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CITY OF SANTA CRUZ WATER DEPARTMENT

Residential and Commercial Baseline Water Use Survey

City of Santa Cruz Water Department
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With Envirosmart Solutions Group &
Western Policy Research

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Acknowledgements

Introduction

The City of Santa Cruz Water Department (SCWD) relies on local resources for the community's drinking water supply. With limited supplies, it is important to SCWD that water be used efficiently. The city of Santa Cruz has been committed to water conservation for future generations. In the year 2000, SCWD adopted a long-term water conservation plan and have been pursuing best management practices for over a decade. SCWD is working to develop a new Water Conservation Master Plan that will serve as the basis for water conservation and water use efficiency for the next ten years. To place its future water supply plans on a strong empirical foundation, SCWD sponsored, in 2011, a fairly extensive survey of its residential and commercial customers called the Residential and Commercial Baseline Water Use Survey Program (Baseline Survey) to paint a picture of the current state of water using equipment within the service area before developing the next water conservation planning project.

The Baseline Survey was designed to cover SCWD's three largest customer categories, which account for 83% of the city's overall water consumption (Figure 1). The survey excludes the large University of California Santa Cruz (UCSC) campus located within the water department's service area and large landscape customers. Because of its non-comparability to other customers, including the UCSC campus into a random customer survey would have made little sense. Although UCSC is not a part of this study, SCWD has a close relationship with the UCSC and the campus has a water conservation plan in place that was developed specifically for the university. Large landscape customers are also excluded from this study because SCWD already has detailed information and conservation strategies in place for such customers.

This random survey was designed to meet two goals: (1) to estimate the stock of indoor plumbing fixtures and appliances, and to determine what percentage of this stock is compliant with the latest efficiency standards; and (2) to determine the prevalence, size and characteristics of landscapes, irrigation systems, and other outdoor water using features, such as pools and spas. Determination of customer attitudes toward water supply and environmental issues, or the level of satisfaction with their water service, was not a study goal. While attitudinal and satisfaction surveys can be conducted over the phone, the emphasis here was on expert observation and measurement, necessitating field visits in each and every case.

Limited resources and the high expense of field surveys, makes it impossible to design a survey large enough to address each and every question at a high level of precision. One, therefore, must set priorities by separating questions where a high level of precision is desired from those where a less precise answer would still be considered adequate.

In the case of this survey, the highest priority was accorded to understanding the efficiency level of indoor plumbing fixtures, followed by indoor appliances, and lastly, outdoor characteristics. Efficiency of plumbing fixtures was given the highest priority because this information is not available from any other government survey. On the other hand, some information about the efficiency of installed clothes washers and dishwashers is available from government surveys, although only at the state level, not specifically for the City of Santa Cruz. The point being that one is not totally in the dark when it comes

to appliances, as one is with plumbing fixtures[1]. The statistical precision of outdoor characteristics was accorded less priority than indoor characteristics, for two reasons. First, based on the experience of other studies we knew that much larger samples would be required to estimate parameters, such as, irrigated landscape or turf area per account, with a high level of precision. But, exactly what these sample sizes would need to be was indeterminable without some information about landscape heterogeneity across customers, which was unavailable. This problem does not occur with indoor fixtures where we have a pretty good idea about how many fixtures and appliances one is likely to find in an average single-family or multi-family housing unit, which can then be used to design the samples. Second, field visits seemed a very expensive way of collecting landscape related information when other techniques, such as aerial imagery, may become more cost-effective in the future.

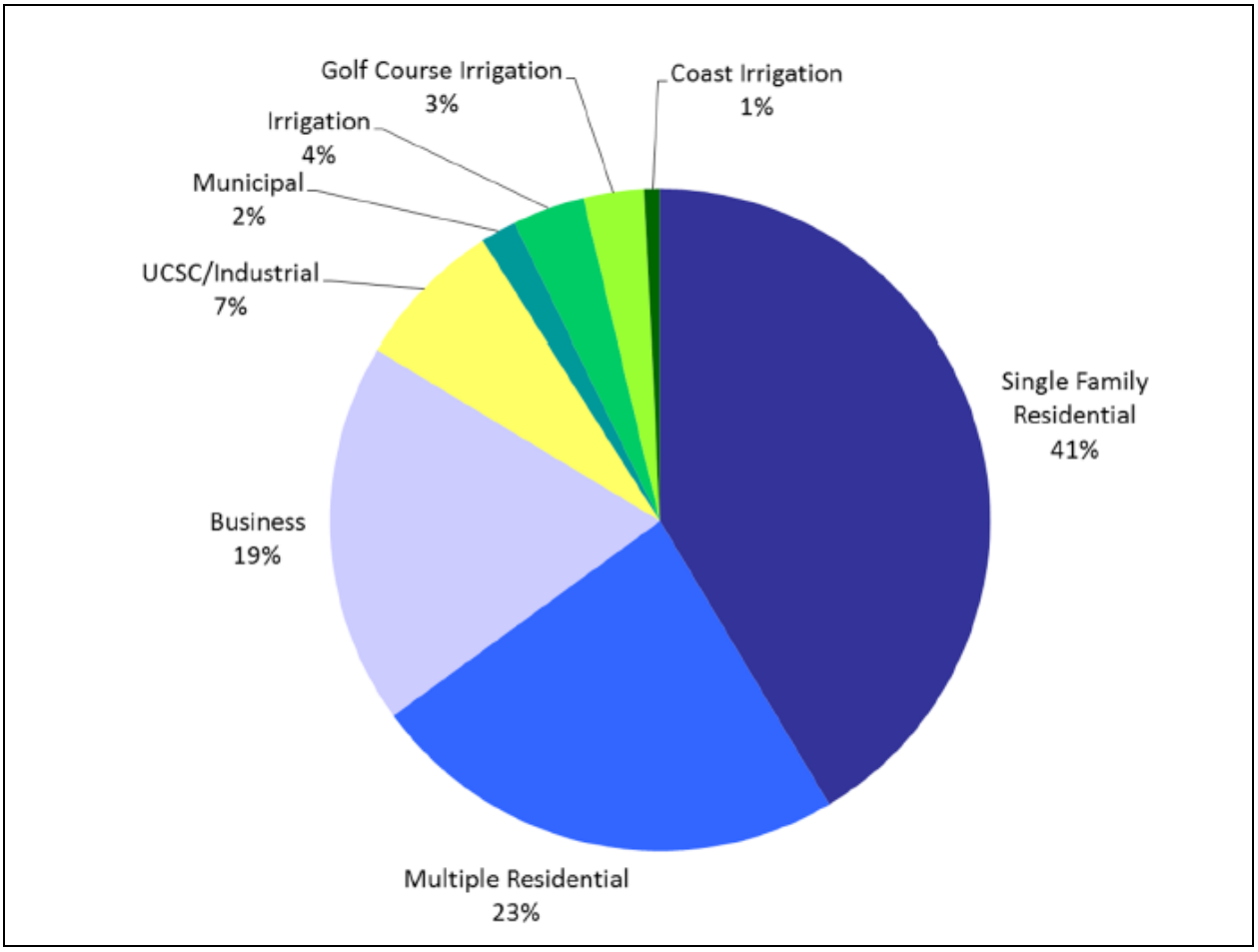

Figure 1 Water use by customer category.

[1] Appliance data are collected by the *Residential Energy Consumption Survey* (RECS) and can be found at the US Energy Information Administration's website: http://www.eia.gov/consumption/residential/data/2009/

Methodology

The main objective of the Baseline Survey was to determine the current saturation of plumbing fixtures and appliances that are compliant with or exceed current plumbing codes as well as investigate landscape irrigation equipment and outdoor water features among residential and commercial facilities within SCWD's service territory. SCWD determined what information they needed from the Baseline Survey. Representative samples of customers were selected from the single-family residential, multi-family and commercial customers for the survey. The following section describes the data that were collected at each residential and commercial facility during the survey.

Residential Water Use Information

- **General Information:**
  - Dwelling type, address, number of residents, rented vs. owned, years lived at site, number of bathrooms, year constructed, if the water using fixtures were original or new.
- **Water Use Information:**
  - Account number, meter reading, leak detection, leak location, gallons lost per day.
- **Interior Water Use:**
  - Showerheads –location and flow rate in gallons per minute (gpm).
  - Faucets –location, flow rate in gpm, number of minutes used per day, and leak detection
  - Toilets –toilet type, location, flush volume in gallons per flush (gpf), and leak detection
  - Dishwashers –manufacturer/model information, quantity, and age of appliance.
  - Clothes Washers –manufacturer/model information, quantity, age of appliance, and efficiency level.
- **Exterior Water Use:**
  - Water Features –feature type, available cover, drain/refill interval, leak detection, filter or backwash interval.
  - Landscape information –description or location. Irrigated or non-Irrigated, landscape measurements, irrigation method, sprinkler type(s), plant type(s), water need.
  - Irrigation Controller(s) –make/model, number of stations, presence of smart controller, rain sensor check.
  - Landscape Management –irrigation schedule, management type, water pressure reading, and sub meter check.

Commercial Water Use Information

- **General Information:**
  - Facility type, address, number of employees, number of visitors/guests, leased vs. owned, property square footage, building square footage, business type, year constructed, and account number.
- **Public Restroom Information:**

  - Restroom description –location and the number of restrooms per type throughout the facility.
  - Toilets –type, flush volume in gpf, leak detection, and quantity per restroom.
  - Urinals –type, flush volume in gpf, leak detection, and quantity per restroom.
  - Showerheads –type, flow rate in gpm, leak detection, and quantity per restroom.
  - Faucets –type, flow rate in gpm, leak detection, and quantity per restroom.
- **Guestroom Information:**
  - Guestroom description –location and the number of restrooms per type throughout the facility.
  - Toilets –type, flush volume in gpf, leak detection, and quantity per restroom.
  - Showerheads –type, flow rate in gpm, leak detection, and quantity per restroom.
  - Faucets –type, flow rate in gpm, leak detection, and quantity per restroom.
  - Bathtubs/Whirlpool –type, quantity, and capacity in gallons.
- **Kitchen Water Use:**
  - Dishwashers –type and quantity
  - Ice Machines –type and quantity
  - Pre-Rinse Spray Valves –quantity and flow rate in gpm.
  - Faucets –type, flow rate in gpm, leak detection, and quantity.
- **Cooling Purposes:**
  - Inventory cooling towers, evaporative coolers, and once-through cooling systems.
- **Laundry Water Use:**
  - Clothes Washers –on site laundry, type, quantity per type, and existing conservation technologies.
  - Utility Faucets –quantity and flow rate in gpm.
- **Classroom Water Use:**
  - Faucets –type, quantity, and flow rate in gpm.
- **Process Water Use:**
  - Equipment by GPM –type of equipment, quantity, flow rate in gpm, and check for existing conservation technology.
  - Equipment by Gallons per Event –type of equipment, quantity, gallons used per event, and check for existing conservation technology.
- **Exterior Water Use:**
  - Water Features –feature type, available cover, drain/refill interval, leak detection, filter or backwash interval.
  - Landscape information **–**description or location. Irrigated or non-Irrigated, landscape measurements, irrigation method, sprinkler type(s), plant type(s), water need.
  - Irrigation Controller(s) –make/model, number of stations, presence of smart controller, rain sensor check.
  - Landscape Management –irrigation schedule, management type, water pressure reading and sub meter check.

This was the standard protocol for data collection of all existing water fixtures and equipment for interior and exterior water for residential and commercial facilities. Although this standard protocol was set for each survey, additional data were collected from facilities with unique water uses as well through follow up phone conversations, if necessary.

Incentives

Incentives played a key role in promoting customer participation throughout the survey process. Each sector was offered different incentives. Among the different sectors, methods to solicit participation involved multiple phone calls, mailers, emails, and direct site visits. In order to achieve our desired sample size per sector, incentives were offered after exhausting all solicitation attempts of our primary sample groups per sector. For this study, we surveyed 150 single family residences out of 600 that were contacted to participate giving us a participation rate of 25%. We surveyed 50 multi-family complexes out of 174 complexes that were contacted to participate, giving us a participation rate of 29%. We surveyed 120 commercial and institutional facilities out of 179 sites that were contacted to participate, giving us a participation rate of 67%.

In the single-family sector, secondary sample residents that allowed us to survey their home were offered entry into a drawing to win their choice of a Visa gift card or a rain barrel. This level of incentive was put forth because permission to perform the survey only needed to go through the occupant of the residence.

Multi-family accounts involved obtaining permission to survey an apartment complex, mobile home park, etc. and these had to come from property managers as well as tenants. Since permission had to be obtained from more than one entity to conduct surveys at multi-family facilities, property managers and tenants that volunteered their unit to be surveyed were offered an incentive in the form of downtown dollars. Downtown dollars are a form of gift card that can be used at local retailers within Santa Cruz. This incentive was able to serve two purposes; to allow multi-family accounts to be surveyed and to promote shopping at local businesses.

Incentives for commercial accounts were offered to some of the commercial facilities that were surveyed. Since surveys had to be conducted for these accounts during business hours, which interfered with day to day activities at the facility, the commercial accounts that participated in the study were offered our largest incentive of all three survey groups. Each participating commercial or institutional facility was offered a Visa gift card for allowing their facility to be surveyed. Getting permission from commercial and institutional facilities involved having a facilities manager available to escort our staff around the facility to survey as well as approval from management at the facility. Commercial and institutional facilities that did not receive this incentive were schools, hospitals, hotels, restaurants, and laundromats.

Database

A database was developed to compile all of the information collected during the Baseline Survey. The database allowed us to pinpoint specific information needed in each sector and summarize the data collected for each of the surveyed sites as well as totals for each sector as needed for the study.

Data Evaluation

After all of the data were entered into the database, the evaluation process began. Data evaluation became an extensive back and forth of checking for anomalies in the survey data as compared to the information that SCWD data may have had on the surveyed sites, such as landscape area. This process was vital for maintaining the integrity of the data and results.

Sample Design

Three different samples were prepared for this survey, including; (1) a single-family sample, which also includes duplex multi-family accounts; (2) a multi-family sample that targeted multi-family complexes with 3 housing units or more; and (3) a commercial and institutional sample that targeted every type of commercial account, such as, hospitals, hotels, restaurants (including fast food), schools, retail establishments, medical, dental, and veterinarian offices, other offices, and laundromats. Delineation of SCWD's customers into the single, multi and commercial categories was based on how customer accounts are identified in SCWD's billing system, which may or may not always match county assessor codes. But, this is of little consequence as long as sample results are scaled to the population also on the basis of SCWD's customer class codes.

Single Family

The goal of the single-family survey was to complete site visits in 150 randomly selected accounts from a total population of 20,457 single-family and duplex accounts, with 100 accounts receiving both an indoor and outdoor inspection, and an additional 50 receiving only an outdoor inspection. Expecting greater heterogeneity in outdoor characteristics compared to indoor, and given that the single-family sector accounts for a large proportion of total water use, we thought it prudent to allocate some extra surveying resources to this sector's outdoor characteristics. It was expected that 100 indoor surveys would yield estimates of the efficient portion of fixture and appliance stocks not exceeding an error band of ±10%, which was considered acceptable. As it turns out, we have been able to generally meet or exceed this goal. With respect to outdoor characteristics, however, we had no specific precision goals to aim for.

The single-family sample was selected using simple random sampling, which makes it self-weighting.

Multi Family

Whereas the single-family sample was selected using a simple random sampling approach, we resorted to stratified sampling for the multi-family and commercial sectors. This was done to ensure that our sample had a good mix of small, medium, and large complexes in the multi-family case, and a good mix of businesses from all sectors in the commercial case. Why this was necessary can be seen from the next two tables.

Table 1 Multi-Family Sampling Approach

	MF Complexes in Santa Cruz				Sample			
Complex Size	# of Complexes	% of Complexes	# of Total Units	% of Total Units	# of Complexes	# of Total Units	# of Survey Units	Strata Weight
TOTAL	**1,178**	**100.0%**	**14,285**	**100.0%**	**50**	**1,992**	**127**	
3-13 units	939	79.7%	4,701	32.9%	24	133	49	35.34
14-53 units	187	15.9%	4,797	33.6%	15	442	45	10.85
54 or more	52	4.4%	4,787	33.5%	11	1,417	33	3.38

Table 1 provides a comparison of the total multi-family complexes with the sample number of multi-family complexes chosen using the stratification approach.

Table 1 shows the distribution of multi-family complexes and corresponding housing units in Santa Cruz as a whole, as well as in our sample. So, for example, there are 1,178 multi-family complexes in Santa Cruz with 3+ housing units. Overall, these complexes account for 14,285 housing units or roughly 12.1 units per complex on average (for the 3+ units universe). If this population of multi-family complexes is stratified three ways such that each strata accounts for roughly equal number of housing units, then complexes need to be split into the following three categories: 3-13 units, 14-53 units, and 54 or greater, units. The largest category includes only 4.4% of all multi-family complexes. A simple random sampling approach could miss this entire group, and with it a third of the multi-family housing units, because of a bad luck of the draw. To prevent such outcomes, stratification becomes necessary.

The other decision we had to make was about the number of housing units to survey and how to distribute these surveys across various multi-family complexes. We expected once again a survey of 100 housing units to yield sufficiently accurate information about indoor plumbing fixtures and appliances. To select a large multi-family complex and survey 100 units in that one complex would not lead to a representative sample. On other hand, to recruit 100 complexes only to survey one unit per complex would have been expensive. We compromised by recruiting 50 complexes, aiming for roughly 125 indoor surveys (we ended up with 127 surveys), or roughly 2-3 randomly selected surveys per complex. The number of indoor surveys was bumped up 25% relative to the projected need for 100 indoor surveys to buy some insurance against inter-cluster correlation. This phenomenon refers to the correlation of information across units within the same complex, which has the deleterious effect of reducing effective sample size. Table 1 shows how the 127 surveyed housing units are distributed across the three sampling strata. We could have distributed these surveys equally across the three strata to mimic the distribution of housing units overall. But we deliberately chose to direct a few more of the surveys toward the smaller complexes under the surmise that these may be slightly more heterogeneous compared to the medium and large complexes.

One downside to surveying multiple units per complex is that outdoor information is only available from 50 complexes, while indoor information is available from 127 unit-level surveys. Once again this compromise was deemed acceptable because multi-family complexes have much less outdoor water use per capita compared to single-family accounts, making investment of resources into high levels of statistical precision on the outdoor side less important.

Another downside to stratification involves the need for weighting while estimating averages for the multi-family sector as a whole. Moreover, a different weighting scheme is required for averaging complex level information (e.g., units per complex, common laundry characteristics, landscape, etc.) and unit level information (e.g., toilets, showerheads, etc.). Take, for example, estimation of average units per complex in the sample, a question that involves averaging of complex-level information. Without any weighting, one would estimate that the sampled complexes had 39.8 units (1,992/50) on average. While this estimate is correct for the sample, to infer that this estimate is also a good representation of average units per complex across all 3+ unit multi-family complexes would be wrong because large complexes are over-weighted in the sample, accounting for 71.1% of the sample's housing units (1417/1992) compared to 33.5% overall. To correct for this, it is necessary to take a weighted average using the strata weights (ratio of total units in the population over total units in the sample by strata).

When one does this, average units per complex works out to 13.6 in the sample, quite comparable to the estimate of 12.1 (14,285/1178) units per complex overall.

Commercial

The commercial sample was also developed using stratified sampling to ensure a good mix of commercial and institutional customers. A master list of accounts by business type was developed for this purpose, which include 16 strata (Table 2). Without stratification, rare yet important commercial accounts, such as hospitals may never have made it to the sample, because of a bad luck of the draw. And the more frequent accounts, such as retail establishments and offices would dominate the sample. Stratification is meant to prevent both types of outcomes. The overall commercial sample size was driven by the available budget, not a specific precision goal. But, we were quite confident that our approach would yield sufficiently precise results with regards to indoor fixtures and appliances for the commercial sector as a whole.

Table 2 Commercial Sampling Approach

Commercial Strata	Total Number of Accounts in Santa Cruz	Total Number of Accounts Surveyed
Hospitals	**2**	**2**
Schools	**26**	**10**
Schools –elementary	9	3
Schools – middle	3	1
Schools – high	2	2
Schools – other	12	4
Laundromats	**12**	**4**
Hotels/Motels	**68**	**18**
Hotels/Motels (large, >= 32 units)	26	8
Hotels/Motels (small, <32 units)	42	10
Restaurants	**119**	**25**
Retail	**326**	**22**
Retail-single establishment	164	11
Retail-multi establishment	79	7
Retail-store w/living unit	83	4
Office	**201**	**19**
Office-single establishment	78	10
Office-multi establishment	123	9
Medical	**104**	**19**
Medical/Dental/Veterinary – single	97	17
Medical/Dental multi establishment	7	2
TOTAL	**858**	**119**

Table 2 highlights the commercial and institutional facilities broken down into sub-sectors, which allowed for a better survey sample for the study. This breakdown allowed for a representative sample of survey sites.

As mentioned earlier, one of the downsides of stratified sampling is that the data have to be weighted to correct for the sample not exhibiting the same proportionality as does the population from which it is drawn. For example, take the school sample where we have selected a third of elementary, middle, and other schools, but all of the high schools. Taking a simple average across the ten school surveys will provide a misleading picture for schools as a whole because high schools are over represented in the

sample. On the other hand, estimation of average characteristics of hospitals, laundromats and restaurants requires no weighting since they have not been sub-stratified. But these sectors would nonetheless have to be weighted when the objective is to derive overall results that apply to the commercial sector as whole. While surveying hospitals, hotels, and larger schools it is important to note that based on the large size of these facilities, our survey team conducted representative samples of guest rooms, patient rooms, and classrooms to avoid invading privacy of patients and guests. The data gathered from the sampled rooms was then extrapolated to match the total number of rooms by type at each facility. While all our analyses for the multi-family and commercial sectors include this weighting in the background, it can sometimes throw a reader off, hence this alert here and elsewhere in the report.

Sample Validation

For the randomly selected single-family and multi-family customers, it took a great deal of effort involving mail and telephone solicitation, and financial incentives, to obtain permission for our surveyors to visit the selected properties. In the commercial sector we were able to obtain a higher response rate (67%) because the water department was able to leverage its contacts with its commercial customers to promote this survey. However, response rates were much lower in the single and multi-family sectors (25% and 29% respectively) making selection bias in the survey results for these two sectors a greater possibility. To test for the presence of selection bias, the Santa Cruz Water Department compared the average annual consumption of the single-family and multi-family samples against their respective population averages. These are shown below in Table 3, and indicate a very good match between the sample and population averages. Based on this comparison, we conclude that selection bias, if present, is minimal.

