Davis
California

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Subject: Water Supply Demand / Capacity Forecasting

SUMMARY

In early November of 2008, the City Water Division began looking at our firm water supply capacity versus system demand as a result of questions regarding the ability to supply water for new housing developments. The term "firm", in this instance, indicates the water delivery capacity of our system assuming two of the wells are off-line. Over the next few months, research of our existing water supply planning documents, analysis of our raw data from our Supervisory Control and Data Acquisition (SCADA) system, and research of current accepted practices for determining future demand from other water agencies in the surrounding area was completed. These efforts resulted in adoption of a new methodology for forecasting our firm water supply capacity to meet projected demands.

This document is organized to characterize the current state of our water system, discuss proposed system upgrades that are immediately anticipated in addition to long term projects that have been identified, and to explain the methodology that we developed to project our water system demand needs. The intent of this document is to update, on an annual basis, our analysis of supply versus demand to reflect changes to the system as they occur. A list of acronyms has been provided on the last page.

The results of this year's analysis, further described on pages 8 through 12, show that we are currently operating in a calculated deficit. Our firm water supply capacity is 25,000 gpm, and our calculated demand is 26,620 gpm. Completion of some of the projects that are discussed in the "Water System Upgrades" portion of this report increase our firm capacity and bring us out of this deficit.

CURRENT STATE OF THE WATER SYSTEM

The City of Davis relies solely on groundwater to meet 100 percent of its potable water demands. Water has historically been pumped primarily from the intermediate depth aquifer (to a depth of approximately 300-600 feet below ground surface [bgs]). Beginning in 1991, all newly drilled wells were designed to pump water from the deep aquifer (deeper than 700 feet bgs) due to the need to target source water that was lower in Total Dissolved Solids (TDS), selenium and nitrates.

Water from the intermediate depth aquifer is generally very hard (high calcium and magnesium levels) and high in total dissolved solids. Nitrate levels are close to the drinking water limit in some wells, and required the abandonment of Wells No. 16, 18 and EM2. Boron levels are high enough to adversely affect sensitive plants, but not high enough to adversely affect human health. Arsenic levels are relatively low and hexavalent chromium levels are high in most wells, and both may exceed future drinking water limits. Regulatory standards for drinking water limits are projected to become more stringent for both of these constituents. Selenium concentrations are below drinking water limits (50 parts per billion [ppb]), but high enough to exceed regulatory discharge limits at the City's Waste Water Treatment Plant (WWTP) (4.4 ppb).

Water from the deep aquifer has moderate levels of hardness and total dissolved solids. Available information indicates that while boron exists in the aquifer, hexavalent chromium, selenium, and nitrates are not problematic constituents. Arsenic levels do not exceed current drinking water limits, but may exceed possible future limits for this constituent. Manganese does exist in this deeper aquifer, and treatment will be necessary at some of the deep well sites. The deep aquifer zone appears to exist throughout most of the Davis area; however, it may be less predominant toward the east and may not have sufficient water quality to meet future standards.

Water levels in the intermediate depth aquifer vary with hydrogeologic conditions and are impacted by drought conditions. However, the aquifer has historically fully recovered following drought periods with some minor subsidence. Availability of water from the intermediate depth aquifer is not a concern at the present level of withdrawal. However, the intermediate depth aquifer is relied on by agricultural uses and is susceptible to land subsidence. Recent studies of long-term quality and yield of the deep aquifer suggest that the reliability of the aquifer could be at risk of over pumping if both the City of Davis and UC Davis rely on the deep aquifer as their only water supply source. Two major deep aquifer studies and a hydrologic model suggest this concern is warranted, and it is noteworthy that the water quality of the deep wells is not adequate to meet both the current and expected drinking water and wastewater quality regulations without some future water quality treatment at each source.

