June 4, 2012

To: John Mundy, General Manager

From: David Lippman, P.E., Director of Facilities & Operations

Subject: BACKBONE IMPROVEMENT PROGRAM

The Backbone Improvement Program that was indentified in the 2007 Potable Water Master Plan consists of transmission main improvements in Agoura Hills and Calabasas, expansion of the Westlake Treatment Plant, modernization of the Westlake Pump Station and a 5-million gallon tank located at the Las Virgenes Reservoir. All of these facilities are necessary to correct the storage and supply deficiencies that exist today and provide for future growth. In October of 2009 the board approved the Alternative Study and certified the Mitigated Negative Declaration for the program. The transmission main improvements in Agoura Hills are completed and a call for bids for the transmission main improvements in Calabasas is scheduled for August of 2012.

The Backbone Improvement Program will:

- Address a deficiency of 4 million gallons of storage in the western portion of the district.
- Provide 1 million gallons of storage for future growth based on a population increase of 16 % to 22%.
- Meet a projected 17% increase in water demand.
- Assure sufficient supplies to meet regulatory fire protection requirements.
- Increase the rated capacity of the Westlake Filtration Plant from 16.7 MGD to 20 MGD to meet peaking demands.
- Provide supply and storage capacity that allows the district to meet winter time demands when supply is interrupted from MWD and no emergency supply is available from LADWP.

The basis of design for these facilities is:

- Title 22 of the California Code of Regulations that requires the district to have the ability to meet maximum day demand at all times.
- Regulation No. 8 of the Los Angeles County Fire Department that requires the district to meet a fire flow of 5,000 gallons per minute for 5 hours.
- Provide sufficient storage, 8 – 10 hours, in both the western and eastern portion of the backbone system allowing the filtration plant to be brought on line in an emergency.
- Meet winter time demands when supplies are interrupted from MWD and there is no emergency supply from LADWP.
- Provide a safe and reliable supply of potable water and fire protection to the whole district.

If these facilities are not constructed there is a risk of low pressures, water outages and inadequate emergency supplies and fire flows.

- There is not enough storage in the western portion of the backbone system to supply water to customers during an emergency.
- There is not enough capacity in the system to supply even winter time demands with a loss of water from MWD and LADWP.
- Growth will occur in the district and demands will approach pre-drought demands in the very near future, even with meeting the state mandated 20 % reduction by 2020 goal the backbone system does not have the capacity to meet these needs.
- District wide demands would have to drop to 1987 levels which is a sustained reduction of 38% from 2007 to eliminate the need for the tank and backbone improvements.
- The district will not meet its regulatory requirements under Title 22 or the Los Angeles County Fire code.

The attached technical memorandums address in detail the need for the tank, the basis of design, supply capacity, post drought water demands and the level of conservation needed to eliminate the need for the tank.

Staff's recommendation to move forward with the improvements is unchanged. There has been a delay of over a year and a half from the original schedule. The district has been fortunate that this delay occurred during a drought when demands were suppressed because of mandatory water use restrictions. The design of the tank at Site A needs to start as soon as possible, the call for bids for the Calabasas transmission main improvements should move forward as planned, and following a call for bids for the tank, design of the filtration plant expansion and modernization of pump station should move forward. All facilities should be completed within the next 4 to 5 years.

June 4, 2012

To: John Mundy

From: David Lippman, P.E.

Subject: DESIGN BASIS AND NEED FOR 5-MILLION GALLON TANK

What is the basis of design for a storage tank in a water distribution system?

Three components are considered when designing a water storage tank. The first is fire flow as defined by Los Angeles County Fire Department Regulation 8. The type and size of structures served by the tank determine the fire flow. Fire flows are expressed as a flow rate, *in gallons per minute*, for duration, *in hours*. Knowing the flow rate and duration, the volume of water needed to meet the fire flow can be calculated. In the western and eastern portion of the backbone system the greatest fire flow requirement is 5,000 gallons per minute for 5 hours[1]. The volume of storage needed to meet this fire flow is 1,500,000 gallons[2].

The next two components are based on maximum day demand (MDD) or the maximum consumption that will occur on any single day in gallons per minute. The use of MDD is required by California Code of Regulations Title 22 that states *"At all times, a public water system's source(s) shall have the capacity to meet the system's maximum day demand."*[3] Consumption is also defined by average day demand (ADD) or the yearly use divided by 365 days and peak hour demand (PHD) or the maximum consumption for any single hour during the maximum day, both measured in gallons per minute.

Operational storage is the volume of water needed to meet demand beyond the pumping duration and capacity of the system. The shorter the pumping duration the greater the volume of operational storage is needed. The backbone system is designed for 24 hour pumping with a pumping rate equal to the maximum day demand. Seven hours of MDD are needed for operational storage based on the diurnal curve for the backbone system.

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[1] Private schools, hotels, apartments, high rises, commercial, industrial over 35,000 square feet such as Oaks Christian School and the Four Seasons require this fire flow.

[2] 5,000 gallons/minute * 5 hours * 60 minutes/hour = 1,500,000 gallons

[3] Title 22, Division 4, Chapter 16, Article 2, 64554 (a) of the California Code of Regulations, California Waterworks Standards.

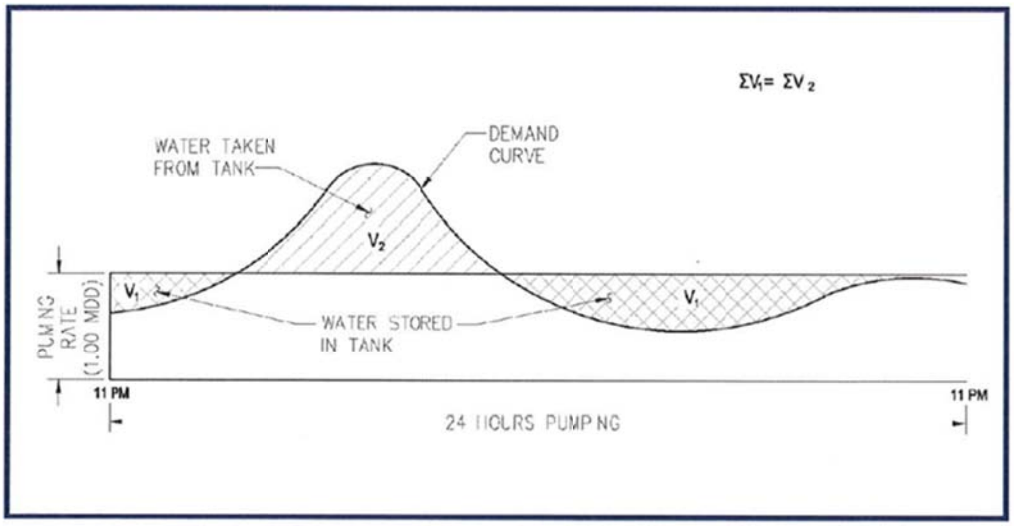

Figure 3-3
LVMWD
Master Plan Update
Peak Hour Pumping

The district's standard for emergency storage is the volume of water needed to provide 5 hours of MDD. This volume allows for a timely response to most localized emergencies and unplanned outages such as loss of power or pipeline breaks.

The required volume in a storage tank is the sum of fire flow, operational storage based on MDD and pumping duration and five hours of emergency storage based on MDD.

How is the maximum day demand calculated?

Actual water consumption is used to determine the MDD. MDD is determined by projecting the ADD then applying a factor of 2.1. The 2.1 factor is based on an analysis of the relationship of ADD to MDD for previous years. This factor is different for different water districts, as an example a district that is primarily industrial will have a different peaking factor than a residential district.

The future ADD is calculated using two different methods. The first method uses the local cities and county general plans land use categories and consumption rates for those categories to project future consumption. The second method uses census tracts information and projects population increases based on SCAG[4] projections then a consumption rate is applied to project future demand.

Using the first method the 2007 Master Plan projects a population of 90,828 and annual water demand of 30,700 acre-feet by 2030. Using the second method the 2010 Urban Water Management Plan projects a population of 85,323 and annual water demand of 29,380 acre-feet by 2030[5].

What maximum day demand was used in sizing the tank?

In the 2007 Master Plan the tank was sized using 40% of an estimated 2006 MDD of 32,773 gpm. [6,7] This results in needed storage of 3.86 million gallons to meet existing demand. Future needs were based on a MDD of 14,134 gpm resulting in needed storage of 4.48 million gallons.