Table 3 Comparison of Sample and Population Water Use

	Average CCF Per Year		
Residential Sector	**2008**	**2009**	**2010**
	Per Single Family Residence		
Total population of single family accounts	98	86	84
All 150 surveyed single family accounts	99	86	87
Single family indoor + outdoor surveys (100)	100	85	86
Single family outdoor only surveys (50)	98	86	89
	Per Multi-Family Housing Unit		
Total population of multi-family complexes	55	52	52
All 50 surveyed multi-family complexes	55	51	51

Table 3

Figures 2 and 3 shows the geographical distribution of the residential and commercial surveys. The wide dispersion in these surveys across the water district's service area once again bolsters our confidence in the representativeness of our surveys.

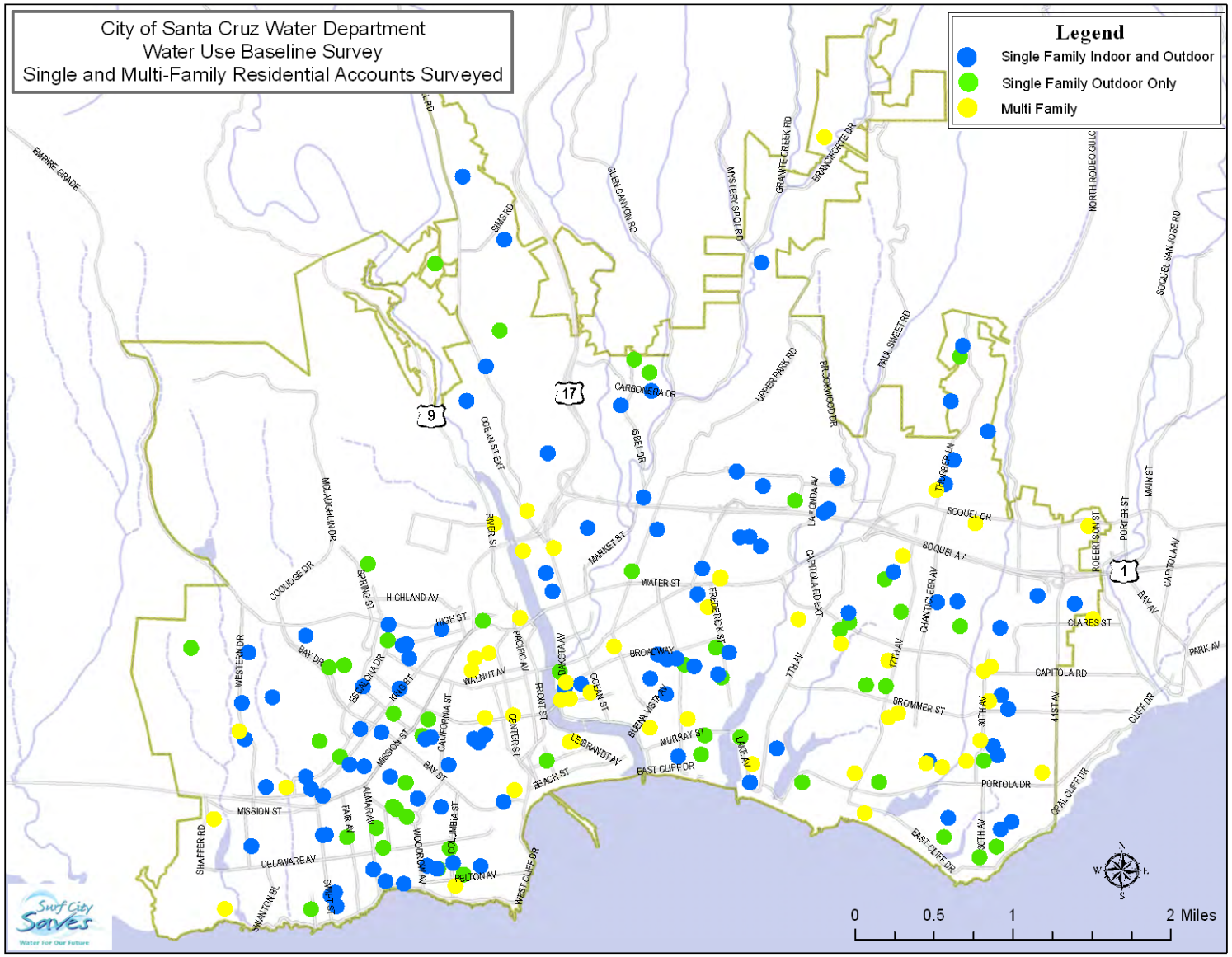

Figure 2 Geographic Distribution of Residential Surveys.

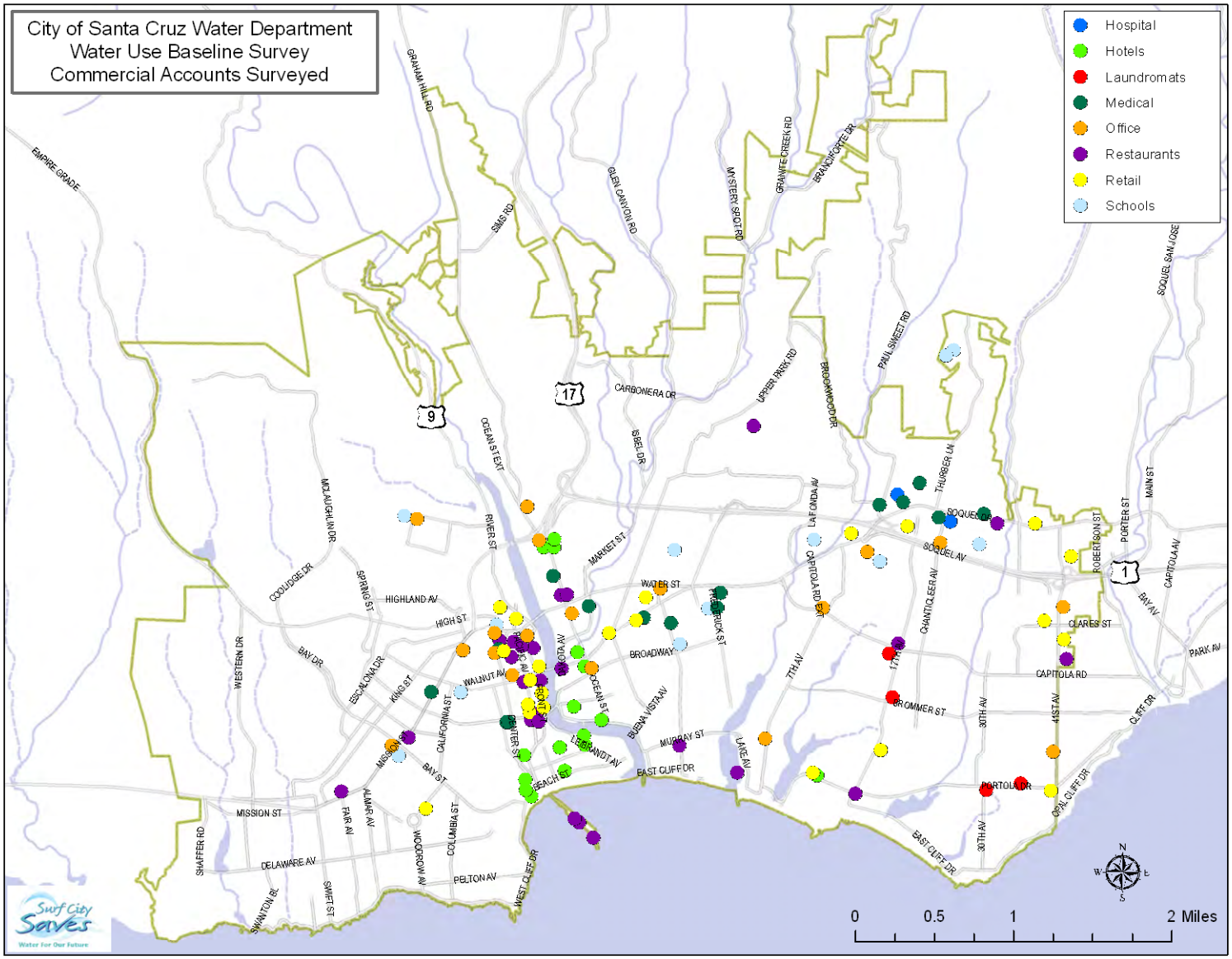

Figure 3 Geographic Distribution of Commercial Survey.

Results from the Single Family Survey

Indoor Characteristics

Indoor characteristics of single-family homes are based on 100 surveys. Table 4 shows some of the key summary statistics. We estimate that the average single family household in Santa Cruz has 2.6 residents, and that 86% of all dwelling units were constructed prior to 1992. The average dwelling unit has 3.52 faucets, 1.76 showerheads, and 2.08 toilets. A large fraction of these plumbing fixtures appear to be compliant with the latest efficiency standard; 83% in the case of faucets, 92% in the case of showerheads, and roughly 90% in the case of toilets. The error band surrounding these percentage estimates (95% confidence interval) is estimated to be roughly ±5%.

On average, 96% of single-family homes have a clothes washer, and 81% have a dishwasher. Among the stock of clothes washers, roughly 63% are estimated to be of the front load high efficiency kind, and among dishwashers, roughly 65% are no more than 5 years old, which likely makes them compliant with the latest efficiency codes, although this is hard to verify exactly.

Leaks were found in roughly 5% of the homes, and when the leakage in these homes is averaged over the 150 surveyed homes, the average leak rate amounts to 1.5 gallons per household per day.

Figures 4 through 8 show the distribution of measured flow rates of faucets and showerheads, flush volumes of toilets, and the machine type and age distribution of clothes washers and dishwashers. All of these graphs confirm that the prevalence of inefficient fixtures is quite low in single-family homes within Santa Cruz. However, when it comes to appliances, there is still considerable potential for improving the efficiency of clothes washers and dishwashers, although in terms of water used, clothes washers are by far more important than dishwashers.

Table 4 –Single-Family Indoor Water Use Characteristics

Item	Total, Mean or Proportion
Total number of sites surveyed	100
Average number of residents per household	2.6
Percent of homes built prior to 1992	86.0%
Faucets	
Total number of faucets surveyed	352
Bathroom	228
Kitchen	112
Other	12
Mean number of faucets per dwelling unit	3.52
Proportion of all faucets that are efficient (<2.2 GPM)[‡]	83.0%
Bathroom	89.9%
Kitchen	70.5%
Other	66.7%
Showerheads	
Number of showerheads surveyed	176

Item	Total, Mean or Proportion
Mean number of fixtures per dwelling unit	1.76
Proportion of showerheads that are efficient (<2.5 GPM)‡	92.0%
Toilets	
Number of toilets surveyed	208
Mean number of toilets per dwelling unit	2.08
Proportion of toilets that are efficient (1.6 or 1.28 GPF)‡	89.9%
Clothes Washers	
Number of clothes washers surveyed	96
Percentage of homes with clothes washers	96%
Proportion of clothes washers that are efficient (HECW)†	62.5%
Dishwashers	
Number of dishwashers surveyed	81
Percentage of homes with dishwashers	81.0%
Proportion of dishwashers that are efficient (<=5 years of age)†	65.4%
Other	
Percentage of homes with leaks	5.3%
Average leak rate among homes with leaks (GPD)	28.4
Average leak rate across all surveyed homes (GPD)	1.5

‡Error band ±5% or less. †Error band ±10% or less. Error bands include correction for inter-cluster correlation where present.

Table 4 highlights the average number of indoor water-using fixtures and appliances in proportion to the survey sample for single-family residences.

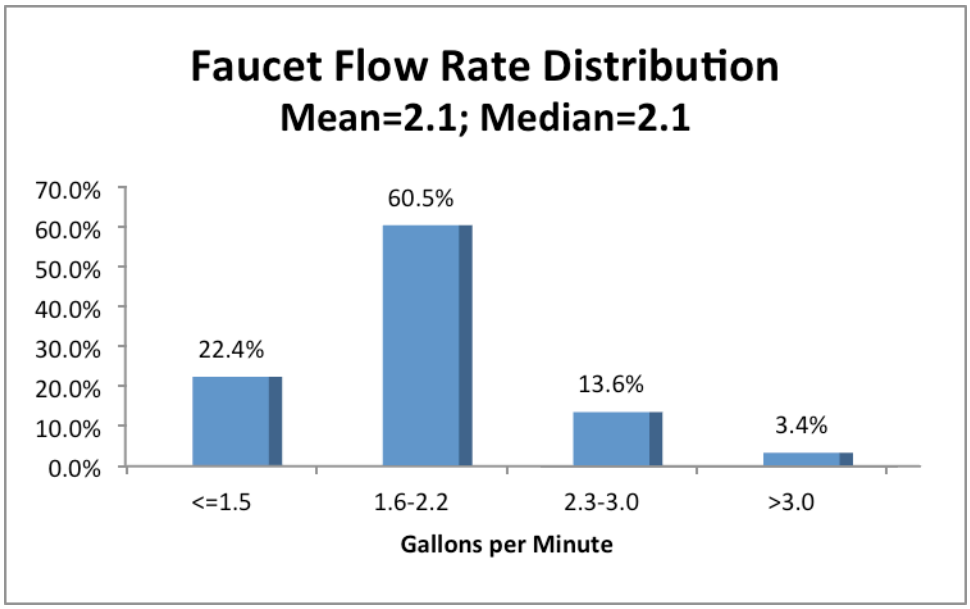

Figure 4 shows a representative distribution of faucet flow rates among single-family homes in the City of Santa Cruz. It was discovered that faucet flow rates average between 1.6-2.2 gallons per minute among a majority of the single-family homes.

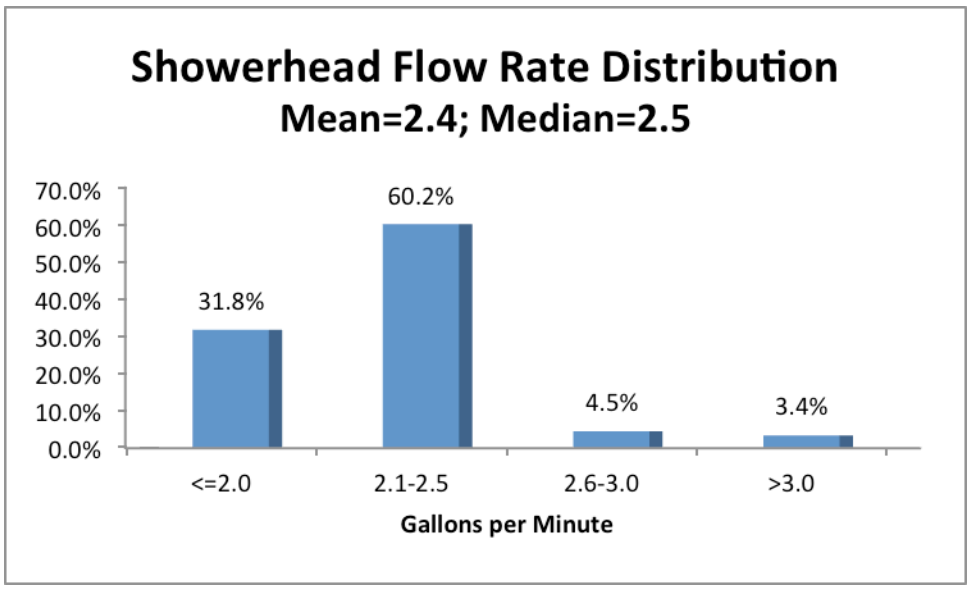

Figure 5 shows a representative distribution of showerhead flow rates among single-family homes in the City of Santa Cruz. The average flow rate of showerheads among single-family homes was between 2.1-2.5 gallons per minute.

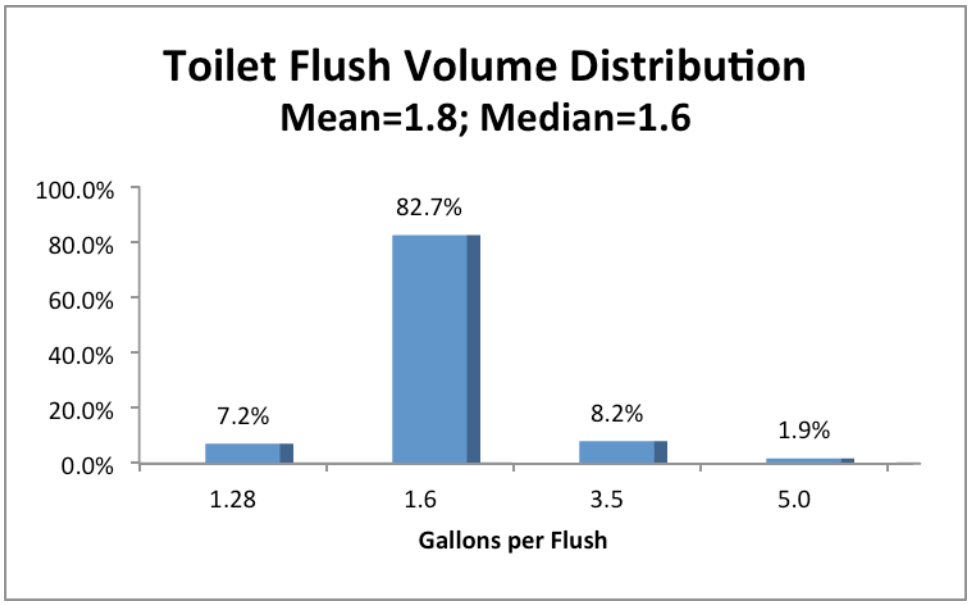

Figure 6 shows the representative distribution of toilet flush volume among single-family homes in the City of Santa Cruz. A majority of the single-family homes that were surveyed appeared to have toilets that flushed at 1.6 gallons per flush with the least amount of homes having toilets that flushed at 5 gallons per flush.

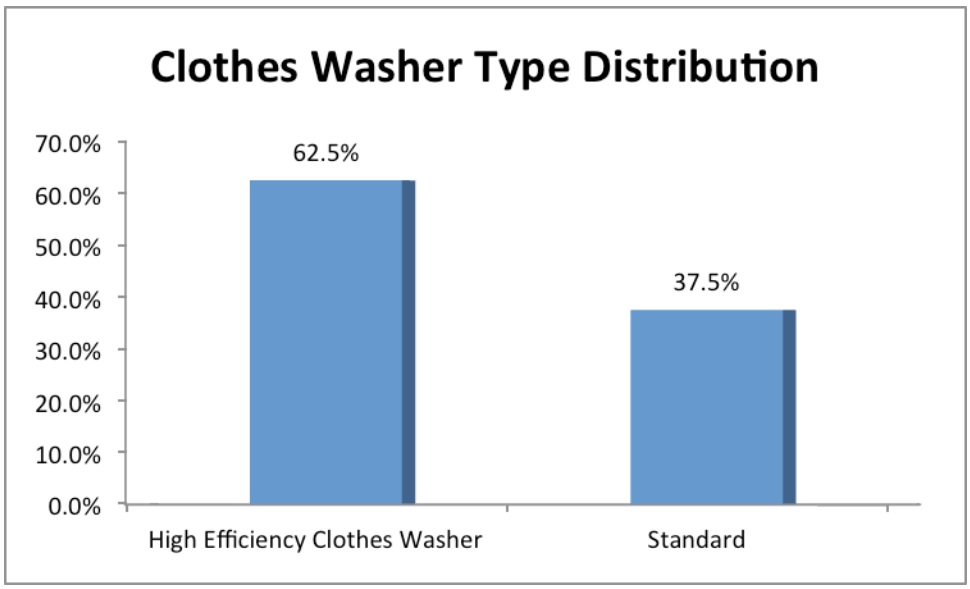

Figure 7 shows a representative distribution of high efficiency clothes washers versus standard clothes washers among single-family homes in the City of Santa Cruz. The graph shows that more than half of the single-family homes have high efficiency-clothes washers.

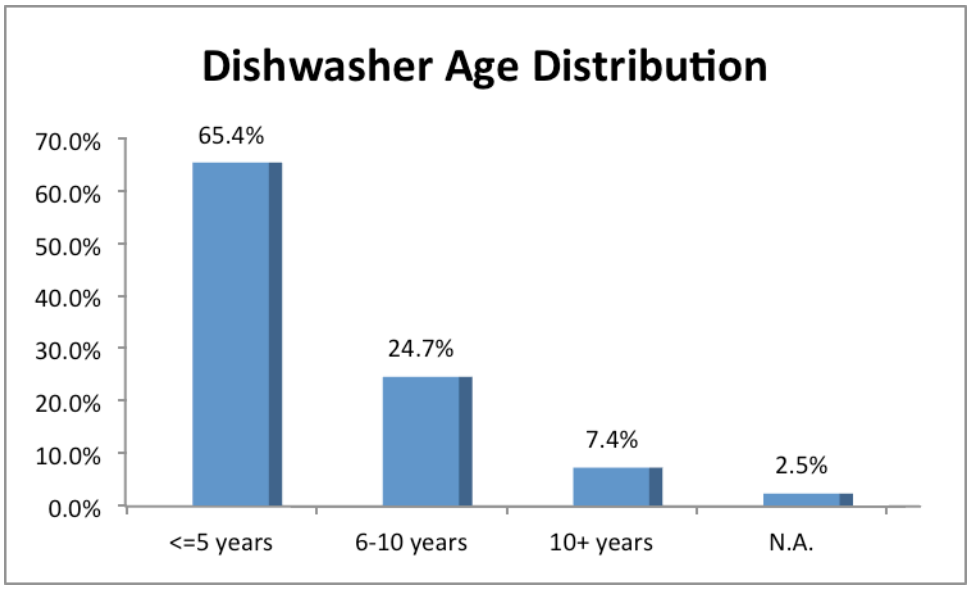

Figure 8 shows the distribution of dishwasher age among single-family homes in the City of Santa Cruz. A majority of the homes have dishwashers that are less than five years old, which means there is a potential that these homes have efficient dishwashers.