Existing Well Facilities

The City of Davis draws water from 21 wells located throughout the city. All but six wells tap into the intermediate depth aquifer. The water does not pass through a central treatment or distribution facility, but rather is filtered naturally by the sand and gravel in the aquifers and enters the distribution system at the well location. The only treatment administered is the addition of chlorine (sodium hypochlorite) at all wells for disinfection, and activated carbon to treat an odor problem at Well 29. Well 32 is currently off-line due to excess manganese, a Secondary Health Standard constituent. Efforts are underway to address this problem and we should have this well on-line by summer. Pumping rates from each well vary depending on the seasonal groundwater levels and the distribution system hydraulic conditions.

The active wells range in age from nearly new to over 50 years old. Since 1987, the City has removed six intermediate depth wells from service due to age, poor water quality, production, and/or operations and maintenance problems. The average life of a City well is approximately 31 years, though we do have one that has lasted over 50 years. All of the active wells except Well 32 are available to supply water to the system. However, Well No. 14, powered by an internal combustion engine, is primarily available for usage in an emergency such as the loss of electrical power. Table 1 summarizes the characteristics of the existing wells.

Table 1. Existing Wells

WELL NO.	LOCATION	YEAR CONSTRUCTED	2008 Average Capacity (gpm)	Aquifer / Depth of Well (ft bgs)
1	Central	1982	950	Intermediate / 522
7	Central	1952	1000	Intermediate / 340
11	Central	1961	1320	Intermediate / 344
14	Central	1970	1600	Intermediate / 352
15	East	1965	1750	Intermediate / 520
19	North	1973	1330	Intermediate / 615
20	West	1976	1100	Intermediate / 456
21	South	1977	1130	Intermediate / 450
22	East	1977	1140	Intermediate / 510
23	Central	1980	1750	Intermediate / 419
24	Central	1982	1600	Intermediate / 460
25	West	1987	1200	Intermediate / 466
26	South	1987	1480	Intermediate / 492
27	North	1989	1300	Intermediate / 366
EM3	South	1991	1030	Intermediate / 471
28	West	1991	820	Deep / 1491
29	East	1996	1190	Deep / 1502
30	West	2001	2600	Deep / 1780
31	West	2001	2410	Deep / 1802
33	Central	2007	1840	Deep / 1520
32	South	2008	1450	Deep / 1600

Existing Distribution System and Storage

The hydraulic grade line in the system (system pressure) is primarily determined by the water level in the 200,000 gallon elevated storage tank at Eighth Street. The water level typically varies between 95 and 115 feet above ground surface, maintaining system pressures between 40 and 60 pounds per square inch (psi) under most demand conditions. All of the facilities are monitored by a SCADA system, which turns wells and booster pump facilities on and off based on the water level in the elevated storage tank and/or pressure at selected locations in the distribution system.

In 2002, the City constructed the West Area Water Storage Tank (4 million gallons) and booster pump station, located in West Davis. The tank stores water primarily filled by Well No. 31 during off-peak periods for delivery by booster pumps to meet system demands. The booster pump station acts essentially similar to the wells, as the timing and number of pumps operated are also governed by the water level in the elevated tank as well as the water level in the ground-level tank. In addition, the tank is operated routinely to provide adequate "turnover" of the water and provides both fire protection and emergency storage needs.

The infrastructure of our distribution system is aging and water main pipelines are in need of replacement. Due to the current state of the economy and budget constraints, our replacement projects are being deferred and we continue to maintain the integrity of our system with repairing problem sections as they occur.

Current Well Production

The total well production in 2008 was approximately 14,400 acre-feet (averaging approximately 12.8 million gallons per day [mgd]). Maximum well production occurs during the hot summer months when irrigation demands are the greatest. Minimum well production occurs during the wet winter months when irrigation demands are drastically reduced. Water production nearly triples in the hottest months (e.g. July at 18.5 mgd) vs. the coolest months (e.g. January at 6.4 mgd).

Water Quality Challenges

The City monitors water quality to meet all federal, state and local water quality requirements and closely monitors water produced by the wells. The latest water quality data is contained in the 2007 Annual Water Quality Report, published by the City of Davis and available on our website at http://cityofdavis.org/pw/water/pdfs/2007-waterqualityreport.pdf.

