5	4	4
Baseline GPCD	165	157	154	180	253	248	285	248	237	346
% of Baseline GPCD	3%	3%	3%	2%	5%	5%	3%	2%	2%	1%

Table 3-2: 2020 Efficiency Code Water Savings – GPCD

HR Number ->	1	2	3	4	5	6	7	8	9	10
HR Name ->	North Coast	SF Bay	Central Coast	South Coast	Sacramento River	San Joaquin	Tulare Lake	North Lahontan	South Lahontan	Colorado River*
Residential - Indoor	5	5	5	4	8	7	6	5	5	5
Residential - Outdoor	0	0	0	0	10	9	5	0	0	1
CII/Landscape	1	2	1	1	1	1	1	2	1	1
Water loss control (BMP 3)	0	0	0	0	0	0	0	0	0	0
Total savings GPCD	7	7	7	6	19	17	12	7	6	6
Baseline GPCD	165	157	154	180	253	248	285	248	237	346
% of Baseline GPCD	4%	5%	4%	3%	7%	7%	4%	3%	3%	2%

Table 3-3: 2015 Efficiency Code + Cost-Effective Measures – GPCD

HR Number ->	1	2	3	4	5	6	7	8	9	10
HR Name ->	North Coast	SF Bay	Central Coast	South Coast	Sacramento River	San Joaquin	Tulare Lake	North Lahontan	South Lahontan	Colorado River*
Residential - Indoor	4	5	4	5	5	5	4	4	4	4
Residential - Outdoor	0	0	0	0	7	8	3	0	0	0
CII/Landscape	3	12	5	12	1	4	3	7	10	44
Water loss control (BMP 3)	0	3	0	4	0	0	0	0	0	0
Total	8	20	9	21	13	17	10	11	13	48
Baseline GPCD	165	157	154	180	253	248	285	248	237	346
% of Baseline GPCD	5%	13%	6%	11%	5%	7%	3%	4%	6%	14%

Table 3-4: 2020 Efficiency Code + Cost-Effective Measures – GPCD

HR Number ->	1	2	3	4	5	6	7	8	9	10
HR Name ->	North Coast	SF Bay	Central Coast	South Coast	Sacramento River	San Joaquin	Tulare Lake	North Lahontan	South Lahontan	Colorado River*
Residential - Indoor	6	7	5	6	8	7	6	5	5	5
Residential - Outdoor	0	0	0	0	10	9	5	0	0	1
CII/Landscape	5	12	9	12	2	4	3	9	10	46
Water loss control (BMP 3)	0	3	2	4	0	0	0	0	0	0
Total savings GPCD	11	22	16	22	19	21	14	15	15	51
Baseline GPCD	165	157	154	180	253	248	285	248	237	346
% of Baseline GPCD	7%	14%	10%	12%	8%	8%	5%	6%	7%	15%

4 Conclusions

The estimates presented here suggest several important conclusions. First, efficiency codes still have considerable potential to further reduce water consumption in California on a per capita basis, even in hydrologic regions with already less than average use. Second, implementation of BMPs to a level that is regionally cost effective can almost double the impact of efficiency codes in certain hydrologic regions, such as San Francisco Bay and South Coast that account for a large share of the state's population, thus also water use. On the other hand, simply following a BMP strategy, which relies on voluntary implementation of locally cost-effective conservation measures, would fail to achieve significant conservation in many other hydrologic regions, such as Sacramento River, San Joaquin River, North and South Lahontan, and Tulare Lake that are also home to a significant share of California's population, but where urban water supply costs remain low relative to other parts of the state (Appendix A includes data that highlight some of these differences). Different mechanisms will need to be devised to incentivize water suppliers in these regions to aggressively pursue conservation. The AB 1420 legislation already attempts to do this, and it will help, but will not provide sufficient spur to each region to reach its 2020 target.

Our estimates of projected savings are derived from uncertain data. Device turnover rates, BMP implementation rates, the negative interaction between the two due to free-ridership, device-specific savings, all suffer from varying levels of uncertainty. It is thus imperative that state agencies monitor statewide water use to cross-check whether GPCD declines in the aggregate match with our bottom-up savings projections. This is more difficult than it seems. Conservation will make consumption drop, say, at a rate of 1-2 GPCD per year, which relative to the 1995-2005 average (192 GPCD) requires very sensitive models to detect, especially if factors are at play that are simultaneously increasing per-capita consumption at about the same rate.

5 References

- California Department of Water Resources (2005). “California Water Plan Update 2005: A Framework for Action.” Bulletin 160-05, December 2005
- CALFED Bay-Delta Program (2006). “Water Use Efficiency Comprehensive Evaluation,” CALFED Bay-Delta Program Water Use Efficiency Element, August 2006
- American Water Works Association Research Foundation, “The Residential End Uses of Water.”
- Santa Clara Valley Water District (2004). “Santa Clara County Residential Water Use Baseline Survey: Final Report.” August 2004
- Metropolitan Water District of Southern California and Municipal Water District of Orange County (2001). “Orange County Saturation Survey.”