Outdoor Characteristics

Several metrics were developed to describe the non-dwelling unit portion of a lot that has some bearing on water use. These include description of the size and composition of a landscape, plant type, irrigation systems and controllers, water features, and so on. These data were collected from a total of 150 sites.

Figure 9 shows the most basic disaggregation of an average single family lot into its key components. Data collected via the survey suggest that 78% of a lot on average is not landscaped, being devoted to the dwelling unit and hardscape. Of the remaining area, 6.3% is covered with turf, 12.7% with flowers, trees, or shrubs, 2.8% appears to be landscaped but not irrigated, with the irrigation status of a small sliver (0.2%) remaining unclear.

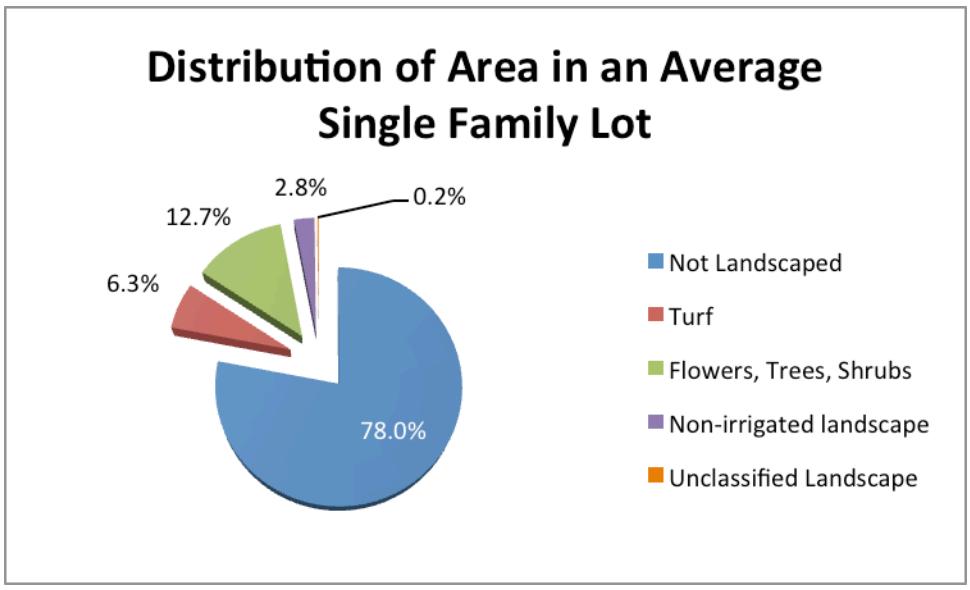

Figure 9 shows a representative distribution of area that a typical single-family residential property uses among the single-family customers within the City of Santa Cruz.

Table 5 shows many more summary metrics that flesh out the varied characteristics of single family landscapes and water features, while Figures 10 through 20 show how several of these metrics are distributed.

Table 5 –Single-Family Outdoor Landscape and Water Use Characteristics

Item	Total, Mean or Proportion
Landscape Area/Lot Characteristics	
Number of sites surveyed	150
Of all sites, percentage with landscaping	98.0%
Lot size (square feet)	8,574
Percent of lot area in landscaping	22.0%
Square footage of landscape area	1,884
Plant Type	
Of all sites, percentage with turf	48.0%
Percent of lot area in turf	6.3%
Percent of landscaped area in turf	28.8%
Square footage of turf area	542
Percent of landscape in non-turf area	71.2%
Square footage of non-turf landscaped area	1,342
Distribution of irrigated area by plant water need	Fig. 15
Irrigation Systems	
Percentage of sites with no irrigation	7.3%
Percentage of sites with irrigation status unknown (likely no irrigation)	6.7%
Percentage of sites where all landscape area is irrigated	81.3%
Percentage of sites with mix of irrigated and non-irrigated landscape area	4.7%
Square footage of irrigated area vs. non-irrigated area	1647 vs.237
Breakdown of irrigated area by irrigation method (hand watered, manual in-ground, automatic system)	Fig. 16
Percent of sites with lawn watering with in-ground irrigation system	62.5%
Percent of sites with lawn watering with hose/sprinkler	22.2%
Percent of all sites using some drip irrigation	31.3%
Breakdown of sprinkler types	Fig. 17
Breakdown of who manages irrigation	Fig. 18
Average pressure reading (based on 141 sites, 9 unavailable)	67.4 psi
Percent of sites with separate, dedicated irrigation meter	0.0%
Irrigation System Controller	
Number of controllers surveyed	67
Percentage of sites with automatic controllers	44.0%
Average number of controller stations	5.5
Distribution of # stations per property	Fig. 19
# of weather-based controllers, # soil moisture sensors	0/0
percentage with rain sensors	1.5%
Breakdown of how irrigation is managed: never, seasonally, monthly, more often	Fig. 20
Water Features	
Percentage of sites with swimming pools	2.0%
Percent of swimming pools using covers	66.60%
Average drain/refill interval	1 time/year to never

Item	Total, Mean or Proportion
Filter backwashed?	33.0%
Leaks	None
Percentage of sites with spas/hot tubs	14.0%
Percent of spa/hot tubs using covers	100.0%
Average drain/refill interval	1-2 times/year
Filter backwashed?	81.0%
Leaks	None
Percent of sites with ponds	5.3%
Percent of sites with other water features (Fountains)	6.7%

Table 5 highlights the average number of outdoor landscape characteristics, irrigation equipment, and outdoor water features in proportion to the survey sample for single-family residences.

There is wide dispersion in the percentage of a lot that is devoted to landscape: On average it may only be 22%, but in 6% of the properties this percentage is over 60% (Figure 11). It should also be noted that Table 5's estimate of lot area that is devoted to landscape (22%) is a ratio of two averages (landscape area over lot area). On the other hand, Figure 11 shows the average of the site-specific ratios (23.5%). The two averages are close, not identical, as there is no reason for them to be so. The latter is of greater interest, however, as discussed next.

With a bit more work, Figure 11's data offer a significant advantage in estimating the error band around average landscape per single family account. We estimate that a single family lot has 1,884 square feet of landscape on average (Table 5). The error band surrounding this average estimate is calculated to be roughly ±20%, somewhat higher than indoor characteristics because of the greater heterogeneity outdoors. But the error band (95% confidence interval) around the average percentage of a lot that is devoted to landscape in Figure 11 is calculated to be only ±13%. In other words, we estimate that the average proportion of a lot devoted to landscape may vary between 20.4% and 26.6% with 23.5% being the best estimate. If one could estimate lot size without any sampling error, which requires averaging lot size for all single family households from the county assessor database, then one could estimate landscape area with only a ±13% band of error, a significant improvement over this sample's results. To be sure, additional massaging of the county assessor database would involve some work and expense, but a lot less than undertaking additional field surveys.

It is also notable that 52% of the properties either have no landscape or no turf in their landscapes. Yet in a small proportion of cases (12.7%), the entire landscape consists of turf.

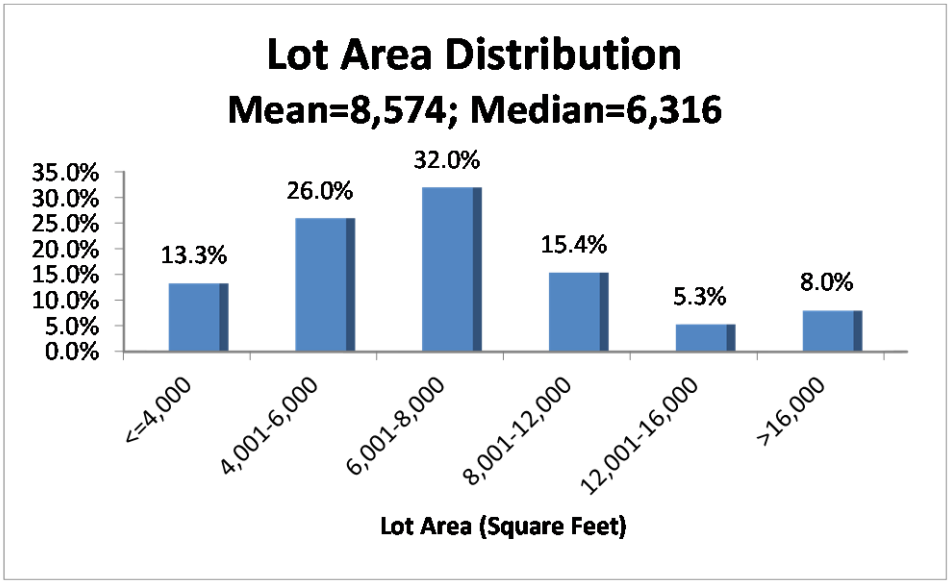

Figure 10 shows the representative distribution of property size in square footage of single-family residential customers within the City of Santa Cruz.

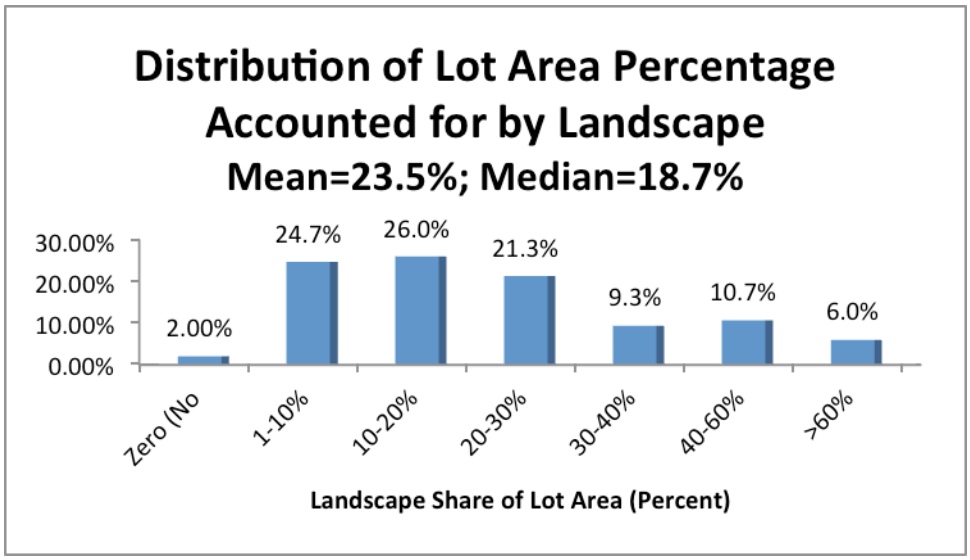

Figure 11 shows the representative distribution of the percentage of landscape area by lot among single-family customers within the City of Santa Cruz.

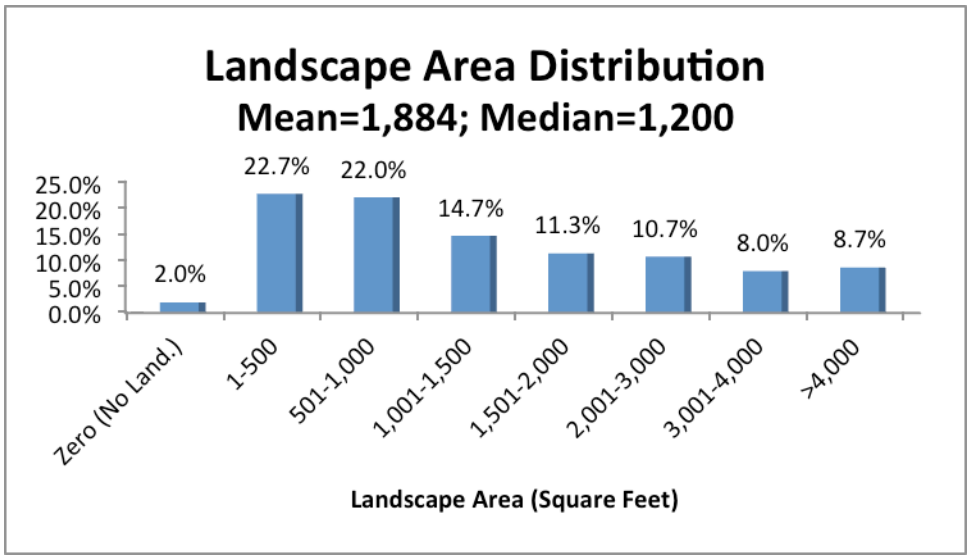

Figure 12 shows the distribution of landscape size among the representative sample of single- family customers within the City of Santa Cruz.

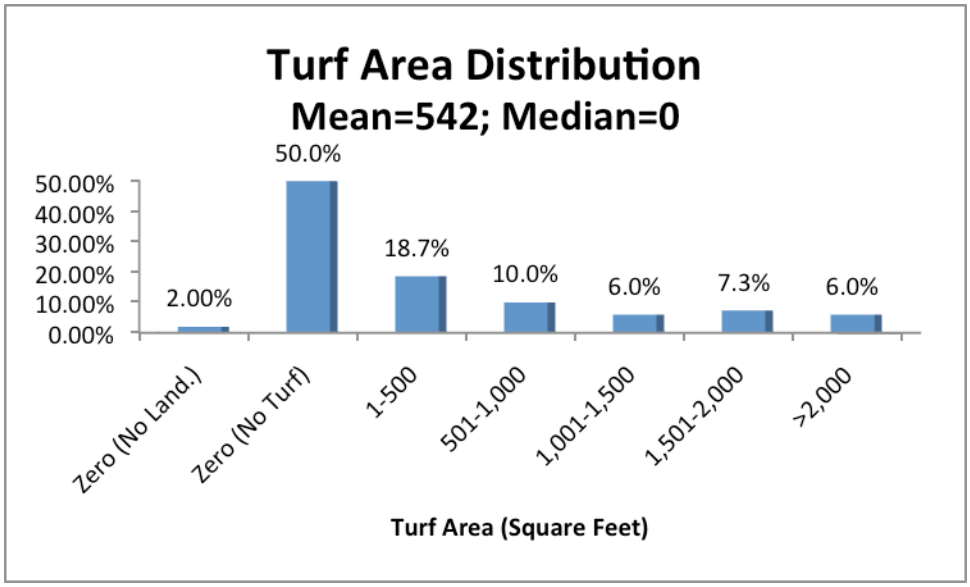

Figure 13 shows the distribution of turf grass area among the representative sample of single-family customers within the City of Santa Cruz.

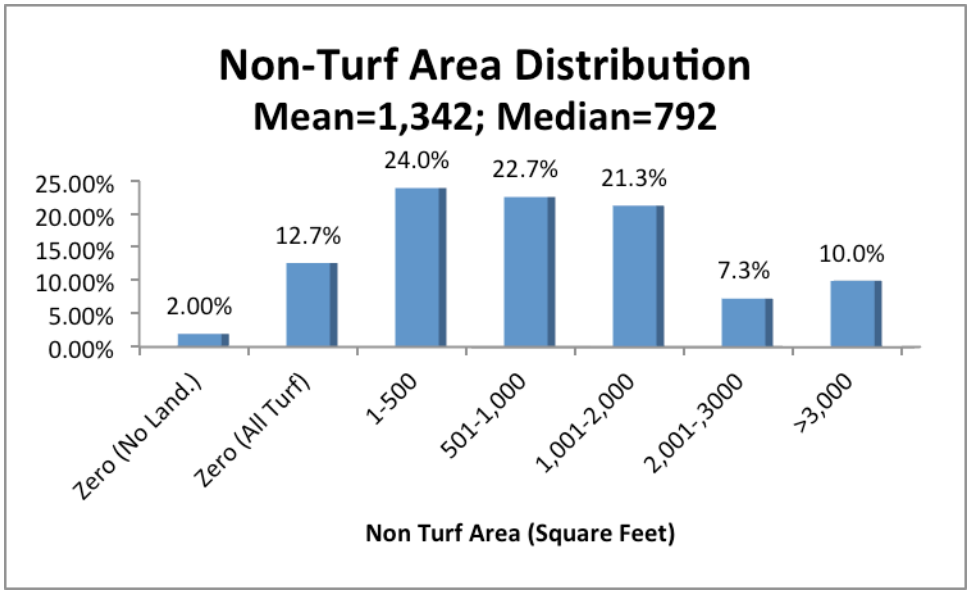

Figure 14 shows the distribution of landscape that was not designated as turf grass area among the single-family customers within the City of Santa Cruz. Other types of landscape consisted of trees, flowers, shrubs, etc.

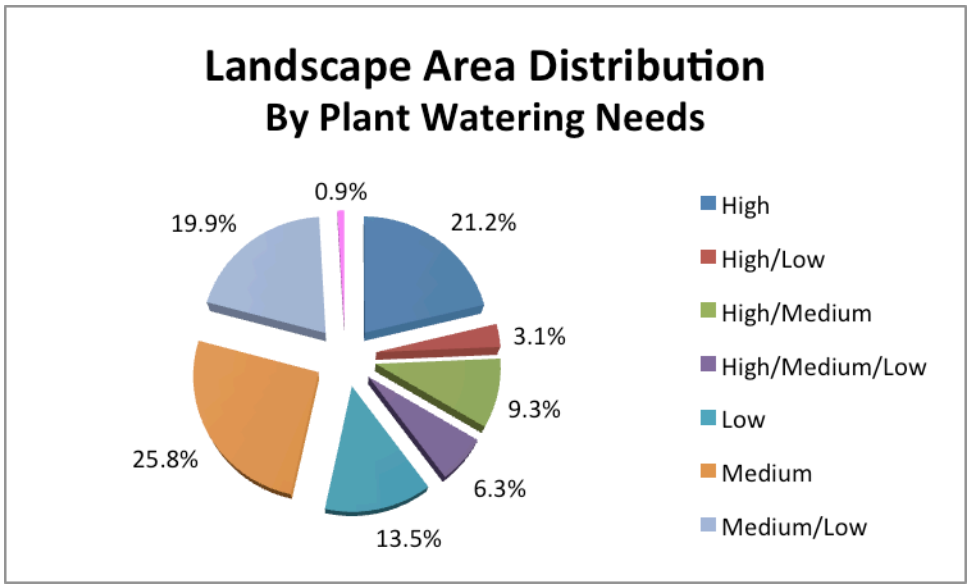

Figure 15 shows the distribution of water need based on plant types found among the single-family homes within the City of Santa Cruz. High water needs consisted mainly of turf grass area. Medium water needs consisted of flowers, trees, and other plants that were watered at a moderate level. Low water needs consisted of plants shrubs or drought tolerant plants that did not need much upkeep. In cases where water need is varies means that there are plant types of different water needs in that given area of landscape.

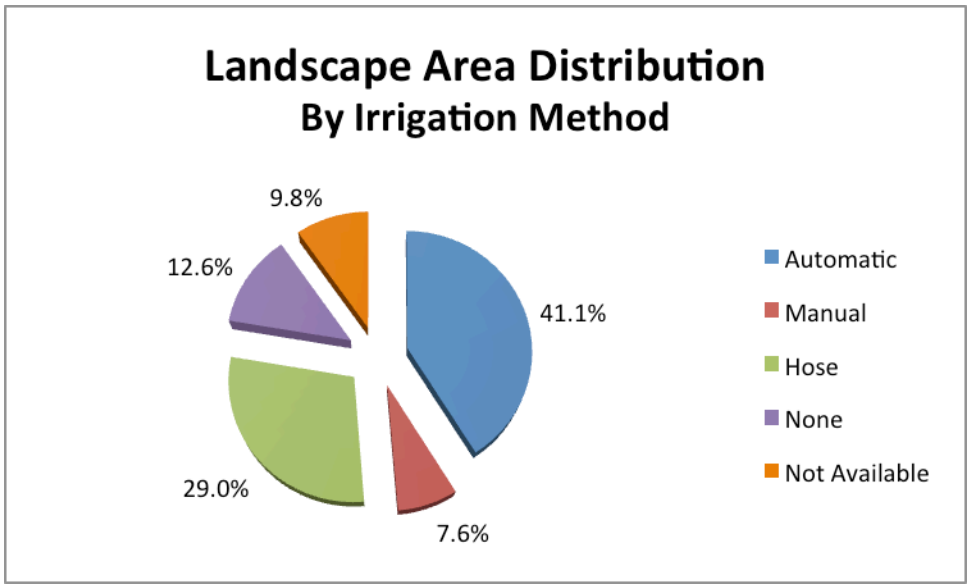

Figure 16 shows the distribution of methods used to irrigate landscape among the single-family customers within the City of Santa Cruz. A majority of the landscape irrigation in this group relied on automatic irrigation controllers, followed by customers watering their landscape using hoses.

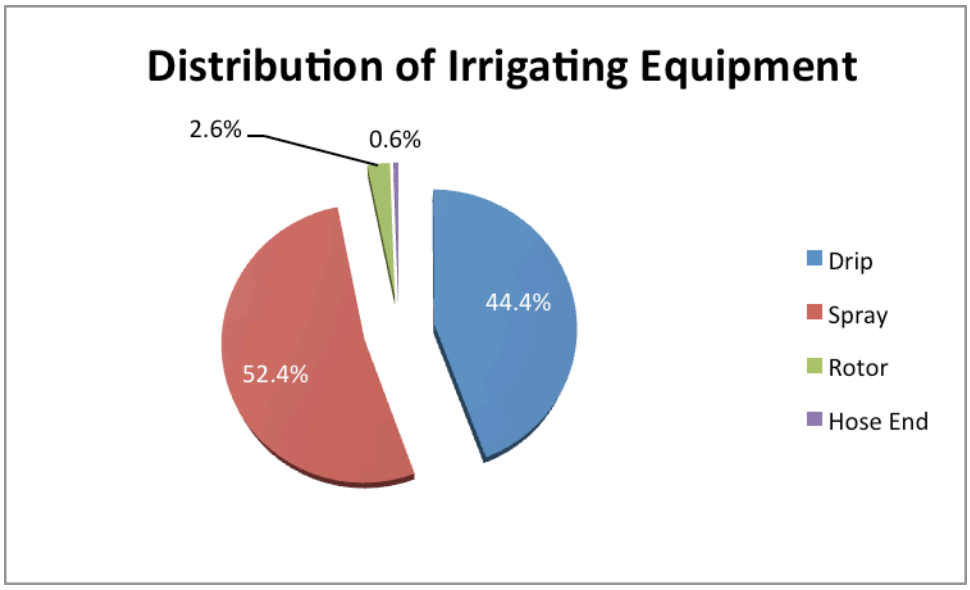

Figure 17 shows the distribution of irrigating equipment used among the single-family customers within the City of Santa Cruz.