The City strives to provide the best water quality possible to its customers. We have been drilling in the deep aquifer to avoid hardness, nitrates, and selenium. In addition, the City is pursuing a surface water supply to largely replace its reliance on the groundwater supply. Regardless of the actual source, the City continues to seek better water quality for its customers, to improve the overall system reliability, and improve discharge quality from the Waste Water Treatment Plant to meet its effluent NPDES permit discharge requirements.

Over half of Davis homes and businesses are estimated to be using water softeners, resulting in significant salt loading into the sewer system. A water source with low hardness would negate the need for softeners (that are expensive to the consumer) and improve the reclamation possibilities for wetlands and agricultural irrigation purposes. Hard water also damages customer appliances and fixtures, shortening their useful life and increasing water-related expenses for ratepayers. In addition, hard water reduces the life of the City's water system, including meters, valves, and hydrants.

Based on previous studies, and recent findings at Well 32, it appears that the concentrations of some objectionable trace constituents in the deep aquifer are higher for wells in the far eastern portion of the service area. Parameters of greatest concern in the deep aquifer are arsenic and manganese. Manganese levels in some deep strata exceed secondary drinking water standards and treatment is currently being contemplated. Arsenic levels are within current drinking water standards, but could be problematic if the limit is substantially reduced as may be promulgated by the EPA and the State of California.

Wellhead treatment for manganese will add substantial capital and maintenance cost and not every well site that needs treatment has site capacity for the treatment facilities. Wellhead treatment removing hardness and calcium concentrates would be expensive, would pose a significant brine discharge disposal challenge, and is therefore considered infeasible at this time.

WATER SYSTEM UPGRADES

There are several water system upgrades that have been identified, some to improve reliability, some to increase system capacity and some to improve water quality. Table 2 provides a list of projects and a brief description of current status. Further detail of items 1-8 is provided after the table.

Table 2. Water System Upgrades

Item	Name of Project	Description / Status
1	East Area Tank	Design almost complete / On-line by summer 2010
2	SCADA Pilot Project	Upgrade of system / Pilot will be complete by summer 2009
3	Well 32 Manganese Testing	Reduce to meet MCL / anticipated on-line by June 2009
4	Well 34	Design almost complete, but Manganese treatment and mainline upsize will be required / On-line by summer 2010
5	Well 35	May not complete if we can get 4500 gpm from combination of Well32 and Well 34
6	East Area Main Upsize	Identified as necessary to improve capacity for peak hour / Not designed yet but anticipated on line 2011
7	West Area Main Upsize	Identified as necessary to improve capacity for peak hour / Not designed yet but anticipated on line 2011
8	UCD Inter-tie Upgrade	Agreement negotiations underway / estimated delivery 2009
9	Surface Water Supply	Still pursuing – possible delivery by 2016
10	Automated Meter Reading	Pursuing funding
11	El Macero Valve Replacement	Deferred for a year
12	Water Main Replacement	Deferred for a year
13	Corrosion Control	Deferred for a year

East Area Tank

The City is currently in the design phase of the East Area Water Storage Tank (4 million gallons) and booster station located in East Davis. Construction is anticipated to begin in summer of 2009 and be complete in summer of 2010. The booster station was originally designed to bring 3 pumps on-line in 2010, and then add an additional pump to meet future demands. The current distribution system pipe sizes in the area will not support the full flow of future capacity, so additional system piping is needed to transport the water. Because we determined that this additional capacity is needed now, the fourth pump is being added at the same time as the other three, and the additional piping has been added as another project (see East Area Main Upsize). Water delivery from the tank will be 4000 gpm in 2010, and 6000 gpm as soon as the pipe upsizing is complete (no later than 2011).

Funding for the East Area Tank is being pursued through IBANK which would result in a low interest rate loan. Final determination of this funding source will be made by late April 2009 and the project will go out to bid soon afterwards. Notice to proceed for construction is anticipated by July 2009.

