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Technical Memorandum 2

Historical Data Collection and Review

Introduction

Santa Clara Valley Water District (Valley Water) has developed a new model to forecast total water demand in Santa Clara County. Demand projections from the model will be used to support several planning initiatives and documents including:

- The 2021 Urban Water Management Plan (UWMP);
- Monitoring of and updates to the Water Supply Master Plan;
- Inputs to Valley Water's water supply planning model; and
- Evaluation of conservation programs and capital projects.

The purpose of this Technical Memorandum (TM 2) is to document the data collection and data processing activities performed to support development of the water demand model. Data sources documented in this TM are limited to historical datasets; review of datasets describing projected future conditions/assumptions are documented in *TM 4: Future Demand Analysis*. This TM reviews the following topics:

- Purpose and scope of historical data collection;
- Data collected from retail agencies;
- Development of retail agency driver units;
- Calculation of retail agency rate of use;
- Data collected from non-retailer groundwater pumpers; and
- Collection and processing of explanatory variables used in the demand model.

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1. Purpose and Scope of Historical Data Collection

The benchmarking analysis conducted in TM 1 reviewed a typology of commonly used demand forecasting methods. Together with a review of Valley Water data availability and forecasts performed by other peer agencies, it was recommended that the following methodological elements would meet Valley Water's needs:

- Model segmentation by type of provider (i.e., retail agency, non-retailer groundwater pumper), geography, sector/billing classification, and time of year.
- Differentiation of rate of use (i.e., characterizing consumption to reflect water use intensity) based on dividing billed consumption by a count of driver units (e.g., housing units).
- A statistically based modeling approach (e.g., regression/econometric, modified forecast factor).[1]

Development / parameterization of segmented statistical models requires a robust historical dataset consisting of water consumption, driver units, and explanatory variables used to explain variability in water use. Table 1-1 provides a summary of the datasets obtained for these categories as well as the raw data sources collected to support them. The following sections in this TM provide a detailed description for each dataset summarized in Table 1-1.

Table 1-1: Summary of Historical Data Collected for Model Development

Data Category	Dataset	Data Source(s)
Water use	Historical billed consumption and accounts	• Retailer billing records • Groundwater production from Valley Water's Water Supply Production Database (WSPD)
Driver units	Single family and multifamily housing units	California Department of Finance
	Sectoral employment	US Census
	Campus population[(a)]	Bay Area Water Supply and Conservation Agency (BAWSCA) Annual Survey
Explanatory variables	Observed weather	Parameter-elevation Regressions on Independent Slopes Model (PRISM)
	Water rates	• Valley Water provided compilation of retailer residential sector water rates • Groundwater rates by charge zone
	Drought restrictions	Valley Water records of timing of restrictions (i.e., beginning and end dates) and severity (i.e., the requested amount of cutback in percentage terms)
	Economic index	Economic Cycles Research Institute (ECRI) U.S. Monthly Coincident Index
	Median income	US Census
	Housing density	• California Department of Finance • Valley Water GIS data
	Persons Per Household	
	Relative sectoral economic activity	• US Census • Association of Bay Area Governments (ABAG)

[(a)] Campus population is a driver unit for Stanford University only. See Section 3.3.

[1] A detailed summary of the model segmentation, rate of use differentiation, and statistical approach is provided in TM 3: Model Approach and Development, Section 1.

2. Data Collected from Retail Agencies

Each of Valley Water's 13 water supply retail agencies provided historical records of billed consumption and number of accounts to support development of the demand model. This Section provides an overview of the data provided and discusses how retailer data was standardized prior to use in model development.

2.1 Description of Retailer Data

Valley Water's retailer agencies were asked to provide monthly historical billed consumption and accounts, by billing classification, from year 2000 to 2018 (or as many years that were reasonably obtainable). Billed consumption is representative of total water use from all supply sources (i.e., treated water purchased from Valley Water, groundwater, local surface water, and deliveries from SFPUC). Figure 2-1 provides a summary of the historical data provided by each retail agency as well as an identification of the implemented billing cycle (i.e., monthly, or bimonthly). The time period requested for water use data covers a representative period of modern water use while obtaining a statistically robust dataset size.

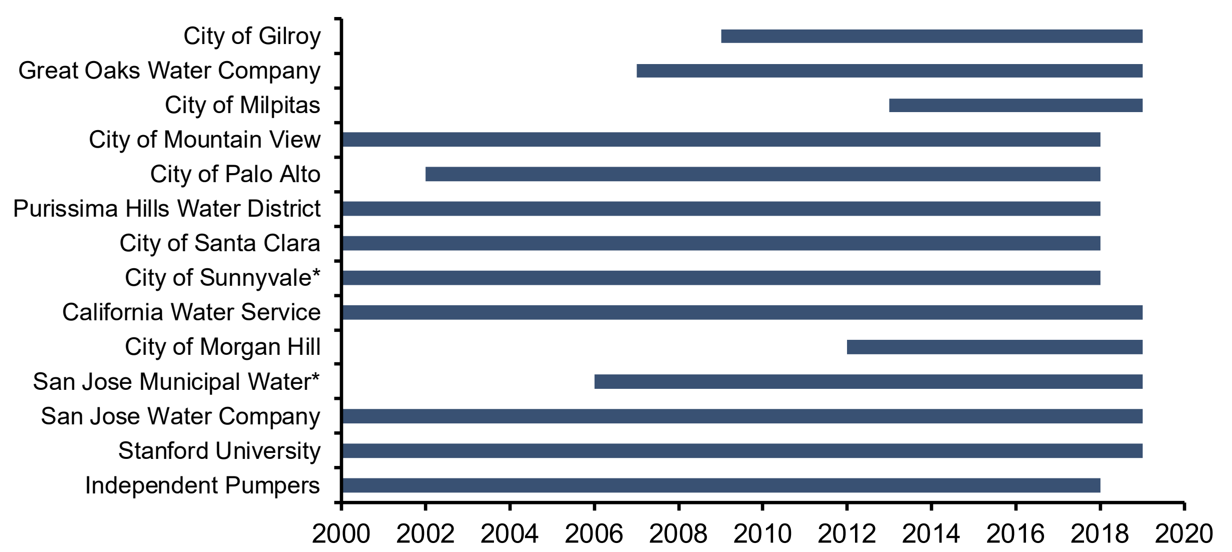


Figure 2-1: Summary of Time Range of Available Billing Data Provided by Retail Agencies (Agencies with Bi-Monthly Data Marked with Asterisk)

Consumption data was not consistently available back to 2000 for all retailers. The majority of retail agencies (8 of 13) provided historical consumption and account data as far back as at least 2002 and all agencies were able to provide data up to at least 2018. Five agencies provided a smaller record of data, spanning 6-12 years rather than the requested 18 years. In order to maximize the number of observations for estimation, all available water use records were retained in the modeling dataset. Thus, the dataset represents an "unbalanced panel" (i.e., not all retail agencies have the same number of observations for the same time periods).

Retail agencies provided billing and account data organized by their internal billing classifications. Billing classifications were relatively consistent between retailer agencies for defining residential water use (i.e., most retail agencies characterized separate classifications for single family and multifamily sectors). Billing classifications were less consistent in describing non-residential uses. Most agencies defined a commercial billing classification, however distinction and definition of industrial, institutional, and irrigation (i.e., landscape) classes were inconsistent across retail agencies. It is not uncommon for water utilities to differ in how specific non-residential accounts/end uses are classified and billed. For example, certain retail agencies include industrial or institutional uses within their commercial billing classification. Similarly, landscape use is not necessarily limited to a single end use and not all retailers reported landscape use (e.g., water billed within a landscape category could represent use at commercial, industrial, institutional, and residential properties). A summary of billing classifications provided by each retail agency is provided in Appendix A.

2.2 Standardization of Retailer Data

As identified in Section 2.1, data provided by retail agencies had unique characteristics, particularly associated with billing classifications and billing cycles. The proposed statistical modeling strategy involved pooling historical observations across all retail agencies, which requires standardization of retail agency billing classification and consumption.[2] Billing classifications for each retail agency were initially assigned a standardized water use sector which are further summarized in Table 2-1 below.

Table 2-1: Summary of Standardized Water Use Sectors

Standardized Water Use Sector	Description
Single Family	Water use associated with single family residential homes
Multifamily	Water use associated with multifamily residential properties
Commercial	Water use associated with commercial developments (e.g., offices, hotels, restaurants)
Industrial	Water use associated with industrial applications (e.g., manufacturing, mining, warehousing)
Institutional	Water use associated with institutional activity (e.g., educational services, public administration, hospitals/health care)
Landscape / Recycled	Water use associated with outdoor non-residential (typically non-agricultural) irrigation
Other	Other water use, often categorized as “other” by retail agencies, but also inclusive of classifications not well represented by the standardized water use sectors above (e.g., construction, fire line, miscellaneous)

For each retail agency, water consumption was converted to million gallons (MG) and totaled by standardized water use sector. Analysis of these data (including initial testing of econometric model development[3]) suggested inconsistent classification of commercial, industrial, and institutional activity among retail agencies (e.g., inclusion of industrial or institutional water uses within a commercial billing classification). Additional data, such as identification of specific accounts and associated water uses, was not available to further pre-process and standardize the retail agency non-residential consumption.

[2] Ibid.

[3] Ibid.

Uncertainty and inconsistency in retail agency definitions associated with commercial, industrial, and institutional water use can affect the fit and performance of statistical demand models. To address this, the commercial, industrial, and institutional sectors were combined into an aggregate "CII" sector for modeling. Discussions with retail agencies' staff provided additional information supporting the allocation of landscape and recycled water use into other modeled sectors. For Valley Water's modeling, recycled water is considered a supply to meet demands rather than as a demand. Valley Water relies on retailer UWMP forecasts of the proportion of total demands that would be met through recycled water and uses those numbers to quantify the non-potable recycled water demand within Santa Clara County. A summary of the final model sectors used for model development is provided in Table 2-2 below. A detailed summary of the translation between retail agency billing classifications, standardized water use sectors, and model sectors is presented in Appendix A. Figure 2-2 provides a historical record of total annual billed consumption for all 13 retail agencies for years in which all data was available (i.e., 2013-2018).

Table 2-2: Summary of Final Sectors Used for Demand Model Development

Standardized Water Use Sector	Model Sector	Description
Single Family	Single Family	Water use associated with single family residential homes
Multifamily	Multifamily	Water use associated with multifamily residential properties
Commercial	CII	Water use associated with all CII activity
Industrial		
Institutional		
Landscape / Recycled	Included in CII and/or multifamily sectors based on input from retail agencies	Water use associated with outdoor non-residential (typically non-agricultural) irrigation
Other	Other	Other water use, often categorized as "other" by retail agencies, but also inclusive of classifications not well represented by the standardized water use sectors above (e.g., construction, fire line, miscellaneous)

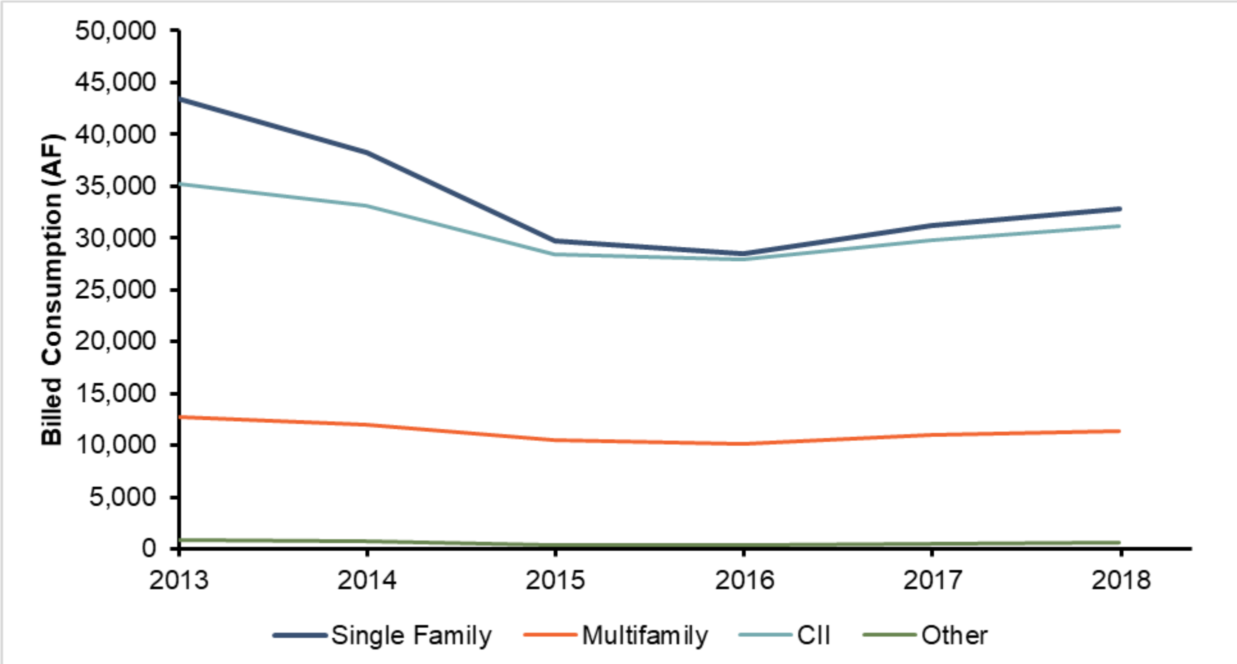


Figure 2-2: Total Annual Consumption by Model Sector

3. Development of Retail Agency Driver Units

Driver units reflect the size or scale of a water use sector and allow for differentiation of rate of use from total consumption. In order to be useful for model development and forecasting, driver units must have a consistent historical record coincident with consumption and have a corresponding future dataset representing projected driver unit counts. Driver units were selected for each model sector to meet criteria for model development and efficient forecasting. The selected driver units for each model sector are shown in Table 3-1. The following sections detail the data sources and data processing used to develop estimates of drivers for each retail agency and model sector.

Table 3-1: Driver Units by Model Sector

Model Sector	Driver Unit
Single Family	Housing Units
Multifamily	Housing Units
CII	Jobs, Population (for Stanford only)
Other	N/A[(a)]

[(a)] Other water use was projected as a percentage of total single family, multifamily, and CII consumption. See *TM 4: Future Demand Analysis.*

3.1 Residential Housing Units

Housing units for the residential sectors (single family and multifamily) were developed based on data from the California Department of Finance (DOF) and retail agency provided number of accounts. Driver units for single family residential water use were assumed to be equal to the number of single family accounts reported by retail agencies as the number of single family accounts is generally a good indicator of the number of single family housing units. Multifamily accounts are an inappropriate measure of housing units, as many multifamily dwellings are collectively billed based on a single meter. To account for this, multifamily housing units were calculated by subtracting the estimated total number of single family housing units (equal to single family accounts) from the total number of housing units reported by DOF. Note that only total residential accounts were available for San Jose Water Company rather than single family and multifamily accounts; as such, single family housing units for San Jose Water Company were estimated directly from single family housing units reported by DOF.

Distinct housing unit data were required for each retail agency to support model development. DOF data were available by city boundaries, which required geoprocessing to retailer service area boundaries. Geoprocessing was performed using GIS overlays of city and census tract boundaries[4], retail agency service area boundaries[5], and parcel-level land use data from the Santa Clara County Assessor. Figure 3-1 illustrates an example of how city boundaries were aggregated to retailer service area boundaries. In Figure 3-1, the two large bold boundaries represent two retailer boundaries and the six numbered boundaries with dashed borders represent city boundaries. The number of residential parcels were first spatially aggregated within city boundaries. The percent of parcels in each city that fell within each retailer service area boundary was then calculated, resulting in a city-retailer ratio. For example, in Figure 3-1, 50% of city 5 falls within the Retailer A boundary, and 50% falls within the Retailer B boundary. The DOF housing units associated with each city were multiplied by the city-retailer ratio and values were summed by retailer boundary, as demonstrated in Table 3-2.

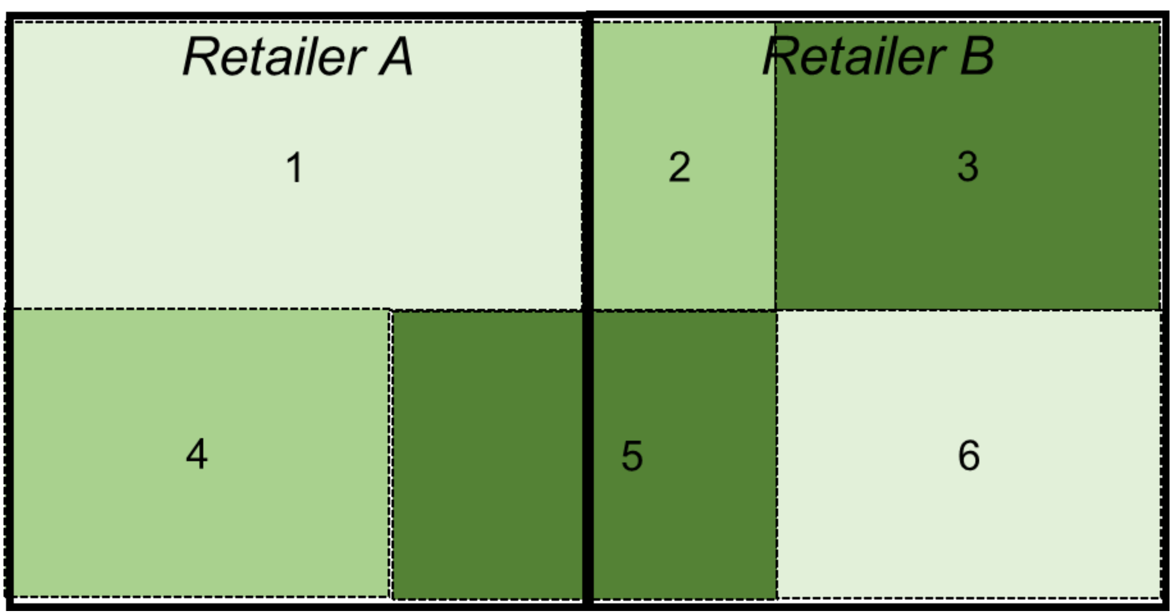


Figure 3-1: Example of City Boundaries within Retailer Service Area Boundaries

[4] Obtained from the County of Santa Clara Open Data Portal (https://data.sccgov.org/).

[5] Obtained from the CA Department of Water Resources Water Management Planning Tool (https://gis.water.ca.gov/app/boundaries/).

Table 3-2: Example of City-Retailer Ratio Calculations

City	DOF Housing Units	City-Retailer Ratio		DOF Value x City-Retailer Ratio	
		Retailer A	Retailer B	Retailer A	Retailer B
1	100	1	0	100	0
2	200	0	1	0	200
3	100	0	1	0	100
4	300	1	0	300	0
5	500	0.5	0.5	250	250
6	300	0	1	0	300
Total	**1500**	**-**	**-**	**650**	**850**

The processed housing units for the latest concurrent year (2017) are presented by retailer in Table 3-3. Note that Purissima Hills Water District has no parcels classified as multifamily residential land use and was therefore excluded from the multifamily residential model. Time series plots of processed residential housing units are presented in Appendix B.

Table 3-3: 2017 Residential Driver Units by Retailer (Average Housing Units)

Retailer	Single Family Housing Units	Multifamily Housing Units
California Water Service	16,943	6,569
City of Gilroy	13,210	1,115
City of Milpitas	12,397	9,106
City of Morgan Hill	10,002	2,851
City of Mountain View	12,495	20,683
City of Palo Alto	15,167	13,688
City of Santa Clara	17,181	29,263
City of Sunnyvale	23,794	30,681
Great Oaks Water Company	19,834	10,681
Purissima Hills Water District	2,070	-
San Jose Municipal Water	25,452	12,832
San Jose Water Company	206,175	114,104
County-Wide Retail Agency Total	**374,719**	**251,573**

3.2 CII Jobs

CII jobs were estimated from data obtained from the U.S. Census Bureau Longitudinal Employer-Household Dynamics (LEHD) Origin-Destination Employment Statistics (LODES) dataset.[6] The LODES dataset provides a historical estimate of the number of jobs by industry, provided by census tract for 2002 to 2017. Similar to the residential sectors, census tract-level CII jobs needed to be geo-processed to align with retail agency service area boundaries. Tract-retail agency scaling ratios were calculated based on non-residential parcels using the same general approach described in Section 3.1.

The LODES data categorizes jobs by North American Industry Classification System (NAICS) sector, which is the standard used by federal statistical agencies. Historic driver units used for model fitting were equivalent to the sum of all non-agricultural jobs reported in the LODES dataset. All NAICS sectors excluding "Agriculture, Forestry, Fishing and Hunting" were aggregated to estimate total CII jobs. The

[6] U.S. Census Bureau. (2020). LEHD Origin-Destination Employment Statistics Data (2002-2017). Washington, DC: U.S. Census Bureau, Longitudinal-Employer Household Dynamics Program [distributor], accessed on 7/1/2020 at https://lehd.ces.census.gov/data/#lodes. LODES 7.4.

processed CII jobs for the latest concurrent year (2017) by retail agency is shown in Table 3-4. Time series plots of processed CII jobs are presented in Appendix C.

Table 3-4: 2017 CII Driver Units by Retailer (Average Non-Agricultural Jobs)

Retailer	Total Jobs
California Water Service	57,736
City of Gilroy	13,156
City of Milpitas	43,708
City of Morgan Hill	15,482
City of Mountain View	85,356
City of Palo Alto	115,603
City of Santa Clara	110,535
City of Sunnyvale	68,720
Great Oaks Water Company	21,294
Purissima Hills Water District	2,618
San Jose Municipal Water	84,085
San Jose Water Company	417,012
County-Wide Retail Agency Total	**1,066,863**

Although driver units are the total number of all non-agricultural jobs, distinct economic sectors were maintained to use as explanatory variables in the model. These explanatory variables are described in Section 6.8.

3.3 Stanford University Population

Stanford University has several characteristics that dictate different driver unit classification and processing from the other retail agencies. As an educational institution, all water use associated with Stanford University was classified with the CII sector for the purposes of Valley Water's demand model development. Despite being classified as CII, number of jobs is not an entirely appropriate driver unit since employees make up only a portion of the water users at the university; as of 2015, Stanford serves approximately 23,000 students in addition to 14,000 faculty and staff. To account for all water users the total population (students and staff) of the Stanford campus is used as the driver unit.

Total population reported by the 2018-2019 BAWSCA annual survey[7] was used as driver units for Stanford. Figure 3-2 shows the historical total population for Stanford from this data source.

[7] Obtained from BAWSCA Annual Survey Fiscal Year 2018-2019. (http://bawsca.org/uploads/userfiles/files/Annual%20Survey%2018-19_FINAL(2).pdf)

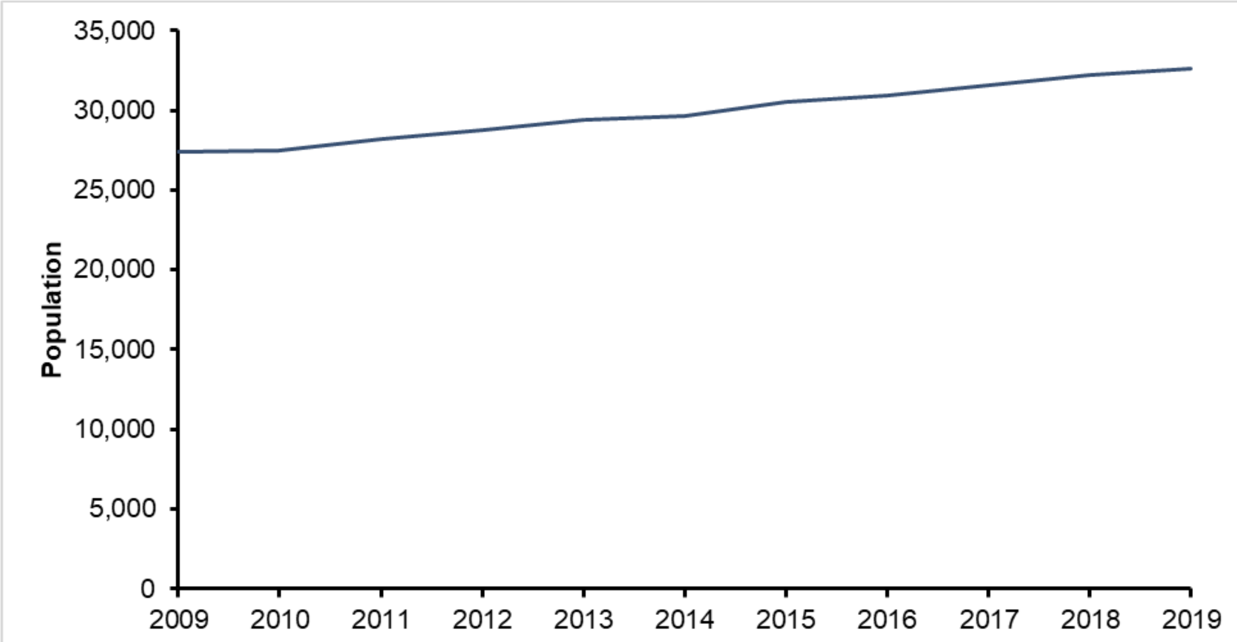


Figure 3-2: Stanford Total Population (Staff and Students)

4. Calculation of Retail Agency Rate of Use

Consistent with the recommended modeling approach reviewed in Section 1, historical rates of water use (gallons per driver unit per day) were calculated for each of the retail agencies and model sectors identified in Table 2-2 using the consumption data reviewed in Section 2 and the driver unit data reviewed in Section 0. Calculated historical rates of use were also smoothed in order to standardize for consumption billed on monthly and bimonthly cycles. The smoothing approach for rate of use calculations is summarized below:[8]

1. Calculate the average number of monthly billed accounts for each year, retail agency, and model sector. For retail agencies billed on a bimonthly basis, the average number of monthly billed accounts is multiplied by 2.
2. For each year, retail agency, and model sector calculate the ratio of driver units (i.e., housing units and number of jobs) by the average monthly billed accounts calculated in (1) above.
3. Multiply the annual units per account ratio calculated in (2) above by the observed number of billed accounts. This provides an estimate of the number of monthly driver units billed (U_t).
4. Calculate the smoothed rate of use for bimonthly retail agencies (1) and monthly retail agencies (2), where q is the smoothed rate of use, Q_t is the billed consumption in the current month, U_t is the billed number of driver units in the current month. The variables $t+1$ and $t+2$ denote the next two subsequent months.