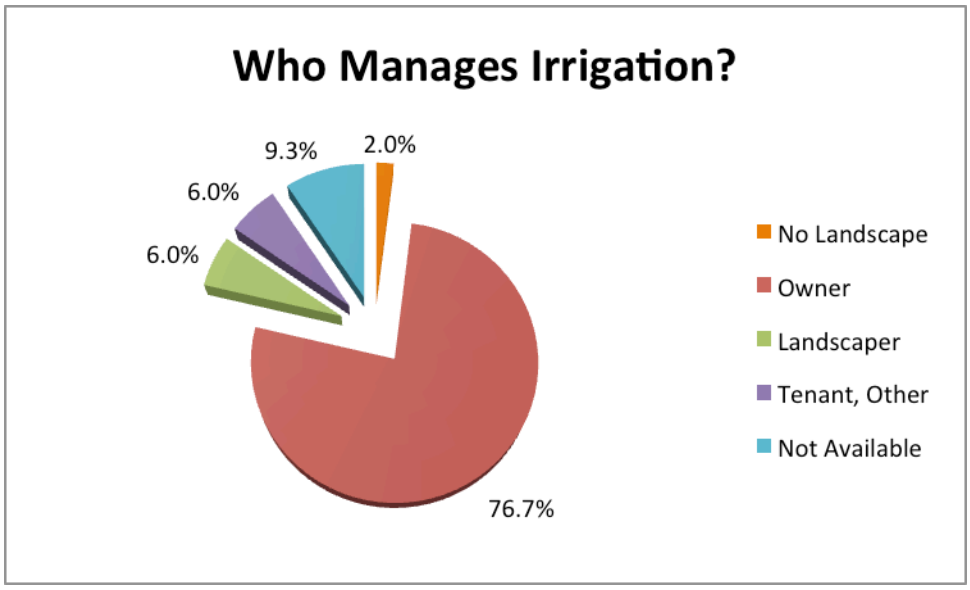

Figure 18 shows the distribution of who takes care of the landscape management among the representative sample of single-family customers within this study. Among the single-family customers, a majority of landscape is managed by the property owner.

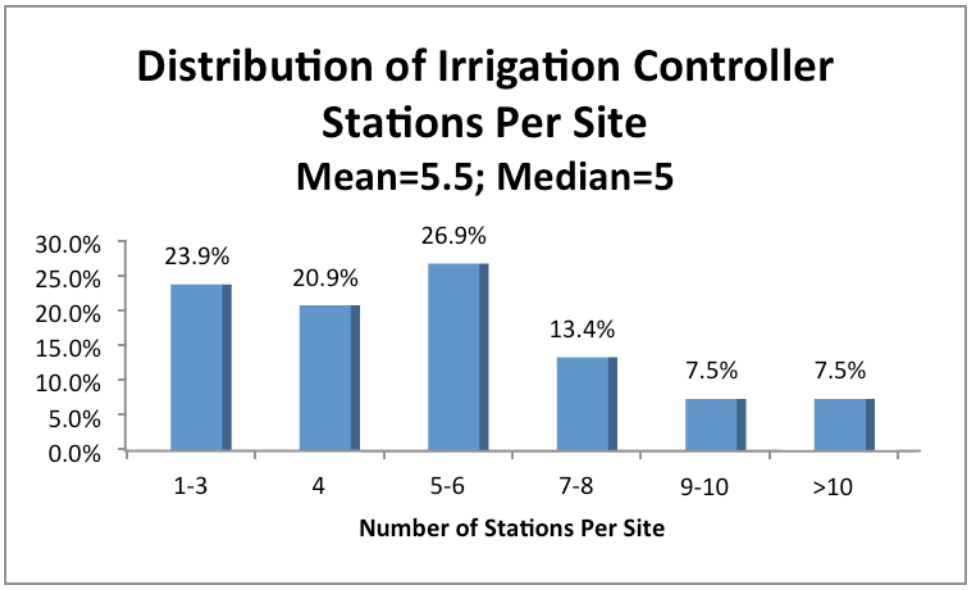

Figure 19 shows the distribution of irrigation stations or zones available per irrigation controller per site at the sampled single-family homes within the study area. A higher volume of controllers consisted of 5-6 irrigation stations or zones per controller.

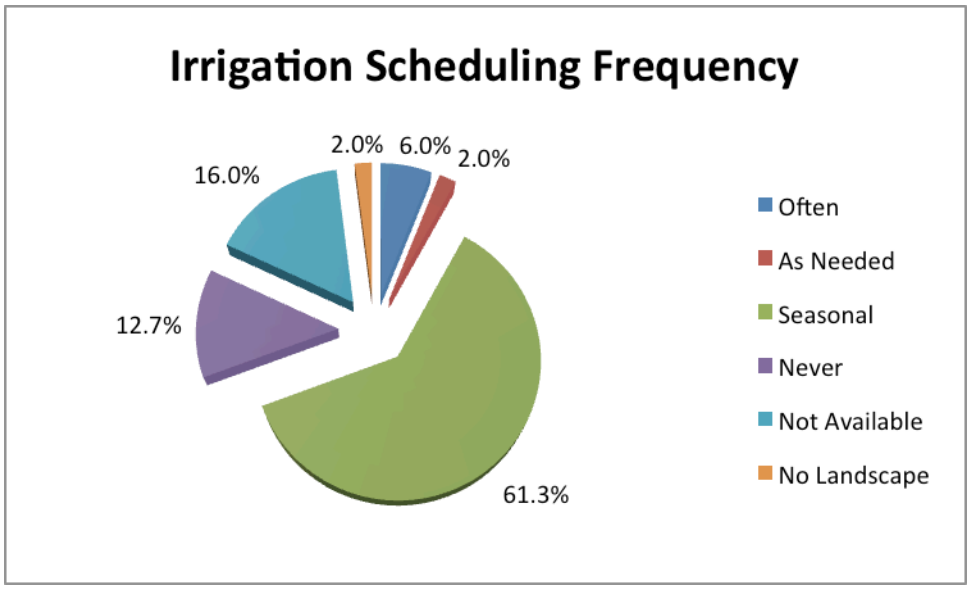

Figure 20 shows the distribution of irrigation frequency among the single-family customers within the City of Santa Cruz. The graph shows that a majority of the single-family customers adjust their irrigation schedules on a seasonal basis.

Results from the Multi Family Survey

Indoor Characteristics

Indoor characteristics of multi-family housing units are based on 127 indoor surveys. Table 6 shows some of the key summary statistics, which are all based on weighted calculations because of the use of stratified sampling. Because of the weights operating in the background, estimates of average fixtures per unit will not tally up with a simple ratio of total fixtures and total units surveyed, as was the case with single-family surveys. We were unable to collect reliable information about multi-family residents or the building's year of construction, so these data are not reported for this sector.

The average dwelling unit has 2.35 faucets, 1.21 showerheads, and 1.34 toilets. A large fraction of these plumbing fixtures appear to be compliant with the latest efficiency standards; 87% in the case of faucets, 95% in the case of showerheads, and roughly 89% in the case of toilets. The error band surrounding these percentage estimates (95% confidence interval) is estimated to be roughly ±5%.

On average, 36% of multi-family units have an in-unit clothes washer, and 42% have a dishwasher. Multi-family complexes also have common laundry rooms, and we estimate that there are 0.08 common clothes washers per unit, or 1 washer for roughly 12-13 housing units[2]. Among the stock of clothes washers, roughly 58% of in-unit washers, and 46% of common laundry washers, are estimated to be of the front load high efficiency kind. Among dishwashers, roughly 45% are no more than 5 years old, which likely makes them compliant with the latest efficiency codes, although this is hard to verify exactly. The prevalence of old dishwashers (10+ years), however, seems to be much greater in the multi-family residential stock compared to single-family.

Leaks were noted in these complexes only if associated with outdoor water features, and are discussed in the outdoor characteristics section. The normal procedure of identifying indoor leaks, that is, shutting all indoor uses and observing the water meter, could not be used because of complicated logistics.

Figure 21 shows the breakdown of our multi-family sample by county assessor codes to illustrate the diversity of multi-family properties that were included in our survey. Figures 22 through 26 show the distribution of measured flow rates of faucets and showerheads, flush volumes of toilets, and the machine type and age distribution of clothes washers and dishwashers. All of these graphs confirm that the prevalence of inefficient fixtures is quite low in multi-family homes of Santa Cruz. However, when it comes to appliances, there is still considerable potential for improving the efficiency of clothes washers and dishwashers, although in terms of water used, clothes washers are by far more important than dishwashers.

[2] This estimate ties nicely with common laundry sizing recommendations, which suggest installation of 1 washer per 10-15 apartment housing units. Additional details can be found at the Multi-Housing Laundry Association's website: http://www.mla-online.com/guide.htm

Table 6 –Multi-Family Indoor Water Use Characteristics

Item	Total, Weighted Mean or Proportion
Total number of accounts (complexes) surveyed	50
Total number of apartment units surveyed	127
Faucets	
Total number of faucets surveyed	322
Bathroom	179
Kitchen	121
Other	22
Mean number of faucets per apartment unit	2.35
Proportion of all faucets that are efficient (<2.2 GPM)‡	86.7%
Bathroom	88.9%
Kitchen	92.3%
Other	72.9%
Showerheads	
Number of showerheads surveyed	152
Mean number of fixtures per apartment unit	1.21
Proportion of showerheads that are efficient (<2.5 GPM)‡	94.8%
Toilets	
Number of toilets surveyed	181
Mean number of toilets per apartment unit	1.34
Proportion of toilets that are efficient (1.6 or 1.28 GPF)‡	88.8%
Clothes Washers	
Number of in-unit clothes washers surveyed	44
Average number of in-unit clothes washers per unit	0.36
Proportion of in-unit clothes washers that are efficient (HECW)†	58.0%
Number of laundry room clothes washers surveyed	109
Average number of laundry room clothes washers per unit	0.08
Proportion of laundry room clothes washers that are efficient (HECW)¥	45.7%
Dishwashers	
Number of dishwashers surveyed	49
Number of dishwashers per apartment unit	0.42
Proportion of efficient dishwashers (less than or equal to 5 years of age)†	45.1%

‡ Error band equals ±5%. ¥ Error band equals ±9%. † Error band equals ±14%. Error bands adjusted for inter-cluster correlation where present.

Table 6 highlights the average number of indoor water-using fixtures and appliances in proportion to the survey sample for multi-family residences.

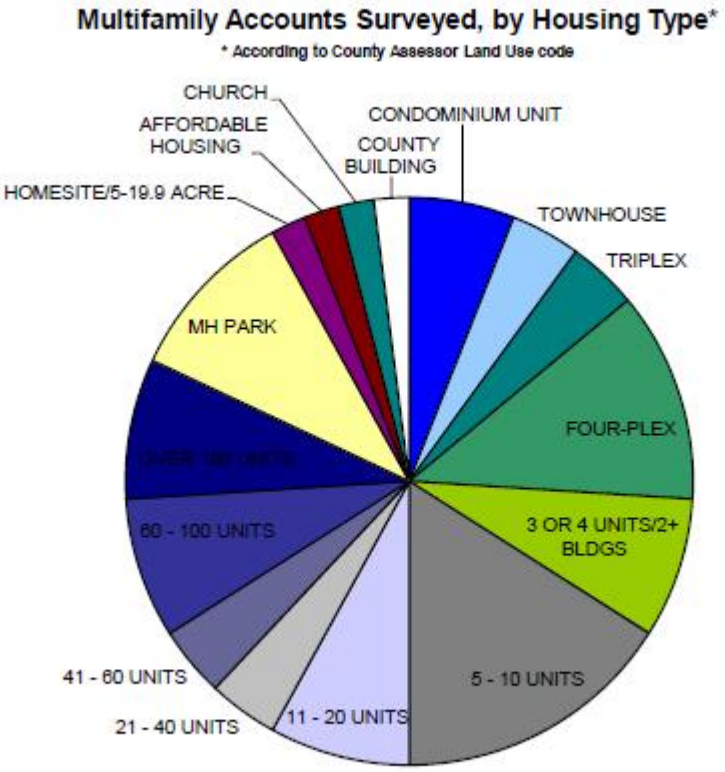

Figure 21 shows a breakdown of multi-family housing types in SCWD's service area according to Santa Cruz County Assessor data.

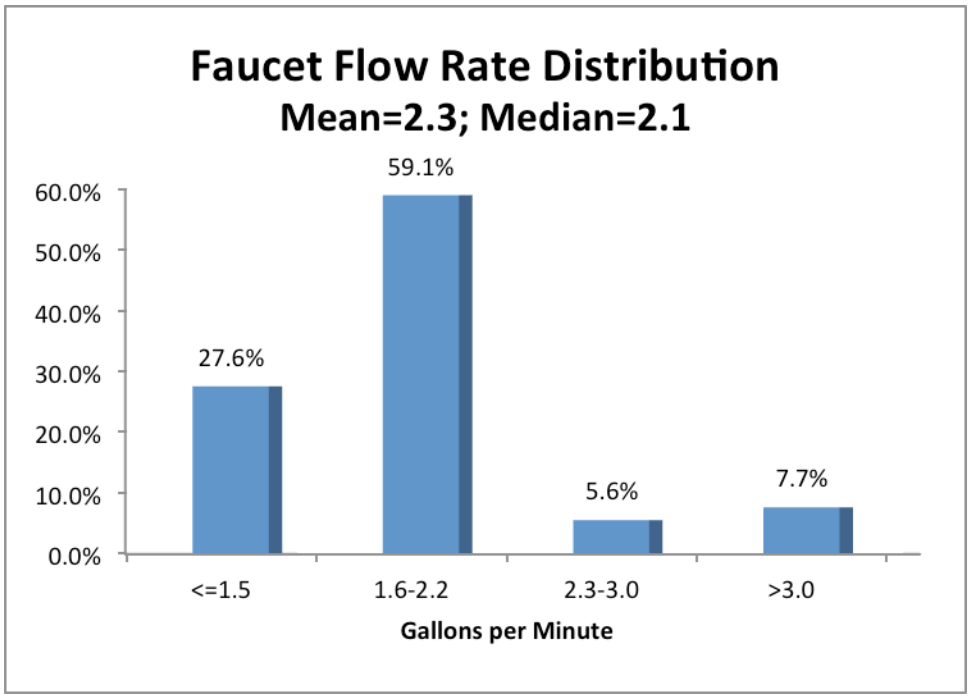

Figure 22 shows a representative distribution of faucet flow rates among multi-family residences in the City of Santa Cruz. It was discovered that faucet flow rates average between 1.6-2.2 gallons per minute among a majority of the multi-family residences.

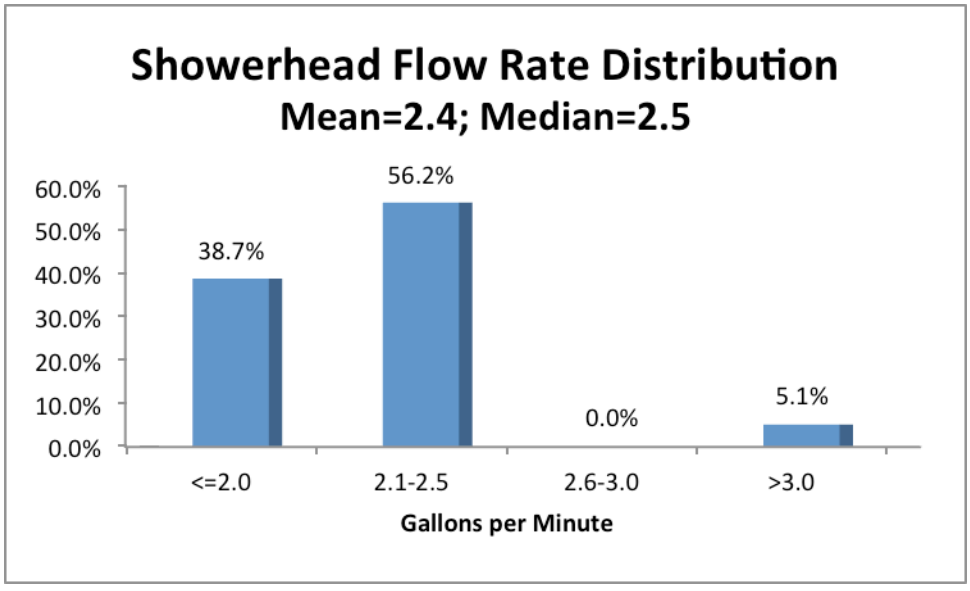

Figure 23 shows a representative distribution of showerhead flow rates among multi-family residences in the City of Santa Cruz. The average flow rate of showerheads among multi-family residences were between 2.1-2.5 gallons per minute.

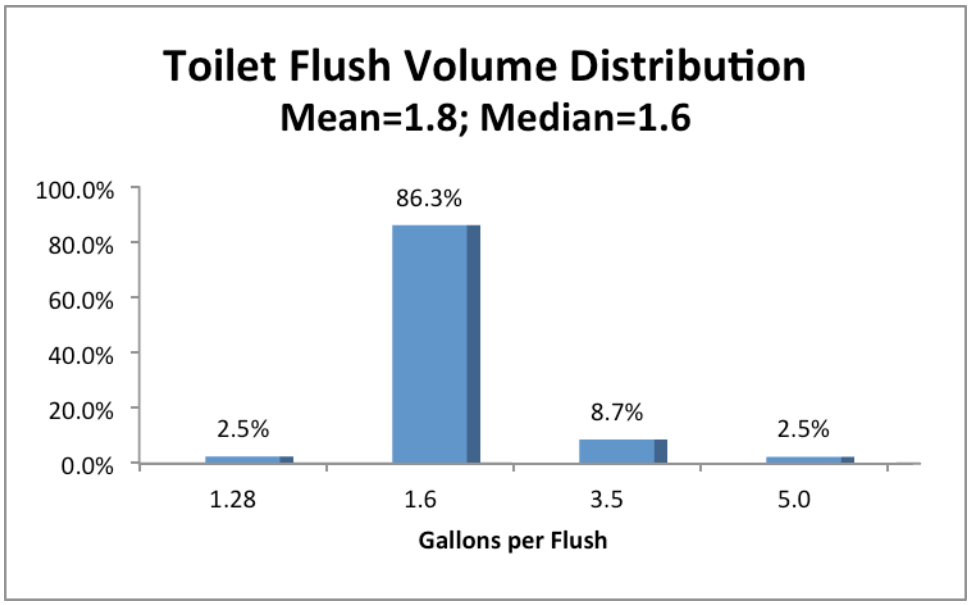

Figure 24 shows the distribution of toilet flush volume among multi-family residences in the City of Santa Cruz. A majority of the multi-family residences that were surveyed appeared to have toilets that flushed at 1.6 gallons per flush with the least amount of homes having toilets that flushed at 5 gallons per flush.

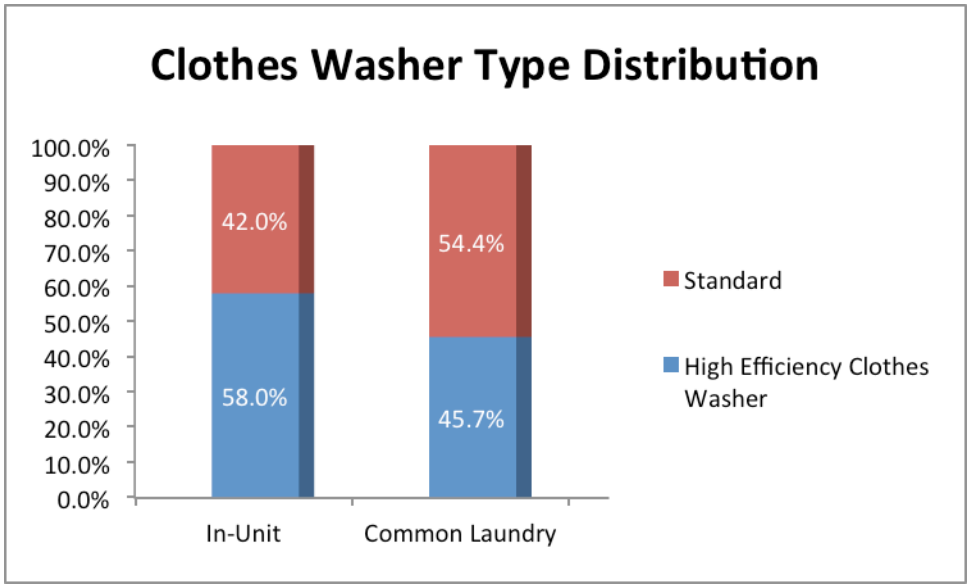

Figure 25 shows a comparison of the distribution of high efficiency clothes washers versus standard clothes washers among in-unit clothes washers and common laundry rooms in multi-family residences within in the City of Santa Cruz. The graph shows that a clothes washer in-unit is more likely to be high efficient compared to a clothes washer found in a common laundry area.

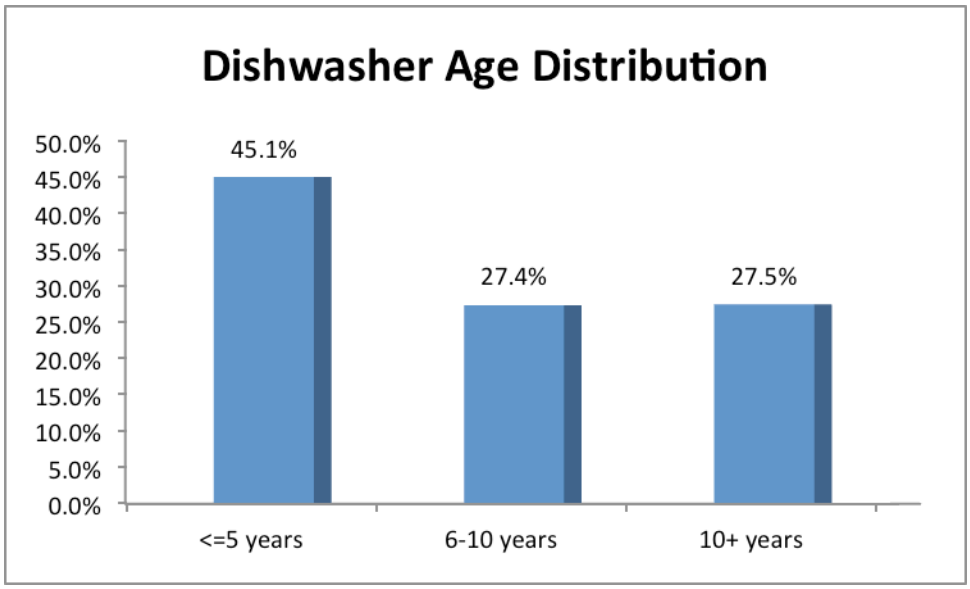

Figure 26 shows the distribution of dishwasher age among multi-family residences in the City of Santa Cruz. A majority of the units have dishwashers that are less than five years old, which means it is likely that the dishwashers are high efficiency.