[4] Southern California Association of Governments
[5] Assuming compliance with 20 by 2020 the UWMP projects annual demand of 23,504 acre-feet by 2030

Based on the Master Plan 3.86 million gallons of storage are needed to meet current demands and 4.48 million gallons of storage are needed to meet future demand in the western portion of the backbone system.

What storage is needed when different maximum day demands are used?

Operational and emergency storage make up the bulk of storage needed in a distribution system. Because these volumes are based on MDD, the amount of storage needed can vary depending on what MDD is used. The following table shows the results of needed storage in the western portion of the backbone system based on several different conditions. The smallest amount needed is 0.36 million gallons if 2010 actual MDD was used. In 2010 mandatory water allocations were in place which artificially depressed demand. The largest amount needed is 4.48 million gallons using the Master Plan 2030 projection.

Condition	MDD	Fire Flow	Operational	Emergency	Storage Required	Existing Storage	Needed Storage
	(GPM)	(MG)	(MG)	(MG)	(MG)	(MG)	(MG)
2007 Actual	12,114	1.50	5.09	3.63	10.22	7.20	**3.02**
2010 Actual	8,414	1.50	3.53	2.52	7.56	7.20	**0.36**
2011 Actual	8,690	1.50	3.65	2.61	7.76	7.20	**0.56**
2007 MP - 2006 Estimate	13,272	1.50	5.57	3.98	11.06	7.20	**3.86**
2007 MP - 2030	14,134	1.50	5.94	4.24	11.68	7.20	**4.48**
2010 UWMP - 2020 w/o conservation	12,711	1.50	5.34	3.81	10.65	7.20	**3.45**
2010 UWMP - 2020 with conservation	10,169	1.50	4.27	3.05	8.82	7.20	**1.62**
2010 UWMP - 2030 w/o conservation	13,559	1.50	5.69	4.07	11.26	7.20	**4.06**
2010 UWMP - 2030 with conservation	10,847	1.50	4.56	3.25	9.31	7.20	**2.11**

Needed storage varies from 0.36 to 4.48 million gallons depending on the maximum day demand that is used to calculate operational and emergency storage.

Which recommended maximum day demand should be used?

The Master Plan predicted a 3.86 million gallon shortage based on an estimated 2007 MDD, based on the actual 2007 MDD the shortage was 3.02 million gallons. Voluntary water reductions in 2008 reduced demand about 10% and in 2009 and 2010 mandatory water allocations reduced demands 28% from 2007 levels. In 2011, demands increased 5%. A similar pattern occurred in the 1990 -1991 drought. From a high of 21,328 acre feet in 1989 demands were reduced 28.5% in two years because of mandatory conservation measures. Within six years, demands were back to 1990 levels. During this six year period there was modest growth, a continued focus on conservation and normal weather patterns. The same pattern can be expected between 2010 and 2016; modest growth, continued focus on conservation and normal weather patterns. By 2016 or earlier it is not unreasonable to anticipate that demands will grow back to 2007 – 2008 levels.

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[6] 2006 actual MDD was 30,500 gpm

[7] 40% of system wide MDD is in the western portion of the backbone system the primary service area of the tank

The use of either the estimated 2007 MDD from the master plan or the actual 2007 MDD should be used to determine the current shortage deficient of 3.02 to 3.86 million gallons.

It is prudent when designing and constructing facilities with life spans of over 50 years to include capacity for future needs. Both the Master Plan and Urban Water Management Plan projected needs to 2030, only 18 years in the future. Projections for needed storage range from 2.11 million gallons to 4.48 million gallons. The 2.11 million gallons assumes that the 246 gallons per capita per day 20 by 2020 target is maintained to 2030. The 2.11 million gallons is less than what is required now. The Master Plan projects 4.48 million gallons by 2030 and the Urban Water Management Plan projects 4.06 million gallons if 20 by 2020 levels are not realized. It is likely that future per capita per day consumption will fluctuate between current levels and the 20 by 2020 level depending on weather, growth and availability of water. Storage facilities need to have the capacity to meet these fluctuations in demand.

Four to five millions gallons of additional storage is needed to meet current and future needs.

What alternatives are there to the tank?

Fire flows, emergency supply, maximum day demand and peak hour demand can be met in a variety of ways and each water system uses a unique mix of storage, supply and pumping to meet these needs. The district uses a combination of pumping and storage to meet these needs[8]. In the backbone system 24 hour pumping is used already, reducing storage volumes, so if increased pumping was used pump station capacity would have to be increased and larger, longer transmission mains would be needed. This increased capacity would be needed from the MWD connection in Calabasas across the district to Las Virgenes Reservoir, not only in the western portion of the backbone system. Relying on pumping to meet fire flow and emergency supply requires that stand-by power be available at all times at the pump stations.

Meeting demand with pumping rather than storage will require extensive increases in pumping capacity, larger and longer transmission mains and emergency power facilities.

If conservation that reduces demand was used to eliminate the need for the tank then maximum day demands must drop to a level where existing storage is sufficient. To achieve this level demands would have to drop 35 to 38 percent district wide. This is similar to the annual demands seen in the late 1980s.

If conservation is used to eliminate the need for storage consumption levels must drop back to 1987 levels.

What could happen if the tank is not built?

Maximum day demands can occur more than once a year, the most common time this happens is during extended heat spells in the summer time. During this condition the system is operating at or near capacity. Any failure in the system such as a power outage at a major pump station or the filtration

[8] Peak hour demand is the highest demand hour during the maximum day. Pump stations are designed to not only replenish tanks but also to meet peak hour demands.

plant would cause drops in system pressures impacting service. In a prolonged event some areas will experience water outages. If a structure fire occurs during the times where demand is at or near maximum day demands there will not be adequate supplies to meet fire flow or demands.

Without additional storage there is a risk of low pressures, water outages and inadequate emergency supplies and fire flows.

Should the tank be constructed now?

Yes, the tank should be constructed now. There is a current deficiency in system storage that creates a risk of low pressures, water outages, inadequate emergency supplies and fire flows. The district is unable to meet maximum day demand at all times as required by Title 22. Four to five million gallons of storage is needed to negate the risk, meet Title 22, LACFD regulations and provide facilities for future needs.

The tank should be built now to avoid risks, meet regulatory requirements and future needs.

June 4, 2012

To: John Mundy

From: David Lippman, P.E.

Subject: POTABLE WATER SYSTEM SUPPLY CAPACITY

Where does the district's supply of water come from under "normal" conditions?

There are two main sources of supply for the district, purchased water from the Metropolitan Water District of Southern California (MWD) and the Las Virgenes Reservoir/Westlake Filtration Plant. There are three MWD connections; LV-1, LV-2 and LV-3. LV-1 is the original source of supply and was used prior to construction of the MWD Jensen Treatment Plant and Calabasas Feeder. It is rarely used now and is limited in capacity. There are two small areas in Woolsey Canyon and Box Canyon served from connections with the City of Simi Valley and Ventura County.

LV-2 is the primary supply of water to the majority of the district and is located in Calabasas at the end of the MWD Calabasas Feeder. LV-3 is the source of supply to the district's service area located north of the 118 Freeway in Chatsworth; this area cannot currently be served by the Westlake Treatment Plant.

The Las Virgenes Reservoir and Westlake Filtration Plant located in Westlake Village are used to meet peak summer demands. From June to September treated water from the filter plant is served to the western portion of the district to reduce peaking on MWD's system. The reservoir is then refilled with water purchased from MWD between October and May replenishing the available supply.

The two sources of supply, MWD and the Las Virgenes Reservoir, are both needed to meet peak summer demands.

What happens if MWD has a planned shut down?

MWD plans regular shut downs of their transmission and treatment facilities for maintenance and repair during the winter. Winter is normally the lowest demand period. There are one to two shut downs a year ranging from a few days to several weeks in duration when all three of the district's MWD connections are out of service. The capacity of the Westlake Treatment Plant is not sufficient to serve the district during these planned outages. However the district has the ability to receive an emergency supply of water from the Los Angeles Department of Water and Power (LADWP) during either a planned or unplanned shut down of MWD transmission mains. This additional supply is limited to 20 cfs because of transmission main limitations. However when combined with the treatment plant there is sufficient water to meet demand during the winter.

This agreement with LADWP is contained in a lease agreement between MWD and LADWP for a section of MWD transmission main in the West Valley. It provides that in an emergency LADPW and MWD shall cooperate to maintain service to the district and Calleguas MWD and that during a planned shutdown LADPW and MWD shall provide up to 60 cfs to the district and Calleguas MWD.

During planned MWD shut downs the supplies from the Westlake Treatment Plant and LADWP are sufficient to meet current winter demands.