[8] Smoothing procedures adapted from those presented in *Urban Water Supply Management Tools* (Mays, 2004).

$$q = \left(0.25 * \frac{Q_t}{U_t} + 0.25 * \frac{Q_{t+2}}{U_{t+2}}\right) * \left(\frac{0.5U_t + 0.5U_{t+2}}{0.5U_t + U_{t+1} + 0.5U_{t+2}}\right) + 0.5 * \left(\frac{Q_{t+1}}{U_{t+1}}\right) * \left(\frac{U_{t+1}}{0.5U_t + U_{t+1} + 0.5U_{t+2}}\right) \quad (1)$$

$$q = \left(\frac{Q_t}{U_t}\right) * \left(\frac{U_t}{0.5U_t + 0.5U_{t+1}}\right) + \left(\frac{Q_{t+1}}{U_{t+1}}\right) * \left(\frac{U_{t+1}}{0.5U_t + 0.5U_{t+1}}\right) \quad (2)$$

Figure 4-1 and Figure 4-2 below show the historical smoothed rate of use for the single family, multifamily, and CII sectors averaged across all retail agencies (i.e., county-wide average).

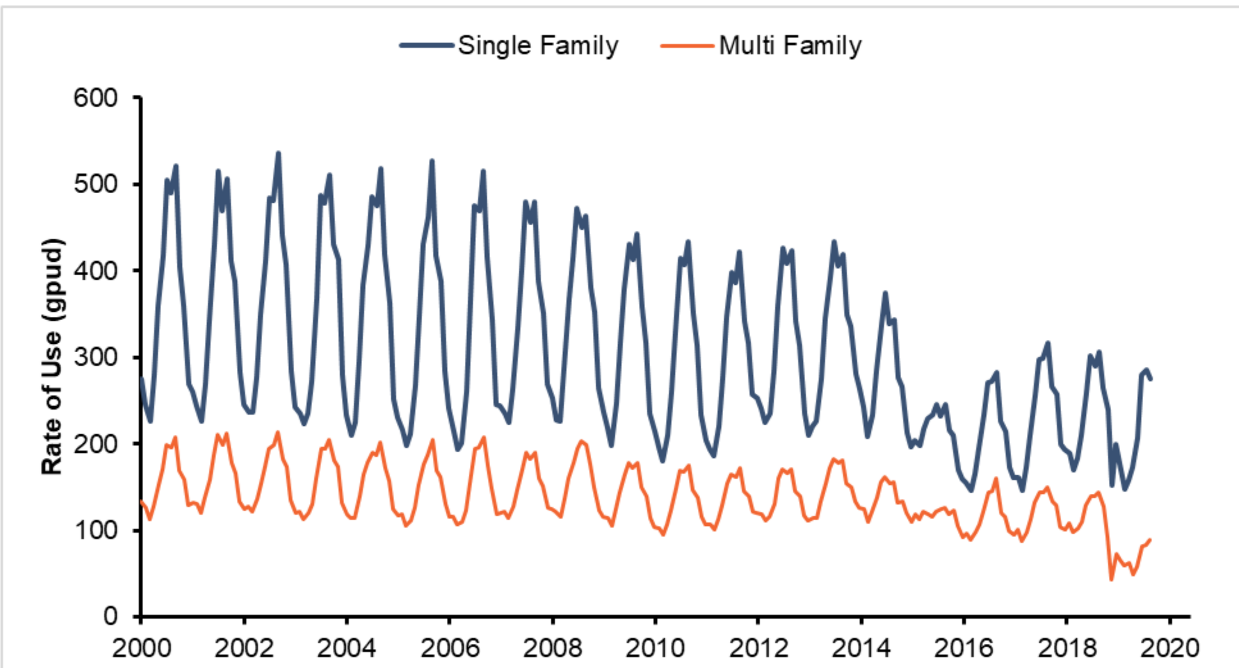


Figure 4-1: County-Wide Smoothed Rate of Use for Single Family and Multifamily Sectors

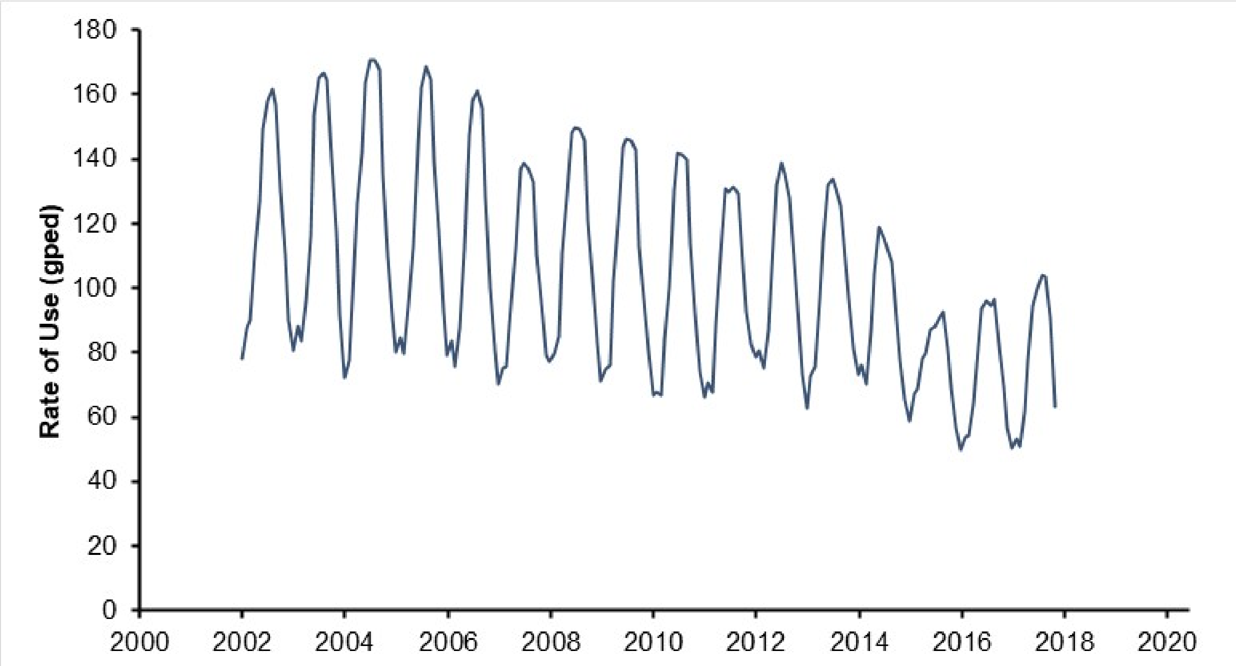


Figure 4-2: County-Wide Smoothed Rate of Use for the CII Sector

5. Data from Non-Retail Groundwater Pumpers

Non-retail groundwater pumpers include private well owners that are outside of the retailers' service areas. Available data for non-retail groundwater pumpers were provided by individual wells and included estimated or measured water use, water use type, groundwater charge zone, data frequency, and well status. The total water use and total number of wells were aggregated annually by water use type and groundwater charge zone.

5.1 Description of Available Consumption Data

Non-retail groundwater pumping data were available from 2000 to 2018. Historic groundwater use was summarized by groundwater charge zone and water use type.

Each well is located in a specific charge zone which corresponds to the groundwater basin or geographic area where the well is located. The groundwater basins include Santa Clara Plain (referred to as charge zone "W2") as well as the Llagas and Coyote Valley sub-basins (referred to as charge zone "W5"). Water use was aggregated by charge zone. Figure 5-1 shows the groundwater charge zones.

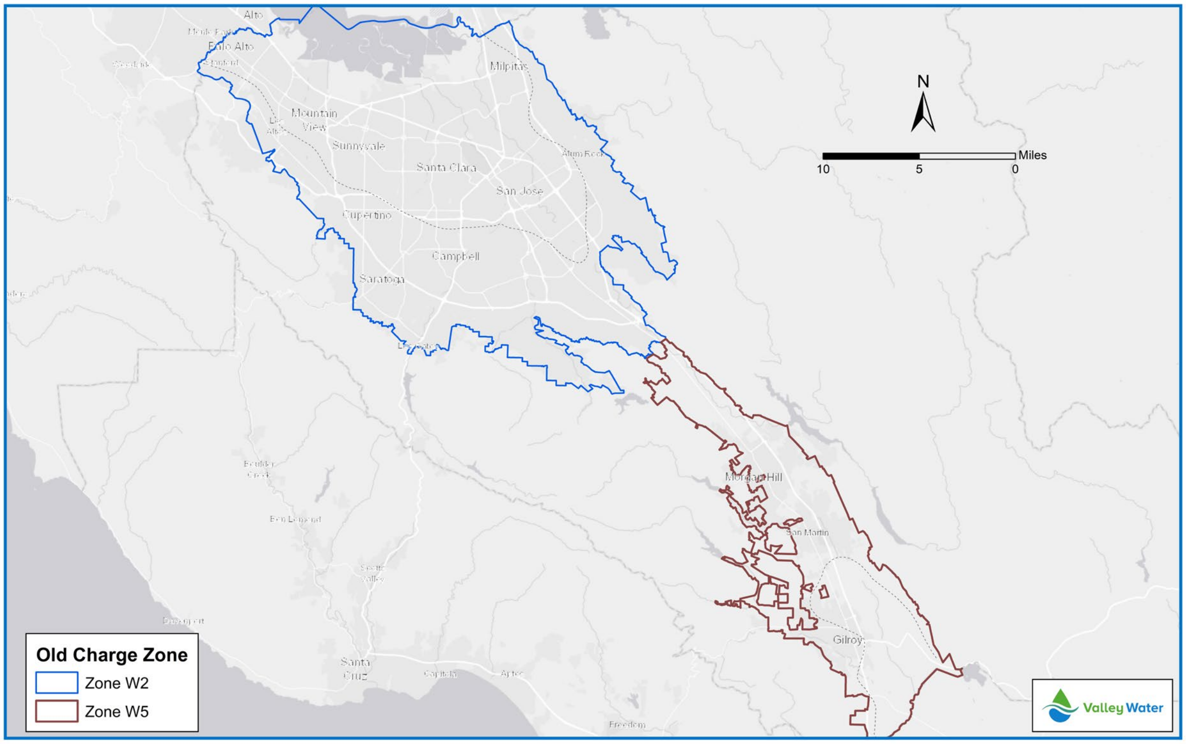
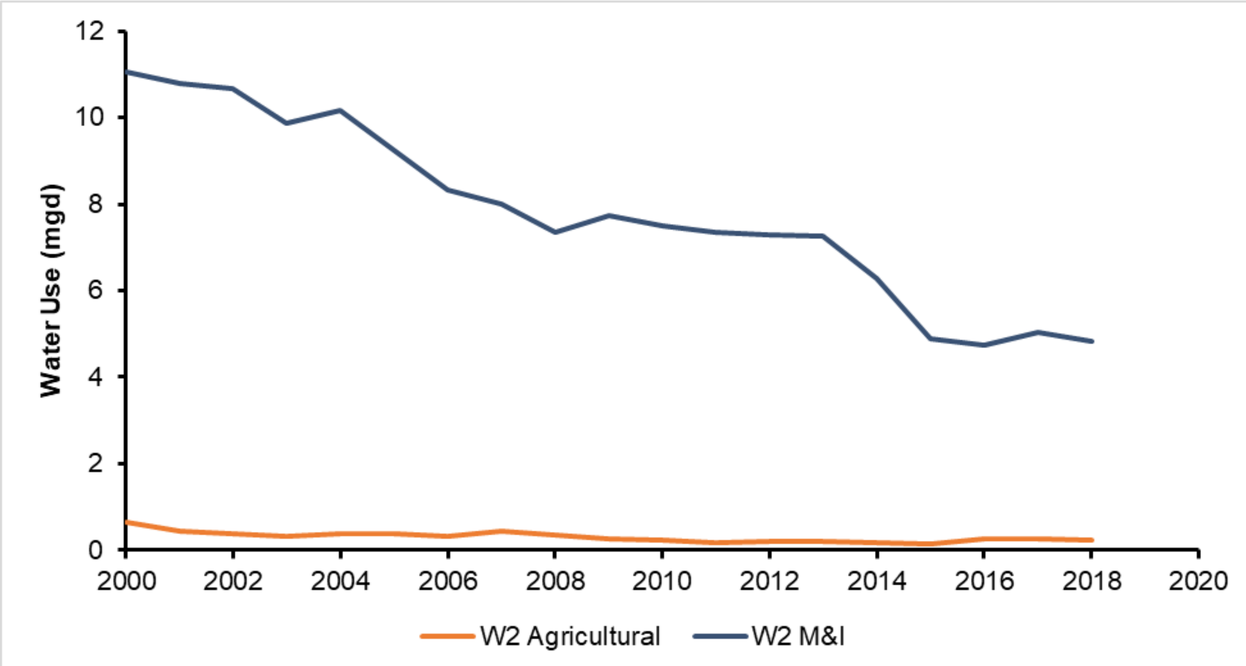


Figure 5-1: Map of Charge Zones Used for this Demand Study (Charge Zones changed in July 2020)

Water use type was originally classified as either agricultural, municipal, or domestic. Municipal and domestic water use were combined into a single municipal/industrial (M&I) category, resulting in two water use types: agricultural and M&I.

Billing data were reported at a monthly, semi-annual, or annual resolution. M&I use was reported monthly or semi-annually. Agricultural water use was typically reported annually or semi-annually. The semi-annual data were typically reported twice a year in January and July. For agricultural water use, the semi-annual and annual data were typically estimated values using a "table of averages" approach that approximates water use based on the crop type being irrigated. As a result, a monthly resolution for model fitting was not possible; water use was aggregated to an annual average water use in million gallons per day (mgd).

Historic annual average water use by groundwater charge zone and water use type is shown in Figure 5-2. Agricultural use in the W5 charge zone represents the majority of overall groundwater use and has remained relatively constant since 2000 with some interannual variability. In the W2 charge zone, M&I use comprises the majority of groundwater use and has been steadily decreasing since 2000, while agricultural use in the W2 charge zone has been less than 0.5 mgd for the last 20 years. Annual M&I use in the W5 charge zone has remained approximately in the range of 5 to 9 mgd.



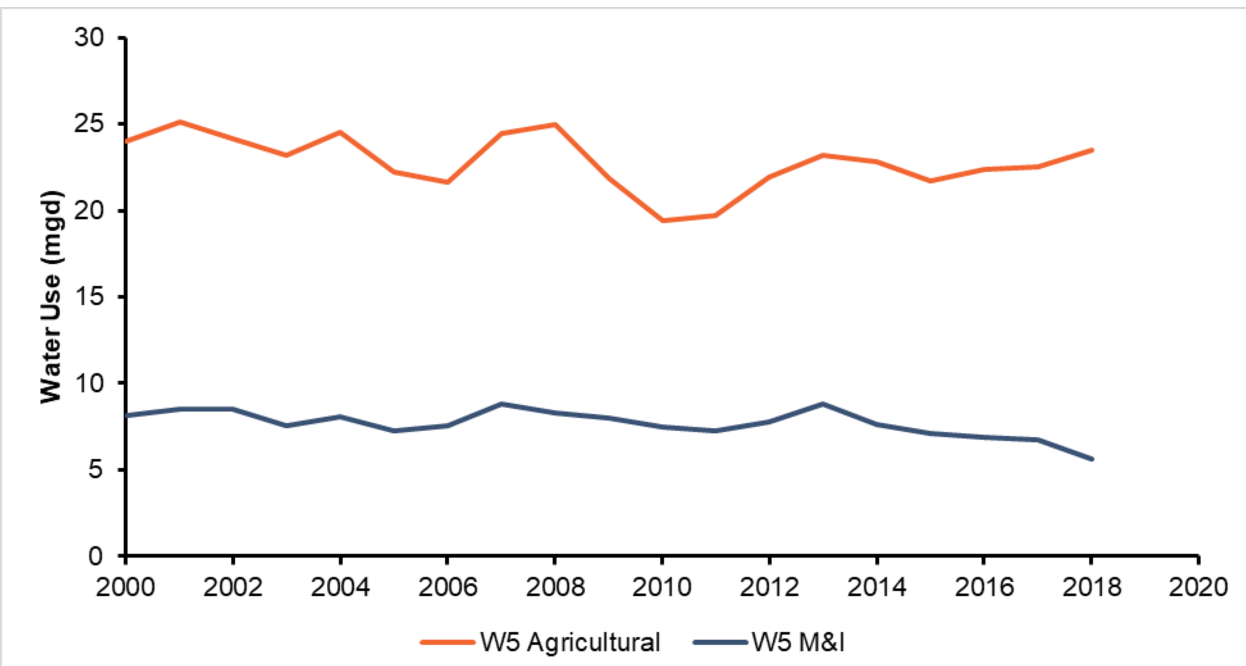


Figure 5-2: Historic Annual Average Groundwater Use (mgd) by Water Use Type for Groundwater Charge Zone W2 (top) and W5 (bottom). Note difference in y-axis scale.

5.2 Driver Units

Groundwater use was not well characterized on a per-unit basis by traditional driver units such as jobs, housing units, or population.[9] Population and number of wells were explored as potential driver units, to calculate average annual water use per person or per well, respectively. Figure 5-3 shows population for the two groundwater charge zones and Figure 5-4 shows the number of wells by groundwater charge zones and water use type. Population has been steadily increasing in both areas. The number of wells has remained relatively constant since 2000, with considerably more wells classified as M&I use than agricultural use. Note that the number of wells for M&I water use was incomplete in 2018 and is not shown.

Figure 5-2 above showed that water use has been decreasing or remaining constant over the last 20 years. The trends in groundwater use and population are opposite. Since both number of wells and groundwater use have remained relatively constant since 2000, there is little to no variability in groundwater use per well, which is not well-represented by a typical econometric demand model built to explain variability. Further, there is no existing data source that projects number of wells into the future that could be used for generating a forecast. As a result, groundwater pumping data used in model fitting was summarized on a volumetric basis (i.e., in mgd) rather than a per-unit use basis (i.e., in gallons per driver unit per day). No driver units were used in model fitting for groundwater use.

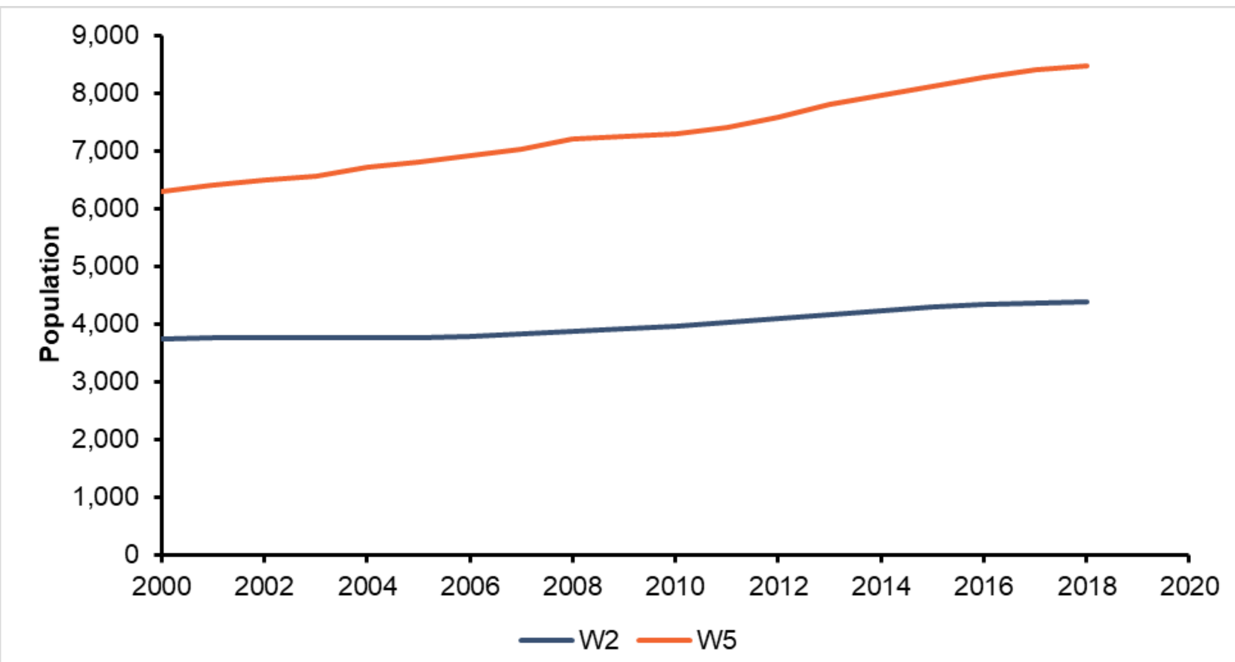


Figure 5-3: Total Population by Groundwater Charge Zone

[9] End uses of water for non-retailer groundwater pumpers is highly uncertain within the M&I sector. For example, it is difficult to determine from billing records whether a particular well within the M&I sector is primarily a residential service or meeting a CII application. Uncertainty in end uses make it difficult to accurately decide on and assign appropriate driver units, such as housing units or number of jobs.

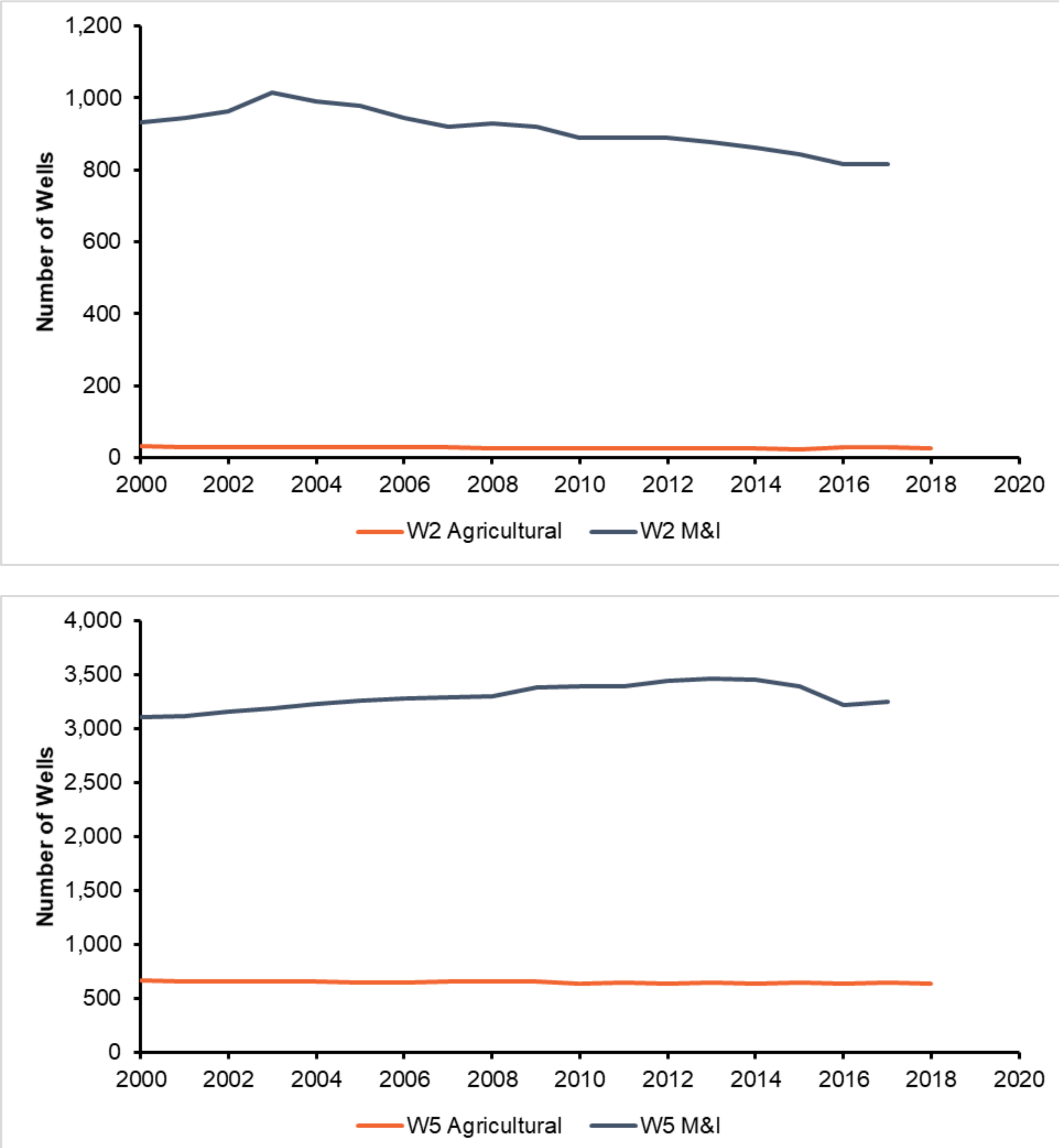


Figure 5-4: Total Number of Wells by Water Use Type for Charge Zone W2 (top) and W5 (bottom). Note the difference in y-axis scale.