Outdoor Characteristics

Several metrics were developed to describe the non-dwelling unit portion of a lot that has some bearing on water use. These include description of the size and composition of a landscape, plant type, irrigation systems and controllers, water features, and so on. As mentioned earlier, outdoor data are available only from a sample of 50 multi-family complexes.

Figure 27 shows the most basic disaggregation of an average multi-family lot into its key components. Data collected via the survey suggest that 88.3% of a lot on average is not landscaped, being devoted to the dwelling units and hardscape. Of the remaining area, 5.5% is covered with turf, 4.8% with flowers, trees, or shrubs, leaving 1.4% that is landscaped but not irrigated.

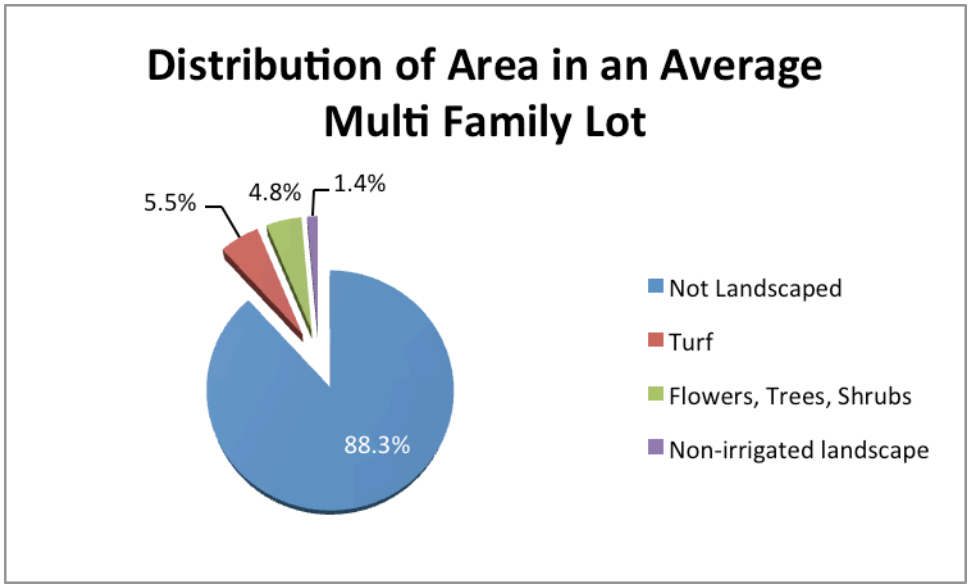

Figure 27 shows a distribution of area that a typical multi-family residential property uses in the City of Santa Cruz.

Table 7 shows many more summary metrics that flesh out the varied characteristics of multi-family landscapes and water features, while Figures 28 through 38 show how several of these metrics are distributed.

Table 7 –Multi-Family Outdoor Landscape Water Use Characteristics

Item	Total, Weighted Mean or Proportion
Number of sites surveyed	50
Of all sites, percentage with landscaping	73.0%
Lot size (acres)	1.141
Percent of lot area in landscaping	11.7%
Landscape area (acres)	0.134
Plant Type	
Of all sites, percentage with turf	51.1%
Percent of lot area in turf	5.5%
Percent of landscaped area in turf	47.0%
Turf area (acres)	0.063
Percent of landscape in non-turf area	53.0%
Non-turf landscaped area (acres)	0.071
Distribution of irrigated area by plant water need	Fig. 27
Irrigation Systems	
Percentage of sites with no irrigation	36.8%
Percentage of sites with irrigation status unknown (likely no irrigation)	0.0%
Percentage of sites where all landscape area is irrigated	62.1%
Percentage of sites with mix of irrigated and non-irrigated landscape area	1.0%
Square footage of irrigated area vs. non-irrigated area	5140 vs.701
Breakdown of irrigated area by irrigation method (hand watered, manual in-ground, automatic system)	Fig. 28
Percent of sites with lawn watering with in-ground irrigation system	71.2%
Percent of sites with lawn watering with hose/sprinkler	20.1%
Percent of all sites using some drip irrigation	25.0%
Breakdown of sprinkler types	Fig. 29
Breakdown of who manages irrigation	Fig. 30
Average pressure reading (based on 41 sites, 9 unavailable)	85.9 psi
Percent of sites with separate, dedicated irrigation meter	1.4%
Irrigation System Controller	
Number of controllers surveyed	26
Percentage of sites with automatic controllers	37.2%
Average number of controller stations	9.0
Distribution of # stations per property	Fig. 31
# of weather-based controllers, # soil moisture sensors	1/N.A.
percentage with rain sensors	1.0%
Breakdown of how irrigation is managed: never, seasonally, monthly, more often	Fig. 32
Water Features	
Percentage of complexes with swimming pools	6.7%
Percent of swimming pools using covers	59.0%
Average drain/refill interval	1 time/2 years to never

Item	Total, Weighted Mean or Proportion
Filter backwashed?	100.0%
Leaks	None
Percentage of complexes with spas/hot tubs	4.3%
Percent of spa/hot tubs using covers	92.6%
Average drain/refill interval	1-2 times/year
Filter backwashed?	92.6%
Leaks	None
Percent of sites with ponds	0.0%
Percent of sites with other water features (Fountains)	7.1%

Table 7 highlights the average number of outdoor landscape characteristics, irrigation equipment, and outdoor water features in proportion to the survey sample for multi-family residences.

There is wide dispersion in the percentage of a lot that is devoted to landscape: On average it may only be 11.7%, but it can account for as much as 25% or more (Figure 29). It should also be noted that Table 7's estimate of lot area that is devoted to landscape (11.7%) is a ratio of two averages (landscape area over lot area). On the other hand, Figure 29 shows the average of the site-specific ratios (9.2%). The two averages are close, not identical, as there is no reason for them to be so. The latter is of greater interest, however, as discussed next.

With a bit more work, Figure 29's data offer a significant advantage in estimating the error band around average landscape per multi-family account. We estimate that a multi-family lot has 5,841 square feet of landscape on average (Table 7). The error band surrounding this average estimate is calculated to be roughly ±78%, considerably higher than indoor characteristics because of the greater heterogeneity outdoors and small outdoor sample size. But the error band (95% confidence interval) around the average percentage of a lot that is devoted to landscape in Figure 29 is calculated to be only ±28%. In other words, we estimate that the average proportion of a lot devoted to landscape may vary between 6.6% and 11.8% with 9.2% being the best estimate. If one could estimate lot size without any sampling error, which requires averaging lot size for all multi-family complexes from the county assessor database, then one could estimate landscape area with only a ±28% band of error, a huge improvement over this sample's results. To be sure, additional massaging of the county assessor database would involve some work and expense, but a lot less than undertaking additional field surveys.

It is also notable that 48.9% of the multi-family properties either have no landscape or no turf in their landscapes. Yet in a small proportion of cases (10.4%), the entire landscape consists of turf.

Finally, landscape per multi-family unit appears to be slightly under a quarter (23%) of landscape per single-family dwelling unit. Landscape per multi-family unit can be estimated by dividing average landscape area per complex (5,841 sq. ft.) by average units per complex in the weighted sample (13.6). Average landscape area per single family household was reported earlier as 1,884 sq. ft. However, compensating somewhat for the smaller multi-family per-unit landscape is the slightly greater turf orientation of multi-family landscapes relative to single-family landscapes. In the former, turf accounts for 47% of the landscaped area; in the latter, it accounts for only 29%.

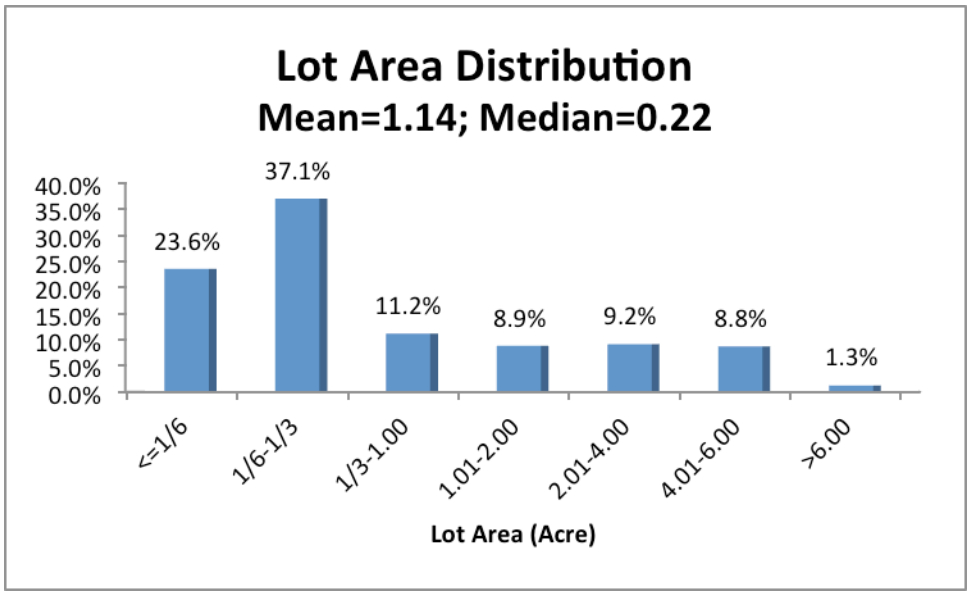

Figure 28 shows the distribution of property size in square footage of multi-family residences within the City of Santa Cruz.

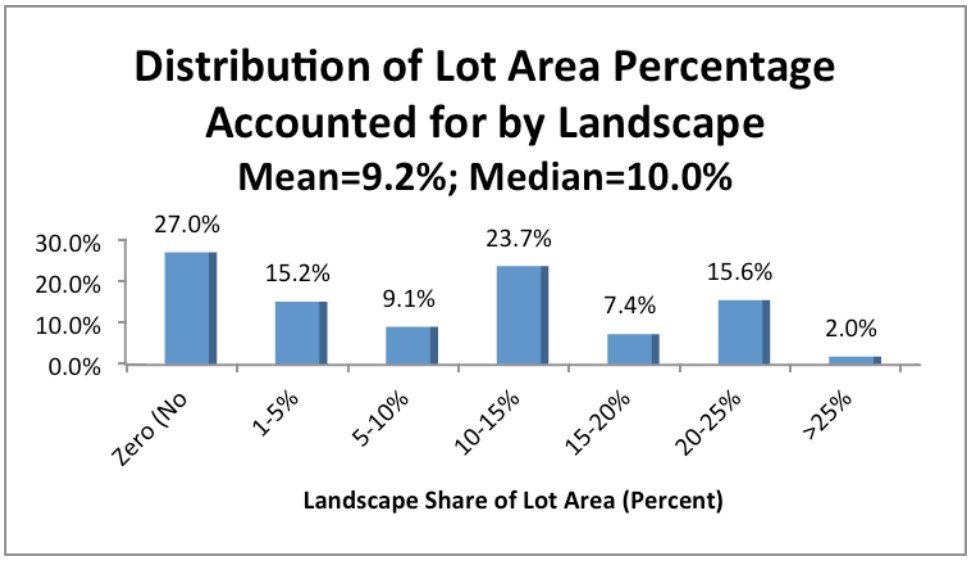

Figure 29 shows the distribution of the percentage of landscape area by lot among multi-family residences within the City of Santa Cruz.

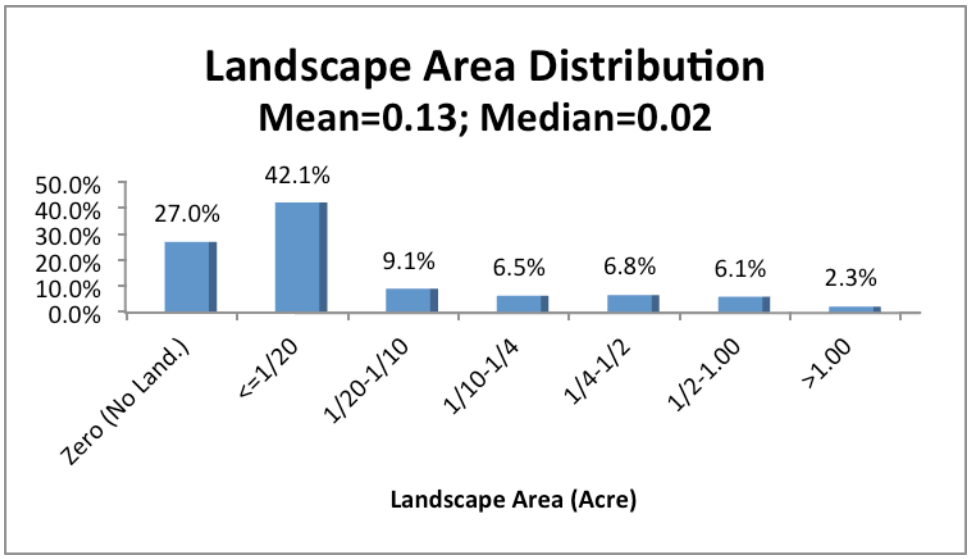

Figure 30 shows the distribution of landscape size among the representative sample of multi-family residences within the City of Santa Cruz.

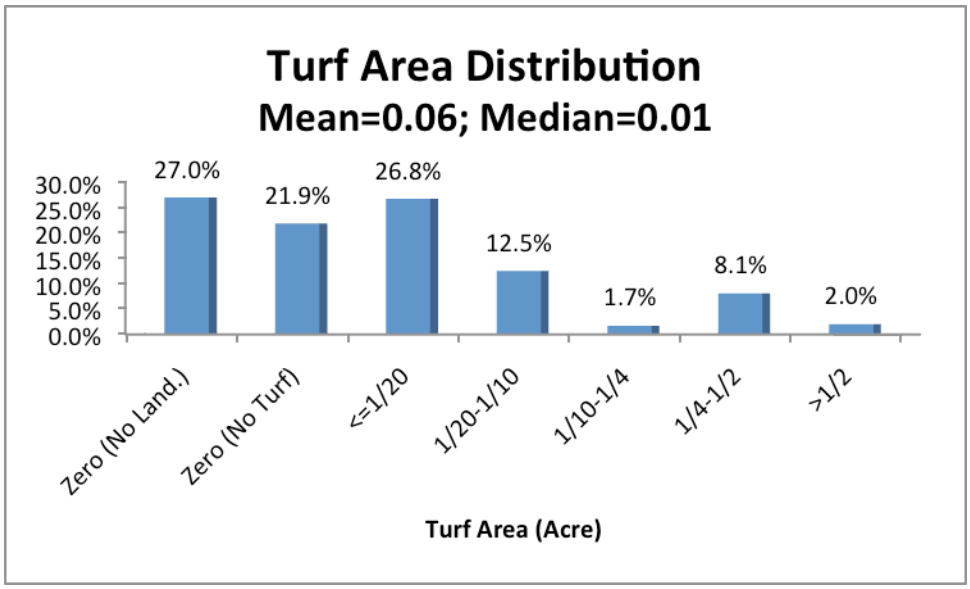

Figure 31 shows the distribution of turf grass area among the representative sample of multi-family residences within the City of Santa Cruz.

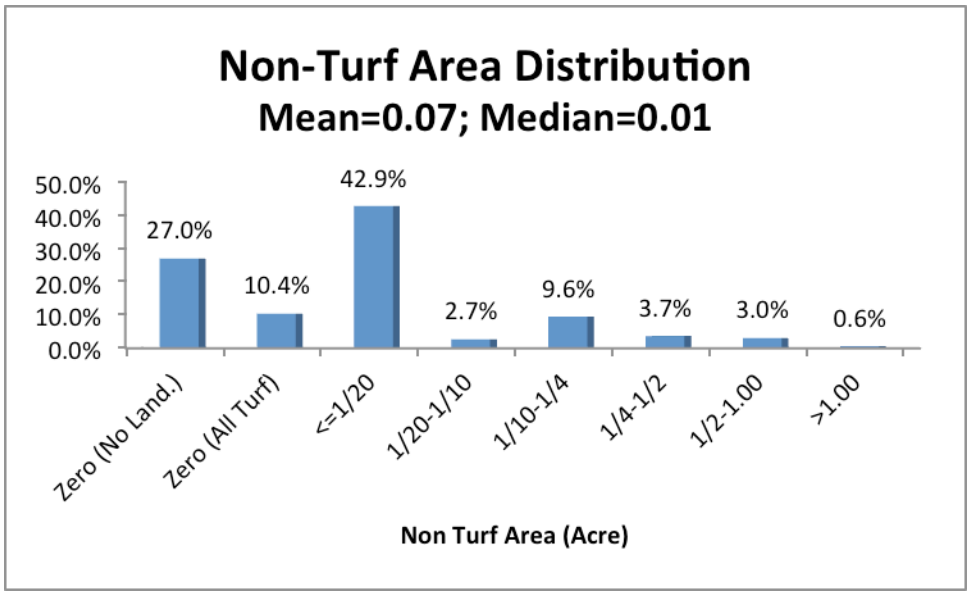

Figure 32 shows the distribution of landscape that was not designated as turf grass area among the multi-family residences within the City of Santa Cruz. Other types of landscape consisted of trees, flowers, shrubs, etc.

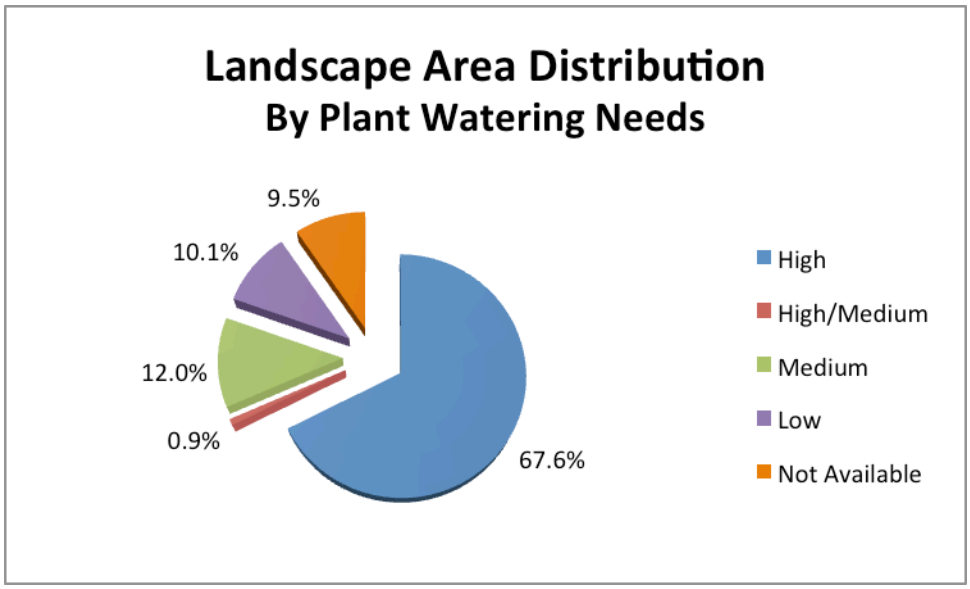

Figure 33 shows the distribution of water need based on plant types found among the multi-family residences within the City of Santa Cruz. High water needs consisted mainly of turf grass area. Medium water needs consisted of flowers, trees, and other plants that were watered at a moderate level. Low water needs consisted of plants shrubs or drought tolerant plants that did not need much upkeep. In cases where water need is varies means that there are plant types of different water needs in that given area of landscape.

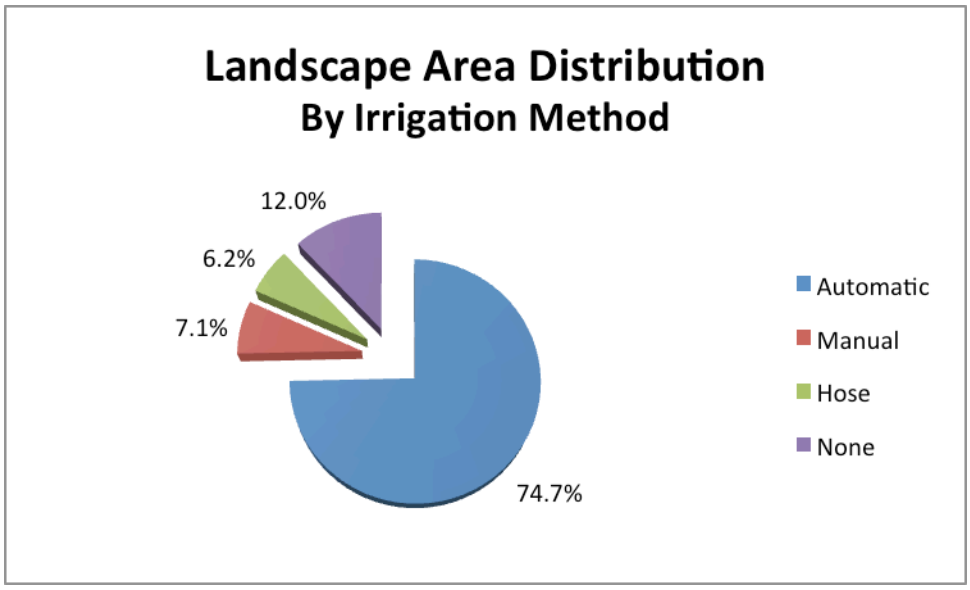

Figure 34 shows the distribution of methods used to irrigate landscape among the multi-family residences within the City of Santa Cruz. A majority of the landscape irrigation in this group relied on automatic irrigation controllers, whereas a small percentage of landscape is irrigated by a hose.