What happens if MWD and LADWP cannot provide water during an emergency?

A regional emergency such the Northridge Earthquake could disrupt both MWD and LADWP supplies to the district. The only remaining source of supply would be water in storage tanks and the Las Virgenes Reservoir. A likely scenario would be an emergency occurring when the plant is off line, there is a maximum day demand event and fire storage in the tanks is not depleted. In this scenario tank storage is quickly depleted before water can be supplied by the treatment plant. In a real emergency of this magnitude mandatory water use restrictions would go into effect. History shows that there would be localized water outages because of failed distribution system components affecting the available storage in the tanks. The chart below shows the number of hours it would take to deplete storage in western portion of the backbone system with and without the 5-million gallon tank. It also includes the eastern portion of the backbone system.

WEST (7.2 million gallons of storage)				
Year	2005	2007	2011	2020
Maximum Day Demand (gpm)	13,272	12,114	8,690	11,037
Hours to deplete without 5 MG Tank	7.2	7.8	10.9	8.6
Hours to deplete with 5 MG Tank	13.4	14.7	20.5	16.2
EAST (8.0 million gallons of storage)				
Year	2005	2007	2011	2020
Maximum Day Demand (gpm)	8,848	8,076	5,793	7,358
Hours to deplete	12.2	13.4	18.7	14.7

Footnotes: Assumes maintaining 1,500,000 gallons of storage for fire protection and no supply to sub-systems.

Under extreme conditions the Westlake Filtration Plant can be online serving disinfected water in 8 to 10 hours. Normally this process takes as long 48 hours to obtain the results of microbiological testing, showing that the water is safe to drink.

Without additional storage in the western portion of the backbone system there is not enough water to supply customers while the filtration plant is brought online in an emergency.

How much water is available from the Westlake Filtration Plant during a MWD shut down?

The current rated capacity of the Westlake Reservoir is 16.7 MGD (11,600 gpm) with a sustained output of 13 MGD (9,000 gpm). The difference between the rated and sustained capacity is the changes in Las Virgenes reservoir water quality and filter performance. With the addition of two filters the rated capacity is increased to 20 MGD (14,000 gpm) and the sustained capacity is 17 MGD (11,800 gpm). Winter demands are equal to 75% of average day demands, spring and fall demand are equal to average day demands and summer demands are equal to 2.1 times average day demands. The following tables show the deficiency in the system with and without LADWP supply under various demand conditions.

Supply Capacity		
	Current Capacity (gpm)	Future Capacity (gpm)
LADWP @ Kittridge	9,000	9,000
WLFP	9,000	11,800
LADWP @ Germain	1,350	1,350
VCWW & Simi	180	180
	19,530	22,330

System Deficiency with Current Supply Capacity

Demand Condition (gpm)	2007 Actual	2010 Actual	2020 UWMP without conservation	2020 UWMP with conservation
Winter	12,045	8,645	13,662	10,929
with LADWP				
without LADWP	**-24%**		**-33%**	**-16%**
Spring/Fall	16,060	11,526	18,216	14,572
with LADWP				
without LADWP	**-43%**	**-20%**	**-50%**	**-37%**
Summer	33,726	24,205	38,253	30,602
with LADWP	**-42%**	**-19%**	**-49%**	**-36%**
without LADWP	**-73%**	**-62%**	**-76%**	**-70%**

System Deficiency with Future Supply Capacity

Demand Condition (gpm)	2007 Actual	2010 Actual	2020 UWMP without conservation	2020 UWMP with conservation
Winter	12,045	8,645	13,662	10,929
with LADWP				
without LADWP	**-1%**		**-12%**	
Spring/Fall	16,060	11,526	18,216	14,572
with LADWP				
without LADWP	**-25%**		**-34%**	**-18%**
Summer	33,726	24,205	38,253	30,602
with LADWP	**-34%**	**-8%**	**-42%**	**-27%**
without LADWP	**-64%**	**-51%**	**-69%**	**-61%**

The current supply capacity of the Westlake Filter Plant can not meet winter, spring/fall and summer demands alone. If the supply from LADWP is available winter and spring/fall demands can be met. In either case, summer time demands <u>cannot</u> be met with supply deficiencies ranging from 62 to 76 percent.

The expansion of the Westlake Filtration Plant will provide enough supply capacity to meet winter time demands under most conditions. Spring/fall demand conditions cannot be met but the system deficiency is reduced to 18% from 37% in 2020. Obtaining an 18% reduction in usage would be more achievable than a 37% reduction. If the supply from LADWP is available winter and spring/fall demands can be met. In either case, summer time demands cannot be met with supply deficiencies ranging from 51 to 69 percent.

Completion of the Backbone Improvement Program including the 5-million gallon tank and expansion of the Westlake Treatment Plant will provide enough supply to meet winter demands today and in the future without emergency supplies from LADWP.

June 4, 2012

To: John Mundy

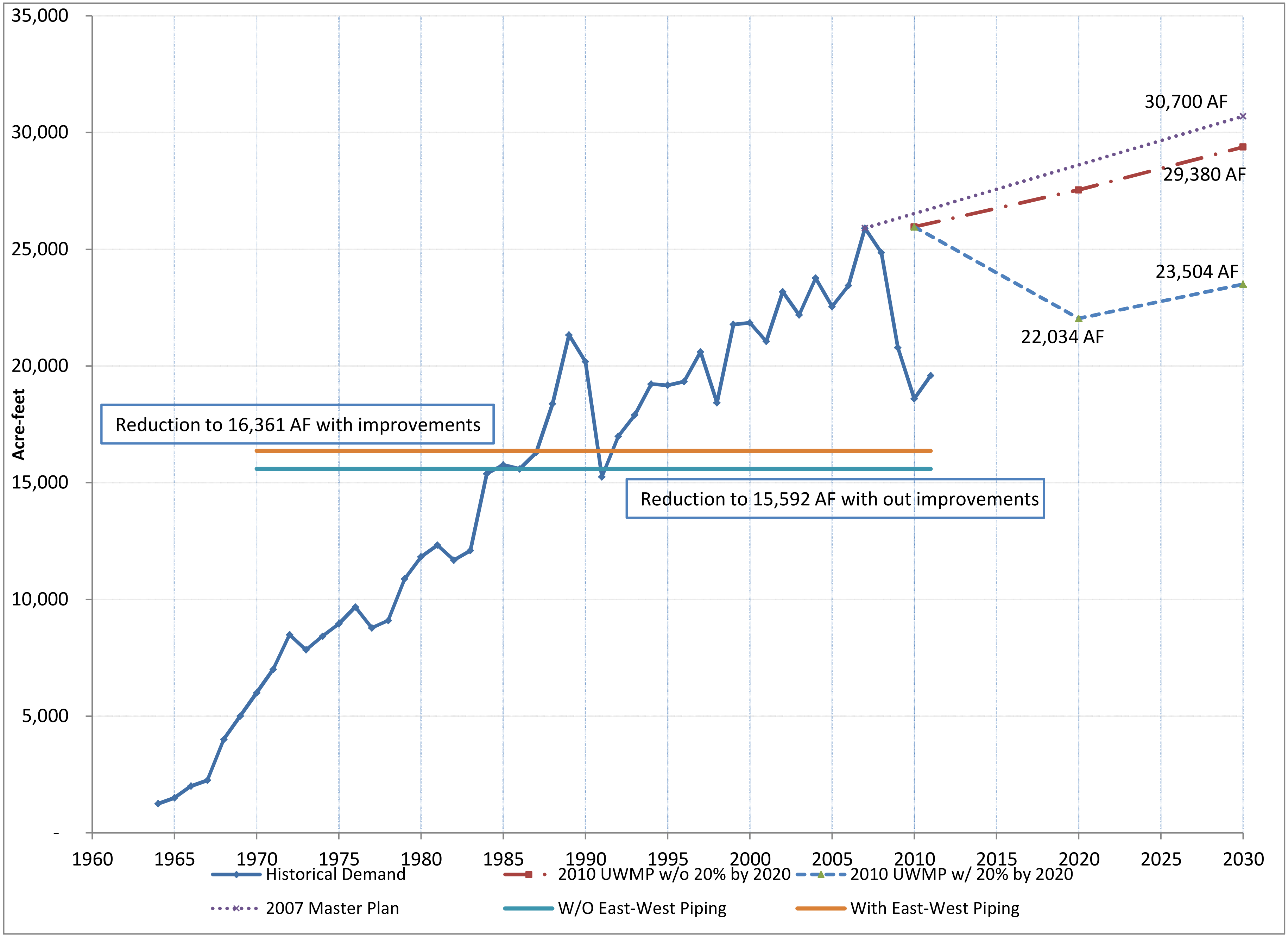
From: David Lippman, P.E.