6. Collection and Processing of Explanatory Variables

Several explanatory variables were collected in the development of Valley Water's demand model. To be considered for use, potential predictors needed to pass the following conceptual criteria:

- Logical connection to explaining changes in water consumption;
- Historical record consistent with the time series of observed water consumption; and
- Availability of future projections consistent with the desired forecast horizon (i.e., 2020-2045) or a reasonable means for assuming projected values.

Table 6-1 provides a general overview of the collected explanatory variables and their relevance to explaining changes in water consumption. The following sections provide documentation of the raw data sources and the necessary data processing implemented for each of these variables.

Table 6-1: Summary of Collected Explanatory Variables

Explanatory Variable	Relevance to Water Consumption
Temperature	Higher than normal temperatures are associated with higher demands.
Precipitation	Higher than normal rainfall is associated with lower demands.
Price	Economic theory suggests negative correlation with demand.
Drought restrictions	The presence of drought restrictions tends to decrease the amount of water consumed by customers.
Economic index	Water demand is positively correlated with economic fluctuations of the business cycle. The index is modeled in form of departures from long-term trend.
Median income	Economic theory suggests positive correlation of income with demand; generally geographical areas with higher median incomes tend to use more water.
Housing density	Housing density is negatively correlated with demand; on average, residences with more units per acre (or smaller parcel sizes) tend to use less water for outdoor uses.
Persons per household	Positively correlated with demand; generally, residences with more people tend to use larger amounts of water.
Mix of Industries / economic activity	The representation of industries / economic activity with a geographical area is related to the amount of water used within the CII sector.

6.1 Historical Weather Data

It is advantageous to have specific weather data for each geographical segmentation (i.e., retail service area boundaries) represented within a demand model, especially in geographic areas that may have micro-climates due to gradients in elevation and proximity to large water bodies. Most weather or climate datasets are provided at individual stations and can be interpolated between stations to obtain data geographically specific estimates for a target location. The Parameter-elevation Regressions on Independent Slopes Model (PRISM) dataset[10] provides gridded weather data at a 4-kilometer resolution and was easily processed to retail agency boundaries. For each retailer, the PRISM grid cell that contained the centroid of the agency's service area boundary was identified. Weather variables collected from the PRISM dataset included maximum temperature (degrees Fahrenheit) and total precipitation (inches per month).

[10] PRISM Climate Group, Oregon State University, http://prism.oregonstate.edu, created 4 Feb 2004.

Weather data were normalized to average conditions, in order to make observed weather independent of normal cyclical seasonal cycles. Weather data was normalized by calculating departures from historical normal values. Historical normal values were calculated for each retailer as the average values by month based on all values from 1981 to 2010. Departures were then calculated as the monthly value minus the historical normal, following the Equation (3:

$$Departure = X_{t,i} - X_i \quad (3)$$

Where $X_{t,i}$ is a monthly value in month i and X_i is the historic normal value in month i. A positive departure indicates above-normal conditions, and a negative value indicates below-normal conditions.

Table 6-2 on the following page summarizes the maximum temperature and total precipitation historical normal values by retailer.

Table 6-2: Historical 30-Year Normal Values (based on 1981 to 2010) for Weather Variables by Retailer

Retailer	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
Maximum Temperature (°F)													
California Water Service	58.7	62.1	65.6	69.5	74.0	78.6	80.6	80.8	80.3	75.3	65.5	58.7	70.8
City of Gilroy	60.2	63.5	67.7	72.7	78.5	83.9	88.1	87.9	85.4	78.4	67.5	59.9	74.5
City of Milpitas	58.4	61.9	65.6	69.3	73.7	78.3	80.7	80.8	80.0	74.5	65.2	58.4	70.6
City of Morgan Hill	59.9	63.2	67.3	71.5	77.7	84.1	88.5	87.6	85.0	77.2	66.8	59.3	74.0
City of Mountain View	58.2	61.5	64.7	68.6	72.5	76.6	77.8	78.1	78.0	73.6	65.0	58.4	69.4
City of Palo Alto	59.2	62.5	66.2	70.6	75.6	80.6	83.0	83.1	82.0	76.4	65.9	59.0	72.0
City of Santa Clara	58.3	61.9	65.5	69.3	73.7	78.3	80.7	80.6	79.9	74.6	65.1	58.3	70.5
City of Sunnyvale	58.6	61.9	65.4	69.3	73.7	78.2	80.2	80.3	79.9	74.9	65.3	58.6	70.6
Great Oaks Water Company	59.1	62.5	66.4	70.2	75.7	81.0	84.6	84.3	82.3	75.6	65.9	58.7	72.2
Purissima Hills Water District	59.9	62.9	66.7	71.9	77.4	82.7	85.4	85.5	84.0	77.9	66.6	59.6	73.4
San Jose Municipal Water	58.5	62.1	66.0	69.9	74.7	79.4	82.1	82.0	81.0	75.0	65.3	58.4	71.3
San Jose Water Company	58.4	62.1	66.1	70.1	75.1	80.0	82.9	82.7	81.5	75.4	65.3	58.3	71.5
Stanford University	58.8	62.3	65.9	70.0	75.0	79.9	82.0	82.2	81.0	75.7	65.5	58.7	71.4
Total Precipitation (in)													
California Water Service	3.48	3.52	2.74	1.12	0.44	0.11	0.01	0.03	0.15	0.83	1.92	3.01	17.35
City of Gilroy	4.49	4.25	3.28	1.30	0.49	0.11	0.00	0.03	0.23	1.08	2.39	3.77	21.43
City of Milpitas	2.98	2.95	2.38	1.08	0.51	0.09	0.01	0.02	0.16	0.83	1.57	2.45	15.03
City of Morgan Hill	4.46	4.40	3.13	1.17	0.54	0.09	0.00	0.03	0.18	0.90	2.03	3.47	20.41
City of Mountain View	3.08	3.06	2.44	1.05	0.41	0.10	0.00	0.02	0.14	0.77	1.75	2.69	15.52
City of Palo Alto	4.15	4.31	3.25	1.33	0.50	0.13	0.01	0.03	0.16	1.00	2.21	3.56	20.64
City of Santa Clara	2.91	2.96	2.34	1.05	0.44	0.09	0.01	0.02	0.13	0.74	1.52	2.38	14.58
City of Sunnyvale	3.12	3.13	2.43	1.07	0.44	0.10	0.01	0.02	0.14	0.77	1.70	2.62	15.55
Great Oaks Water Company	3.30	3.18	2.63	1.07	0.58	0.09	0.00	0.03	0.14	0.86	1.64	2.54	16.06
Purissima Hills Water District	5.01	5.18	3.90	1.58	0.60	0.13	0.01	0.03	0.17	1.13	2.73	4.39	24.88
San Jose Municipal Water	2.91	2.86	2.38	1.12	0.51	0.09	0.00	0.02	0.15	0.77	1.56	2.37	14.74
San Jose Water Company	3.26	3.31	2.63	1.08	0.43	0.09	0.00	0.02	0.14	0.76	1.62	2.70	16.05
Stanford University	3.95	3.93	3.10	1.27	0.49	0.11	0.01	0.03	0.15	0.94	2.24	3.68	19.89

6.2 Water Rates / Price

A time series of historic water rates for each retail agency were represented by water rates for the single family residential billing class, which was provided by Valley Water. Volumetric charges are used as the instrument for price. When consistently available over the period of record, the volumetric charge for the second tier was the price instrument used for retailers with tiered rates. Changes in single family residential water rates tended to reflect timing of changes in other sectors and were therefore used as a convenient proxy for all model sectors to estimate the response in water use to changes in price.

Stanford does not use billing rates. Instead, price for Stanford was modeled using the Water Utility Enterprise (WUE) rates by fiscal year, provided by Valley Water. The M&I groundwater/surface water for the W2 charge zone (North County) was used for Stanford.

Water use rates for non-retail groundwater pumpers were also calculated from WUE rates. For the non-retail groundwater pumpers M&I water use, M&I groundwater/surface water rates for the W2 and W5 charge zones were used. For the non-retail agricultural groundwater pumping, the agricultural groundwater/surface water rate was used for the W2 charge zone, and the net agricultural rate was used for the W5 charge zone.

All water rates were adjusted for inflation by normalizing prices to 2015 dollar values. A time series of historic inflation by year was used to calculate an adjustment factor to achieve this normalization. Table 6-3 on the following page shows the average historic normalized price in 2015 dollar values per hundred cubic feet (2015$/ccf) or per acre-foot (2015$/AF) by retailer, as well as the normalized value in 2018. Historic values ranged widely over the available period of historic data (2000 to 2018). Appendix D provides graphical summaries of historical water rates for each retail agency and non-retail groundwater pumping category identified in Table 6-3.

Table 6-3: Normalized Water Use Rate (2015$/ccf or 2015$/AF) by Retailer

Retailer	Average Normalized Water Use Rate, 2000-2018 ($/ccf)	2018 Normalized Water Use Rate ($/ccf)
California Water Service	$3.23	$5.04
City of Gilroy	$1.96	$3.90
City of Milpitas	$2.32	$0.98
City of Morgan Hill	$1.84	$2.26
City of Mountain View	$4.24	$6.21
City of Palo Alto	$6.86	$8.54
City of Santa Clara	$3.15	$5.41
City of Sunnyvale	$3.44	$4.85
Great Oaks Water Company	$2.54	$3.17
Purissima Hills Water District	$4.16	$6.13
San Jose Municipal Water	$2.76	$3.62
San Jose Water Company	$3.09	$3.42
	Rates Calculated from Valley Water Wholesale Water Rates ($/AF)	
Stanford University	$645.23	$1,113.79
Non-Retail Groundwater Pumpers, Ag W2	$29.64	$23.56
Non-Retail Groundwater Pumpers, Ag W5	$18.55	$23.56
Non-Retail Groundwater Pumpers, M&I W2	$645.23	$1,113.79
Non-Retail Groundwater Pumpers, M&I W5	$286.49	$392.39

6.3 Drought Restrictions

Drought effects were represented by the presence of drought restrictions (a binary value 0 or 1) multiplied by severity of the requested cutback from Valley Water. For example, if 10% cutbacks were in place, the drought effect variable was equal to 0.1. Two indices were developed and evaluated during model development; one index represented cutbacks during the drought of 2006 to 2008, and the second index represented cutbacks from the 2013 to 2016 drought. The time series of the historic drought effect variables are shown in Figure 6-1.

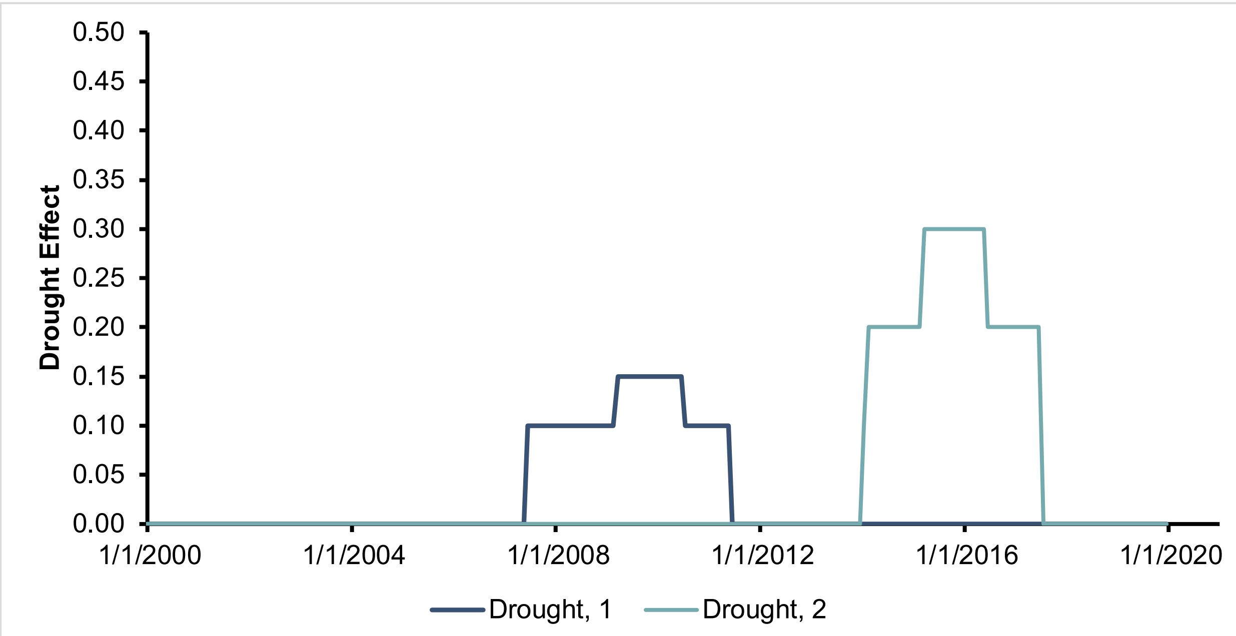


Figure 6-1: Drought Effect

6.4 Economic Indices

Several economic indices were collected and explored as potential model predictors. A summary of these indices is presented in Table 6-4 below.

Table 6-4: Summary of Economic Indices Collected for Model Fitting

Dataset	Source
U.S. Monthly Coincident Index[(a)]	ECRI[(b)]
Monthly Economic Conditions Index for San Jose-Sunnyvale-Santa Clara, CA (MSA) Seasonally Adjusted Annual Rate	Federal Reserve Bank of St. Louis Economic Research Division[(c)]
Monthly Unemployment Rate in San Jose-Sunnyvale-Santa Clara, CA (MSA)	Federal Reserve Bank of St. Louis Economic Research Division[(c)]

[(a)] Proprietary index for entire country. Includes a mix of metrics intended to coincide with the state of the economy in any given time period.
[(b)] https://www.businesscycle.com/download/index/USCI_f
[(c)] https://fred.stlouisfed.org

Figure 6-2 to Figure 6-4 illustrate the economic indices defined in Table 6-4 above. Though these indices are constructed and defined differently, major macroeconomic events, including the early 2000's dot-com bubble and the Great Recession, are clearly visable in each index. Note that peaks in the unemployment rate often lag the timing of recessions with slower recoveries to pre-recession levels.

The ECRI U.S. Monthly Coincident Index (ECRI index, Figure 6-4) shows a steady upward trend throughout the collected record, which is consistent with general long-term growth in the economy. The trend in the time series of the ECRI index was removed during model development, in order to better identify short term fluctuations in economic activity. The additional economic index was derived from the ECRI index by detrending the natural log of the index (i.e., regressing 30 years of monthly log-transformed index values against a linear time counter) (see Figure 6-5). The detrended series clearly shows the timing and magnitude of the dot-com bubble and the Great Recession, while highlighting periods of postive and negative economic growth relative to long-term trend. All economic indices illustrated in Figure 6-2 though Figure 6-5 were tested as predictor variables in model development. The detrended version of the ECRI index was eventually selected as it resulted in the most consistent coefficient estimates from the group.[11]

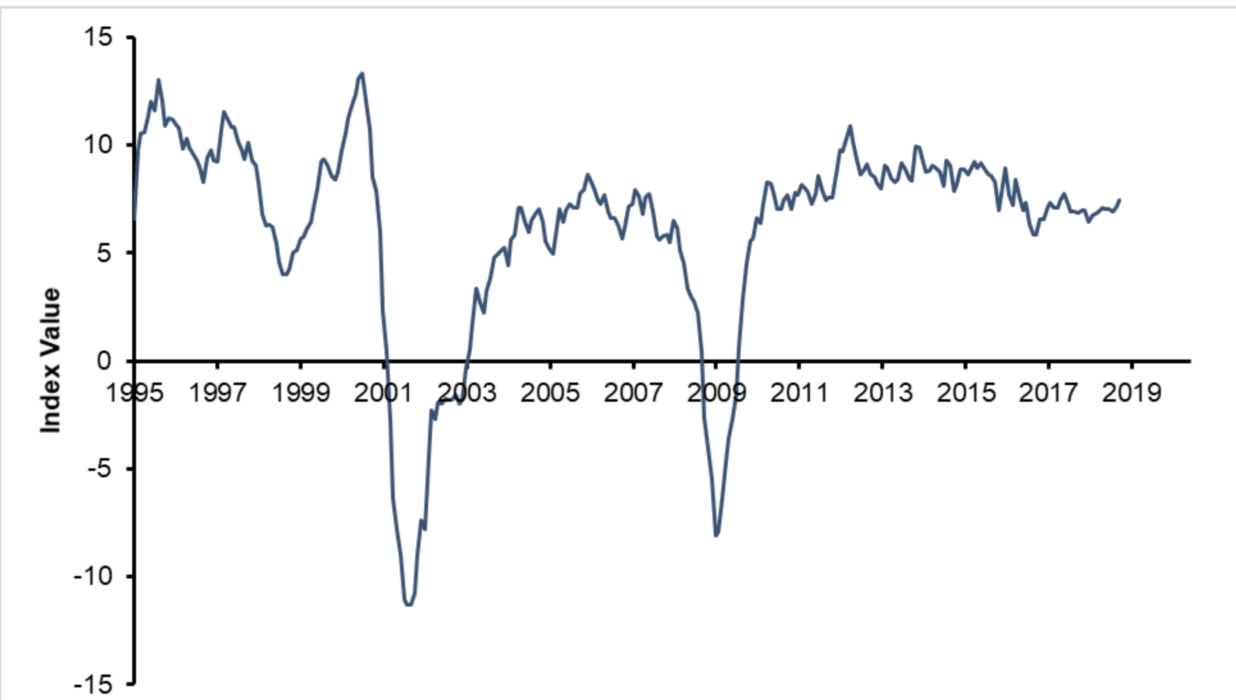


Figure 6-2: Monthly Economic Conditions Index for San Jose-Sunnyvale-Santa Clara, CA

[11] Refer to Section 1.4 from TM 3: Model Approach and Development.

Figure 6-3: Monthly Unemployment Rate in San Jose-Sunnyvale-Santa Clara, CA

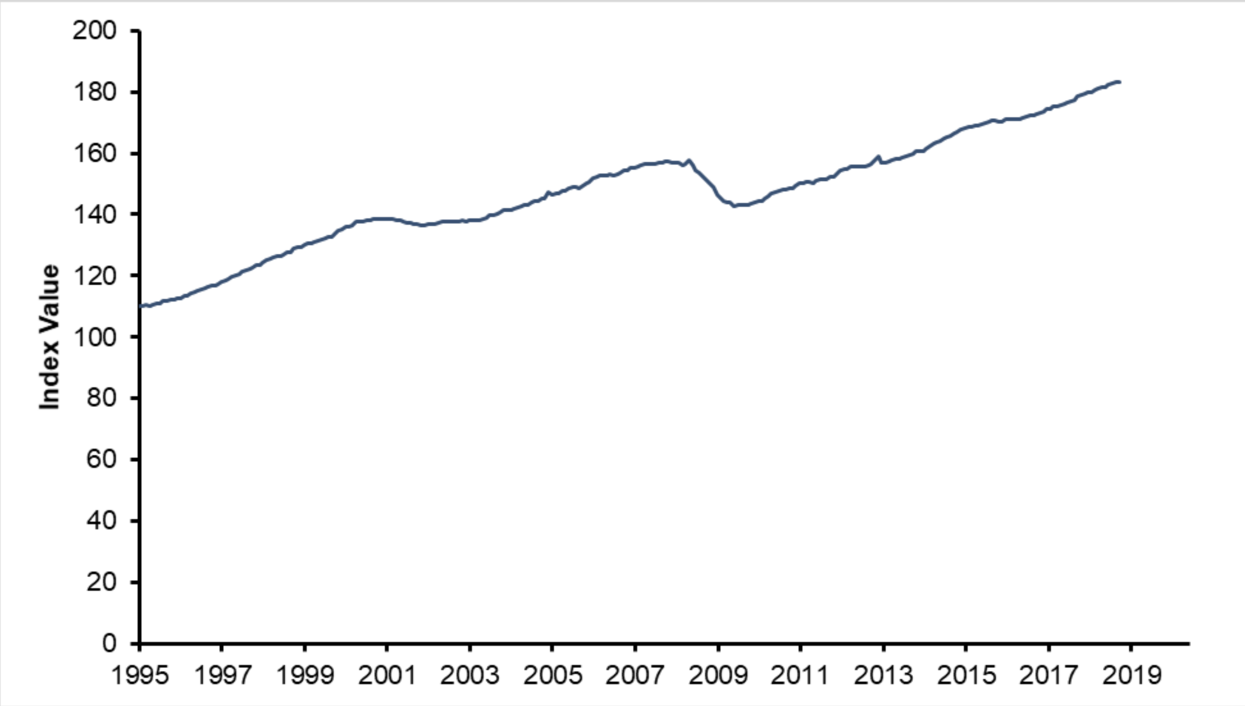


Figure 6-4: ECRI U.S. Monthly Coincident Index

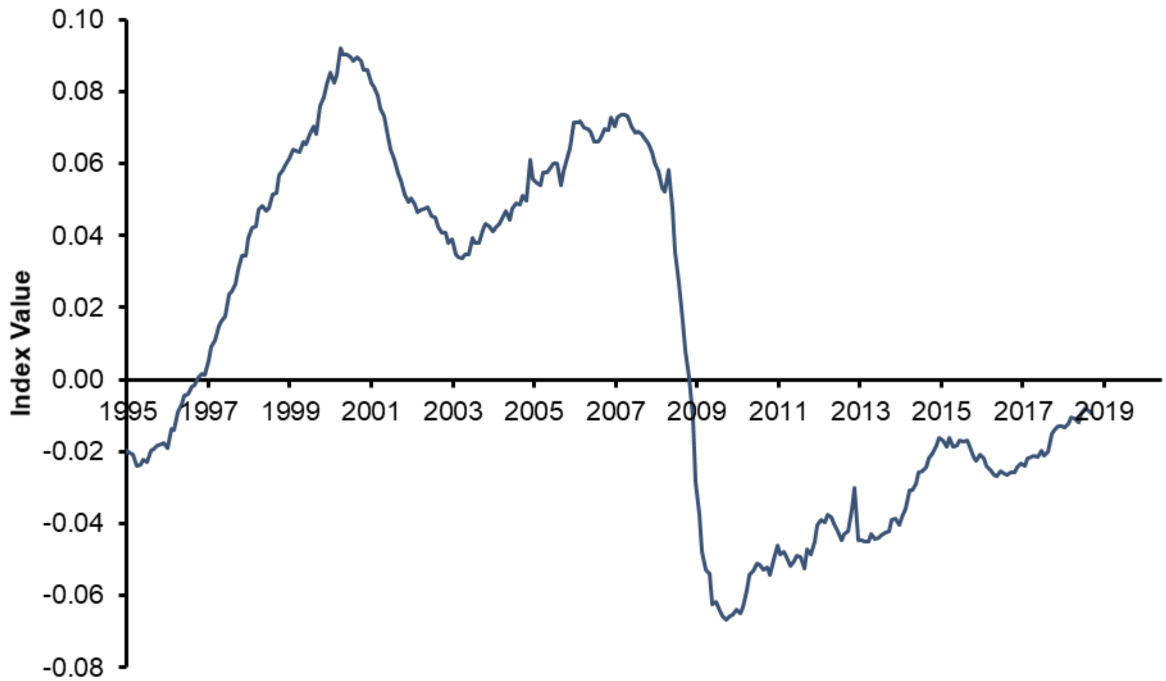


Figure 6-5: Detrended and Logged ECRI U.S. Monthly Coincident Index

6.5 Median Income

Median household income was estimated from the US Census American Community Survey (ACS) data as the median value of all census tracts within each retailer's service area boundary. Median income was identified as a potential explanatory variable for the residential sectors. Values were calculated as the average value across Census ACS survey data available from 2013 to 2017. Median income was adjusted for inflation by normalizing to 2015 dollar values and held constant over time for each retailer. Table 6-5 shows the normalized median income value by retailer. Note that median income for Stanford is not identified in Table 6-5 as its entire demand is considered CII.