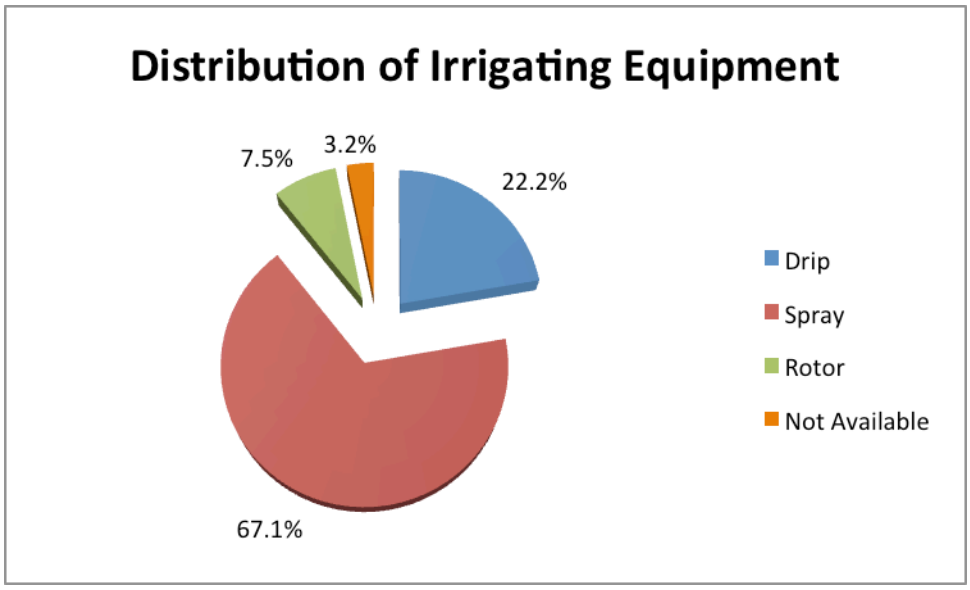

Figure 35 shows the distribution of irrigating equipment used among the multi-family residences within the City of Santa Cruz. Spray type of sprinkler heads are the majority of the sprinkler types that were found at multi-family residences.

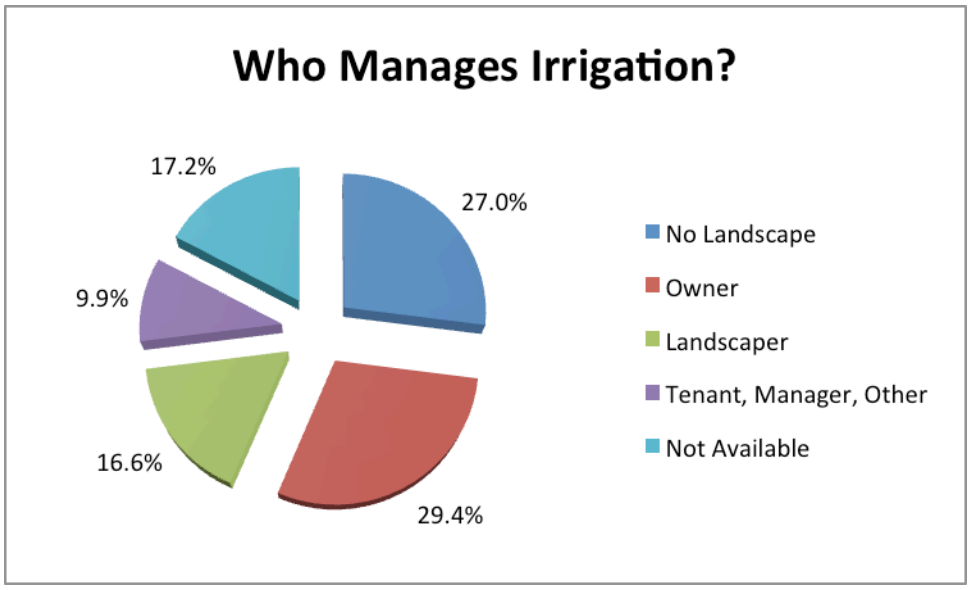

Figure 36 shows the distribution of who takes care of the landscape management among the representative sample of multi-family residences within this study. Among the multi-family residences, a majority of landscape is managed by the property owner.

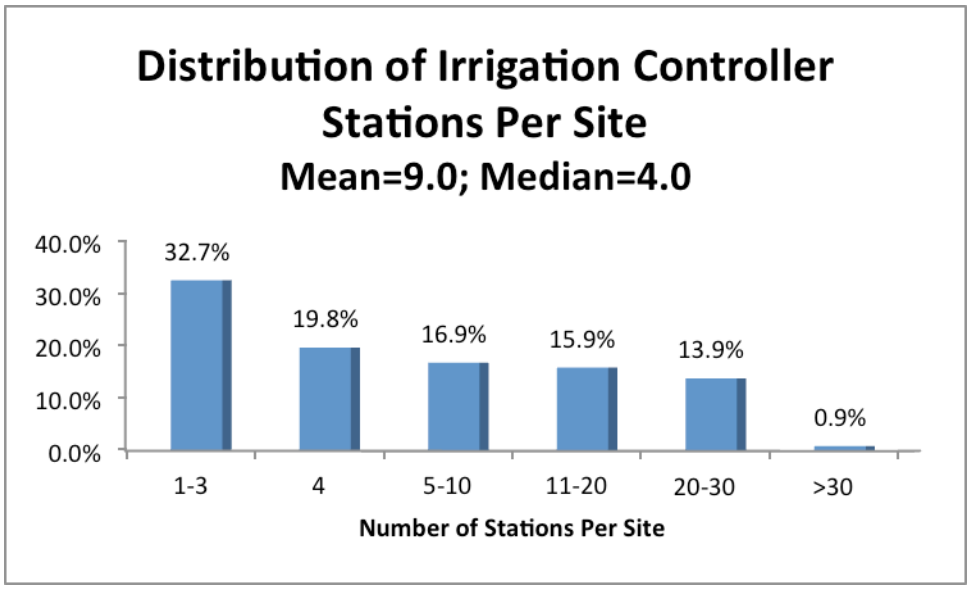

Figure 37 shows the distribution of irrigation stations or zones available per irrigation controller per site at the sampled multi-family residences within the study area. A higher volume of controllers consisted of 1-3 irrigation stations or zones per controller.

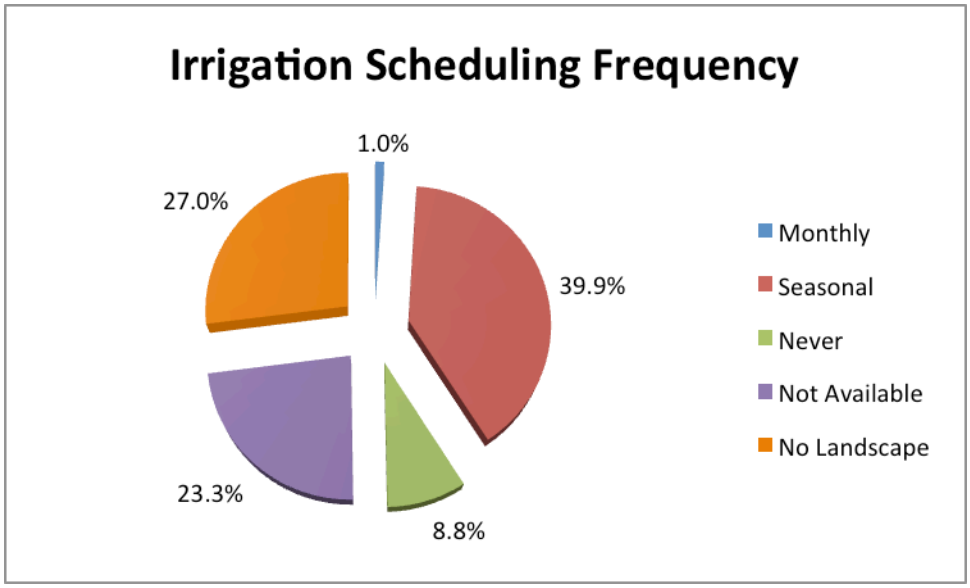

Figure 38 shows the distribution of irrigation frequency among the multi-family residences within the City of Santa Cruz. The chart shows that a majority of the multi-family residential customers adjust their irrigation schedules on a seasonal basis.

Results from the Commercial Survey

Indoor Characteristics

Indoor and outdoor characteristics of commercial sites are based on 119 surveys (120 sites were surveyed, but one had incomplete data). Table 8 shows some of the key summary statistics, by 8 sectors and overall. Figures 39 through 46 amplify these summary statistics by showing overall distributions for a few select metrics. All of these estimates are based on weighted calculations because of the use of stratified sampling. Because of the weights operating in the background, estimates of average fixtures per business type may not tally up with a simple ratio of total fixtures and total sites surveyed, and they certainly won't tally up at the aggregate level because the strata-level samples are not proportional to their prevalence in the population of commercial customers.

Several types of indoor fixtures and appliances were scrutinized by our surveyors including, faucets, showerheads, toilets, urinals, clothes washers, dish washers, pre-rinse spray valves, ice machines, process water use, etc.

Faucets were categorized by their location so that weak areas could be identified. It was especially important to track public restroom faucets separately because the efficiency standard that applies to them is quite a bit lower (0.5 GPM) than the other faucets (2.2 GPM). It appears that public restroom faucets, accounting for almost a third of all faucets, are nowhere near the required efficiency standards. Only 4.2% of public restroom faucets meet the 0.5 gallons-per-minute standard. Among the other faucets, that are supposed to have a flow rate no more than 2.2 gallons per minute, only 79% meet this standard overall (Figure 39), which is slightly below what was observed in the residential sector.

Efficiency of showerheads, toilets, and urinals overall appears quite good, but oddly hospitals seem to be lagging with respect to showerhead efficiency.

Regarding laundry needs on the premises, hotels and obviously laundromats are the biggest users of clothes washers. Overall, roughly 18% of all businesses have one or more laundry machines on their premises, and roughly 52% of this stock is of the front-loading type. Figure 43 shows the overall relative shares of the various types of clothes washers that were encountered during the surveys. These were categorized into five bins, including: (1) front loading residential washer (FLRW); (2) front loading commercial washer (FLCW); (3) top loading residential washer (TLRW); (4) top loading commercial washer (TLCW); and (5) commercial washer extractor (CWE). All of the CWEs were encountered in hotel settings. We counted the front loading clothes washers as being efficient, but not the CWEs since they did not exhibit any conservation features. However, if CWEs were to be considered efficient, the percent of clothes washers found in hotels considered efficient would rise from 53.4% to 69%.

Dishwashers were encountered in all the sectors, except laundromats. Overall, roughly a quarter of all commercial businesses appear to have one or more dishwashers on their premises. These were classified into three bins including: (1) under counter; (2) lift door; and (3) conveyer type. The relative proportions are shown in Figure 44.

Pre-rinse spray valves were found mostly in restaurants, but overall only 21% were found to have a flow rate below the efficiency standard of 1.6 gallons per minute. Figure 45 shows the overall distribution of flow rates encountered.

Ice machines are found in many sectors such as hospitals, hotels, restaurants. Overall about a fifth of commercial sites appear to have ice machines. Most of these (93%) are air cooled, however (Figure 46).

Process water, while found in all sectors except laundromats, appears to be significant only in the case of hospitals and medical offices. Process water in these two sectors involves the operation of specialized medical equipment and laboratory faucets. In the other sectors, process water is not significant and general involves specialized faucet use, such as, faucets next to each styling station in a hair salon, etc.

Cooling towers are not at all common in Santa Cruz. Only 1 hospital had this feature. Nor did our surveyors find very many leaks in the commercial sites that they surveyed.

Table 8 –Commercial Indoor Water Use Characteristics by Sub-Sector

Item	Hospitals	Hotels	Restau-rants	Schools	Office	Medical	Retail	Laundro-mats	Overall
Number of sites surveyed	2	18	25	10	19	19	22	4	119
Faucets									
Number of faucets in surveyed sites	365	866	158	666	93	193	104	5	2450
Mean number of faucets per business type	182.5	45.4	6.3	50.4	5.1	10.0	4.5	1.2	10.5
Public restroom faucets, percent of total	26.6%	2.1%	43.0%	61.6%	71.0%	38.9%	63.5%	40.0%	32.7%
Guest bathroom faucets, percent of total	54.0%	92.8%	0.0%	0.0%	0.0%	45.1%	0.0%	0.0%	44.4%
Kitchen faucets, percent of total	10.1%	3.7%	57.0%	9.3%	24.7%	11.4%	26.0%	0.0%	12.0%
Utility faucets, percent of total	9.3%	1.4%	0.0%	0.0%	4.3%	4.7%	10.6%	60.0%	3.0%
Class room faucets, percent of total	0.0%	0.0%	0.0%	29.1%	0.0%	0.0%	0.0%	0.0%	7.9%
Public restroom faucets, percent efficient (<0.5 GPM)	17.5%	0.0%	0.0%	3.9%	2.9%	3.1%	6.4%	0.0%	4.2%
Guest bathroom faucets, percent efficient (<2.2 GPM)	91.4%	86.4%	--	--	--	93.1%	--	--	87.7%
Kitchen faucets, percent efficient (<2.2 GPM)	51.3%	78.9%	43.3%	59.1%	63.7%	68.2%	80.4%	--	62.7%
Utility faucets, percent efficient (<2.2 GPM)	35.3%	40.6%	--	--	50.0%	100.0%	16.5%	100.0%	40.5%
Class room faucets, percent efficient (<2.2 GPM)	--	--	--	81.8%	--	--	--	--	81.8%
Showerheads									
Number of showerheads in surveyed sites	81	800	0	43	3	5	5	0	937
Mean number of fixtures per business type	40.5	41.8	0	2.7	0.2	0.3	0.3	0	3.7
Showerheads, percent efficient (<2/5 GPM)	63.0%	98.4%	--	95.6%	0.0%	80.0%	78.0%	--	95.3%
Toilets									
Number of toilets in surveyed sites	236	822	74	598	80	73	68	3	1954
Mean number of fixtures per business type	118	42.8	3	34.5	4.5	3.5	2.9	0.8	7.7
Toilets, percent efficient (1.28 or 1.6 GPF)	100.0%	99.1%	100.0%	99.0%	96.1%	68.0%	94.5%	33.3%	96.3%
Urinals									
Number of urinals in surveyed sites	6	5	19	182	17	1	10	0	240
Mean number of fixtures per business type	2	0.24	0.76	10.08	1.04	0.05	0.41	--	0.84
Urinals, percent efficient (<1.0 GPF)	100.0%	100.0%	89.5%	100.0%	80.4%	100.0%	100.0%	--	93.0%
Laundry Water Use, Commercial Clothes Washers									
Number of clothes washers surveyed	0	35	2	0	1	3	4	114	159

Item	Hospitals	Hotels	Restau-rants	Schools	Office	Medical	Retail	Laundro-mats	Overall
Percentage of businesses with laundry use on premises	0.0%	93.8%	8.0%	0.0%	6.8%	11.0%	13.3%	100.0%	17.9%
Breakdown of clothes washer type									
Clothes washers, percent efficient (front loading)	--	53.4%	0.0%	--	100.0%	0.0%	79.3%	49.1%	51.9%
Dishwashers and Pre-Rinse Spray Valves									
Number of dishwashers surveyed	2	6	22	5	5	4	1	0	45
Percentage of businesses with dishwasher use on premises	100.0%	28.1%	72.0%	34.6%	28.2%	16.5%	6.4%	0.0%	24.5%
Breakdown of dishwasher type									
Number of PRSVs surveyed	2	0	27	2	0	0	0	0	31
Proportion of water efficient PRSVs	100.0%	--	18.5%	75.0%	--	--	--	--	21.4%
Ice Machines									
Percentage of businesses with ice machines on premises	100.0%	75.3%	72.0%	7.7%	3.9%	0.0%	6.4%	0.0%	19.8%
Process Water Use									
Percentage of businesses with process water use	100.0%	11.0%	20.0%	26.9%	3.9%	27.4%	14.4%	0.0%	14.4%
Cooling Water Use									
Percentage of businesses with cooling water use	50.0%	--	--	--	--	--	--	--	0.1%
Other									
Number of water leaks detected	--	--	--	1	--	--	--	--	1
Leak rate per business (gallons per day)	--	--	--	9.6	--	--	--	--	0.3

NOTE: Error band around estimates of efficient faucets, showerheads, and toilets is ±5% or less, and around urinals roughly ±10%.

Table 8 highlights the indoor water using characteristics of commercial facilities with an overall picture as well as characteristics divided into sub-sectors.

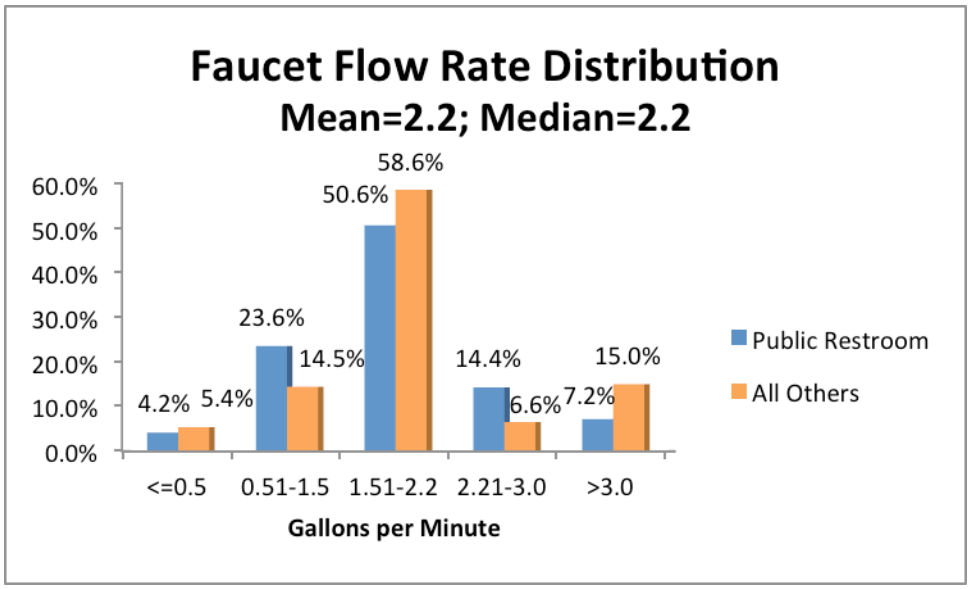

Figure 39 shows a representative distribution of faucet flow rates public restrooms versus all other types of restrooms for commercial and institutional facilities in the City of Santa Cruz. It was discovered that faucet flow rates average between 1.51-2.2 gallons per minute among a majority of the commercial and institutional facilities.

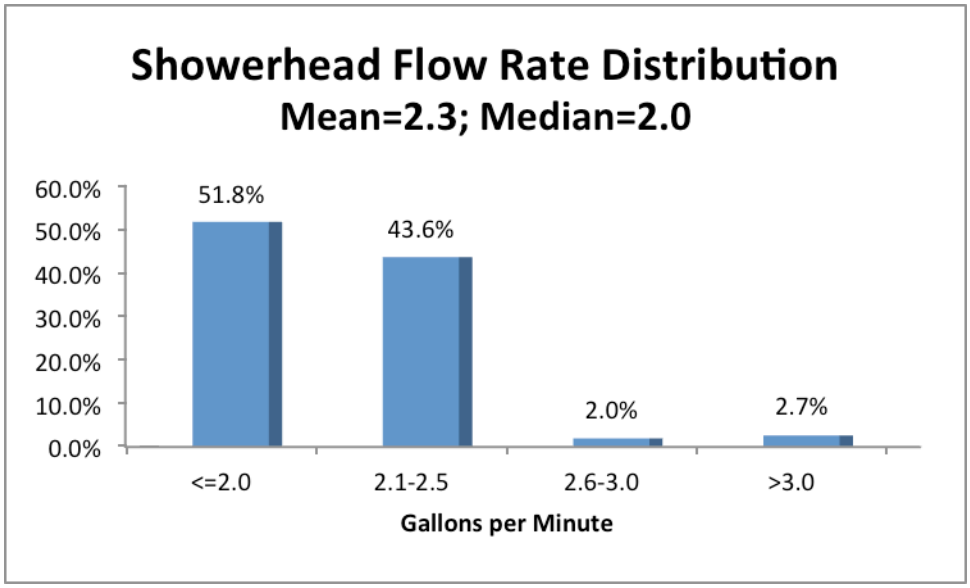

Figure 40 shows the distribution of showerhead flow rates among commercial and institutional facilities in the City of Santa Cruz. The average flow rate of showerheads among the majority of commercial and institutional facilities was 2.0 gallons per minute or lower.

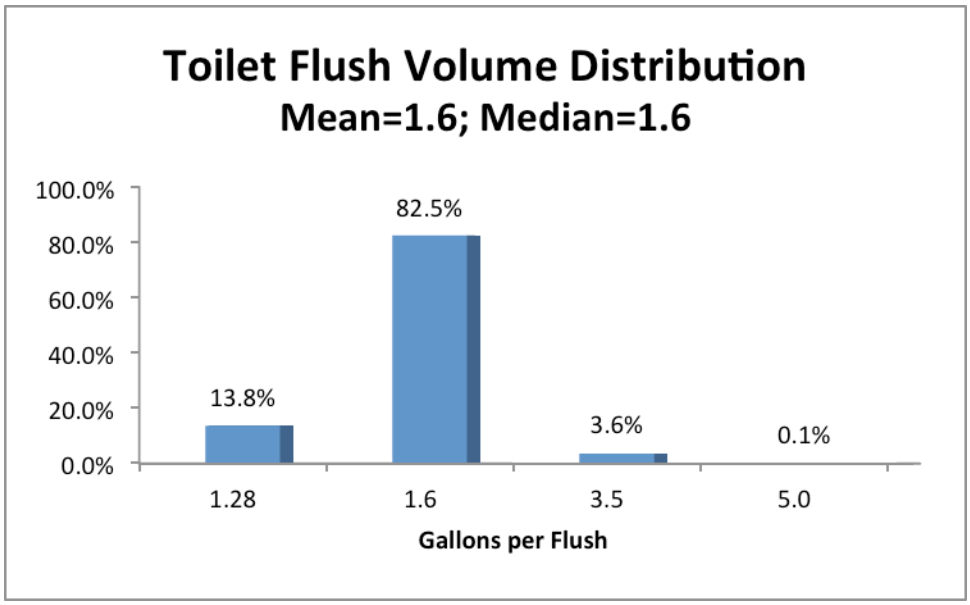

Figure 41 shows the representative distribution of toilet flush volume among commercial and institutional facilities in the City of Santa Cruz. A majority of the commercial and institutional facilities that were surveyed appeared to have toilets that flushed at 1.6 gallons per flush with the least amount of toilets that flushed at 5 gallons per flush.