Subject: LEVEL OF CONSERVATION NEEDED TO ELIMINATE 5-MILLION GALLON TANK

To determine the level of conservation required to eliminate the need for the 5-million gallon tank the maximum day demand value corresponding to the existing storage volume is calculated then converted to annual day demand. To eliminate the need for the tank, the district would need to reduce annual demand to 16,361 AF/YR with additional backbone piping improvements and to 15,592 AF/YR without backbone piping improvements. The 15,592 AF/YR is similar to demands last experienced in 1987. The table below and attached chart helps to put this in perspective. An overall reduction from the 2007 MDD of 38% without the piping improvements and a 35% reduction with the improvements are needed to eliminate the need for the tank. If you compare to 2009 demands of 20,789 AF when mandatory reductions were in place a 27% reduction with the improvements and a 33% reduction without the improvements are needed. Annual demand would need to reduce 35% with the improvements and 41% without them from the 20% reduction by 2020 target. The piping improvements include the Agoura Road pipeline that is currently being completed, the 30" transmission main along Mureau Road to Las Virgenes Road which is ready to go out to bid and a 30" transmission main from Las Virgenes Road to Liberty Canyon Road.

Required Levels of Conservation				
Condition	Units	Value	% Reduction	
			With Improvements	Without Improvements
2007 MDD	GPM	32,773	35%	38%
2007 Equivalent ADD	AF/YR		16,361	15,592
2009 Actual	AF/YR	20,789	27%	33%
20 by 2020	AF/YR	22,035	35%	41%

The attached analysis by HDR Engineering further details the needed reduction to eliminate the need for the tank.



Acre-feet
35,000
30,000
25,000
20,000
15,000
10,000
5,000
-
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025
2030
30,700 AF
29,380 AF
23,504 AF
22,034 AF
Reduction to 16,361 AF with improvements
Reduction to 15,592 AF with out improvements
Historical Demand
2010 UWMP w/o 20% by 2020
2010 UWMP w/ 20% by 2020
2007 Master Plan
W/O East-West Piping
With East-West Piping

To:	John Zhao, PE, Principal Engineer, Las Virgenes MWD		
From:	Dan Ellison, PE	Project:	Backbone Improvements Program
CC:	David Lippman, John Mundy (LVMWD)		
Date:	4/19/12 (revised)	Job No:	

RE: Storage requirements for the Backbone System

This memorandum discusses the demands used to establish the need for the proposed 5MG tank and what level of demands would eliminate the calculated deficit.

To make maximum use of facilities, the Master Plan assumes that the Filtration Plant and transmission systems would be operating at close to their maximum capacities during MDD events, and that peak diurnal demands in the western 1235-ft system would be balanced through the storage in the western backbone tanks (Morrison and Equestrian Trails and the proposed new tank). New transmission pipelines were sized according to this plan. Fire storage was as dictated by Los Angeles Fire Department Regulation No. 8. Emergency storage was per District criteria. The eastern and western 1235-ft zones were treated separately, because of limits to the hydraulic transmission capcity. The two zones are separated by Cornell PS, which has a current maximum capacity of about 9,000 gpm (10,000 when all pipeline improvements are completed).

Master Plan Table 7-1 showed a 2007 storage deficit of 3.9 MG in the west half of the 1235-ft system. This was based on an estimated MDD of 32,773 gpm for the system as a whole of which 13,272 gpm was attributable to the west half of the 1235-ft system. Per District records, the MDD in 2006 was 30,500 gpm, so 32,773 was a reasonable estimate.[1] The 2007 storage deficit was derived by subtracting the needed storage from the available storage:

7.2 MG (available storage) – [1.5 MG (fire) + 4.0 MG (emergency) + 5.6 (operational)] = -3.9 MG

Based on these numbers, a **40 percent** reduction in demands in the western portion of the 1235-ft zone would eliminate the need for the tank. This is based on the following calculation:

1 - [7.2 MG -1.5 MG] / [4.0 MG + 5.6 MG (emergency + operations)] = 40%
[Fire storage is omitted from this calculation, because its need is not related to daily demands.]

Alternatively, if maximum-day demands District-wide were reliably reduced by at least **38 percent**, the calculated deficit would also disappear. Lower demands in the Seminole, Latigo, Saddletree and Kimberly subsystems (each of which have independent storage) would free-up some capacity through Cornell PS that could be used to supply the western 1235-ft system. This equates to a system-wide MDD of 20,300 gpm.

If we assume completion of all backbone pipeline improvements shown in the Master Plan, we can assume about 1000 gpm of additional flow can be delivered through Cornell PS. Using this assumption, a system-wide reduction of **35 percent** would need to be achieved for the deficit to disappear. A 35 percent system-wide reduction is equivalent to a maximum-day demand of 21,300 gpm, similar to what was last experienced in 1991.

The calculations that support these estimates are attached.

[1] As a subconsultant to Boyle Engineering and as author of the District's 2005 Urban Water Management Plan, Psomas estimated the demands for the master plan.

Conclusions. The only ways to eliminate the storage deficit in the western portion of the 1235-ft system are:

1. Reduce demand in the western 1235-ft zone by 40 percent, as compared to the 2007 estimated MDD
2. Reduce demands 38% system-wide, to achieve a MDD of no more than 20,300 gpm.
3. Reduce demands slightly less (35%) system-wide, and implement all master plan pipeline improvements
4. Significantly increase transmission capacity from east-to-west (and/or expand the Filtration Plant much more than currently planned. (Not recommended—would be very, very expensive.)
5. Change the criteria used for the sizing of storage facilities. (Not recommended—criteria are already lean.)

This memorandum does not address the other purposes of the proposed tank, which are to help increase filtration plant reliability/productivity, allow for greater use of reservoir storage, and improve overall emergency supply during a major disaster or other supply interruption.

CASE 1: NO BACKBONE PIPELINE IMPROVMENTS

38% assumed system-wide reduction

	2007 MDD	
Seminole	865	gpm
Latigo	248	gpm
Kimberly	388	gpm
Saddletree	129	gpm
	1630	gpm

619	gpm	available for 1235-ft zone supplement from above subsystems
0	gpm	assumed available as additional flow through Cornell (maxes out the PS capacity)
619	gpm	total flow supplment for the western 1235-ft system

This is equivalent to:

0.4	MG	available added capacity (5 hours emergency + 7 hours of operational storage)

38% calculated system-wide reduction needed to eliminate deficit

CASE 2: ALL 2007 MP BACKBONE PIPELINE IMPROVEMENTS

35% assumed system-wide reduction

	2007 MDD	
Seminole	865	gpm
Latigo	248	gpm
Kimberly	388	gpm
Saddletree	129	gpm
	1630	gpm

571	gpm	available for 1235-ft zone supplement from above subsystems
1000	gpm	assumed available as additional flow through Cornell (maxes out the PS capacity)
1571	gpm	total flow supplment for the western 1235-ft system

This is equivalent to:

0.66	MG	= 7 hours of operational storage @	1571	gpm
0.17	MG	= 5 hours of emergency storage @	571	gpm
0.83	MG	total, available added capacity		

35% calculated system-wide reduction needed to eliminate deficit

April 11, 2012

TO: CARLOS REYES

FROM: RANDAL ORTON[1]