Table 6-5: Normalized Median Income by Retailer (2015$)

Retailer	Average Median Household Income ACS (2013-2017)
California Water Service	$156,235
City of Gilroy	$91,643
City of Milpitas	$108,352
City of Morgan Hill	$109,752
City of Mountain View	$138,060
City of Palo Alto	$144,307
City of Santa Clara	$107,272
City of Sunnyvale	$125,285
Great Oaks Water Company	$108,184
Purissima Hills Water District	$206,782
San Jose Municipal Water	$116,052
San Jose Water Company	$106,368

6.6 Housing Density

Housing density was derived from housing units derived for each retailer (see Section 3.1) divided by the total parcel area of multi-family and single family housing. Total parcel areas were provided by Valley Water based on processed GIS records. Table 6-6 shows the categories used in Valley Water's GIS data and their single family or multi-family characterization.

Table 6-6: Classification of Residential Land Use Categories

Classification	Valley Water Land Use Category
Single Family	Single family
	Single family 5-10 units
	Single family 11-20 units
	Single family <51-100 units
	Single family 51-100 units
	Single family duplicate
Multifamily	Condo/townhouse
	Condo/townhouse 11-20 units
	Condo/townhouse 21-50 units
	Condo/townhouse duplicate null
	Condo/townhouse null
	Five or more family
	Five or more family 5- 10 units
	Five or more family 11- 20 units
	Five or more family 21- 50 units
	Five or more family 51-100 units
	Five or more family > 100 units
	Five or more family apartments/offices
	Five or more family govt restricted/subsidized/other
	Five or more family govt restricted/subsidized/section 221d3
	Five or more family govt restricted/subsidized/section 236
	Five or more family lifecare includes skilled nursing
	Five or more family mobile home park
	Five or more family retirement complex/meals/recreation/no care
	Five or more family seniors only/no services
	Office uses office condo
	Two family
	Three/four family

Table 6-7 shows the average housing density (in units per acre) for each retailer for both single family and multifamily housing. Housing units varied over time, whereas geographic area was held constant. As a result, housing density varied slightly with changes in housing units. Single family housing density was typically within +/-5% of the average value, and multi-family housing density was typically within +/-10% of the average value. Note that housing density for Stanford is not identified in Table 6-7 as its entire demand is considered CII.

Table 6-7: Housing Density by Retailer

Retailer	Single Family Density (Housing Units/Acre)	Multifamily Density (Housing Units/Acre)
California Water Service	3.1	13.83
City of Gilroy	3.48	5.69
City of Milpitas	8.34	21.34
City of Morgan Hill	1.98	8.22
City of Mountain View	11.23	20.18
City of Palo Alto	4.91	33.09
City of Santa Clara	8.58	27.47
City of Sunnyvale	9.06	18.48
Great Oaks Water Company	6.34	20.62
Private well owner	1.47	
Purissima Hills Water District	0.75	19.58
San Jose Municipal Water	4.97	18.62
San Jose Water Company	5.34	13.83

6.7 Persons per Household

Persons per household is a derived parameter calculated as ACS total population by housing type divided by the number of households. Values were first calculated on a census tract level then aggregated to retail service area boundaries. Persons per household was calculated separately for single family and multifamily residences. Table 6-8 shows the average persons per household by retailer. Values varied slightly over time but were typically within +/-5% of the average value. Note that Persons per household for Stanford is not identified in Table 6-8 as its entire demand is considered CII.

Table 6-8: Persons per Household (PPH) by Retailer

Retailer	Persons per Household (Single family)	Persons per Household (Multifamily)
California Water Service	2.87	2.41
City of Gilroy	3.44	3.37
City of Milpitas	3.53	2.66
City of Morgan Hill	3.08	2.91
City of Mountain View	2.66	2.11
City of Palo Alto	2.83	1.93
City of Santa Clara	2.99	2.34
City of Sunnyvale	2.93	2.38
Great Oaks Water Company	3.38	2.91
NASA Ames	3.57	3.69
Private well owner	3.11	2.47
Purissima Hills Water District	2.77	2.78
San Jose Municipal Water	3.77	2.55
San Jose Water Company	3.24	2.53

6.8 Mix of Industries / Economic Activity

For the CII model sector, additional explanatory variables were developed to reflect the mix of CII activity within each retail service area. These parameters were derived from historic LODES employment data (see Section 3.2). LODES employment data by NAICS sector were aggregated to six employment sectors defined by the Association of Bay Area Governments (ABAG), as shown in Table 6-9. The ABAG sectors were used to maintain consistency with available employment projections.

Table 6-9: NAICS Sector Jobs by Model Sector

NAICS Sector	ABAG Sector
Agriculture, Forestry, Fishing and Hunting	Agriculture and Natural Resources
Administration & Support, Waste Management and Remediation	Financial and Professional Service
Finance and Insurance	
Management of Companies and Enterprises	
Professional, Scientific, and Technical Services	
Real Estate and Rental and Leasing	
Accommodation and Food Services	Health, Educational and Recreational Service
Arts, Entertainment, and Recreation	
Educational Services	
Health Care and Social Assistance	
Construction	Information, Government and Construction
Information	
Public Administration	
Manufacturing	Manufacturing, Wholesale and Transportation
Mining, Quarrying, and Oil and Gas Extraction	
Transportation and Warehousing	
Utilities	
Wholesale Trade	
Other Services (excluding Public Administration)	Retail
Retail Trade	

The five non-agricultural ABAG sectors were considered for the mix of industries/economic activity explanatory variables – Financial and Professional Service; Health, Educational and Recreational Service; Information, Government and Construction; Manufacturing, Wholesale and Transportation; and Retail The ratio of jobs within an ABAG employment sector to the total number of non-agricultural jobs was calculated for each retailer. These values varied by year.

Table 6-10 shows the average ratio of jobs within each ABAG sector by retailer, which were used as the mix of industries/economic activity explanatory variables. Historic values from 2002 to 2018 were typically within +/-10% of the average value.

Table 6-10: Average Mix of Industries/Economic Activity by Retailer and ABAG Sector

Retailer	Financial and Professional Service	Health, Educational and Recreational Service	Information, Government and Construction	Manufacturing, Wholesale and Transportation	Retail
California Water Service	20%	31%	5%	30%	14%
City of Gilroy	11%	40%	11%	13%	25%
City of Milpitas	22%	22%	11%	31%	14%
City of Morgan Hill	18%	28%	10%	32%	13%
City of Mountain View	32%	17%	25%	15%	10%
City of Palo Alto	28%	41%	11%	12%	9%
City of Santa Clara	28%	18%	9%	37%	8%
City of Sunnyvale	32%	16%	8%	35%	9%
Great Oaks Water Company	16%	42%	3%	28%	10%
Purissima Hills Water District	21%	57%	6%	7%	9%
San Jose Municipal Water	21%	13%	10%	48%	8%
San Jose Water Company	24%	31%	13%	16%	16%

6.9 Number of Groundwater Wells

For groundwater use, the number of wells was aggregated by billing sector and groundwater basin. The number of wells was considered as an explanatory variable for the groundwater use models only. Figure 5-4 in Section 5.2 above shows the total number of wells.

7. Summary and Conclusions

Data collection efforts resulted in a robust historical dataset consisting of consumption, driver units, and explanatory variables. Several raw data sources required pre-processing in order to be suitable for model development, which included development of rate of use time series, geo-processing of census tract-level socioeconomic data to retail agency service area boundaries, and data normalization/standardization. The overall dataset represents a wide range of explanatory variables that are known to influence water demand and are concurrent with historical observations of retail agency and non-retail groundwater pumper consumption. A detailed review of the demand model development using this dataset is provided in TM 3.

Appendix A: Standardization of Retailer Billing Classifications to Model Sectors

Table A-1: Model Segmentation by Retailer and Billing Classification

Retail Agency	Billing Classification	Standardized Sector	Model Sector
California Water Service	SFR	Single Family	Single Family
	MFR	Multifamily	Multifamily
	COM	Commercial	CII
	GOV	Institutional	
	IND	Industrial	
	IRRI	Landscape	
	OTH	Other	Other
City of Gilroy	SFR	Single Family	Single Family
	MFR	Multifamily	Multifamily
	Commercial/Institutional	Commercial	CII
	Industrial	Industrial	
	Landscape	Landscape	Other
	Other	Other	
City of Milpitas	Single Family	Single Family	Single Family
	Multifamily	Multifamily	Multifamily
	Commercial	Commercial	CII
	Industrial	Industrial	
	Institutional	Institutional	
	Irrigation[(a)]	Landscape	Multifamily / CII
	Other RW[(b)]	Recycled	Multifamily / CII
	Other	Other	Other
City of Morgan Hill	Outside City Residential	SFR	Single Family
	Residential	SFR	
	Multiple	MFR	Multifamily
	Commercial	Commercial	CII
	Fire Sprinklers	Commercial	
	Hydrant Meters	Commercial	
	Landscape Irrigation	Commercial	
	Public City Accounts	Institutional	
	Public City Landscape	Institutional	
City of Mountain View	Single Family	SFR	Single Family
	Multifamily	MFR	Multifamily
	Landscape Irrigation[(c)]	Landscape	Multifamily/CII
	Commercial	Commercial	CII
	Recycled Commercial	Commercial	
	Industrial	Industrial	
	Blended Irrigation	Recycled	
	Recycled Irrigation	Recycled	

Retail Agency	Billing Classification	Standardized Sector	Model Sector
	Other	Other	Other
	Other Recycled (Construction)	Other	
City of Palo Alto	Single Family	SFR	Single Family
	Multifamily	MFR	Multifamily
	Commercial	Commercial	CII
	Industrial	Industrial	
	Public Facility	Institutional	
	City Facility	Institutional	
	Recycled Water	Institutional	
	Irrigation[d]	Landscape	Single Family/Multifamily/ CII
	Other	Other	Other
City of Santa Clara	Single Family	SFR	Single Family
	Multifamily	MFR	Multifamily
	Commercial	Commercial	CII
	Industrial	Industrial	
	Institutional	Institutional	
	Municipal	Institutional	
	Recycled Water[e]	Landscape	Multiple Family/CII
City of Sunnyvale	Single Family	SFR	Single Family
	Multifamily	MFR	Multifamily
	Other (Mobile Home Parks)	MFR	
	Commercial	Commercial	CII
	Irrigation	Commercial	
	Recycled	Commercial	
	Institutional	Institutional	
	Fireline	Other	Other
Great Oaks Water Company	SFR	SFR	Single Family
	MFR	MFR	Multifamily
	Business	Commercial	CII
	Private Landscaping	Commercial	
	Industrial	Industrial	
	Public Authorities	Institutional	
	Schools	Institutional	
	Agriculture	Agriculture	Other
Purissima Hills Water District	Single Family	SFR	Single Family
	Institutional	Institutional	CII
	Irrigation	Institutional	
	Other	Other	Other
San Jose Municipal Water	Single family	SFR	Single Family
	Multi-Family	MFR	Multifamily
	Commercial	Commercial	CII
	Industrial	Industrial	
	Government	Institutional	
	Public	Institutional	

Retail Agency	Billing Classification	Standardized Sector	Model Sector
	Irrigation[f]	Landscape	Multifamily / CII
	Temporary	Other	Other
San Jose Water Company	Residential[g]	Residential	Single Family / Multifamily
	Commercial (Residential and Business) [h]	Residential/Commercial	Single Family / Multifamily / CII
	Business	Commercial	CII
	Industrial	Industrial	
	Irrigation	Institutional	
	Public Authorities	Institutional	
	Recycled Water	Landscape	
	Miscellaneous	Other	Other
	Other Water Utilities	Other	
Stanford University	Academic	Institutional	CII
	Athletics		
	CEF/Cogen		
	Construction		
	Faculty/Staff Housing		
	Flushing		
	Lake System		
	Medical School		
	Other Support Facilities		
	Student Housing/Dining		

[a] The City of Milpitas identified that their Irrigation billing classification is approximately allocated 25-30% to residential, 0.5-1% government irrigation, 20-25% city irrigation, and 40-50% commercial/industrial irrigation. Given this information Hazen allocated historical Irrigation use to the Multifamily sector (28%) and the CII sector (72%).

[b] The City of Milpitas identified that their Other RW billing classification is approximately 1-3% residential irrigation, 1-3% government irrigation, 15-20% city irrigation, and 80-90% commercial/industrial irrigation. Given this information Hazen allocated historical Other RW to the Multifamily sector (2%) and the CII sector (98%).

[c] The City of Mountain View identified that their landscape irrigation billing classification was made up of about 50% commercial, 20% multifamily residential, and 30% parks/city use. Based on this information Hazen allocated landscape irrigation use to the CII sector (80%) and the multifamily sector (20%).

[d] The City of Palo Alto identified that their Irrigation billing classification was made up of 55% commercial, 18% City facilities, 18% multifamily residential, 6% industrial, 2% at public facilities (non-city) and 1% at residential single family. Given this information Hazen allocated historical Irrigation use to the single family sector (1%), multifamily sector (18%), and the CII sector (81%).

[e] The City of Santa Clara identified that their recycled water billing classification was allocated across the commercial, industrial, municipal, institutional, and multifamily billing classes, but did not identify relative proportions. Given this information, Hazen allocated recycled water use to the multifamily and CII sectors proportional to historical water use.

[f] San Jose Municipal Water identified that their irrigation billing classification was allocated across the commercial, industrial, institutional, and multifamily billing classifications, but did not identify relative proportions. Given this information, Hazen allocated recycled water use to the multifamily and CII sectors proportional to historical water use.

[g] San Jose Water Company (SJWC) has a single residential billing classification. Based on SJWC's 2015 UWMP, the 85% of the historical consumption in the residential billing classification was allocated to the single family sector and 15% was allocated to the multifamily sector.

[h] SJWC had a combined residential and CII billing classification between 2000-2010. Based on an analysis of post-2010 consumption data and discussions with SJWC staff, 61.4% of the Commercial (Residential and Business) classification was allocated to the residential classification and 38.6% was allocated to business. Residential consumption in the period was allocated 85% to the single family sector and 15% to the multifamily sector based on the 2015 UWMP.