SCADA Pilot Project

The existing Supervisory Control and Data Acquisition system is in need of replacement and upgrading. In order to determine the solution that best fits our needs, we developed a pilot project to test the capabilities of a new system. We just received the 100% design of this pilot test and installation should be underway by the end of April. We anticipate operating the pilot test for approximately six months and then, assuming the test is successful, continue with full replacement of the SCADA system.

Funding for this project is through our current rate system.

Well 32 Manganese

To remain in compliance with Davis Well Capacity Replacement EIR, dated July 2005, the City must limit replacement capacity to a maximum of 4500 gpm from the deep aquifer. It was initially decided by PW to construct three wells with a pumping capacity of 1500 gpm each. Due to water quality issues at Wells 32 and 34 (described below), it may be beneficial for the city to construct two wells that have a 2250gpm capacity each.

Design of Well 32 began in 2005 and construction was completed in March of 2008. In 2006, the California Department of Health Services (CDPH) made a change in the reporting requirements of secondary health standards. Recent water quality analysis for Well 32 has determined that this well exceeds the secondary standard maximum contaminant level (MCL) for manganese. The MCL is 50 ppb and this well has tested at 68 ppb. Because of this, CDPH will not permit this well to operate as part of our public drinking water system. There have been 5 wells drilled into the deep aquifer since the early 1990's and until the completion of Well 32, the deep wells have come in below the required levels for all constituents.

In order to utilize the water from this well, it is necessary to reduce the level of manganese below the MCL. There are two approaches to this issue; one is to increase the pumping capacity in an attempt to draw more water from the deeper aquifer (with lower manganese levels) which would dilute the manganese to a level below the MCL, the other is to treat the water at the surface to remove the manganese. We are currently pursuing test pumping to see if we can get the manganese below the MCL.

Funding for this project have been re-allocated from other water CIP's that were funded in the adopted FY 2008-09 budget and can be postponed (see projects in Table 2 with "deferred" status).

Well 34

A monitoring well was completed at this site in February 2009 and water quality test results from this well show levels of manganese that exceed the State maximum contaminant level. This well is located in the central area and is in a position to provide water to our system in an area where it is needed. The only options for this site are to complete the well and include treatment of manganese, or to abandon the site completely. Abandoning the site completely is not warranted. The only area of town that we could move to and avoid manganese is to the West and this would not help our distribution of water during peak hour demands. Surface improvements for this site would include the pump station, manganese treatment, and upsizing a pipeline at the connection in Fifth Street to Pole Line Road.

Since we may be increasing the flow rate at Well 32, we are planning on designing Well 34 to achieve a pumping rate such that both wells combined will provide the 4500 gpm allowed in our Davis Well Capacity Replacement EIR dated July 2005.

Funding for this well is through our current rate system. The additional cost of treatment will be offset almost entirely by the fact that we will not need Well 35.

<u>Well 35</u>

A monitoring well was also completed at this site in February 2009 and water quality test results from this well show levels of manganese that exceed the State maximum contaminant level. This well is located in Northeast Davis and is in a position to provide water to our system in an area where it is needed. Further design of a production well at this site is on hold for now as we investigate the production capabilities of Well 32 and 34.

<u>East Area Main Upsize</u>

The East Area Tank site is in design stage. As mentioned above in the tank discussion, we identified the need for building the pump station out to full capacity immediately in order to meet projected demands. The full capacity of the booster pump station is 6000 gpm. The distribution system piping near the tank is not large enough to transport that much flow at acceptable pressures. In order to fully utilize the pump station build out capacity, an additional pipeline must be added from the tank site to the north, around the Mace Boulevard Curve to Alhambra Drive. This will distribute the additional water to system at acceptable pressures.