SUBJECT: POST-DROUGHT WATER DEMAND

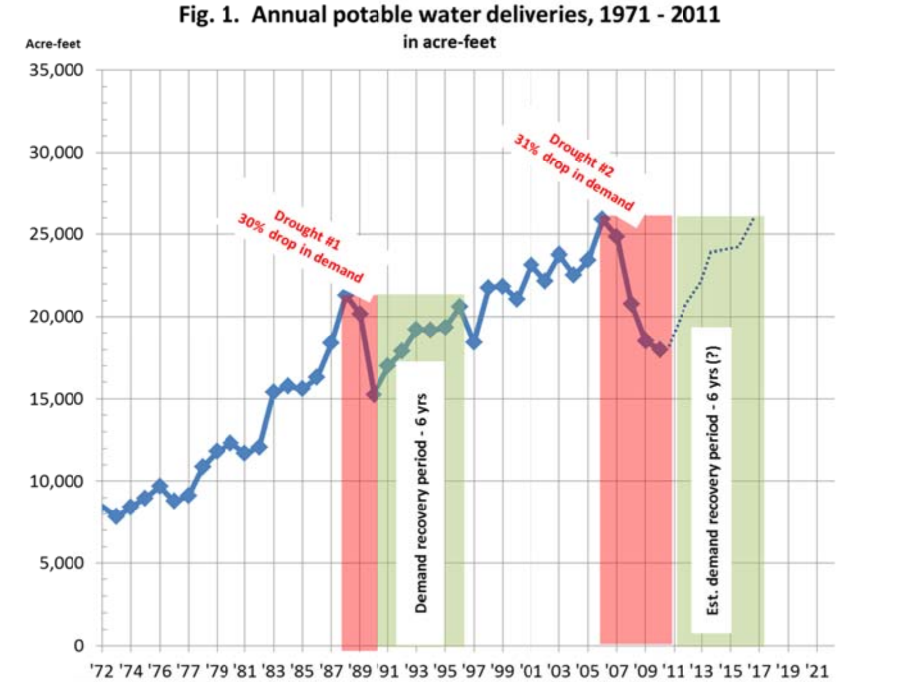
Per your request, we compiled and examined District data[2] on potable water demand over the period 1972 through February 2012, focusing on changes in residential demand[3] during and immediately following both the 1991-2 and 2009-11 state-wide drought water shortage emergencies. Our objective was to estimate how quickly water demand following the recent drought might rise based on our experience following the 1991-2 drought, and to determine what factors most-strongly influence the recovery rate.

Based on our experience with the previous drought recovery (1992 – 1997), we estimate *annual* potable water demand may recover to its pre-drought level in 5-6 years (2016-17) if local weather is drier than normal, but may be delayed until 2017-18 if wetter conditions prevail. Peak summertime monthly demand will likely recover sooner (2014-15), regardless of weather, and peak summertime daily demands are expected to recover sooner still (2012-13).

DISCUSSION

Over the last 20 years, the District has declared a water shortage emergency twice in response to persistent, statewide droughts, once in the 1991-2 drought and again in the 2009-11 drought. Water use during both of these droughts fell about 30 percent from their pre-drought levels in response to conservation measures and financial penalties for over-usage (Fig. 1). Water demand

Fig. 1. Annual potable water deliveries, 1971 - 2011
in acre-feet



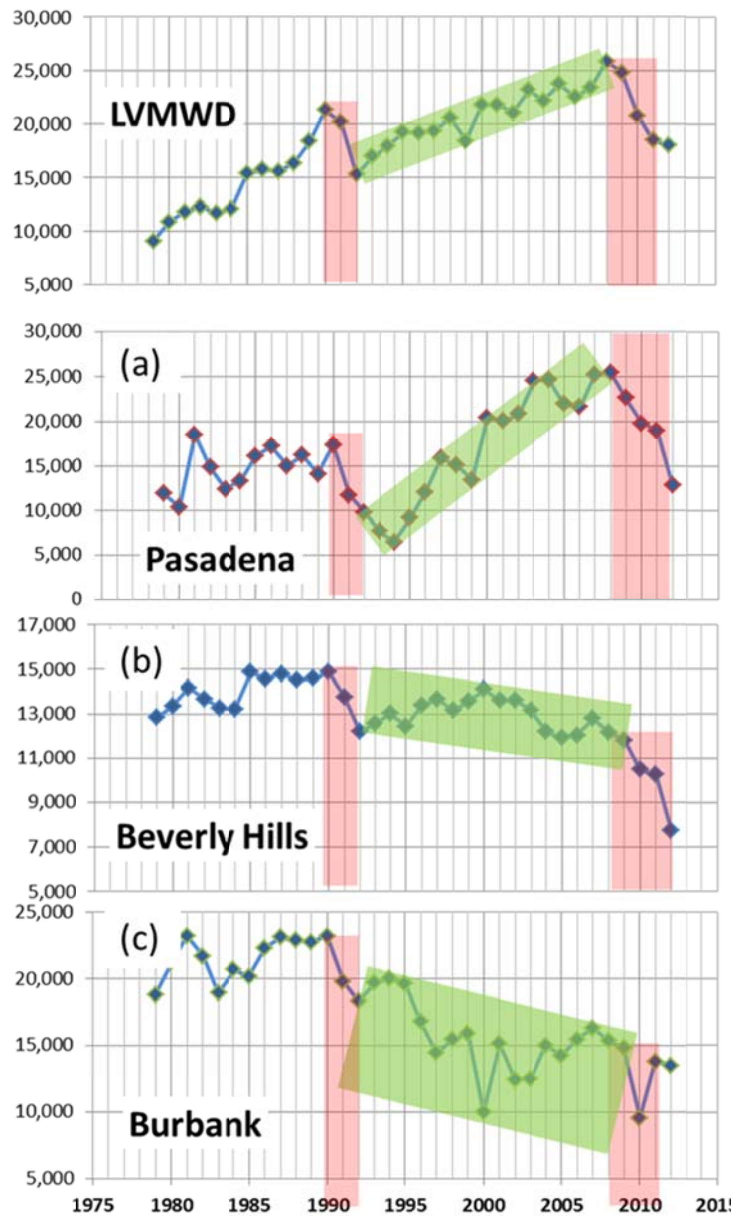
[1] D. Holliday (IS), M. Hamilton (F&A), G. Weston (CS), S. Harris (RC) and J. Dougall (RC) assisted in data compilation and analysis.
[2] Lvdata/district information/annuals/xls.
[3] We considered residential demand only, as it accounts for about 95% of total annual demand in the LVMWD service area.

returned to its pre-drought level in about 6 years following the 1991-92 drought emergency, suggesting a similar period might elapse before current water demands return to their 2009 pre-drought levels. Further, the post-drought rise in demand was steeper in the first three years after the drought, recovering over 85 percent of pre-drought demand in just two years, and 95 percent of pre-drought demand in three years (Fig. 1).

However, different water districts experience drought and post-drought demands differently (Fig. 1b), and the validity of using the earlier drought recovery history to predict future, post-drought water demand depends on our ability to account for the major factors that influence per capita water use in the LVMWD service area, and to show that these factors are comparable for both the historical and current post-drought periods. These factors include:

1. Growth in overall demand due to new connections;
2. Changes in the average residential lot size;
3. Differences in weather
4. Differences in water conserving fixture installation rates (demand hardening)
5. Economic factors, such as differences in the consumer price index (CPI) adjusted for inflation.

Fig. 1b. Other agencies, other experiences – 3 examples. (a) Pasadena experienced both a similar recovery in post-drought and increased usage beyond the recovery period; (b) Beverly Hills only recovered to about 85% of pre-drought demand; (c) Usage in Burbank continued to decline after the 1990-91 drought, but quickly recovered after the 2008-11 drought to pre-2008 levels.



Where these factors differ between the two periods being compared, it may still be possible to adjust or normalize the differences and maintain the validity of the comparison. However, this step proved unnecessary for factors 1-3, as none of these factors were appreciably different in recent years in comparison with the 6 yrs following the 1991-2 drought, as discussed below. The remainder of the memo provides additional detail for each factor we analyzed.

New Connections

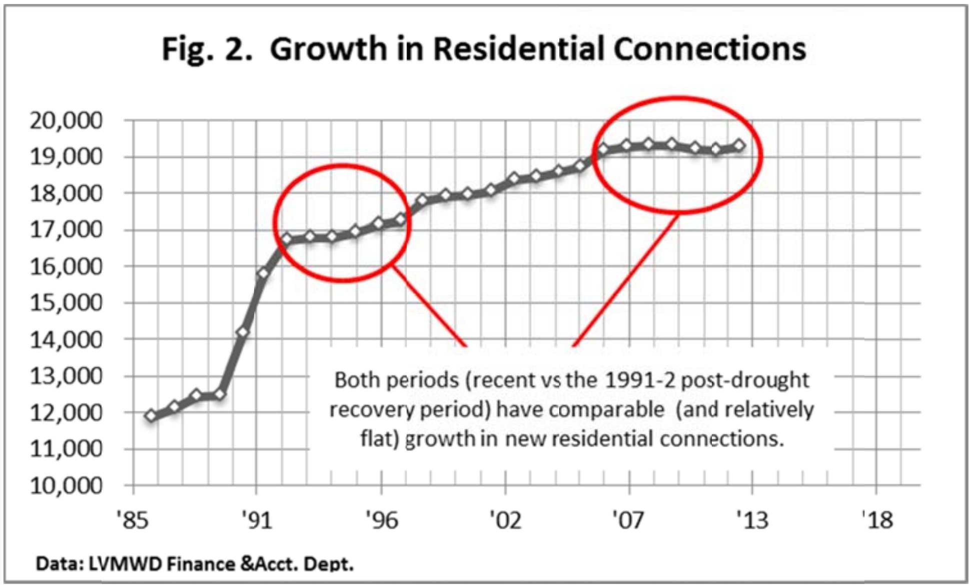


Fig. 2. Growth in Residential Connections

An immediate question is whether the relatively rapid rise in demand following the 1991-2 drought in Fig. 1 was an artifact of growth in new connections (rather than growth in per capita demand to pre-drought levels). Fig. 2 shows this not to be the case; both the post-1991-2 period through 1997 and recent years (2006-12) had comparable, relatively flat growth in new residential connections, with the exception of 1998, the last year of the post-1991-2 drought recovery period, when 526 new residential connections were added to the potable water system. However, by that year demand had already returned to its 1989 pre-drought peak (Fig. 1). In short, the number of residential connections was relatively stable for both the earlier drought recovery (1992-8) and current conditions (2006-12), with changes in demand related more to changes in per capita water use and weather.