Appendix B: Summary of Retail Agency Residential Driver Units

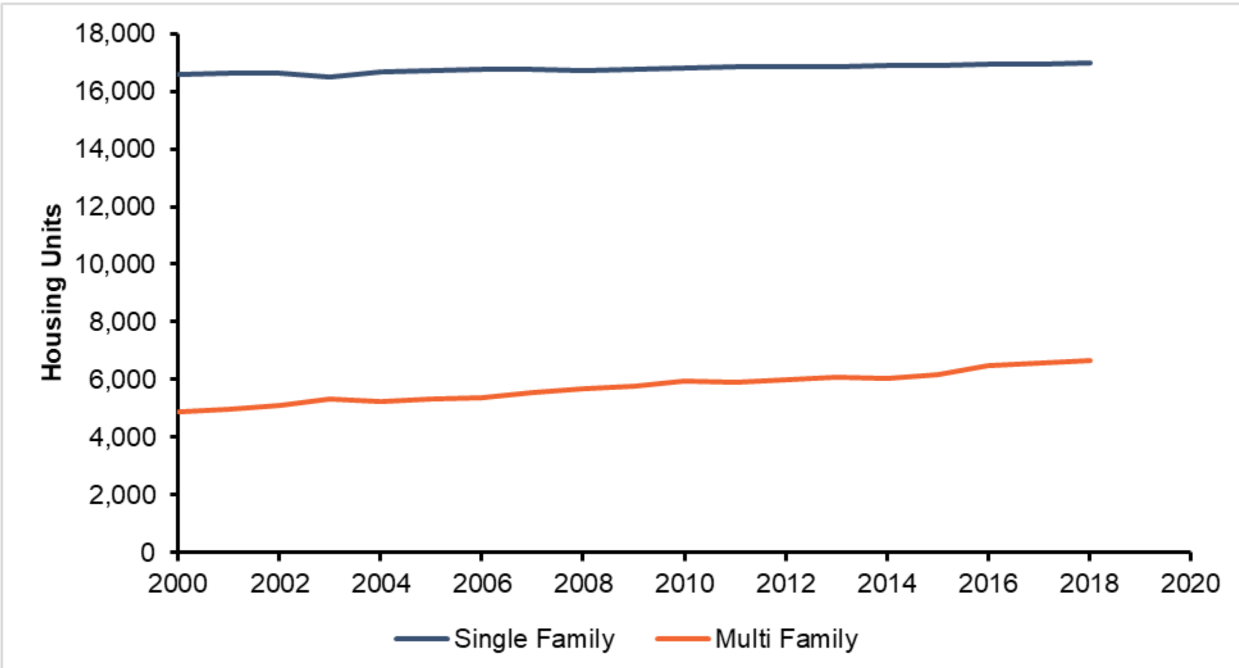


Figure B-1: California Water Service Single Family and Multifamily Housing Units

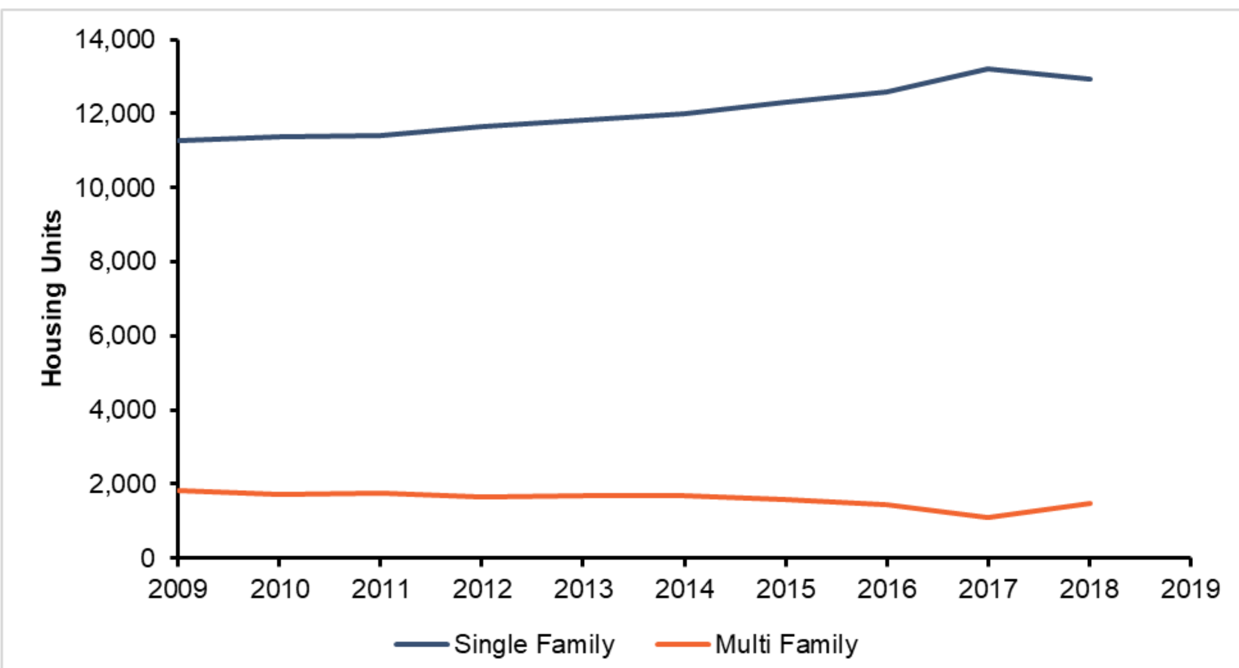


Figure B-2: City of Gilroy Single Family and Multifamily Housing Units

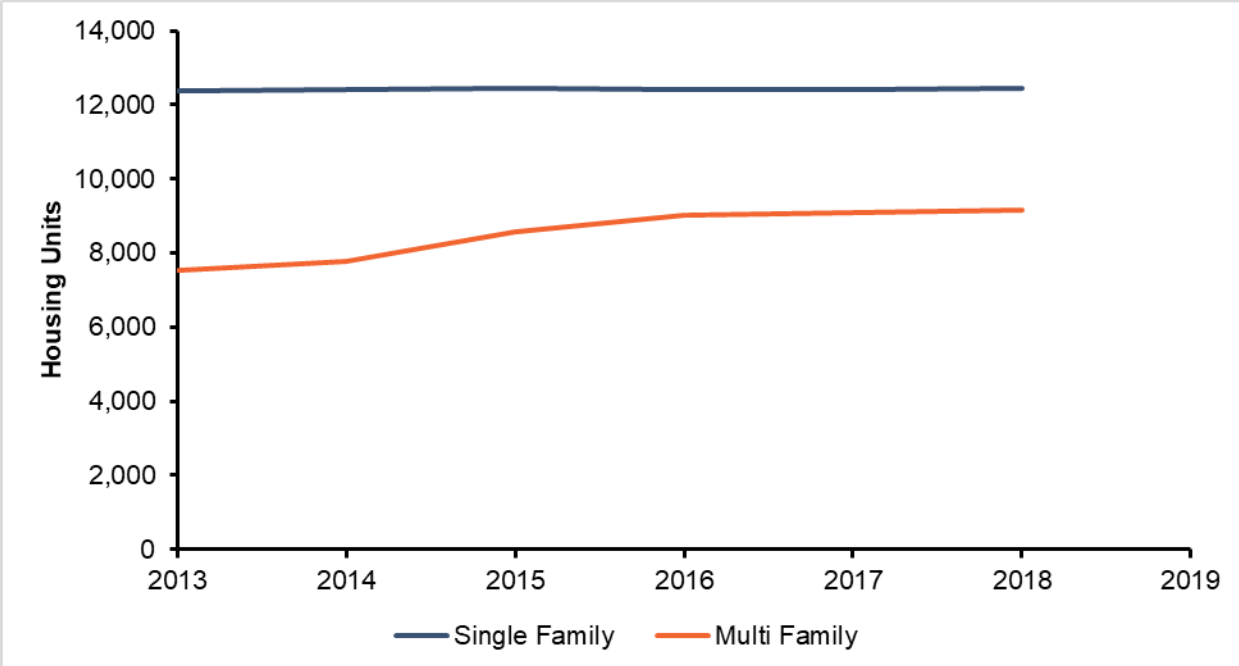


Figure B-3: City of Milpitas Single Family and Multifamily Housing Units

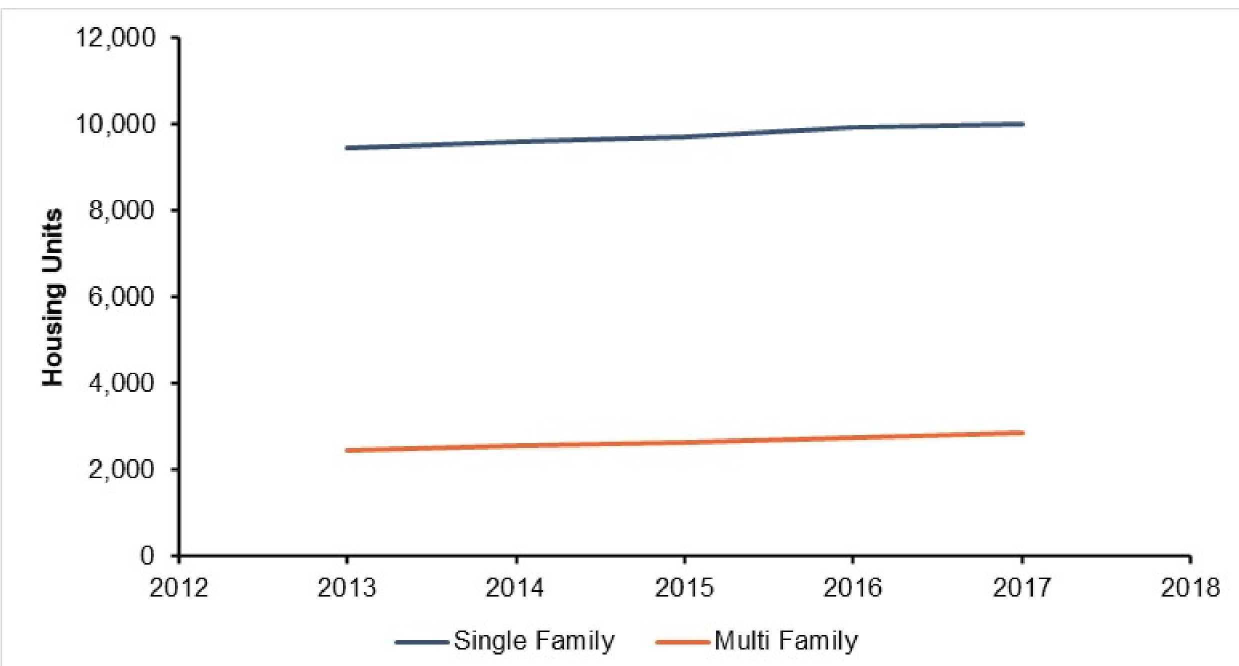


Figure B-4: City of Morgan Hill Single Family and Multifamily Housing Units

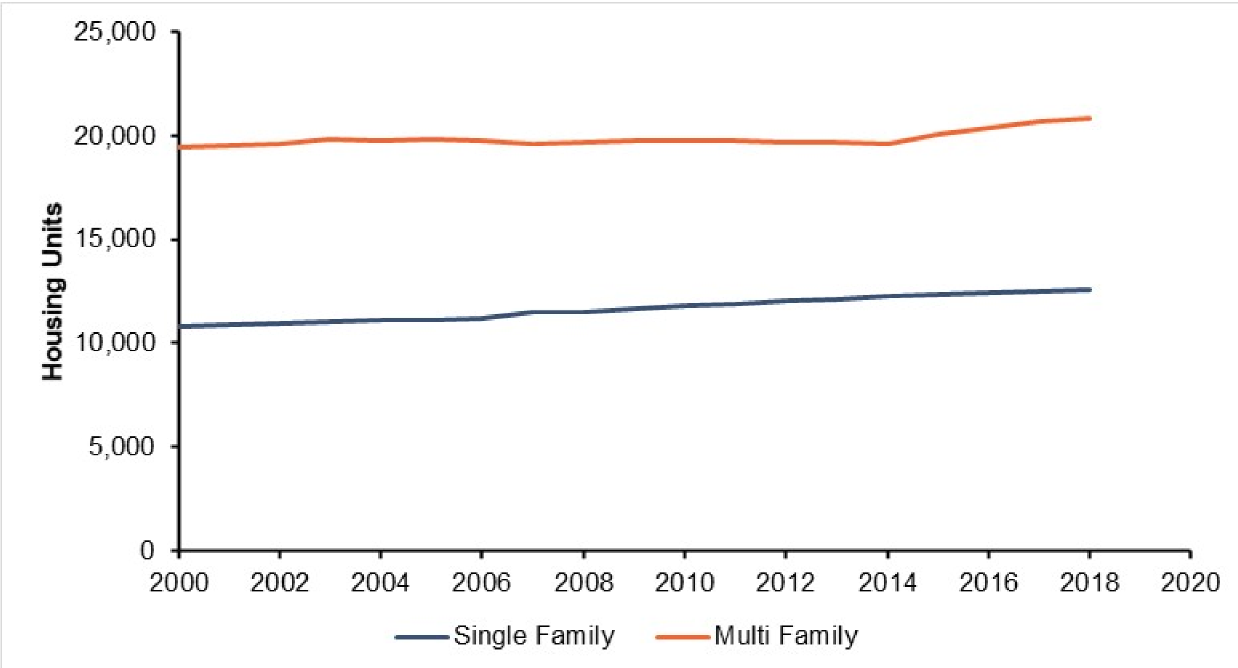


Figure B-5: City of Mountain View Single Family and Multifamily Housing Units

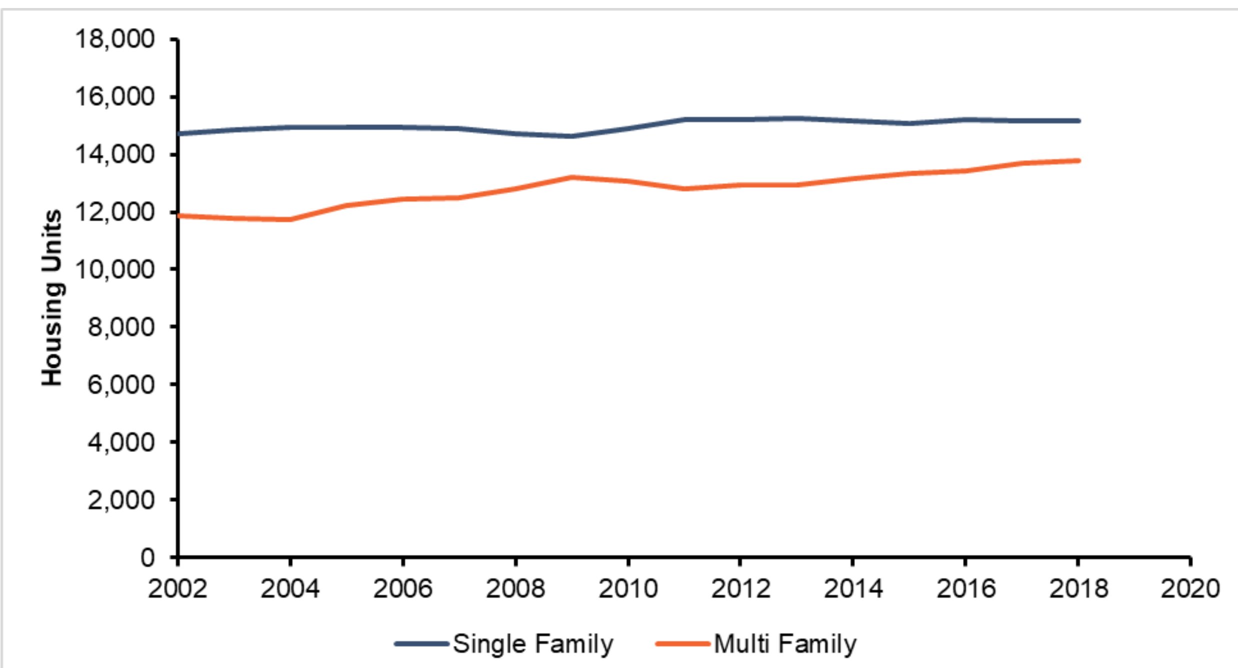


Figure B-6: City of Palo Alto Single Family and Multifamily Housing Units

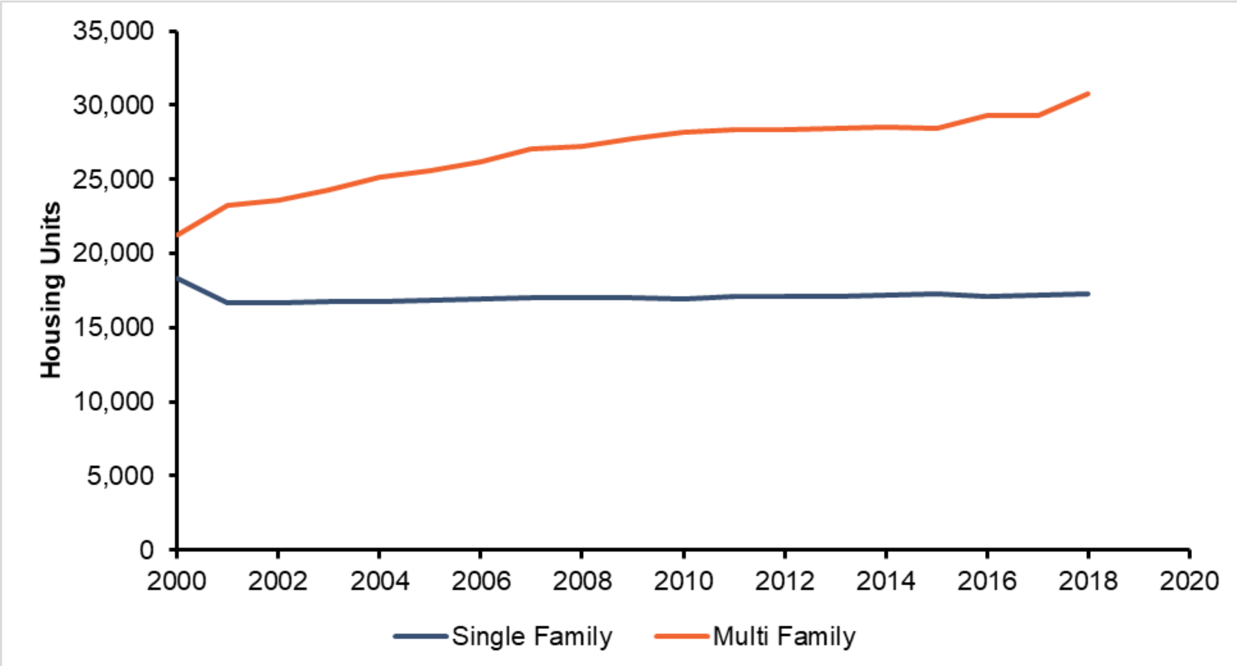


Figure B-7: City of Santa Clara Single Family and Multifamily Housing Units

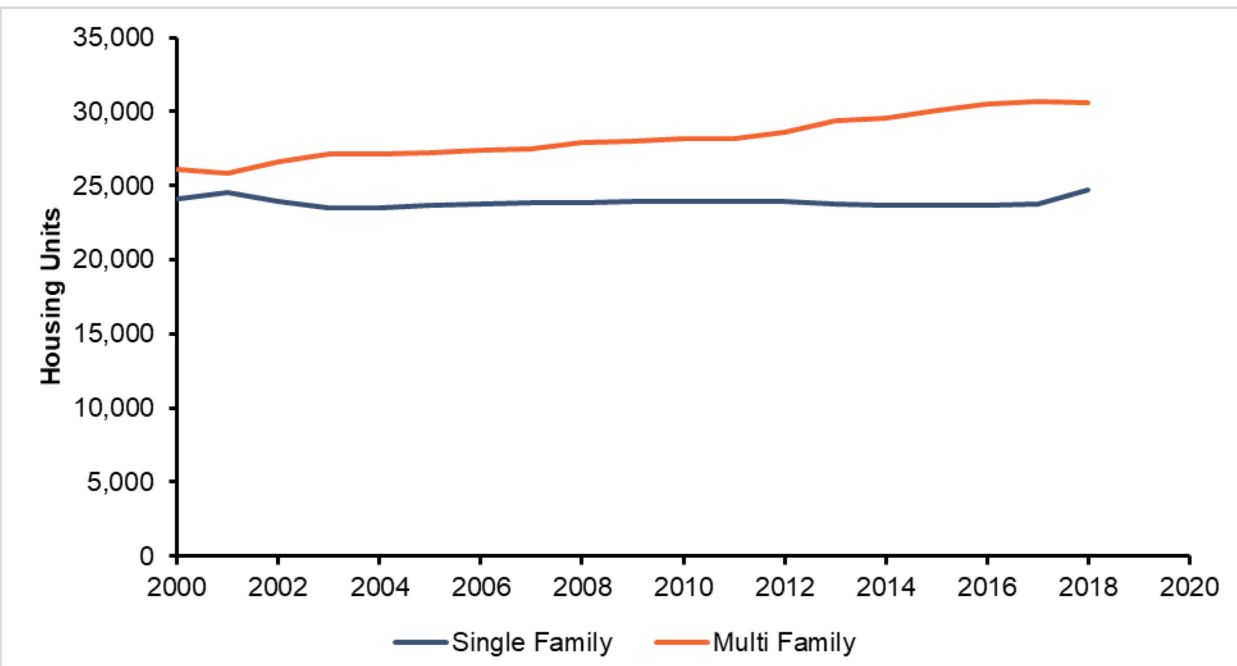


Figure B-8: City of Sunnyvale Single Family and Multifamily Housing Units

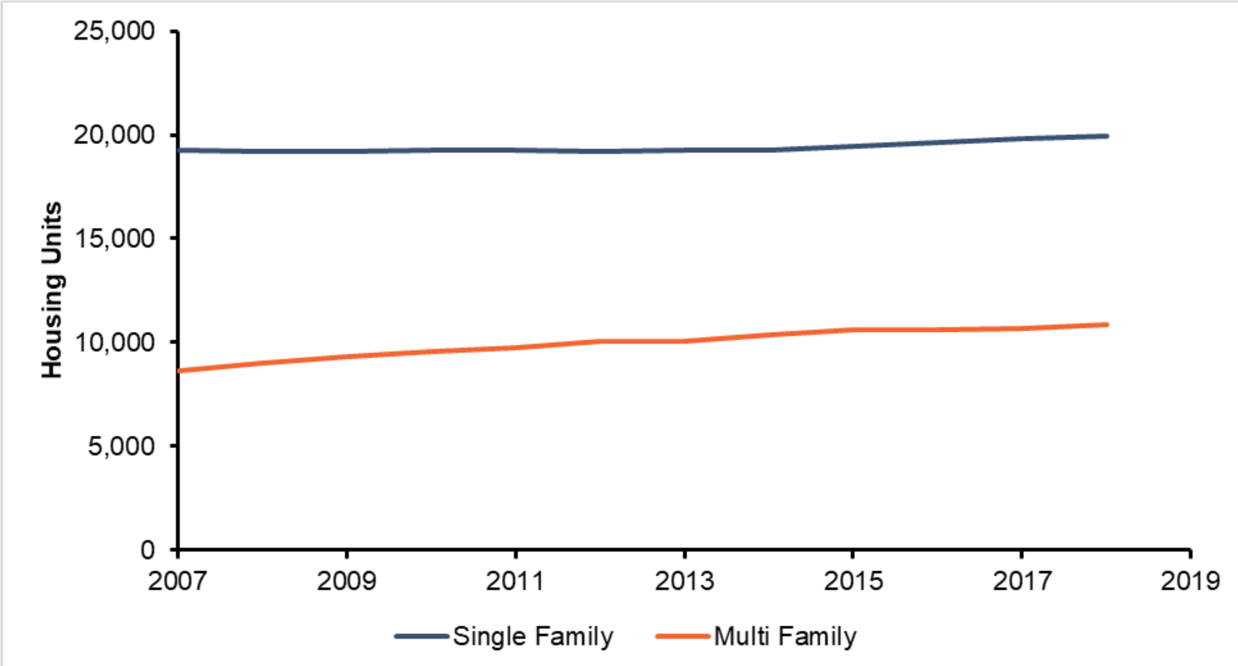


Figure B-9: Great Oaks Water Company Single Family and Multifamily Housing Units

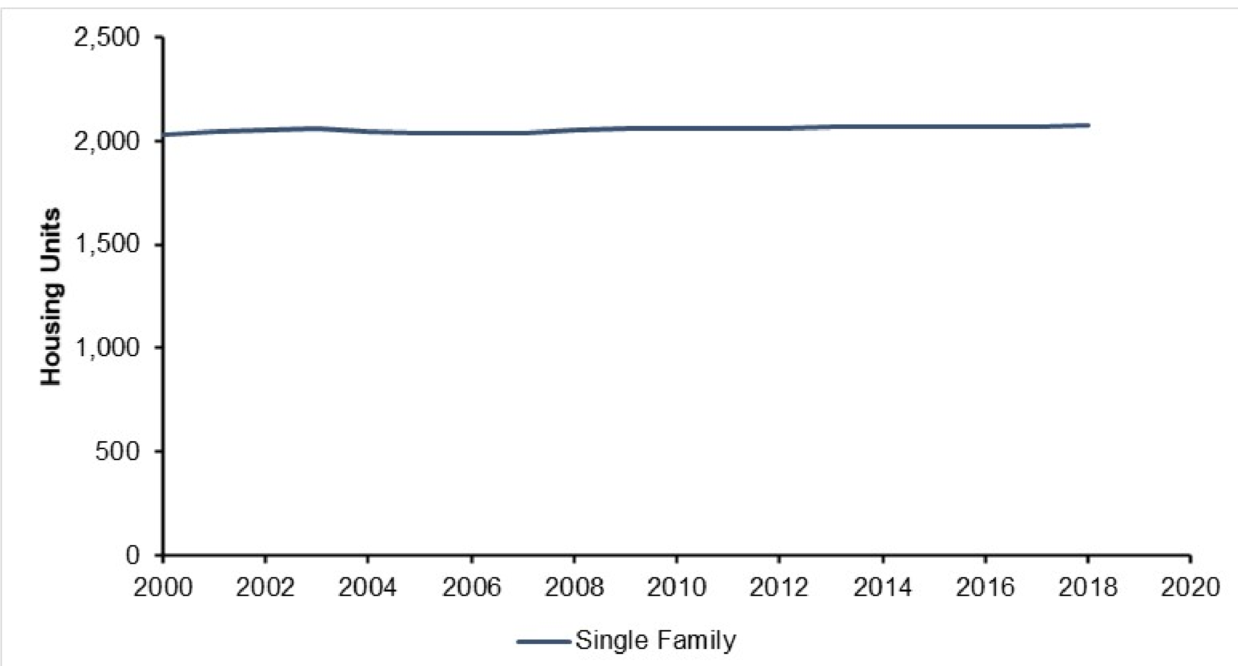


Figure B-10: Purissima Hills Water District Single Family and Multifamily Housing Units

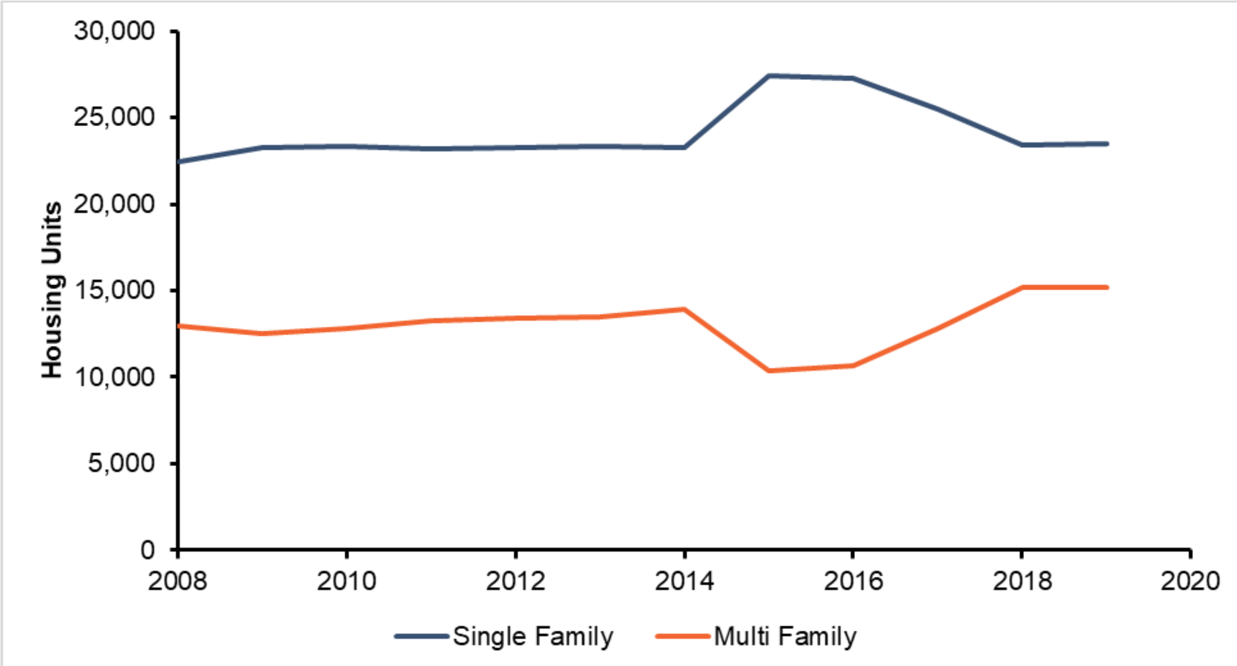


Figure B-11: San Jose Municipal Water Single Family and Multifamily Housing Units[12]

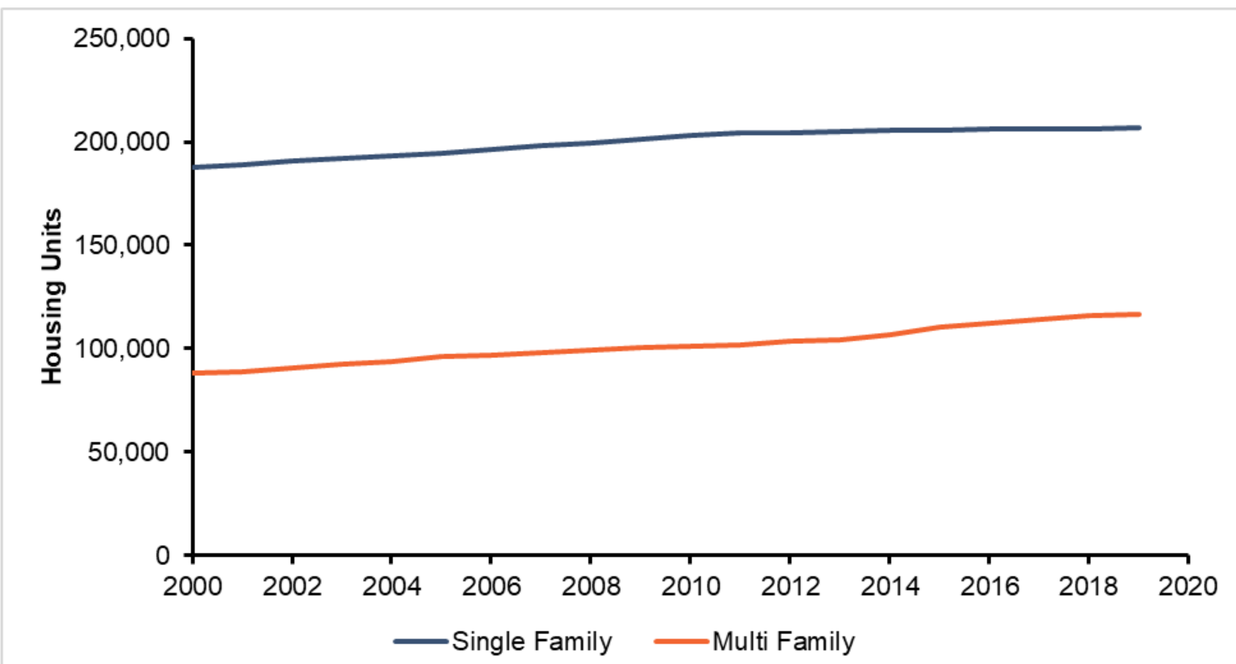


Figure B-12: San Jose Water Company Single Family and Multifamily Housing Units

[12] A temporary shift in single family accounts without associated information on the number of multifamily units per account lead to a corresponding temporary change in multifamily housing units.