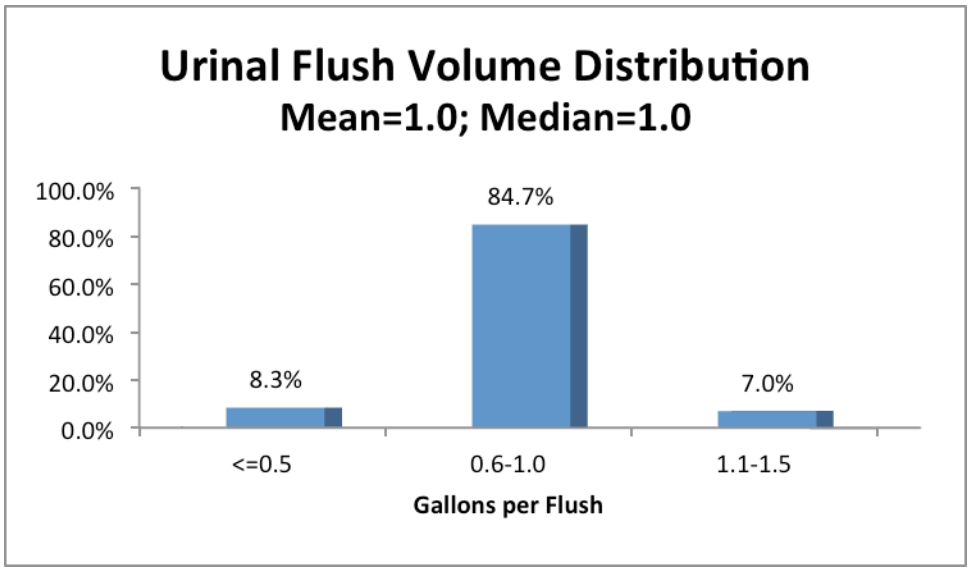

Figure 42 shows the representative distribution of urinal flush volume among commercial and institutional facilities in the City of Santa Cruz. A majority of the commercial and institutional facilities that were surveyed appeared to have urinals that had a flush rate between 0.6-1.0 gallons per flush with the least amount of urinals with a flush rate between 1.1-1.5 gallons per flush.

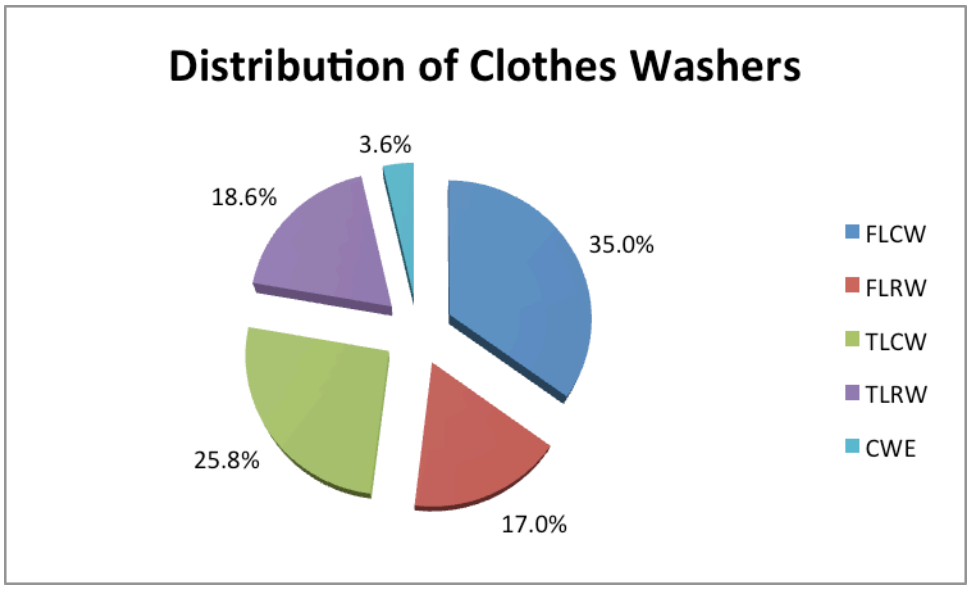

Figure 43 shows the distribution of clothes washers by type found among commercial and institutional facilities in the City of Santa Cruz. In these facilities, the clothes washers varied between front loading commercial washers (FLCW), front loading residential washers (FLRW), top loading commercial washers (TLCW), top loading residential washers (TLRW), and commercial washer extractors (CWE). The chart shows that the majority of clothes washers found in commercial and institutional facilities were FLCW.

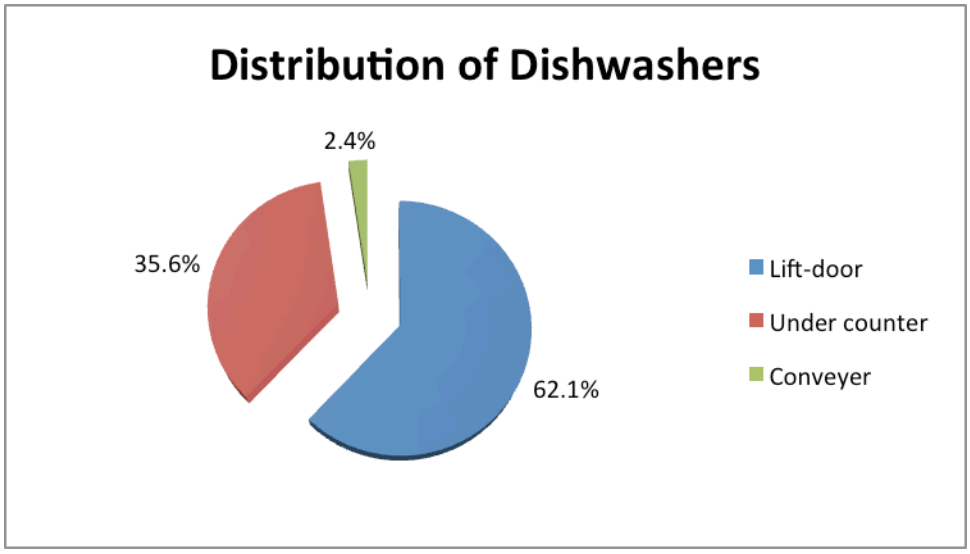

Figure 44 shows the distribution of dishwashers by type found among commercial and institutional facilities in the City of Santa Cruz. In these facilities, the dishwashers varied between lift-door type dishwashers, under counter dishwashers, and conveyor type dishwashers. The chart shows that the majority of dishwashers found in commercial and institutional facilities were the lift-door type.

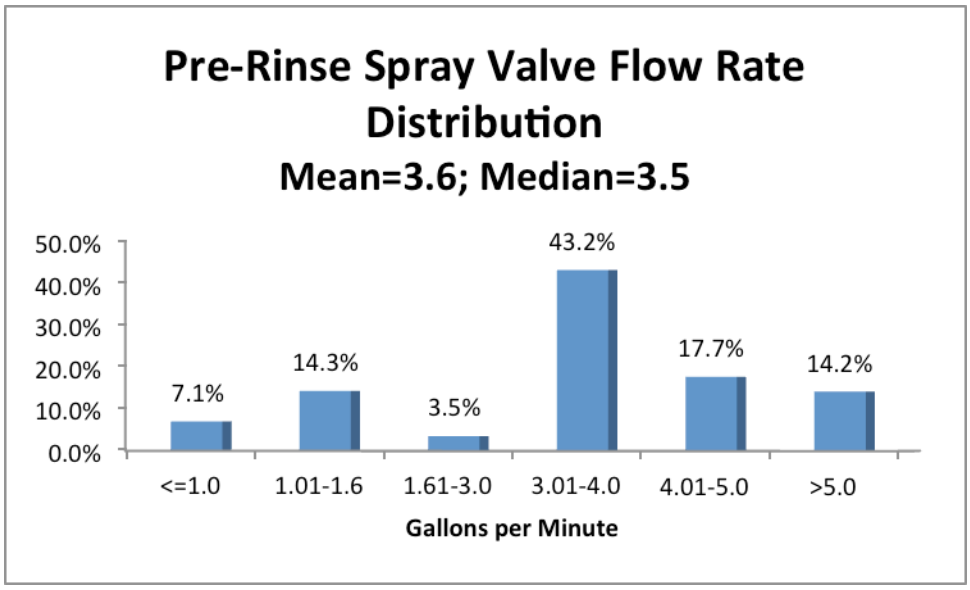

Figure 45 shows the distribution of pre-rinse spray valve flow rates among commercial and institutional facilities in the City of Santa Cruz. The average flow rate of pre-rinse spray valves among the majority of commercial and institutional facilities was between 3.01-4.0 gallons per minute.

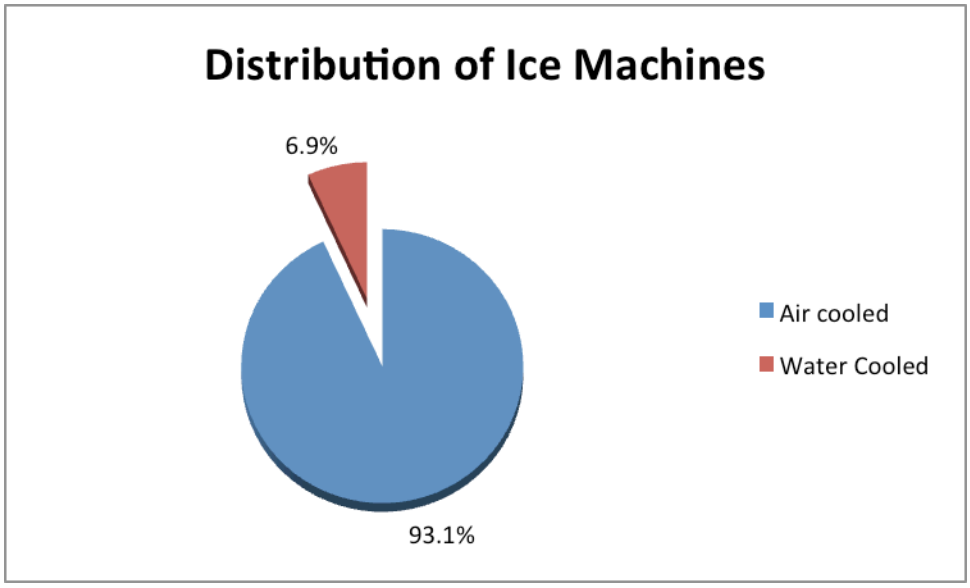

Figure 46 shows the distribution of ice machines among commercial and institutional facilities in the City of Santa Cruz. Air cooled ice machines were found in a majority of the commercial and institutional facilities.

Outdoor Characteristics

Several metrics were developed to describe the non-dwelling unit portion of a lot that has some bearing on water use. These include description of the size and composition of a landscape, plant type, irrigation systems and controllers, water features, and so on. As mentioned earlier, outdoor data were collected from 119 randomly selected commercial sites.

Figure 47 shows the most basic disaggregation of an average commercial lot into its key components. Data collected via the survey suggest that 95.4% of a lot on average is not landscaped, being devoted to the dwelling units and hardscape. Of the remaining area, 2.9% is covered with turf, 1.6% with flowers, trees, or shrubs, leaving 0.1% that is landscaped but not irrigated.

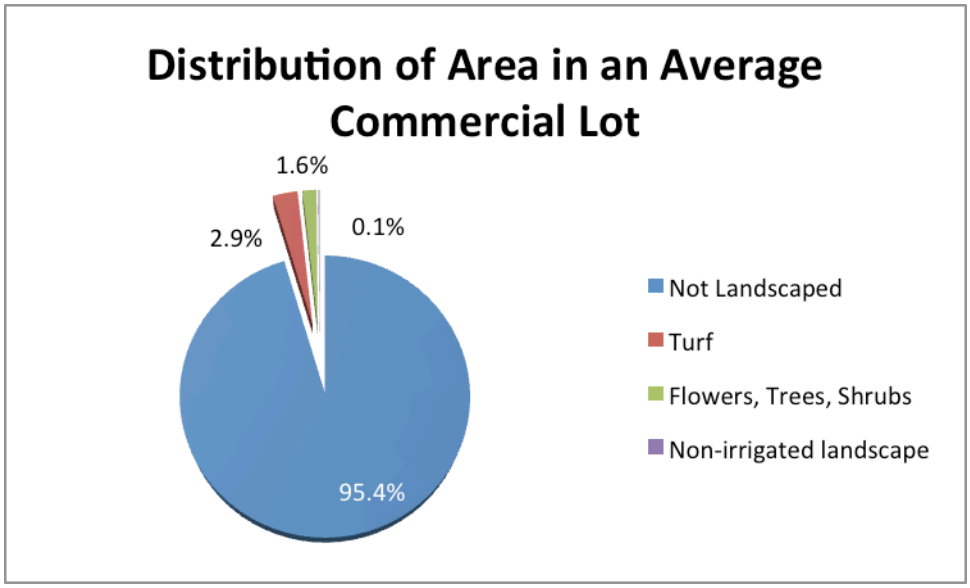

Figure 47 shows a representative distribution of area that a typical commercial or institutional facility has among the facilities of this type within the City of Santa Cruz.

Table 9 shows many more summary metrics that flesh out the varied characteristics of commercial landscapes and water features, while Figures 47 through 57 show how several of these metrics are distributed.

Table 9 –Commercial and Institutional Outdoor Landscape and Water Use Characteristics

Item	Total, Weighted Mean or Proportion
Number of sites surveyed	119
Of all sites, percentage with landscaping	54.0%
Lot size (acres)	2.398
Percent of lot area in landscaping	4.6%
Landscape area (acres)	0.111
Plant Type	
Of all sites, percentage with turf	14.7%
Percent of lot area in turf	2.9%
Percent of landscaped area in turf	62.4%
Turf area (acres)	0.069
Percent of landscape in non-turf area	37.6%
Non-turf landscaped area (acres)	0.042
Distribution of irrigated area by plant water need	Fig. 52
Irrigation Systems	
Percentage of sites with no irrigation	52.5%
Percentage of sites with irrigation status unknown (likely no irrigation)	0.4%
Percentage of sites where all landscape area is irrigated	47.1%
Percentage of sites with mix of irrigated and non-irrigated landscape area	0.0%
Square footage of irrigated area vs. non-irrigated area	4,691 vs. 133
Breakdown of irrigated area by irrigation method (hand watered, manual in-ground, automatic system)	Fig. 53
Percent of sites with lawn watering with in-ground irrigation system	74.4%
Percent of sites with lawn watering with hose/sprinkler	25.6%
Percent of all sites using some drip irrigation	11.8%
Breakdown of sprinkler types	Fig. 54
Breakdown of who manages irrigation	Fig. 55
Average pressure reading (based on 31 sites, 88 unavailable)	70.6 psi
Percent of sites with separate, dedicated irrigation meter	12.0%
Irrigation System Controller	
Number of controllers surveyed	32
Percentage of sites with automatic controllers	23.3%
Average number of controller stations	7.2
Distribution of # stations per property	Fig. 56
# of weather-based controllers, # soil moisture sensors	2/0
percentage with rain sensors	0.4%
Breakdown of how irrigation is managed: never, seasonally, monthly, more often	Fig. 57
Water Features	
Percentage of sites with swimming pools	4.8%
Percent of swimming pools using covers	20.5%

Item	Total, Weighted Mean or Proportion
Average drain/refill interval	1 every 2 years to never
Filter backwashed?	N.A.
Leaks	N.A.
Percentage of sites with spas/hot tubs	2.4%
Percent of spa/hot tubs using covers	20.5%
Average drain/refill interval	Twice per year
Filter backwashed?	N.A.
Leaks	N.A.
Percent of sites with ponds	0.0%
Percent of sites with other water features (Fountains)	2.1%

Table 9 highlights the average number of outdoor landscape characteristics, irrigation equipment, and outdoor water features in proportion to the survey sample for commercial and institutional facilities.

There is wide dispersion in the percentage of a lot that is devoted to landscape: On average it may only be 4.6%, but it can account for as much as 25% or more (Figure 49). It should also be noted that Table 11's estimate of lot area that is devoted to landscape (4.6%) is a ratio of two averages (landscape area over lot area). On the other hand, Figure 48 shows the average of the site-specific ratios (5.5%). The two averages are close, not identical, as there is no reason for them to be so. The latter is of greater interest, however, as discussed next.

With a bit more work, Figure 49's data offer a significant advantage in estimating the error band around average landscape per commercial account. We estimate that a commercial lot has 4,824 square feet of landscape on average (Table 11). The error band surrounding this average estimate is calculated to be roughly ±101%, considerably higher than indoor characteristics because of the greater heterogeneity outdoors. But the error band (95% confidence interval) around the average percentage of a lot that is devoted to landscape in Figure 49 is calculated to be only ±34%. In other words, we estimate that the average proportion of a lot devoted to landscape may vary between 3.6% and 7.3% with 5.5% being the best estimate. If one could estimate lot size without any sampling error, which requires averaging lot size for all commercial sites from the county assessor database, then one could estimate landscape area with only a ±34% band of error, a huge improvement over this sample's results. To be sure, additional massaging of the county assessor database would involve some work and expense, but a lot less than undertaking additional field surveys.

It is also notable that 85.3% of commercial properties either have no landscape or no turf in their landscapes. The estimate of average landscape per commercial site is thus quite a bit influenced by the few sites that have large lots and large landscapes. Any commercial landscape conservation program would need to be specifically target such commercial customers.

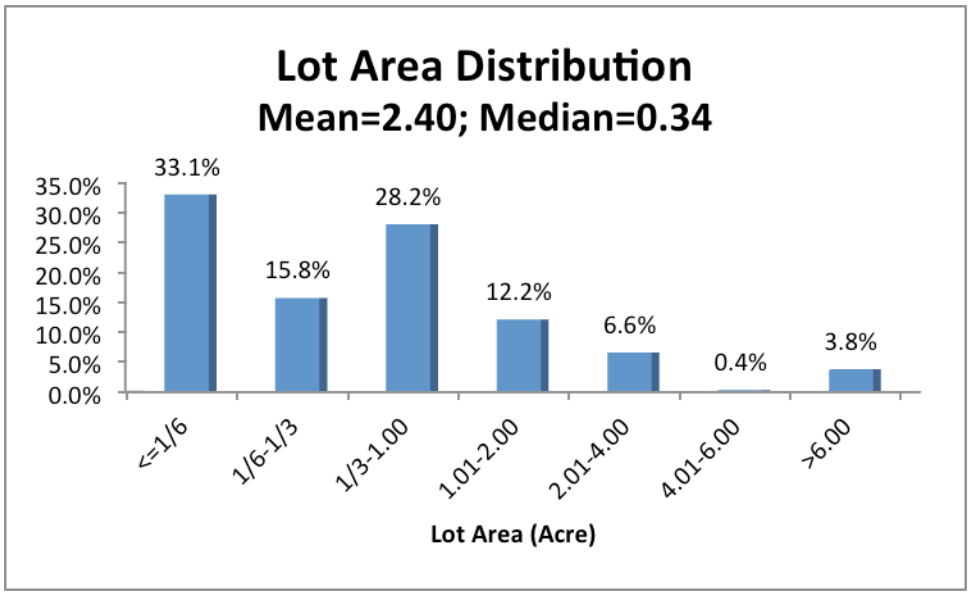

Figure 48 shows the representative distribution of property size in acreage of commercial and institutional facilities within the City of Santa Cruz.

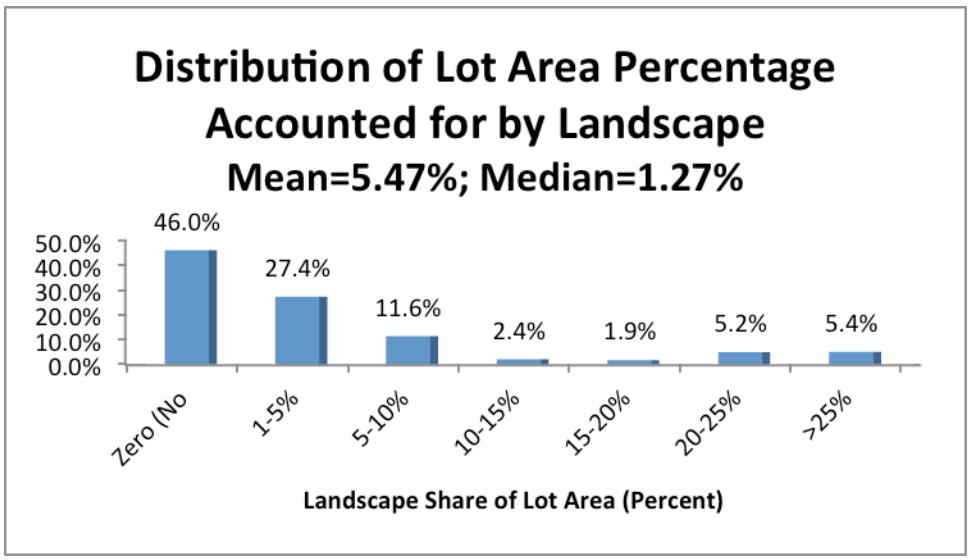

Figure 49 shows the representative distribution of percentage of landscape area by lot among commercial and institutional facilities within the City of Santa Cruz.

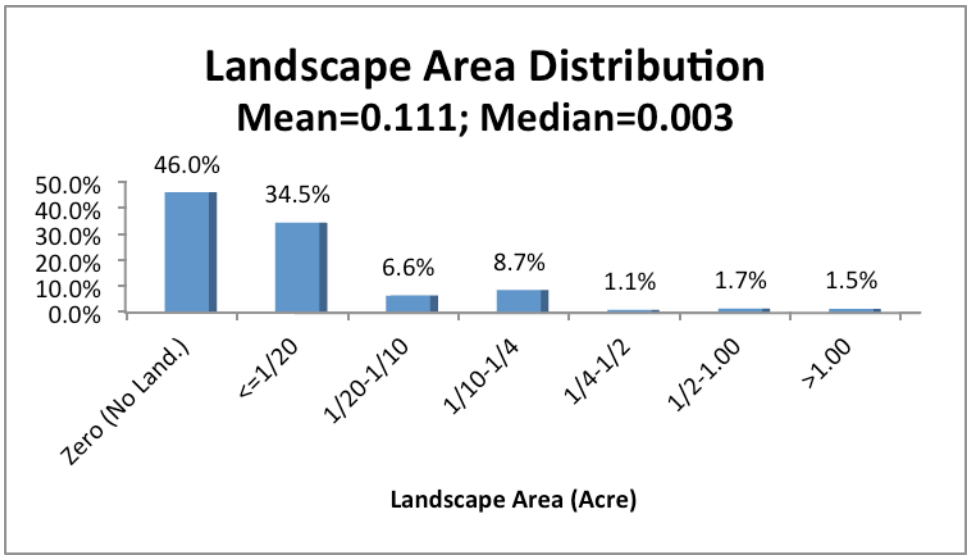

Figure 50 shows the distribution of landscape size among the representative sample of commercial and institutional facilities within the City of Santa Cruz.