This large pipeline was anticipated to be needed once the surface water was brought on-line to transport surface water from the Terminal Reservoir to the tank. Both the Terminal Reservoir and the Corp Yard Tank are components identified in the Davis Woodland Water Supply Project (DWWSP). Funding for the pipeline was previously identified as part of the DWWSP. Building a portion of the pipeline now just accelerates the need for the funds that have already been identified in our rate schedule.

<u>West Area Main Upsize</u>

The existing West Area Tank site is located in West Davis. The current pump station capacity is 3000 gpm and because connection to the distribution system is located so closely to Well 31, the booster pumps can not be run at the same time as the well. The distribution system piping along John Jones Road and partially down Covell Blvd needs to be upsized to transport the combined flow at acceptable pressures. When the pipe upsize is complete, we’ll be able to move forward with a future project of increasing the pump station capacity to 6000 gpm (not on the list yet).

This large pipeline was anticipated to be needed once the surface water was brought on-line to transport surface water from the Terminal Reservoir to the tank. Because of this, funding was previously identified as part of the Davis Woodland Water Supply Project (DWWSP). Building a portion of the pipeline at this time just accelerates the need for the funds that have already been identified in our rate schedule.

UCD Inter-tie Upgrade

There is an existing inter-tie connection between the UC Davis water system and the City of Davis water system. This connection exists to provide emergency water supply should either system need help. We are currently working with UCD to upgrade our connection and have the ability to purchase water from them during our peak demand needs during the irrigation season. Negotiations of water purchase cost and contract language are currently underway with the goal of having construction complete by mid summer 2009. Funding for this project is through our current rate system.

FIRM SYSTEM CAPACITY VS SYSTEM DEMAND

Projections of growth and assumptions of water supply reliability are needed in order to anticipate the needs of our water customers. We have developed a new methodology for doing this that is consistent with current industry practices and is similar to methodology used by neighboring water systems. The first part of this section is the description of our adopted City methodology, and then a discussion of where we are in our ability to supply water for the City of Davis' water customers.

Methodology

Methodology for determining water supply reliability to meet demand is a two step process. The first step is to determine the demand, and the next step is to determine firm system capacity.

Demand

The first step in our analysis is to determine the water demand. The best information we have on water demand is observed, historical, water production. After reviewing more than 50 years of data, we determined that using at least ten years of data gives an adequate assessment of demand level trends. Table 3 shows an accounting of total annual water produced for the last ten years.

Table 3. Historical Water Production

Year	Total Productio n for Year (MG)	Acre-ft
1998	3869	11,875
1999	4477	13,741
2000	4594	14,097
2001	4911	15,071
2002	4924	15,111
2003	4741	14,548
2004	4920	15,098
2005	4709	14,450
2006	4666	14,330
2007	4810	14,760
2008	4633	14,376

The next step is to take the average of the ten years and determine an average daily demand. For the ten years of production listed above, the average annual demand is 4,659 MG which converts to 8,864 gpm average day demand.

Using the average daily demand, we use peaking factors to determine Design Max Day demand and Design Peak Hour demand. We are currently using a factor of 2.0 for Max Day demand and 3.0 for Peak Hour demand. These factors can be verified by looking at the past 5 years of observed data and compare measured Max Day and measured Peak Hour to measured average day. With the factors, the Design Max Day demand is 17,750 gpm and the Design Peak Hour demand is 26,620 gpm for current year design .

In order to project system demand, the industry standard is to use either Max Day plus fire flows or to use Peak Hour, whichever is higher (Mays, 1999). With fire flows of 4500 gpm (Brown and Caldwell, 1989), Max Day plus fire is only 22,250 gpm, so Peak Hour is higher and should be used for projecting demand. Projecting demand into the future can be done by increasing the demand rate by the same factor that anticipated growth rates will occur. We looked at a 1% growth rate and plotted projected new developments (Community Development, Nov 2008) on top of existing population for the next 10 years. The 1% growth rate closely matched the projected developments and so was used for water demand projections. It is important to note that the water use trend over the past ten years is not a consistent upward climb due to water conservation measures and weather patterns that drive irrigation use.