Appendix C: Summary of Retail Agency CII Jobs

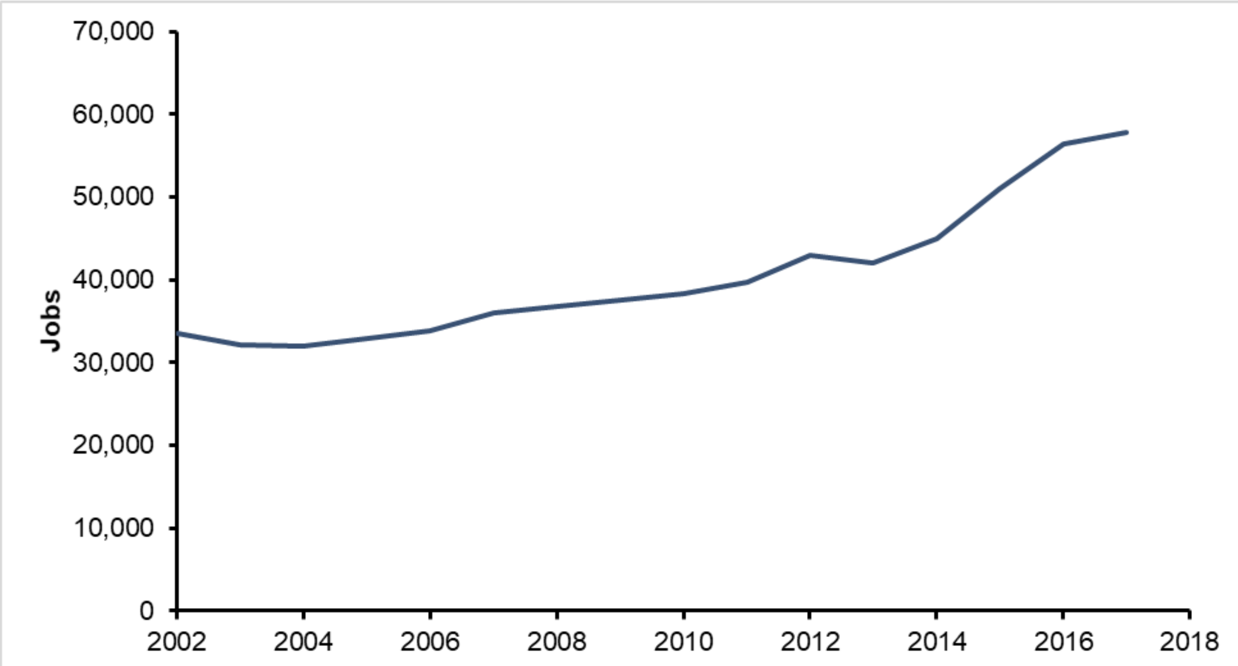


Figure C-1: California Water Service Jobs

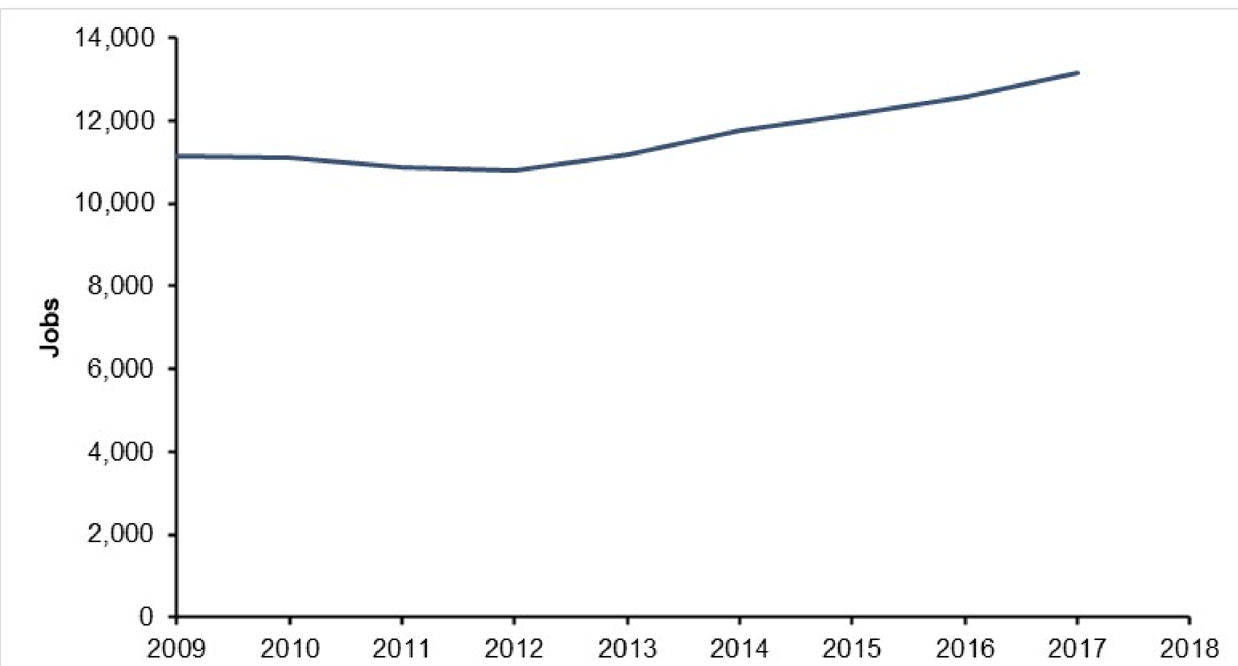


Figure C-2: City of Gilroy Jobs

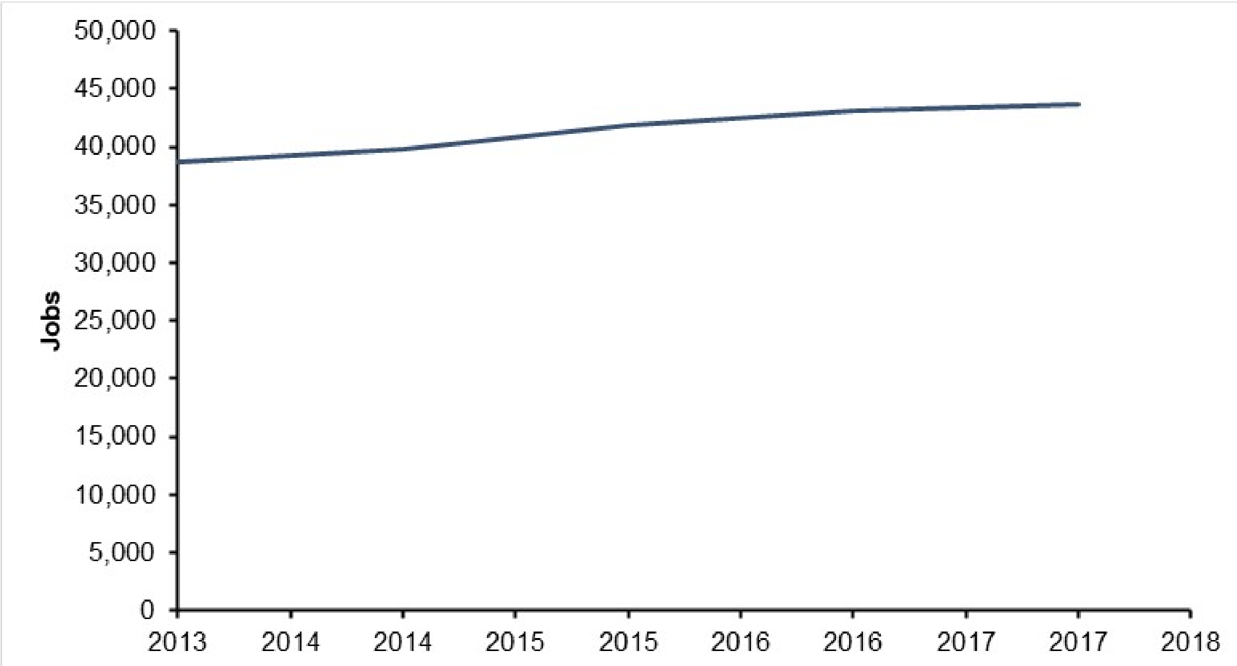


Figure C-3: City of Milpitas Jobs

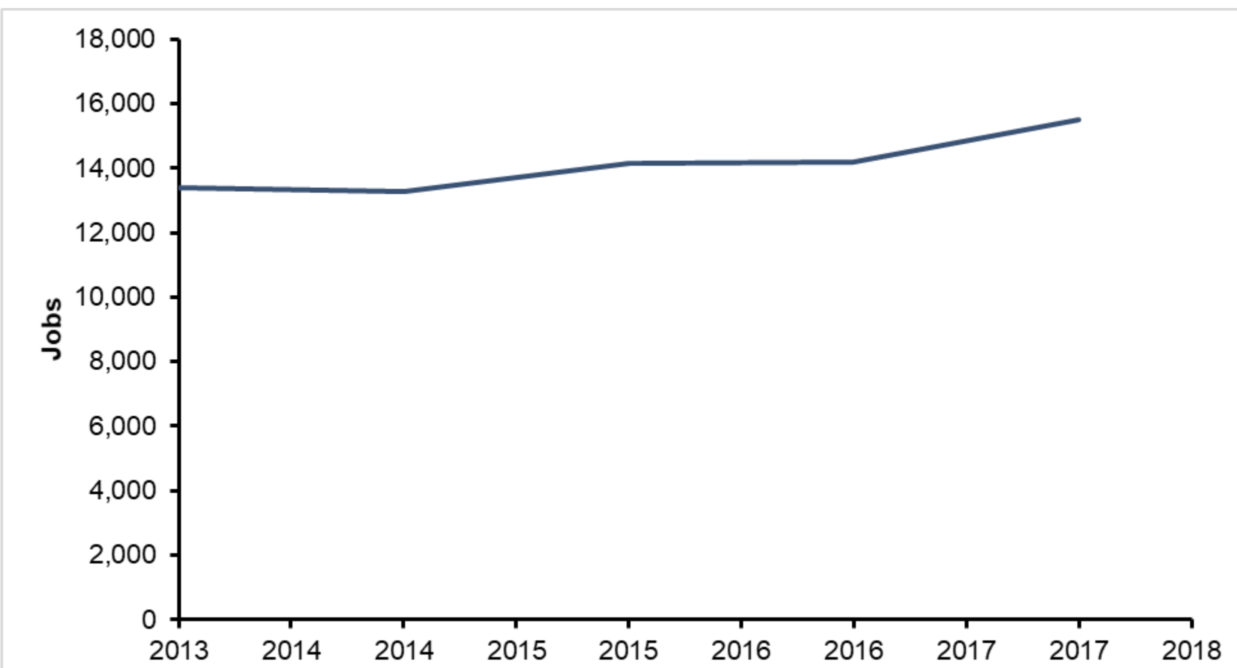


Figure C-4: City of Morgan Hill Jobs

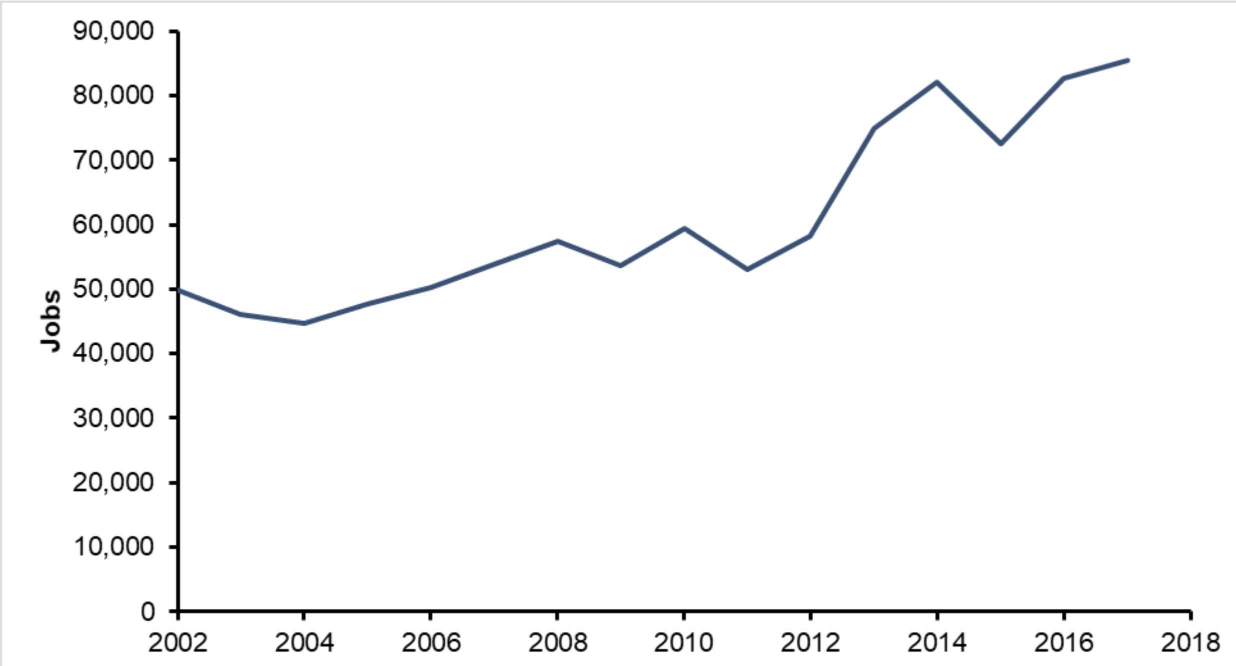


Figure C-5: City of Mountain View Jobs

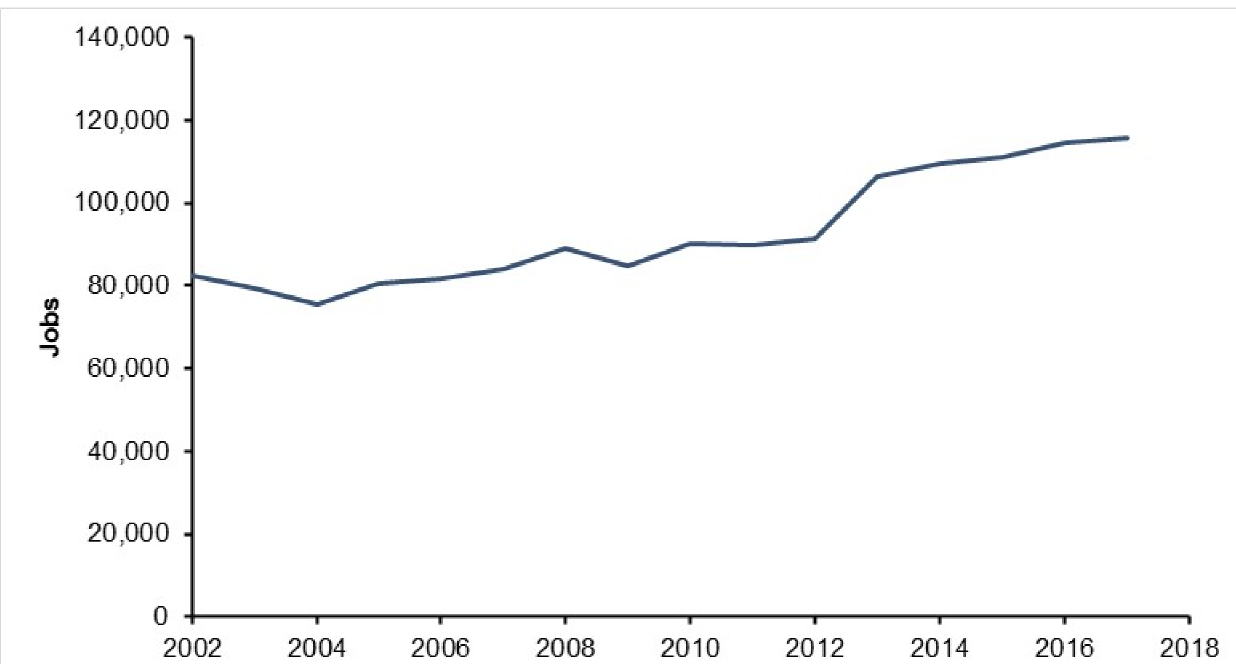


Figure C-6: City of Palo Alto Jobs

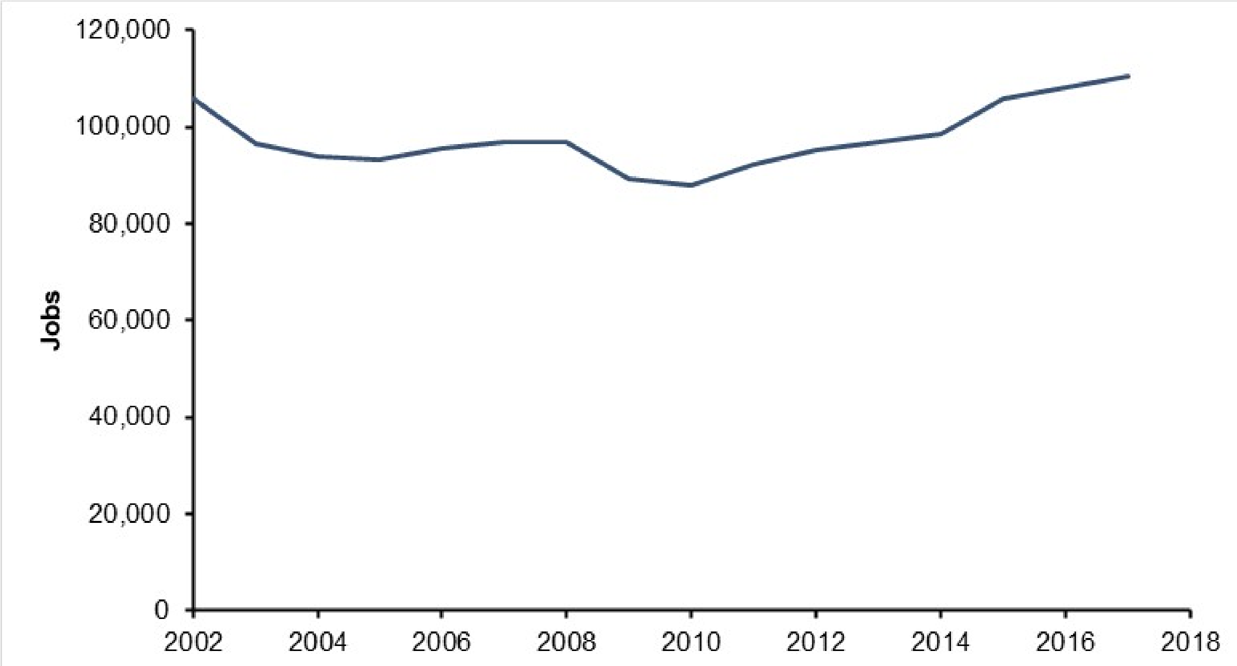


Figure C-7: City of Santa Clara Jobs

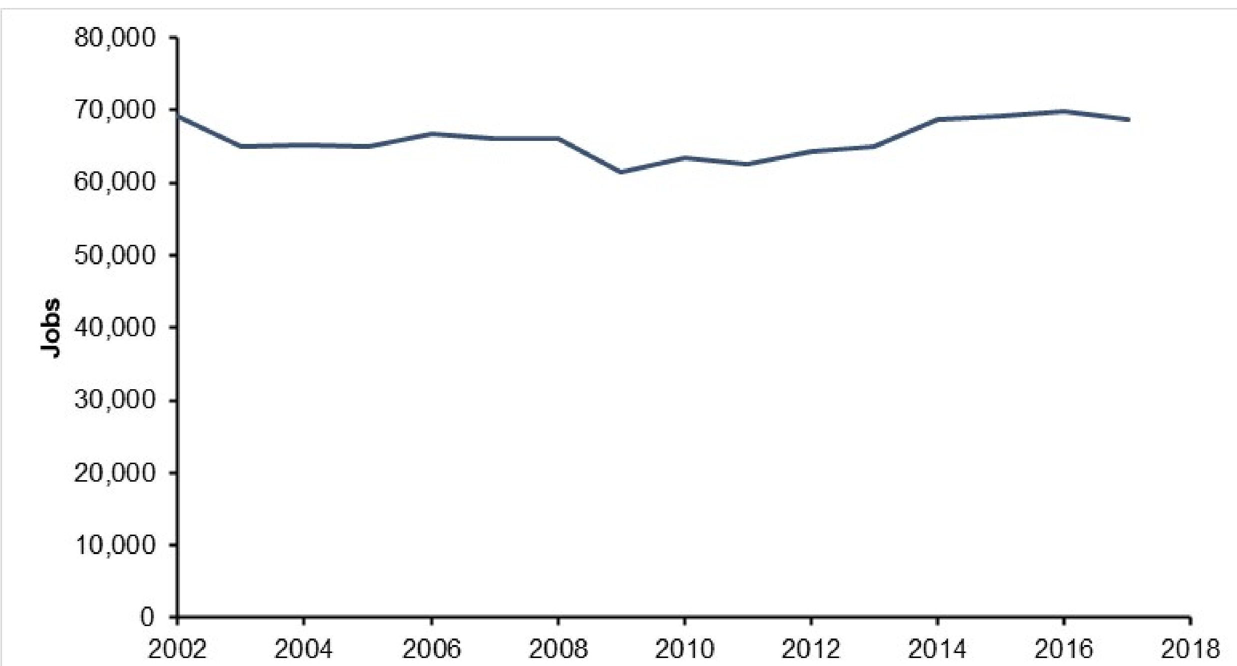


Figure C-8: City of Sunnyvale Jobs

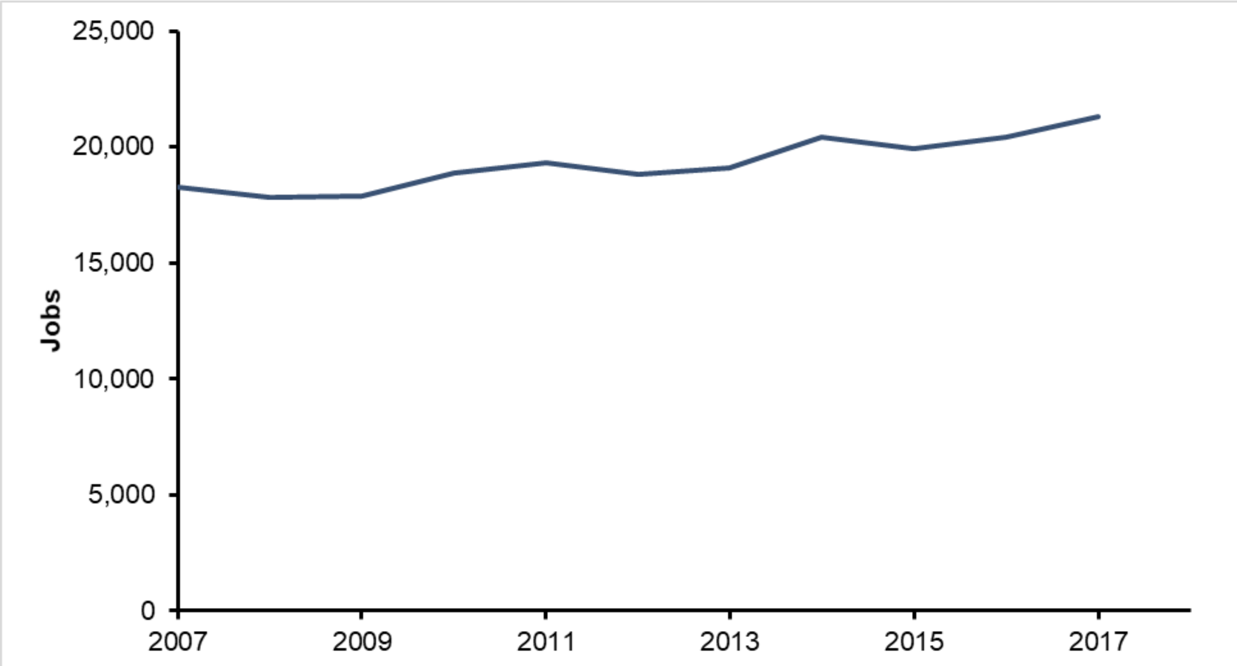


Figure C-9: Great Oaks Water Company Jobs

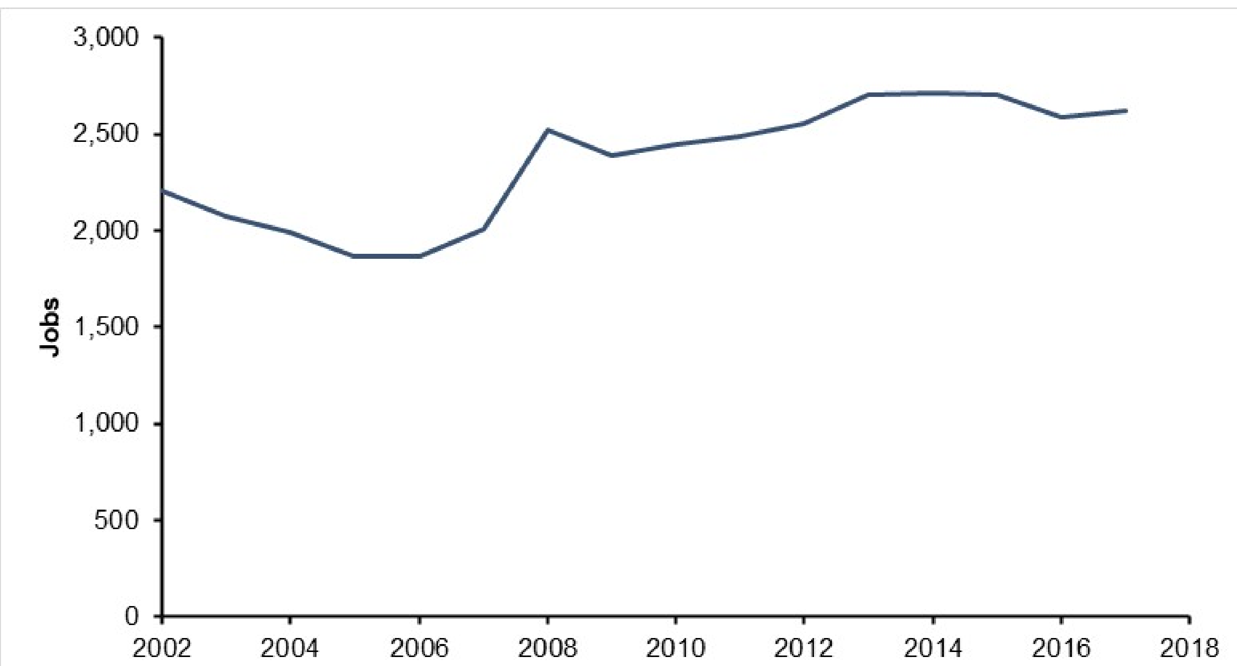


Figure C-10: Purissima Hills Water District Jobs

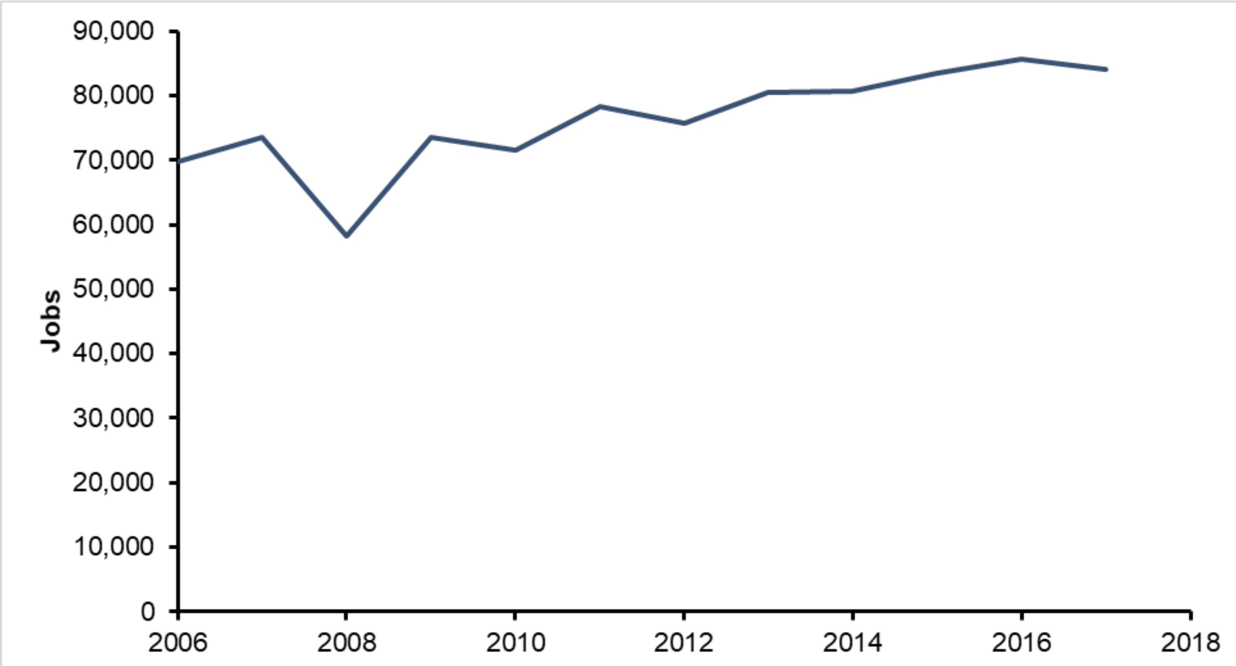


Figure C-11: San Jose Municipal Water Jobs