Median residential lot size

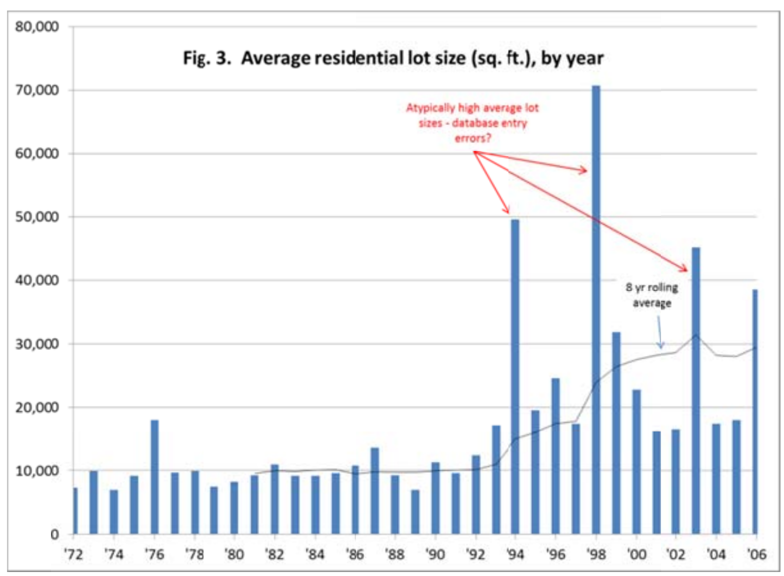
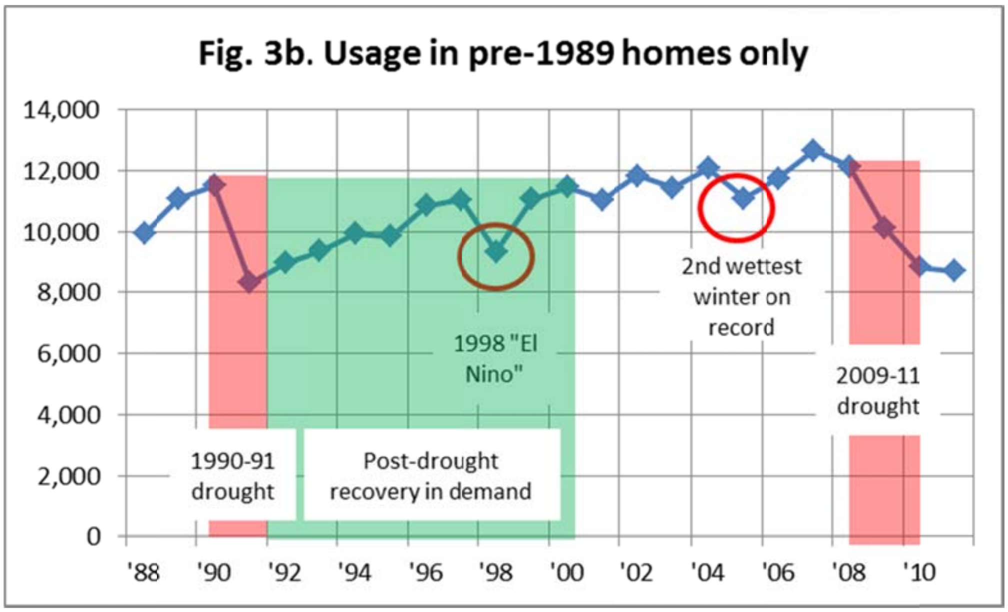


Fig. 3. Average residential lot size (sq. ft.), by year

We used two methods to account for differences in residential lot sizes in our comparison of current water use with usage following the 1990-1 drought. The first method was to compile data on median[4] lot size for the residential customer base for both periods (i.e. 1992-98 vs 2011-12). These values differed by less than ten percent, with median lot size today somewhat smaller than in 1992-98. Further, a large fraction of the ten percent difference may be an artifact of how multifamily residential lot sizes

[4] As a measure of central tendency, the median is less sensitive than the average to extreme values and outliers.

are recorded in the Customer Information System (CIS). Several years had atypically high average residential lot sizes ranging from 100–200 percent higher than the long term, 1972-2012 average (Fig. 3). Inspection of the data from those years found several instances where the square footage of the entire multifamily complex was entered for each of its constituent apartments or condominiums, artificially raising the median lot size. In those cases we found, we estimated the correct lot size by simply dividing the reported lot size (which was identical for every apartment or condo) by the number of units in the complex. However, this correction was limited to our working spreadsheet – we made no changes to the data in CIS – so you may wish to discuss this issue with Customer Service and Information Systems staff[5].



The second method to control for differences in average lot size between the two post-drought periods was to limit our analysis of water use after the recent drought to only those customers who were also connected to the potable water system during the 1991-2 drought cycle (Fig. 3b). Changes in demand in these homes are much less likely to be due to changes in lot sizes, on the assumption that their landscaped footprint changed very little over this period[6]. Post-drought recovery in demand took about nine years for these homes, versus six years for the general residential population, although 95 percent of pre-drought demand was recovered in 5 years, and 85 percent of demand was recovered in three years (Fig. 3b). Interestingly, after reaching pre-drought levels, demand in these homes then continued to rise a little, peaking in 2007 (an exceptionally dry year) at 12,645 AF.

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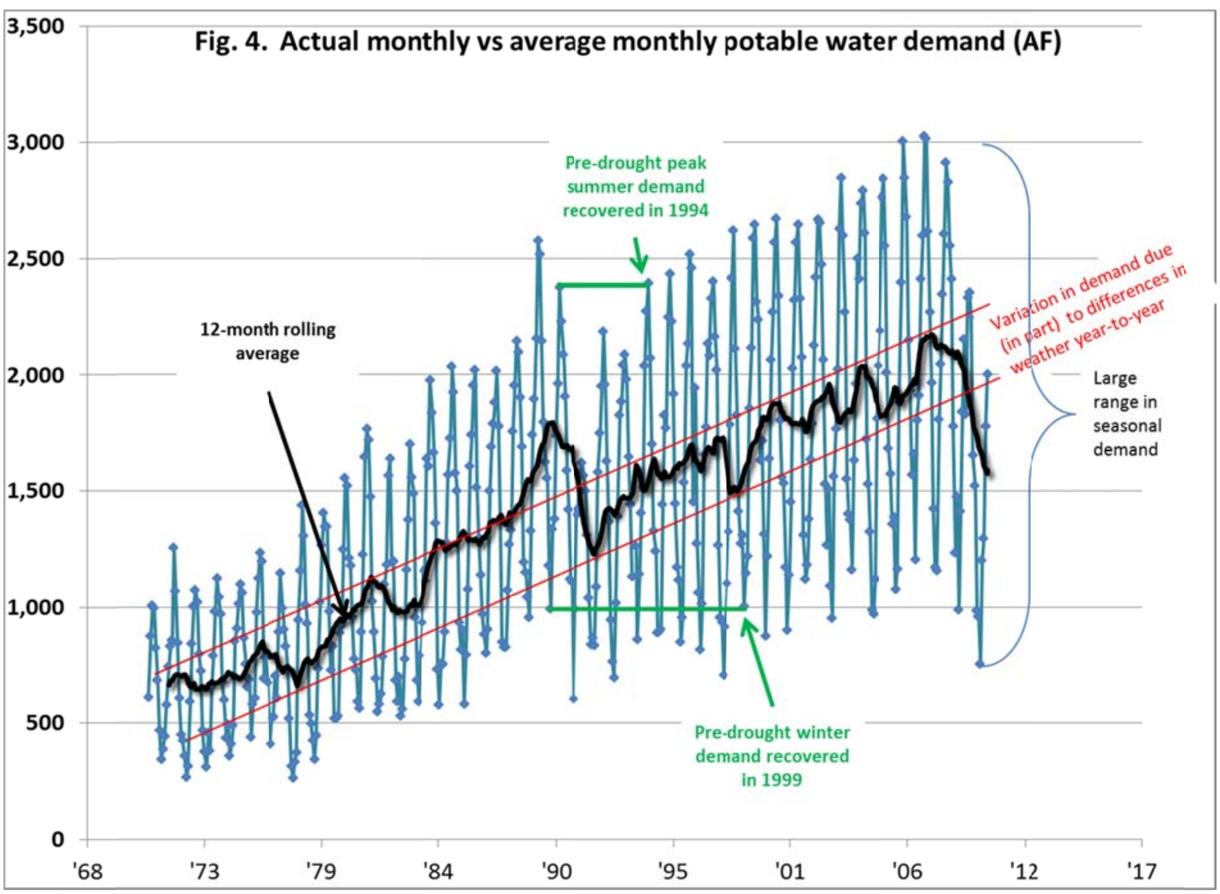
[5] There may be an easier way to identify incorrect lot size data entries for multifamily parcels than visual verification off the District GIS. The total number of accounts potentially affected can be estimated by sorting on lot size and noting all runs of identical lot sizes and install dates and adjacent addresses. This will be an overestimate of the actual number of data entry errors for lot size, because it is not impossible in tract homes for adjacent lots to have identical sizes and water meter install dates.