<u>Firm System Capacity</u>

The next step is to look at the capability of the system to meet demands. Meeting demand is a combination of both water supply capacity and system reliability. We must take into account that some of the wells may not be operational, either due to physical repairs or water quality issues. Taking this into account when looking at system capacity is the approach needed to ensure an accurate estimate of meeting peak demands. This is called “Firm System Capacity”. For the City of Davis, our methodology to establish Firm System Capacity is to remove our highest producing well from service, and also a medium producing well from service. Also, physical limitations of the distribution system are also incorporated: the west area piping upsize issue (discussed above), and we are currently unable to run Well 31 when the booster pumps at the West Area Tank are operating.

There is also a challenge in determining the actual capacity of each well. The amount each well can produce is a function of system pressure and depth to groundwater. The values listed for each well in Table 1 were determined during pump test performed in summer of 2008. As of today, we are unable to run Well 32 into our system due to the manganese exceedance. Our Firm System Capacity is to remove Well 31 (due to pipeline constraints), Well 32(due to water quality issues), and Well 30 and Well 26 (for system reliability) from service during peak hour.

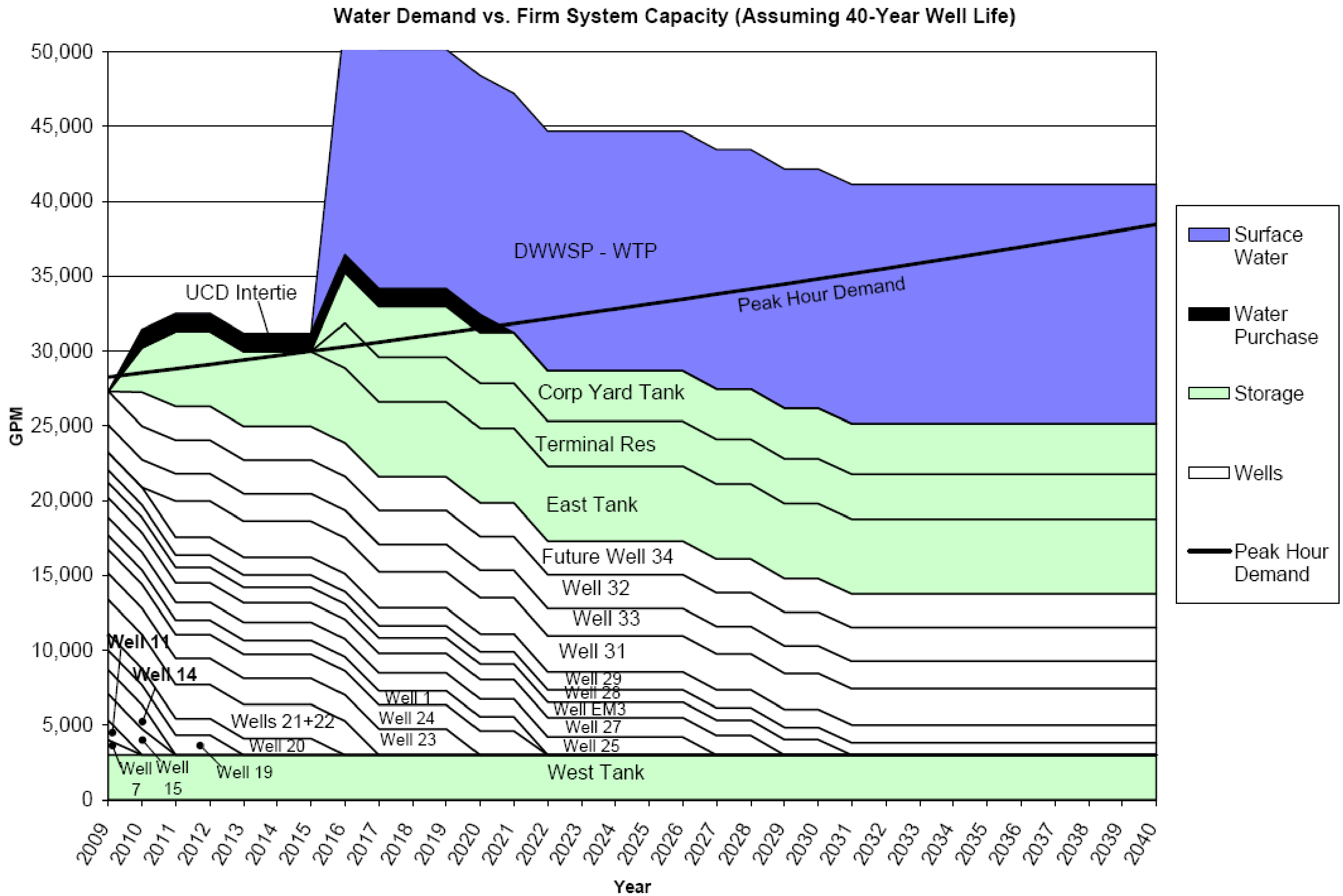
Our Firm System Capacity is 25,000 gpm. Compared to our calculated Peak Hour Demand of 26,620 gpm, we are currently operating in a system deficit.