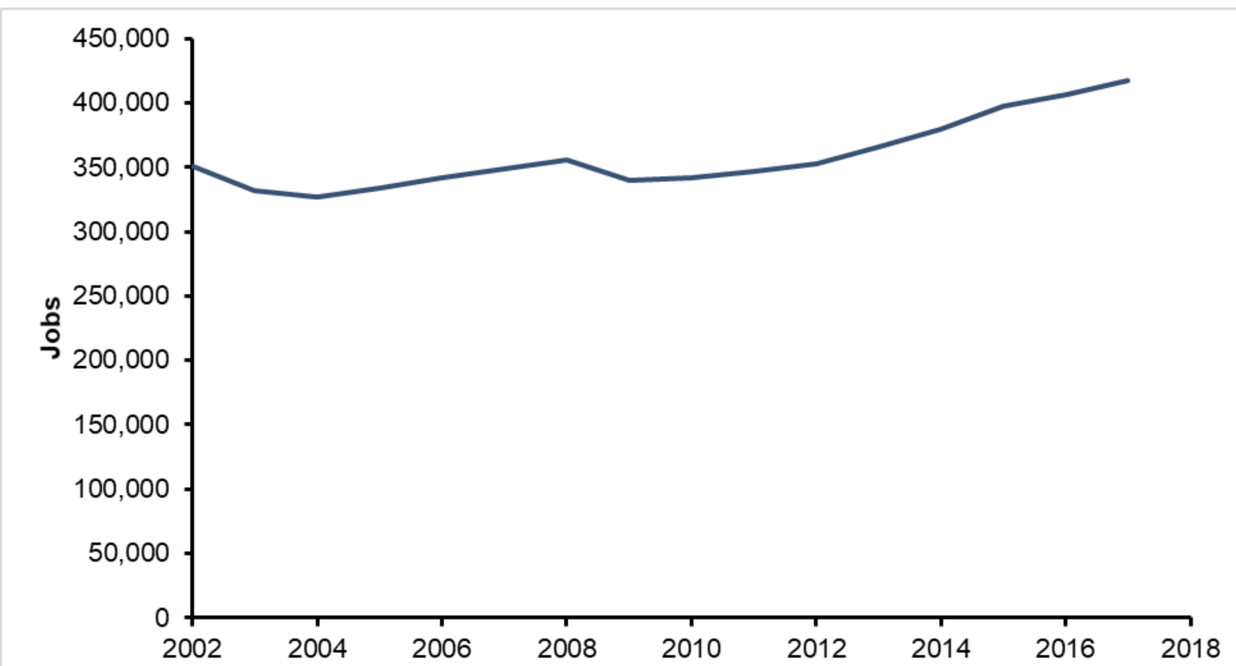


Figure C-12: San Jose Water Company Jobs

Appendix D: Summary of Historical Water Rates

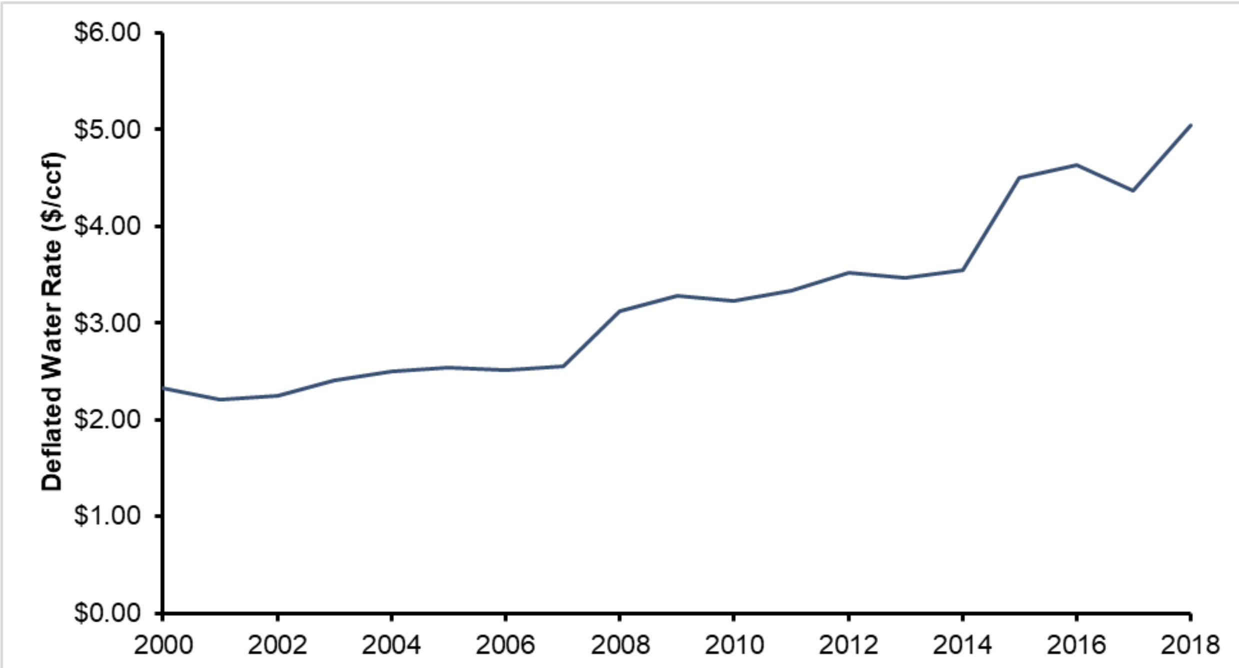


Figure D-1: California Water Service Historical Water Rates

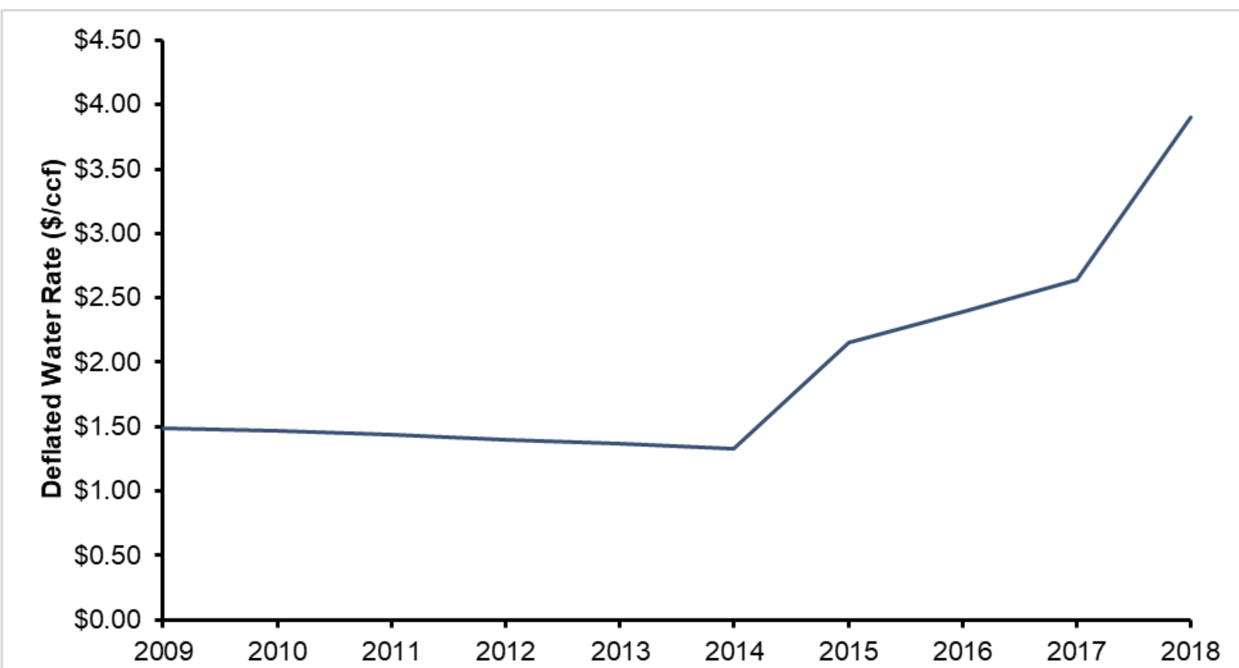


Figure D-2: City of Gilroy Historical Water Rates

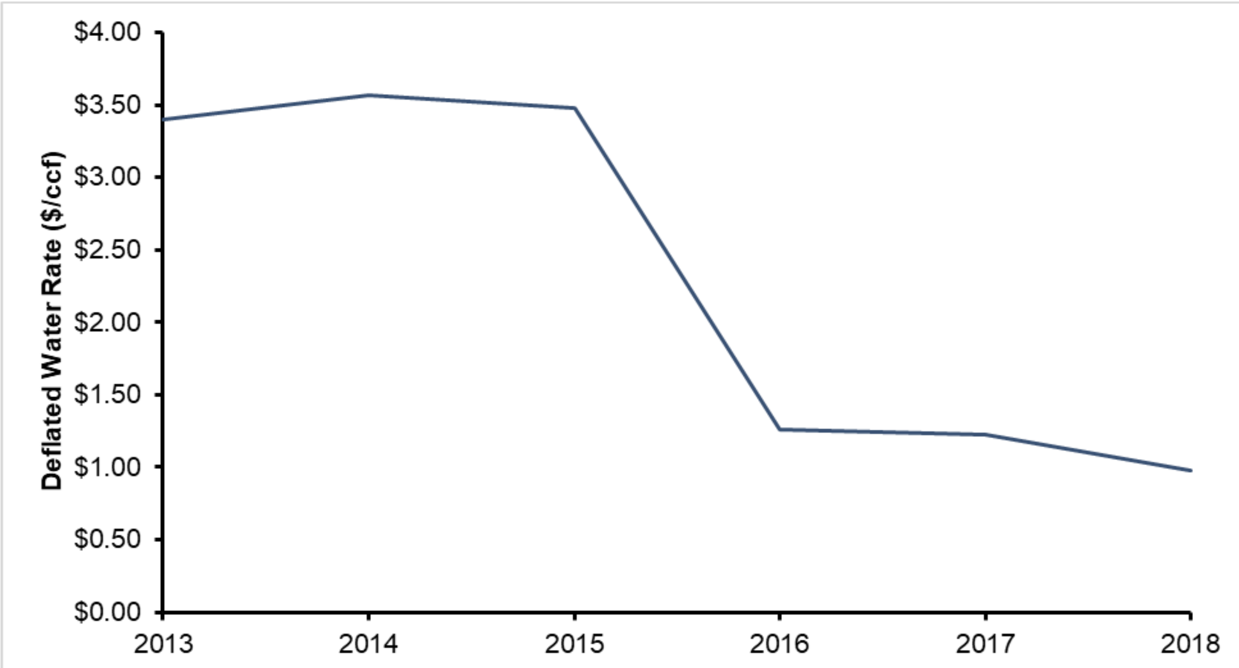


Figure D-3: City of Milpitas Historical Water Rates

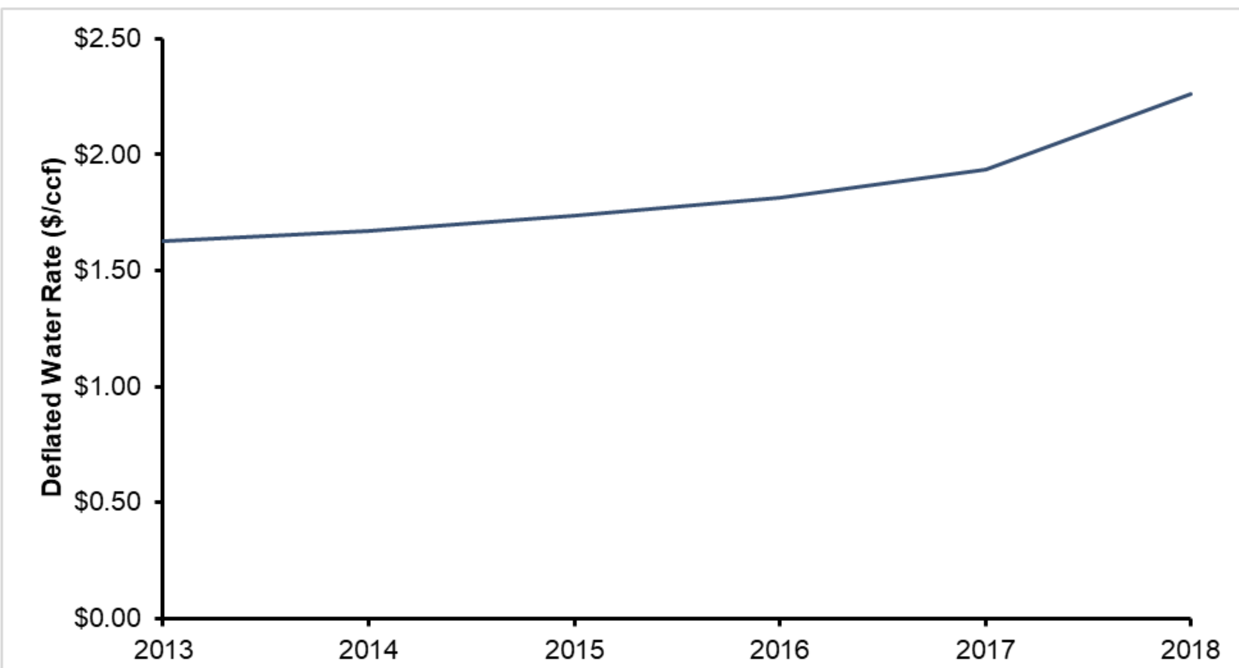


Figure D-4: City of Morgan Hill Historical Water Rates

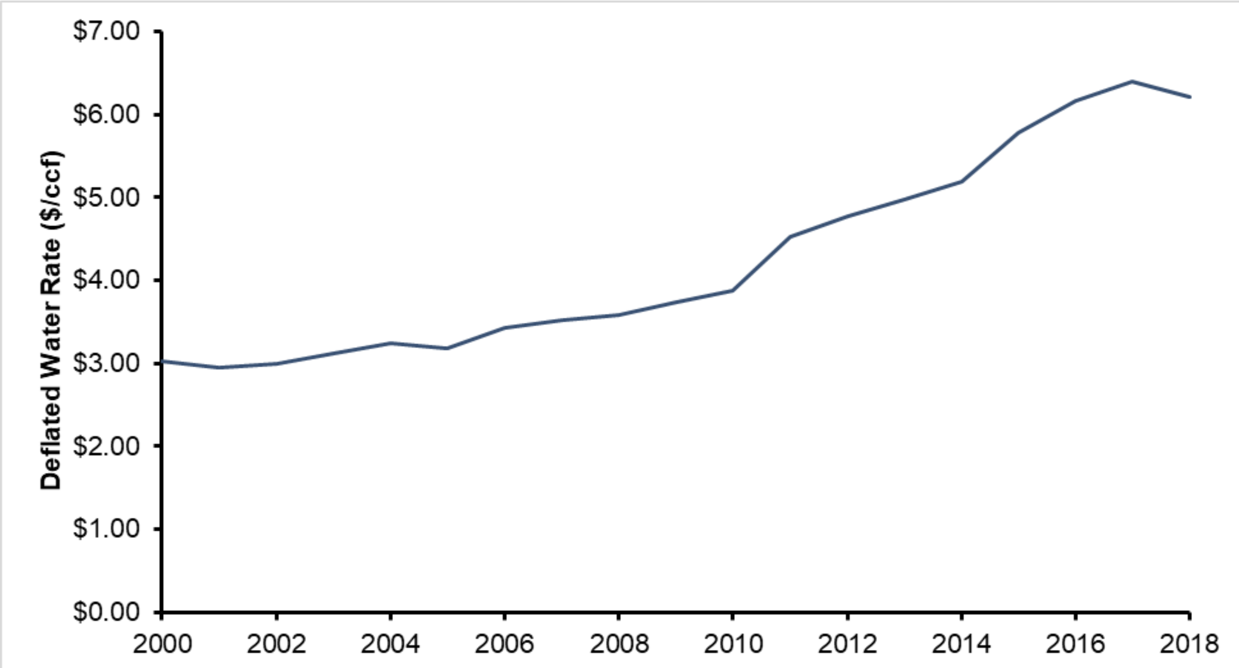


Figure D-5: City of Mountain View Historical Water Rates

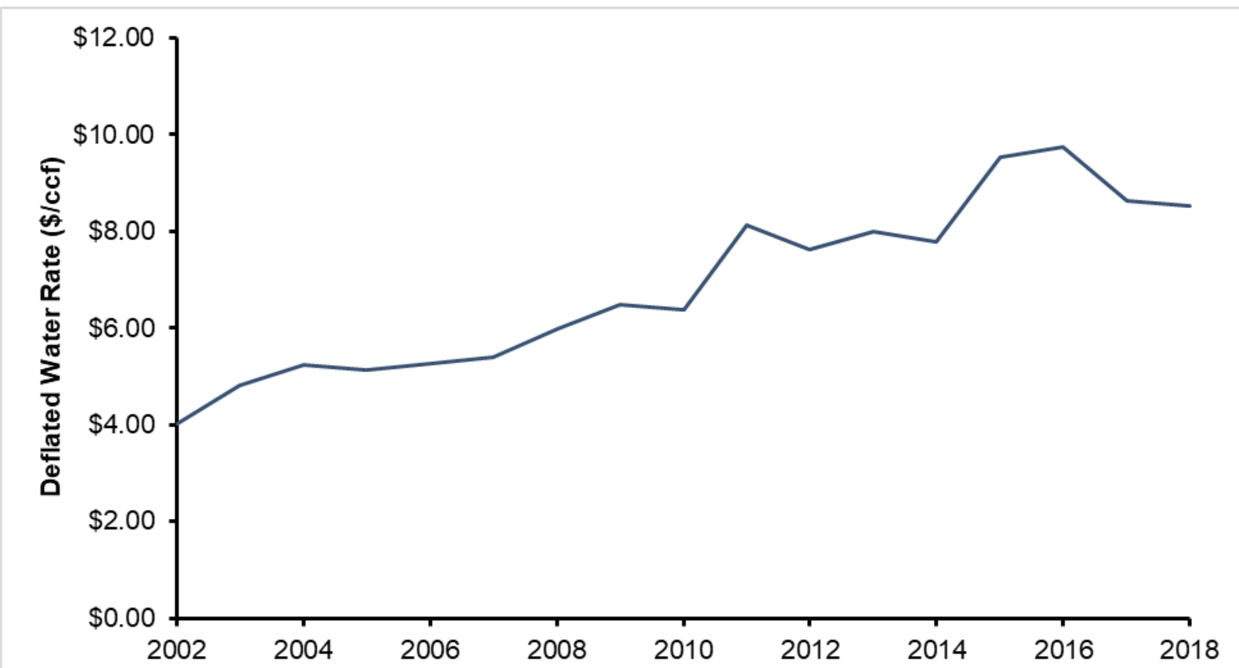


Figure D-6: City of Palo Alto Historical Water Rates

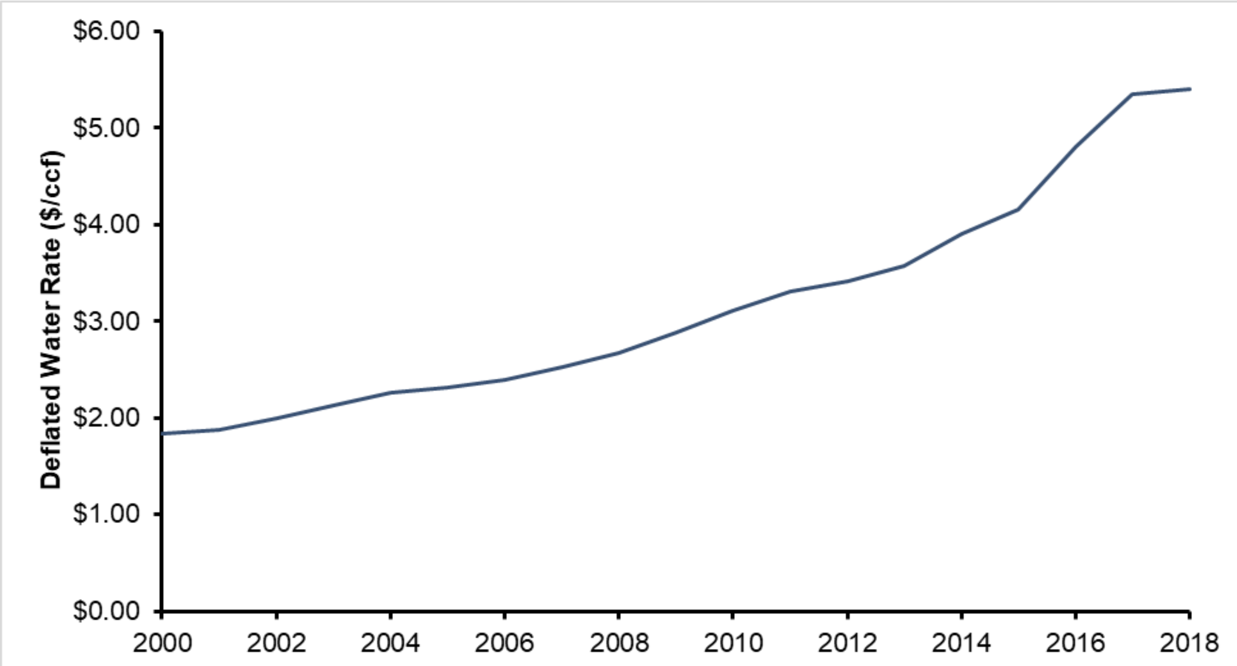


Figure D-7: City of Santa Clara Historical Water Rates

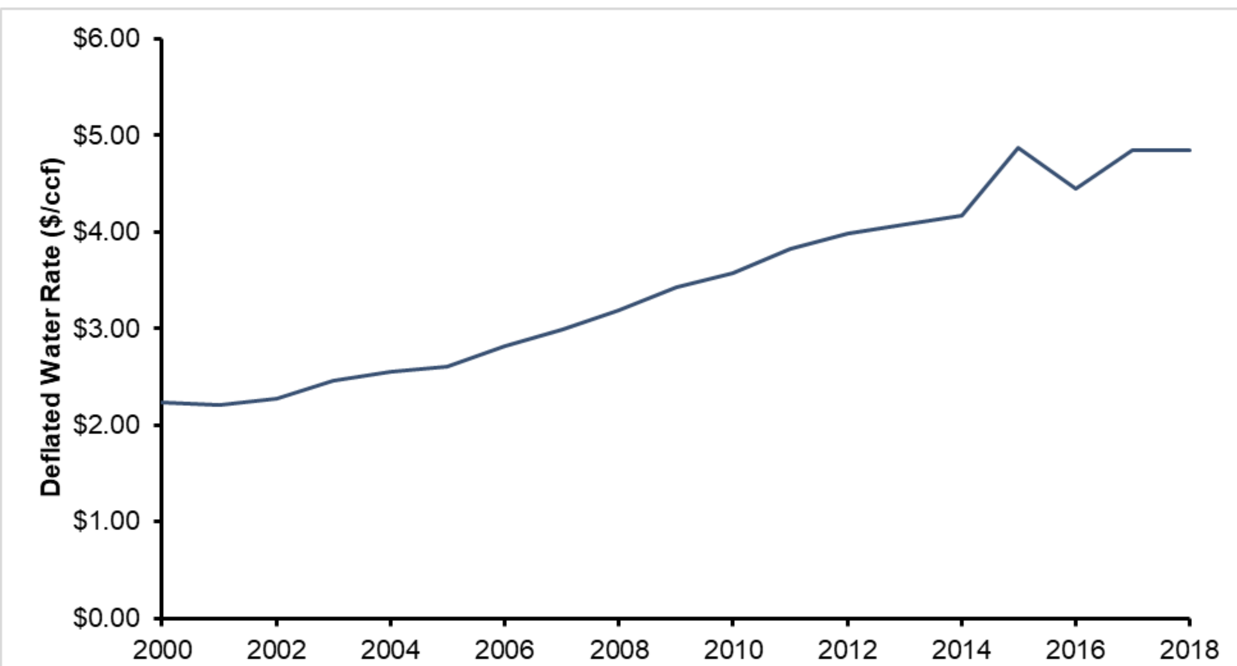


Figure D-8: City of Sunnyvale Historical Water Rates

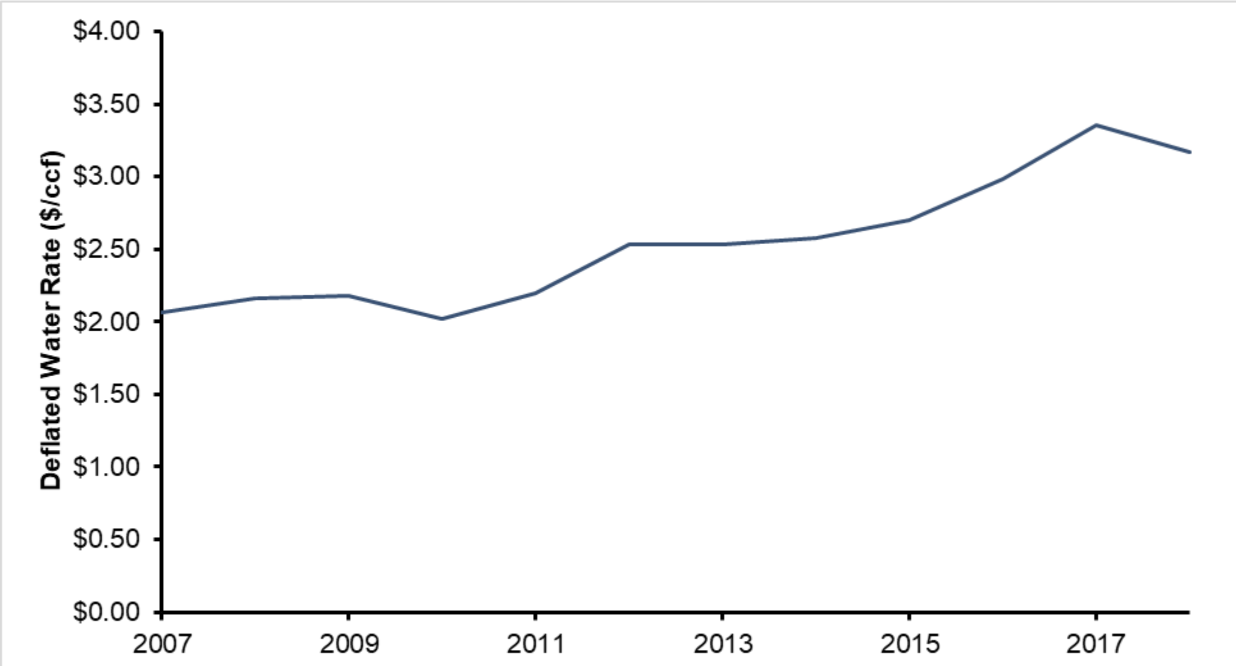