[6] While not performed for this analysis, this assumption could be tested in a subset of homes if IR aerial imagery is available for 1991 and can be compared with recent IR imagery on the District GIS for a subset of homes (5-10 percent of the total would probably be enough).

Weather

Water demand over any given year is strongly linked to weather in the LVMWD service area due to the prevalence of irrigated landscape coupled with large seasonal swings in rain and temperature and (Fig. 4). What this means for post-drought demand recovery is that peak summertime demands are expected to return to their pre-drought levels faster than off peak winter demand. This was the case following the 1991-2 drought, when post-drought peak demand returned to its pre-drought, July 1990 level in two years, versus 7 years for winter demand to return to its pre-drought level. Year to year variation in weather also affects annual demand, but on a monthly basis year to year differences (e.g. June 2011 versus June 2012) due to weather are on the order of 150-350 AF (bracketed by the red lines in Fig. 4), yielding annual differences in demand due to weather on the order of 1,800 – 3,600 AF, which falls to about 1,700 AF on a billing cycle basis[7]. Drop in demand due to wet weather occurs in about one year in four (27%), but is less important over the multi-year timescale of the expected post-drought rise in demand, as consecutive wet years are uncommon. Conversely, unusually dry years (e.g. 2007) can increase demand with about the same frequency. In short, *normal* variation in weather may be expected to delay or advance the rise in post-drought demand by a year or two at most.



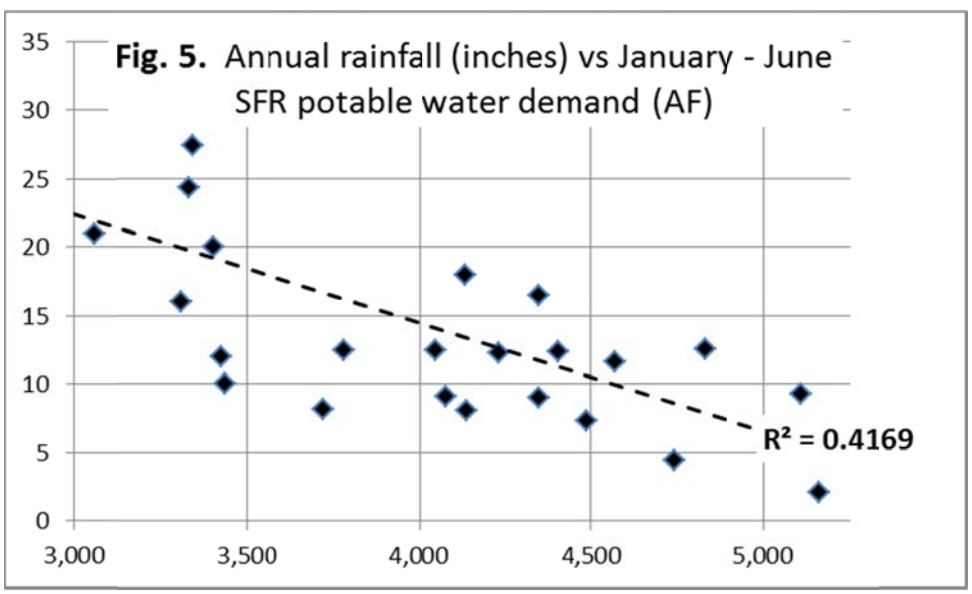
[7] see Fig. 5 and associated discussion on p. 6

In predicating our estimates on the basis of normal variation in weather, one question is whether the weather in the period following the 1991-2 drought was normal in relation to the long term record, or if the rise in demand was associated with unusually *drier* weather? Inspection of rainfall records following the 1991-2 drought also show that the post-drought rise in demand was not associated with drier weather. On the contrary, this period was somewhat wetter than the 40-year long term average, and comparable to 2011, the first year following the end of the 2009-11 drought (Table 1).

Table 1. 1991-2 post drought period was significantly wetter than the long term mean.

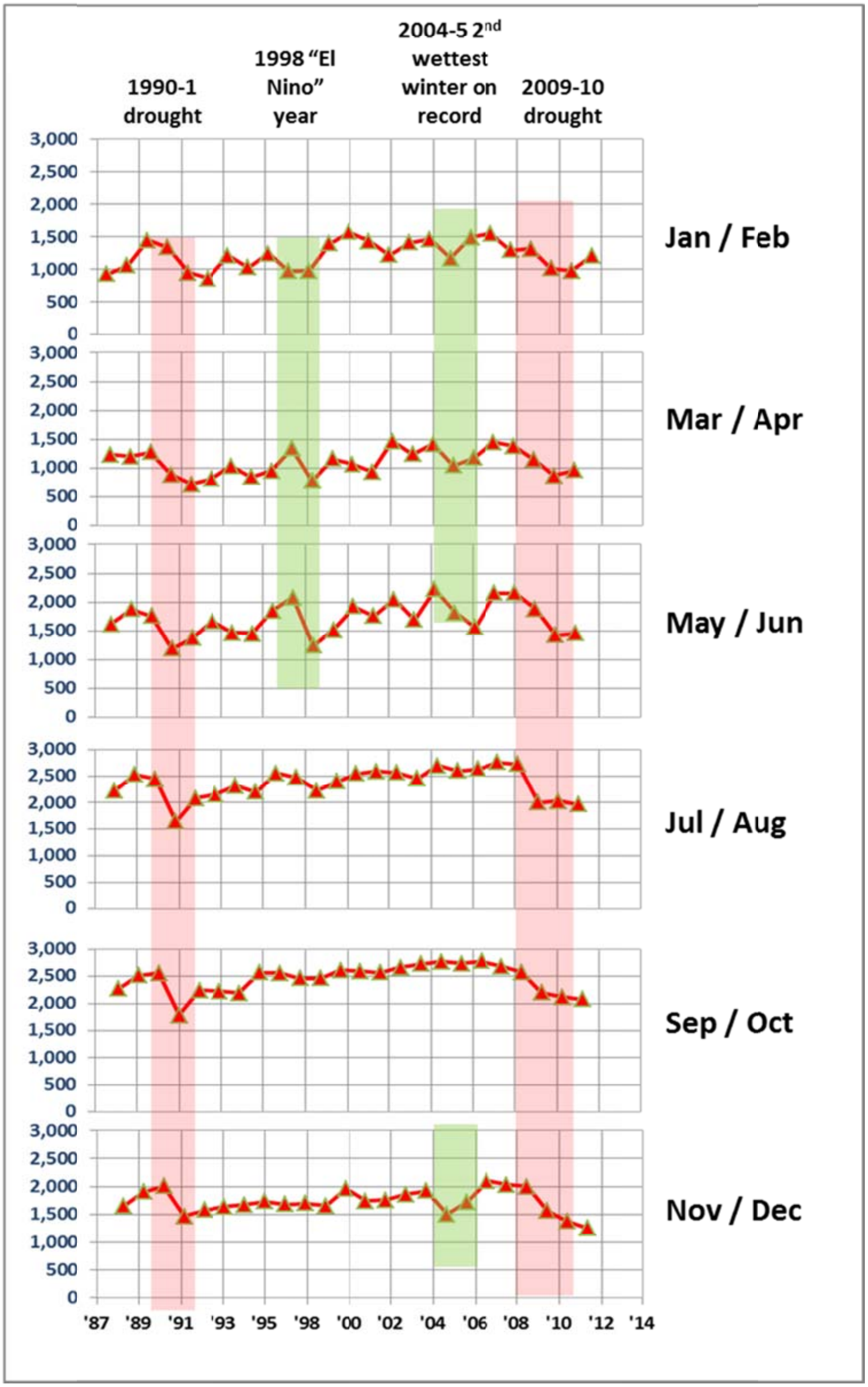
Period	Annual rainfall
1991-2 drought	16.5"
1993-98 post drought recovery	**19.3"**
2009-11 drought	15.0"
2011 (post-drought)	20.0"
Long term average (1971-2011)	**15.2"**