Ability to meet demand

So what are we doing about this deficit and how are we going to meet future water demands? Most of the answer to this was discussed in the previous section of Water System Upgrades. Seven of the twelve items listed in Table 2, page 5, are upgrades that will increase our Firm Capacity. The most critical time frame for us is between now and the completion of those projects. The sooner we can get Well 32, the UCD Inter-tie, Well 34, the East Area Tank and the East Area Tank Upsizing on-line, the sooner we can meet system demand.

We have analyzed the Firm Capacity versus Demand by looking at four separate scenarios, each representing the estimated life of a well. The best case scenario is the assumption that our wells will last at least 50 years, which is a typical industry standard. The City of Davis has actually lost one well at 25 years, and so this is the worst case scenario. Our City average well life span to this date is 31 years. However, given that well drilling technology and materials have improved greatly in the last 50 years, we assume that the existing wells in our system today will last longer than 31 years, so have chosen to rely on the 40 year life well for analysis and have provided a chart, Figure 1, to show our results. The Chart shows wells going out of service after they reach forty years, and capacity being added as projects are completed. Well 31 shows as being capable of operating with the West Area Tank in 2011 with the upsizing of piping occurring in the West. The UCD Inter-tie goes away in 2020. The Corp Yard Tank and Terminal Reservoir come on-line the same time as the surface water as they are project components.

Figure 1



Notes:
1. Deep wells are not shown as going out of service because they would be replaced if they failed.
2. Extra pipeline capacity for both the East Area and West Area Tanks comes online in 2011.
3. Wells 30 and 26 are not shown on chart - remove to show "firm capacity."

System Capacity_west tank no inc.XLS 4/1/2009 Dem-Cap Chrt 40yr

REFERENCES

1. Water Distribution Systems Handbook, Larry W. Mays, 1999
2. City of Davis Water System Management Plan, Brown and Caldwell Consulting Engineers, 1989
3. Final Environmental Impact Report – Davis Well Capacity Replacement, Winzler Kelly Consulting Engineers, July 2005
4. City of Davis Community Development Communications, Bob Wolcott, Brian Abbanat, and Rhys Rowland, November 2008.

ACCRONYMS

CDPH – California Department of Health Services

CIP – Capital Improvement Project

DWWSP – Davis Woodland Water Supply Project

EPA – Environmental Protection Agency

gpm – gallons per minute

mcl – maximum contaminant level

MG – million gallons

mgd – million gallons per day

NPDES - National Pollutant Discharge Elimination System

ppb – parts per billion

psi – pounds per square inch

SCADA – Supervisory Control and Data Acquisition

TDS – Total Dissolved Solids

WWTP – Waste Water Treatment Plant

WTP – Water Treatment Plant