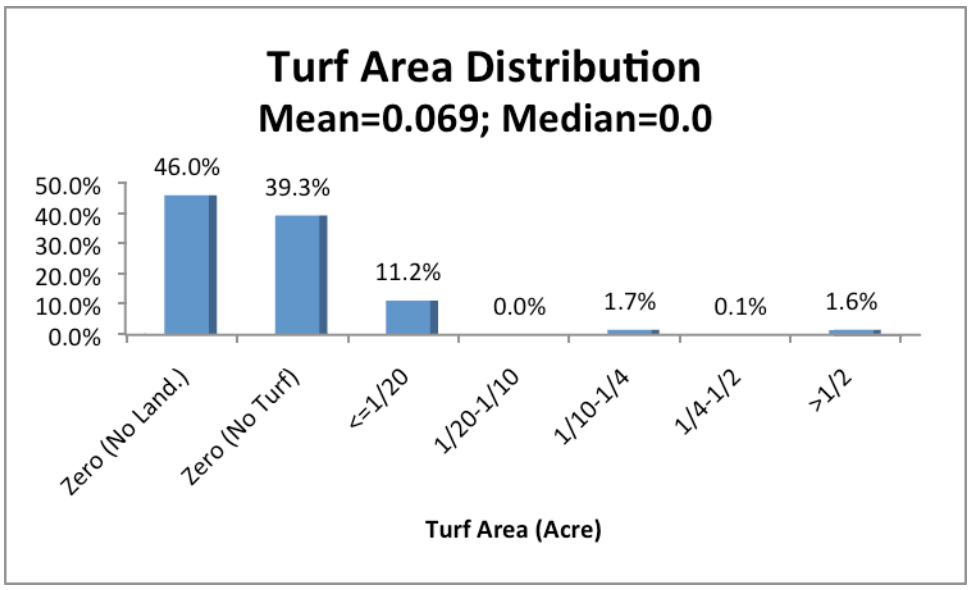

Figure 51 shows the distribution of turf grass area among the representative sample of commercial and institutional facilities within the City of Santa Cruz.

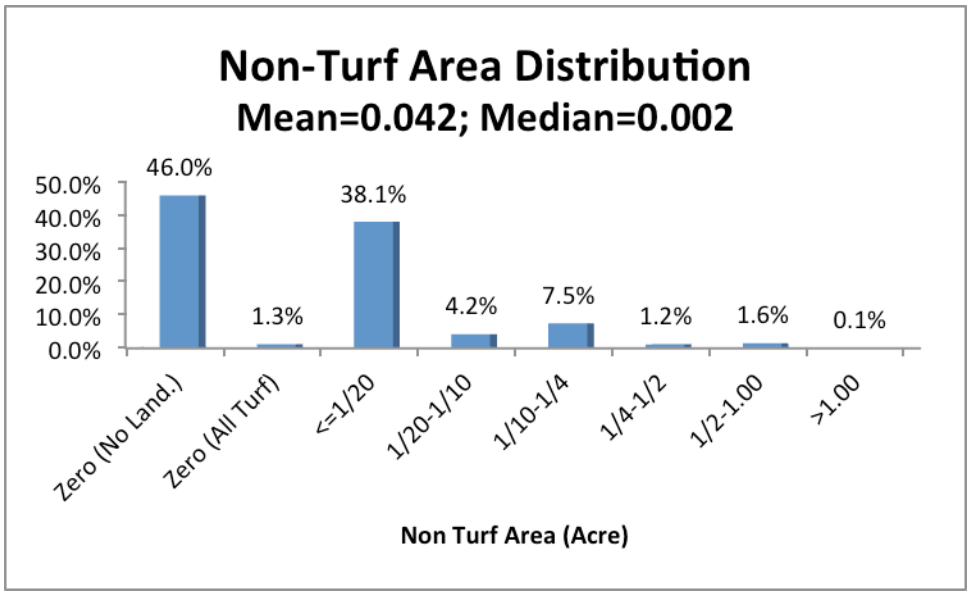

Figure 52 shows the distribution of landscape that was not designated as turf grass area among the commercial and institutional facilities within the City of Santa Cruz. Other types of landscape consisted of trees, flowers, shrubs, etc.

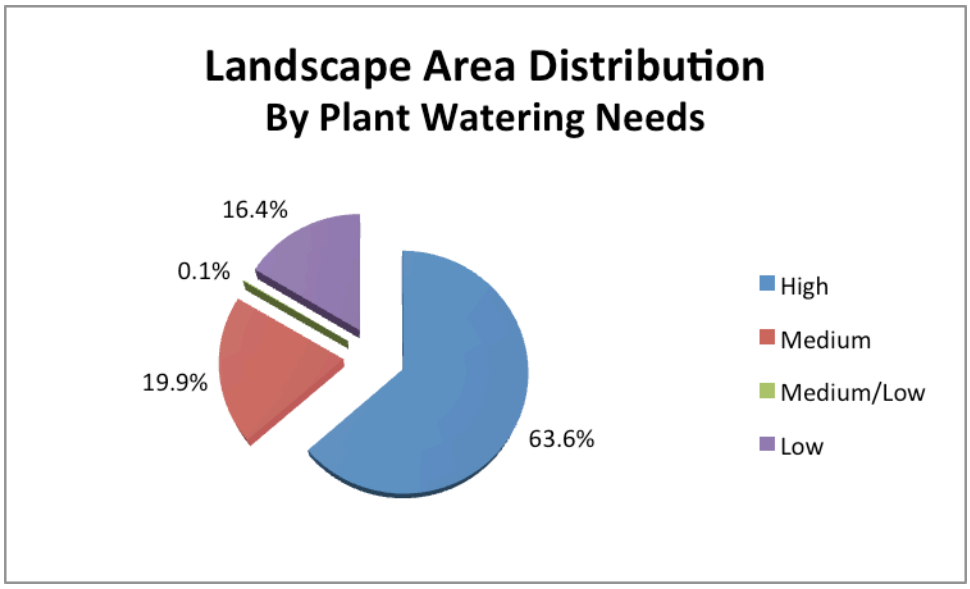

Figure 53 shows the distribution of water need based on plant types found among the commercial and institutional facilities the City of Santa Cruz. High water needs consisted mainly of turf grass area. Medium water needs consisted of flowers, trees, and other plants that were watered at a moderate level. Low water needs consisted of plants shrubs or drought tolerant plants that did not need much upkeep. Landscape areas with mixed levels of water need are due to mixed plant types of varying water needs in the same watering zone.

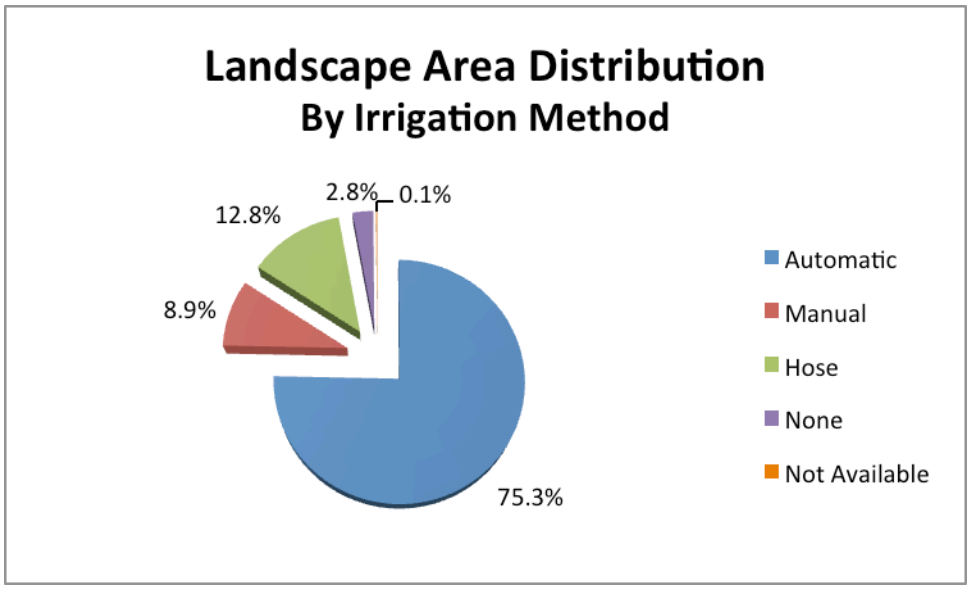

Figure 54 shows the distribution of methods used to irrigate landscape among the commercial and institutional facilities within the City of Santa Cruz. A majority of the landscape irrigation in this group relied on automatic irrigation controllers, followed by customers watering their landscape using hoses.

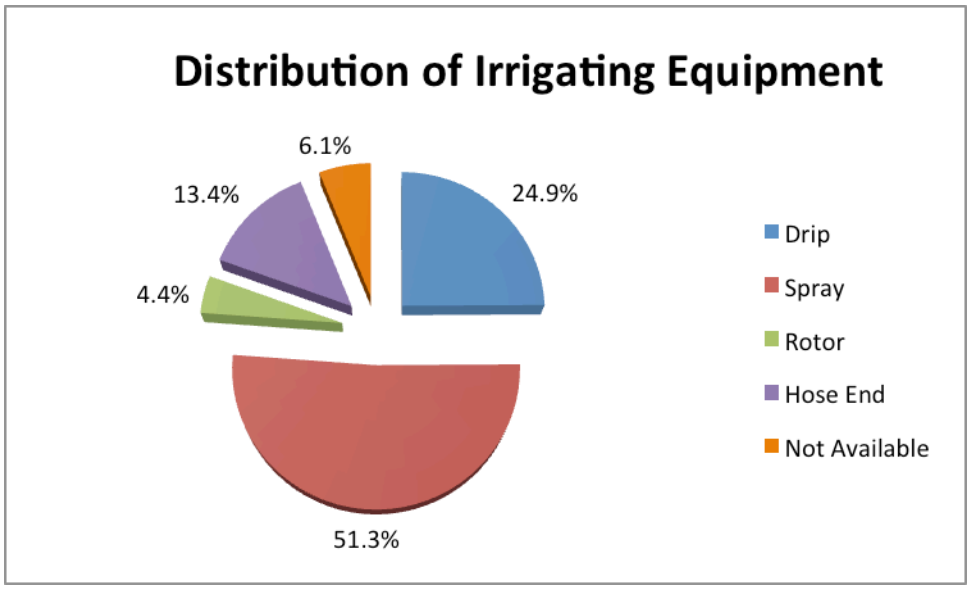

Figure 55 shows the distribution of irrigating equipment used among the commercial and institutional facilities within the City of Santa Cruz. The chart shows that spray type of sprinkler heads cover a majority of the landscape watering equipment in commercial and institutional facilities.

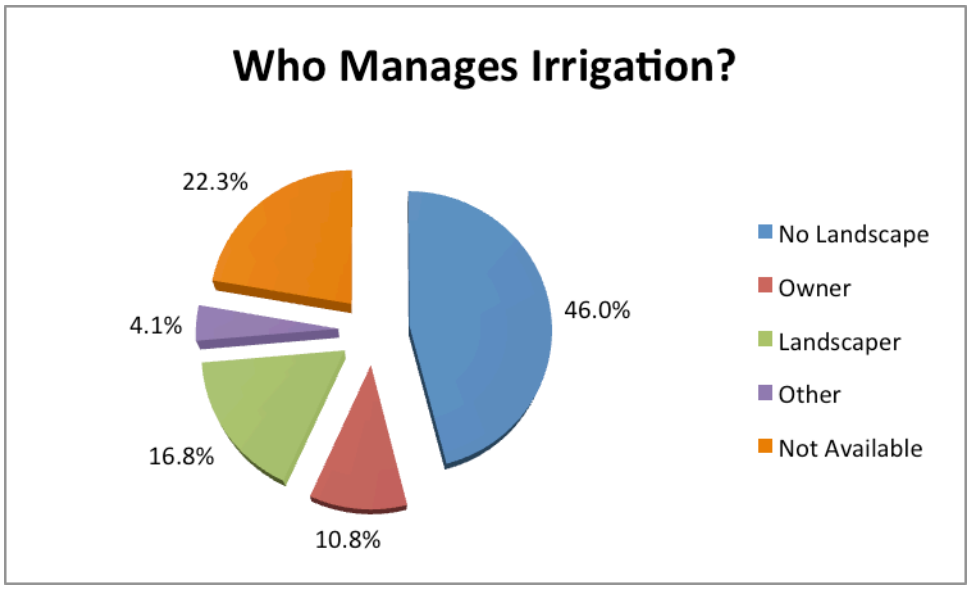

Figure 56 shows the distribution of who takes care of the landscape management among the representative sample of commercial and institutional within the City of Santa Cruz. Although a majority of commercial and institutional facilities did not have landscape, the chart shows that the highest percentage of irrigation management was provided by a landscaper.

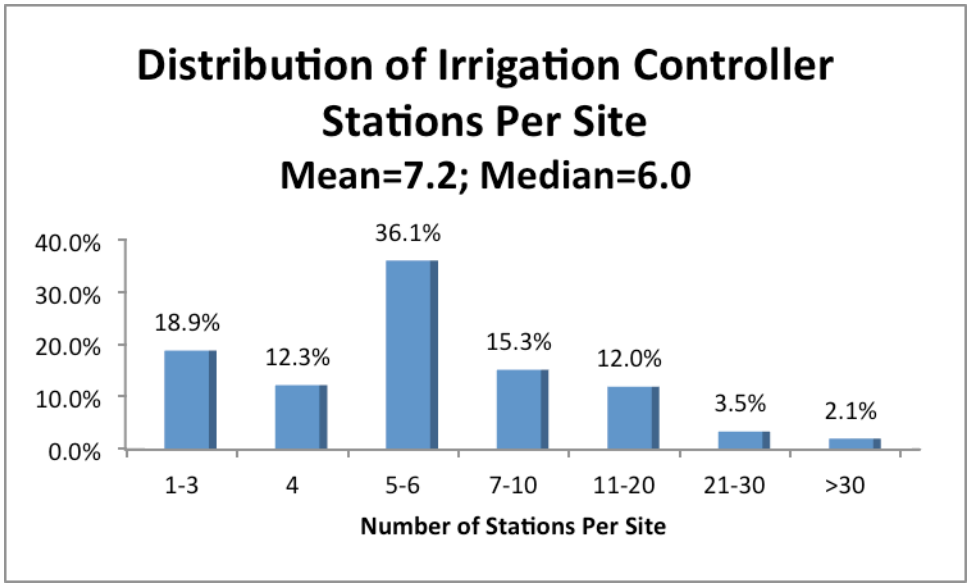

Figure 57 shows the distribution of irrigation stations or zones available per irrigation controller per site at the sampled commercial and institutional facilities within the study area. A higher volume of controllers consisted of 5-6 irrigation stations or zones per controller.

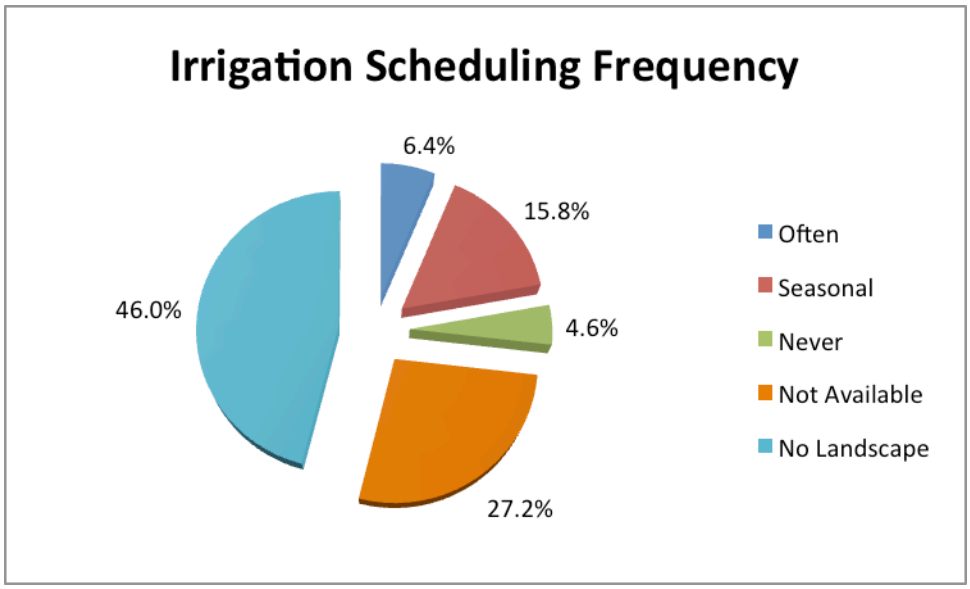

Figure 58 shows the distribution of irrigation frequency among the commercial and institutional facilities within the City of Santa Cruz. The graph shows that a majority of the commercial and institutional facilities adjust their irrigation schedules on a seasonal basis.

Popular Controller Models

The following table (Table 10) shows the most frequently found controller models across all three sectors, in descending order of importance. These few models account for roughly 80% of all controllers surveyed.

Table 10 –Irrigation Controller Popularity

	Controller Model
1	Irritrol Rain Dial
2	Hunter Pro C
3	Irritrol Rain Dial 600
4	Orbit
5	Irritrol Rain Dial 1200
6	Irritrol Rain Dial 900
7	Hunter ICC
8	Rain Bird ISA 304
9	Toro Green Keeper
10	Rain Bird
11	Orbit Irrigation 57900
12	Rain Bird PC 206
13	Toro
14	Richdel
15	Weathermatic SSR 10
16	Irritrol MC 42 Plus
17	Lawn Genie
18	DIG
19	Rain Master RME 24
20	Lego Irrigation
21	Toro ICC
22	Gilmour
23	Gardena T 120
24	Rain Drip
25	Old Mechanical Controller
26	Irritrol Rain Dial Plus

Table 10 represents the frequency of irrigation controllers found throughout the landscape survey portion of the study. The controller models in this table are ranked in descending order from the most common to least common irrigation controller found at a property.

Program Challenges

Throughout the course of the Baseline Survey, there were a number of unforeseen challenges that contributed to delays in the program. Delays came in the form of weak customer participation, minor database issues and changes in program management. However, as each challenge developed, we were able to resolve the issue and maintain the quality of the study.

Customer Participation Challenges

Initial attempts at contacting residential and commercial customers to participate in the Baseline Survey resulted in a tepid response among the different customer types. In the beginning of the program, residential and commercial customers were contacted via phone and/or by email using a cold call style, mailers, and direct site visits to entice customers to participate. Each customer that was initially contacted by this cold call method was informed of the purpose of the program and that their participation would be beneficial for the future of water conservation. Responses to our initial attempts to conduct surveys were met with lack of interest or in some cases, invasion of privacy responses from some customers. After follow up attempts were exhausted, an incentive plan was devised with the assistance of SCWD. The incentives that were offered dramatically boosted participation levels, allowing us to meet our survey sample goals.

Program Management Challenges

During the course of the Baseline Survey, the primary contractor's study team experienced a few management changes. All of the changes in management came from unforeseen events such as program managers leaving to pursue other opportunities. Although management changed hands three times during the course of this survey, we were still able to maintain a high level of quality in the field surveys and integrity of the data that was collected. The data that was collected from the Baseline Survey will be used in part for the Water Conservation Master Plan being conducted by Maddaus Water Management to provide an accurate estimate of the remaining water conservation potential within SCWD's water service area.

Database Challenges

Database issues contributed to program delays in the Baseline Study. Like most databases, a number of bugs have to be worked out before reaching a final working product. While the database was being built, we encountered issues such as data not saving, and tables not linking properly. In spite of this, we were able to make adjustments, work through the issues, and organize all of the collected data. We learned valuable lessons from each challenge and it helped us to provide a better product.

Conclusion

Many lessons were learned throughout the entire process of this study. The team was tested with obstacles in program management, customer participation, database issues, and other unforeseen problems. We overcame these hurdles and in the bargain learned how to circumvent such issues in future programs. Customer participation is always a hot button issue with any type of program. Our understanding of customer behavior became more nuanced over time. Customer interest in our survey increased significantly as incentives began to be offered, a valuable lesson. We also learned how to cope with changes in management without losing momentum. It took active collaboration by all involved parties to reach our objective.

As mentioned earlier, accurate data about household characteristics, especially plumbing fixtures, can only be collected through field audits, which is a very expensive surveying technique. Because resources were limited, we had to devote a great deal of time and attention to devising a sampling strategy that allocated resources in proportion to the importance accorded to a given set of questions. Indoor characteristics were given the highest priority. Our sample design has proven to be very cost-effective in this regard. Outdoor characteristics, such as landscape area per multi-family dwelling unit or per commercial site has not been estimated as precisely as indoor characteristics, but this limitation largely stems from resource constraints, which forced us to curtail sample size. However, we have provided ideas, involving additional county assessor data processing, which if undertaken, can significantly improve the precision of landscape area estimates across all three sectors. We recommend that the Santa Cruz Water Department undertake these additional analyses because they are neither difficult nor expensive to complete. Once complete, then this survey's information will be ready for inputting into models of future water demand. Sensitivity tests of these models should reveal whether future forecasts of water demand are sensitive to assumptions about multi-family and commercial landscape areas, and whether it would be fruitful to invest additional surveying resources in improving the precision of these model inputs.

This survey has succeeded in generating a detailed profile of single family, multi family, commercial and institutional customers served by SCWD. SCWD set out to learn about the saturation level of water efficiency fixtures and appliances within their water service territory and were able to accomplish that goal with this study.