A series of wet years[8] would obviously depress the rise in demand already occurring following the end of the 2009-11 drought, but the frequency of consecutive wet years based on the long term record is low, about once every twenty years. *Nonetheless, even a single winter, if sufficiently wet, can reduce demand in winter months as much as an emergency drought response.* This occurred during the 1998 "El Nino" event and again in the winter of 2004-05, the 2nd wettest winter on record (Fig. 6). Figure 6 also shows that summertime demand over billing cycle timesteps are remarkably independent of year to year differences in weather, but decreased in response to emergency drought demand reduction efforts. Overall, changes in demand due to year to year differences in weather have not affected the overall trend in demand since the end of the 1990-1 drought, merely the variance in demand around the trendline (Fig. 4). Some idea of the magnitude of rainfall's effect on demand can be determined from Fig. 5, where Jan-June demand falls about 1,700 AF over the range of observed rainfall (2.1 – 27.4") . Note the spread in the data, however reflected in the relatively modest correlation coefficient (R^2 = 0.42).



[8] Where a wet year is defined as year where the amount of rain received is greater than one standard deviation from the long term mean

Fig. 6. Potable water deliveries to Single Family Residences (SFR) by billing period. Reduction in SFR demand due to unusually wet weather is comparable to drought response.



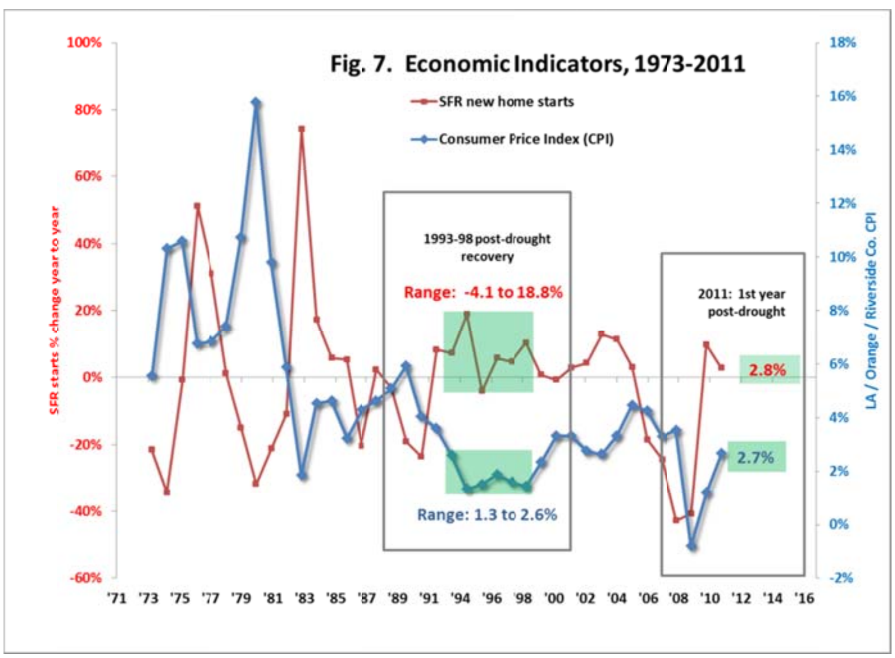
Differences in water conserving fixture installation rates (demand hardening)

In addition to weather and lot sizes, per capita demand depends in part on the intensity of conservation effort in homes. Behavioral conservation practices are notoriously difficult to quantify, but we have data on water conserving plumbing fixture installation rates over the entire period of record (1990 – 2011). We have also data on home build dates, which is important as building standards have become more stringent over time with respect to plumbing fixtures. However, for the purposes of demand forecasting, what matters most is *new* conservation, as residential demand up to the 2009-11 drought already includes all previous conservation measures. Table 2 compiles conservation fixture data since 2008, and suggests that new water conserving fixtures installed during the recent drought will likely reduce overall residential demand by about 600 AF over the recovery period, or about 2.3 percent of peak demand in 2007 and 2.5 percent of annual residential demand in 2008, the year before mandatory conservation rates took effect in the 2009-11 drought.

Table 2. Water conserving fixture installations 2008 to current	**INDOOR**		**OUTDOOR**			**TOTAL**
	HECW	HET	Rotating Nozzle	Synthetic Turf	WBIC	
No. installed	956	99	26	6	17	1,104
AF / YR SAVED	29.8	6.5	6.5	1.3	1.9	46.0
AF (lifetime of device)	419.0	131.1	27.3	12.3	18.0	607.8
AF/YR saved per installation	0.03	0.07	0.25	0.22	0.11	
AF/LIFETIME/DEVICE	0.44	1.32	1.05	2.05	1.06	

HECW: High Efficiency Clothes Washer. **HET**: High Efficiency Toilet. **WBIC**: Weather-Based Irrigation Controller

Economic factors.



We looked at two economic indicators (annual percent change in CPI relative to previous year for Los Angeles, Orange and Riverside Counties, and western Single Family Residential housing starts) to compare current economic conditions with those following the 1991-2 drought. The CPI for 2011 was 2.7% higher than 2010, nearly identical to the rise in the CPI of the first year of the 1991-92 post drought recovery (2.6%). The percent change in new home construction for 2011 vs 2010 as 2.8%, which also falls within the range seen in the period following the 1991-2 drought (Fig. 7).

The inflation-adjusted cost of living, as measured by the annual rate of change in the CPI, was basically flat in the six years following the 1991-2 drought, having seen a steep decline in the preceding five years, whereas the current rate follows two years of steep increases and is already slightly higher than any year during the 1991-2 post-drought recovery. If the annual change in CPI continues to climb, it will exceed the rate of change observed during the previous post-drought recovery period (1993-97), and could in theory slow the rise in potable water demand observed since the end of the last drought. However, residential demand continued to rise when this occurred over the 1998-2005 period (compare Fig. 1 with Fig. 7 for this time period).

Economic factors – rates. While general economic indicators do not appear to be good predictors of potable water demand in the residential sector, steep declines in usage during both the 1990-1 and 2009-11 droughts demonstrate that residential demand is very sensitive to large changes in rates for delivered water. While the public outreach message associated with drought penalties for overuse are very different than general rate increases, the sensitivity of demand to the cost of water during droughts suggests that even general rate increases may reduce demand, depending on the magnitude of the increase. While not part of this study, it may be possible to quantify this effect or at least determine its potential magnitude by compiling water usage for a subset of long-term customers and looking for correlations between their usage and rate increases.

Post-drought recovery and the UWMP. Finally, our longer estimates for post-drought demand recovery fall within a year or two of the 2020 deadline for urban water providers to demonstrate a 20 percent drop in demand under the Urban Water Management Planning Act (UWMP). This requirement should be considered in the District's financial and demand planning, particularly if future rate increases appear to delay demand recovery sufficiently to intersect with the demand target required by 2020 under the UWMP act.

SUMMARY

Based on our experience in previous droughts (1990-1) and an analysis of the main factors that influence demand for potable water in the residential sector of our service area, we believe annual demand following the end of the recent drought will continue to rise, attaining its pre-drought level in six to seven years and 85 percent of that level in two years, depending primarily on the incidence of wet winters. Over shorter timescales, on a billing cycle and monthly usage basis, peak summertime residential demands will likely return to their pre-drought levels sooner although it is difficult to provide a more precise estimate than approximately 2-4 years.

Installation of water conserving plumbing and irrigation fixtures are estimated to reduce ultimate demand by about 2.5% of pre-drought demand. Higher than average increases in the cost of living (CPI) could also reduce the rate of recovery, although this did not occur when it happened before from 1998-2005.