Figure D-9: Great Oaks Water Company Historical Water Rates

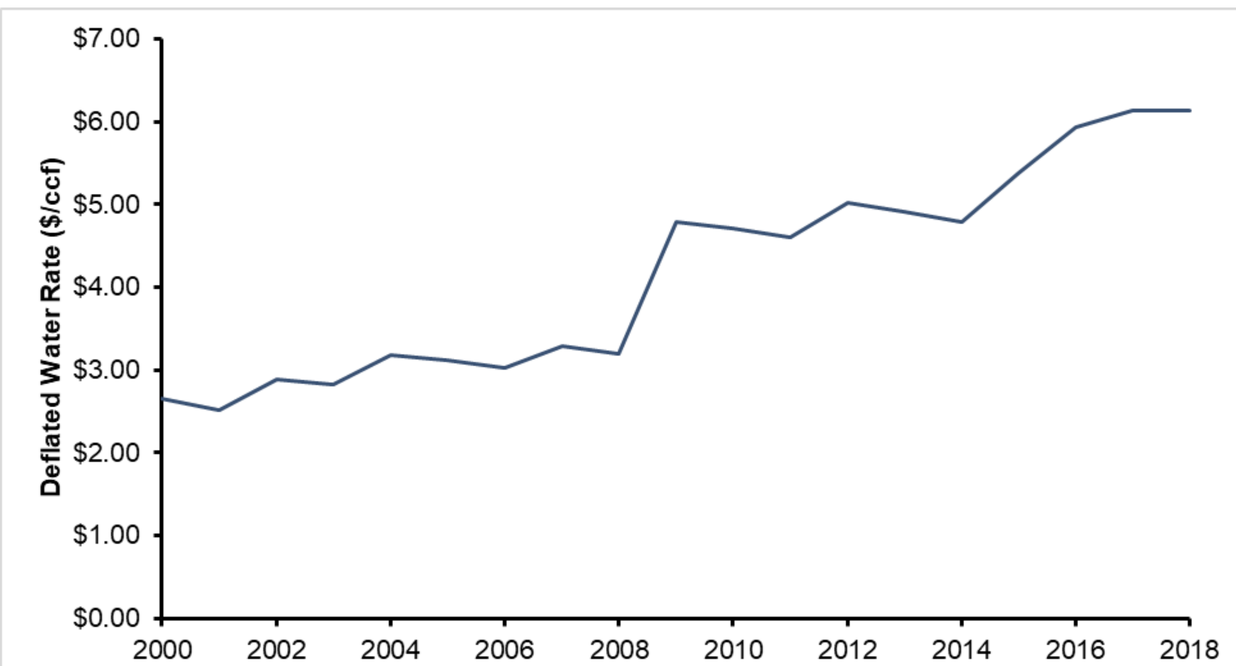


Figure D-10: Purissima Hills Water District Historical Water Rates

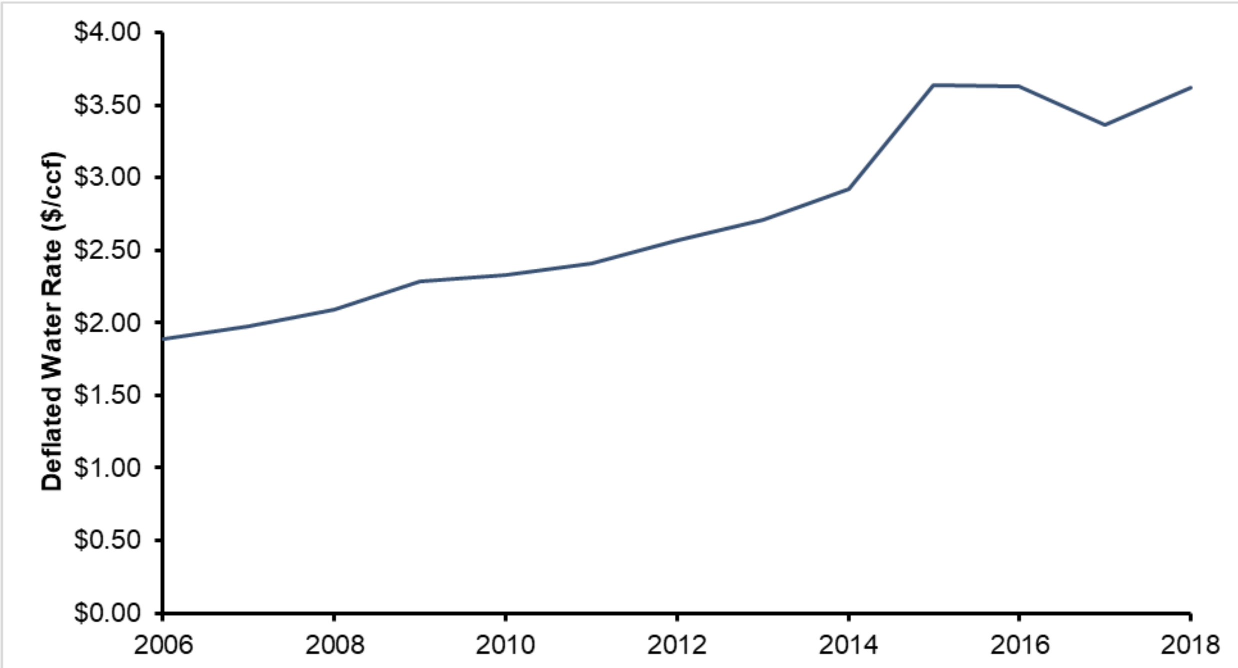


Figure D-11: San Jose Municipal Water Historical Water Rates

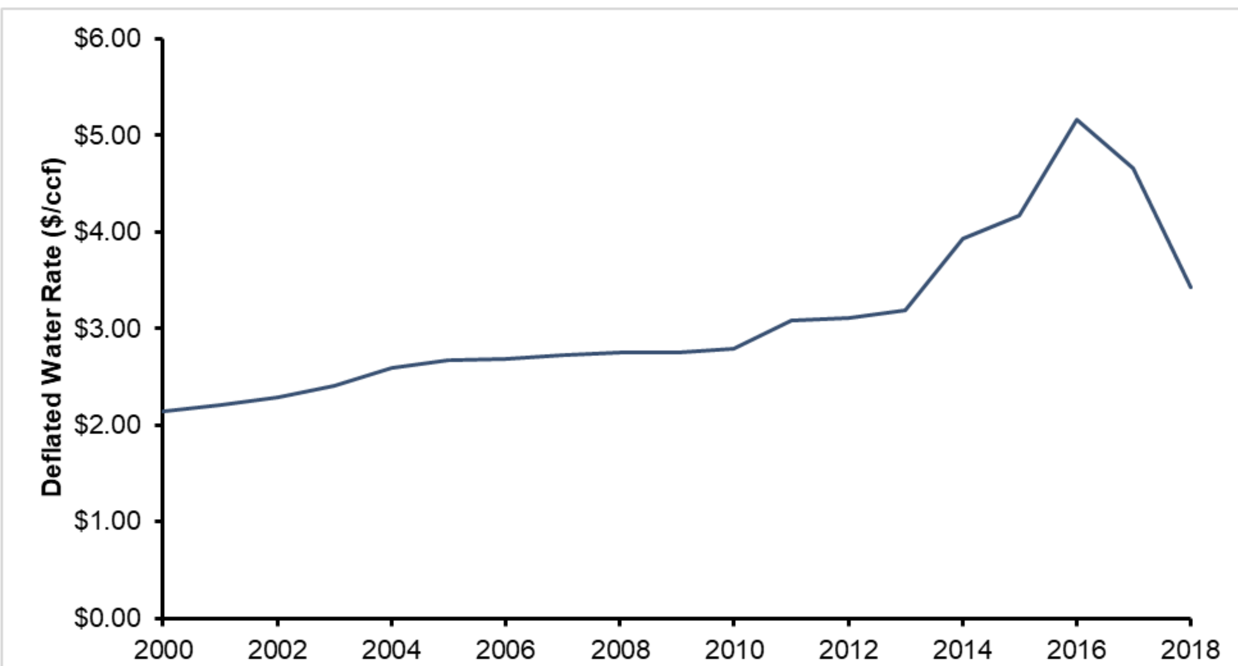


Figure D-12: San Jose Water Company Historical Water Rates

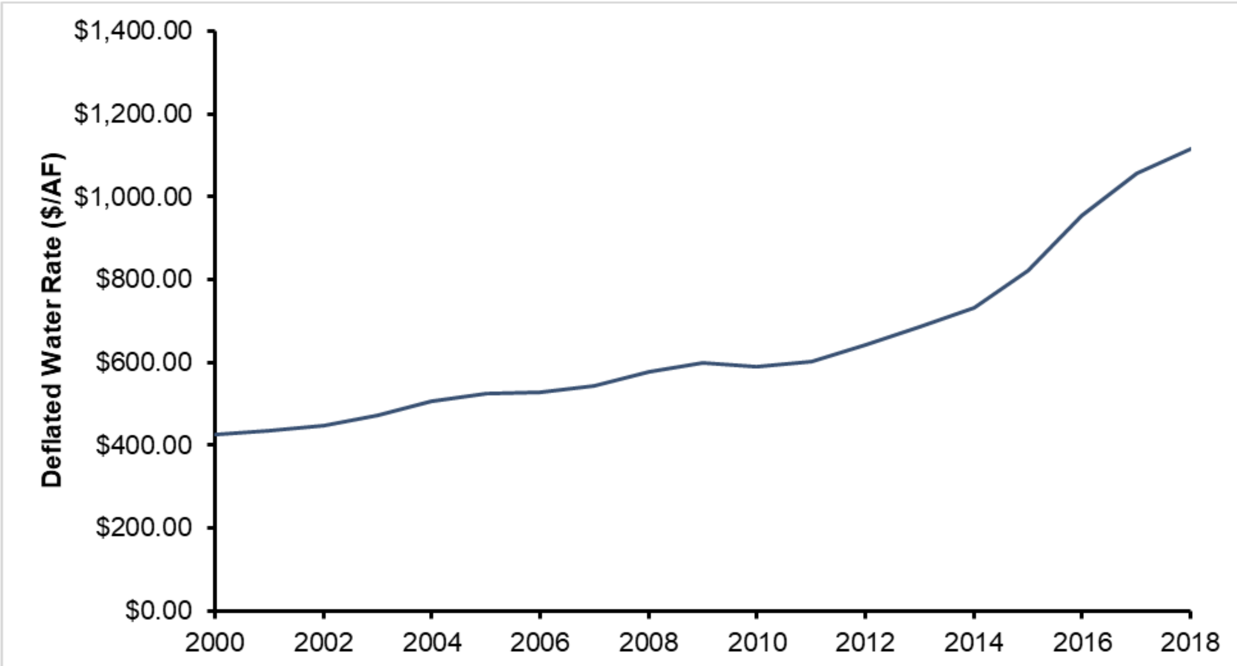


Figure D-13: Stanford University Historical Water Rates

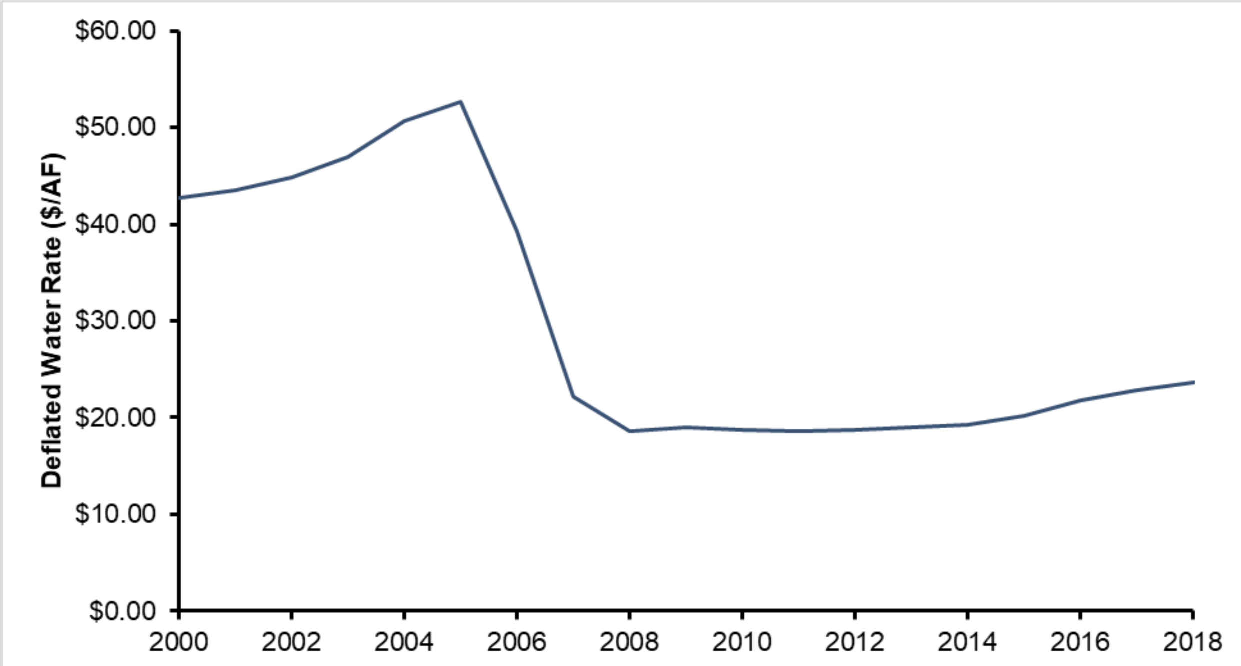


Figure D-14: Non-Retail Groundwater Pumpers, Ag W2 Historical Water Rates

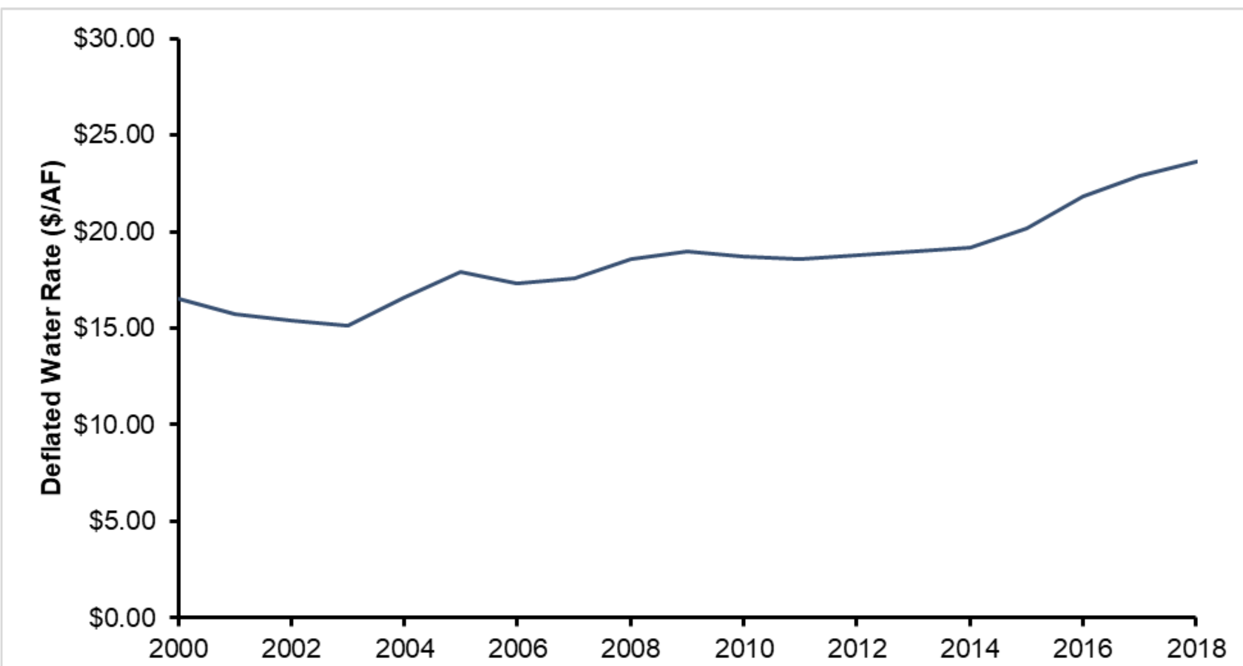


Figure D-15: Non-Retail Groundwater Pumpers, Ag W5 Historical Water Rates

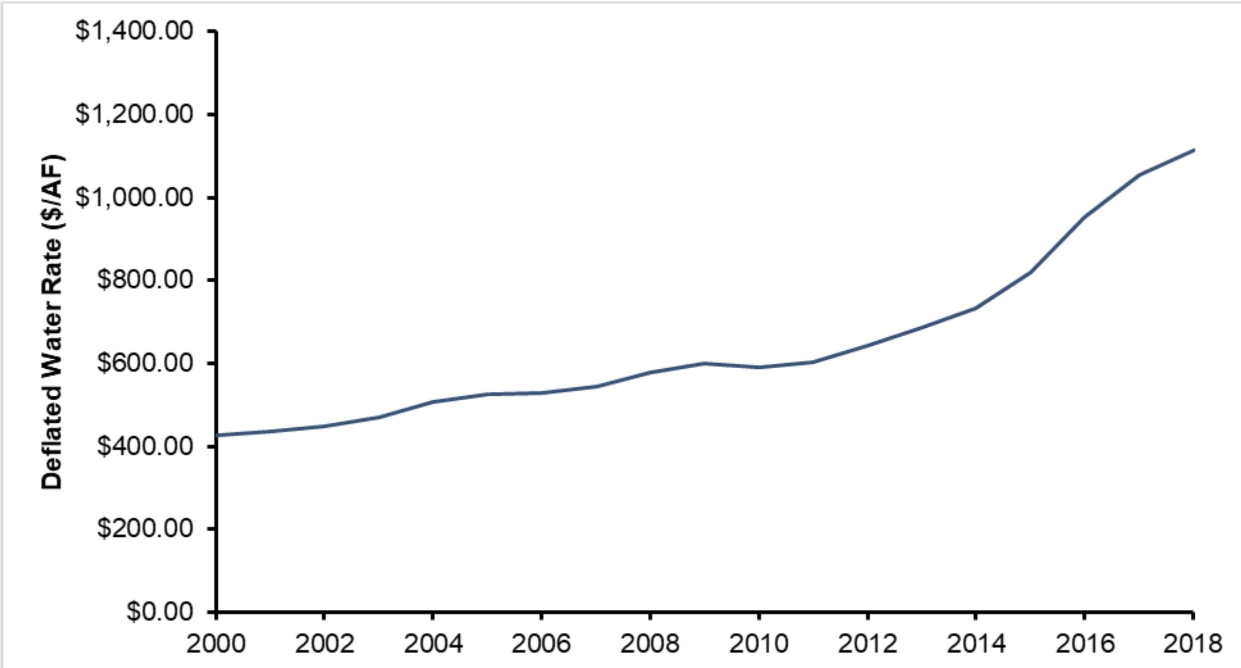


Figure D-16: Non-Retail Groundwater Pumpers, M&I W2 Historical Water Rates

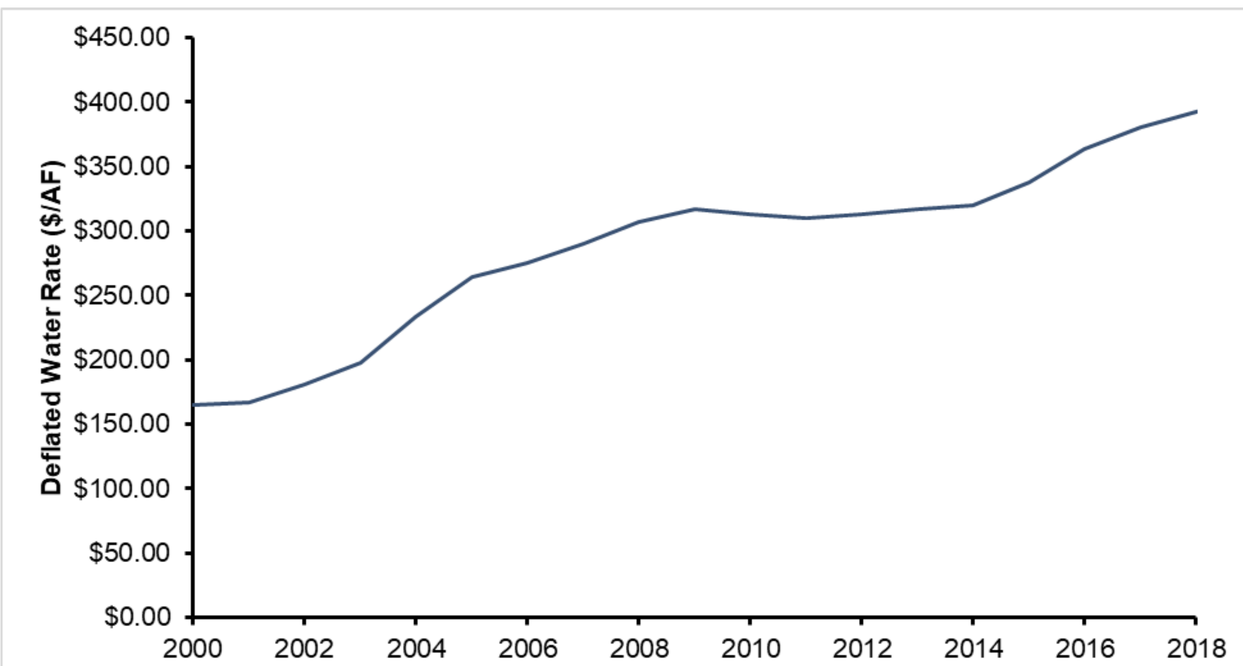


Figure D-17: Non-Retail Groundwater Pumpers, M&I W5 Historical Water Rates