EXHIBIT A-1

TECHNICAL MEMORANDUM 1.1 ANALYSIS OF WATER USE AT THE PRESIDIO OF MONTEREY

FINAL

By

William Y. Davis
Jack C. Kiefer

Planning and Management Consultants, Ltd.
PMCL@CDM A CDM Company
2845 South Illinois Avenue
P.O. Box 1316
Carbondale, IL 62903
(618) 549-2832

Prepared for and Submitted to:

Institute for Water Resources
Decision Methodologies Division
Fort Belvoir, Virginia

and

Directorate of Public Works
Public Utilities Branch
ATZP-DPW-PU
Presidio of Monterey, California

Task Order #36
Contract No. DACW72-00-D-0001

April 2003

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

This technical memorandum documents the analysis of historical water use at the Presidio of Monterey (POM). This memorandum also documents recent water conservation efforts at the POM and provides estimated water savings from these efforts.

Data on annual water use at the POM was obtained from 1967 to 2002. Gaps exist in the available historical water use records due to changes in personnel and record-keeping practices. The data reflects the sum of water use among the four water meters that serve the POM. Historical annual water use is summarized in Figure ES-1.

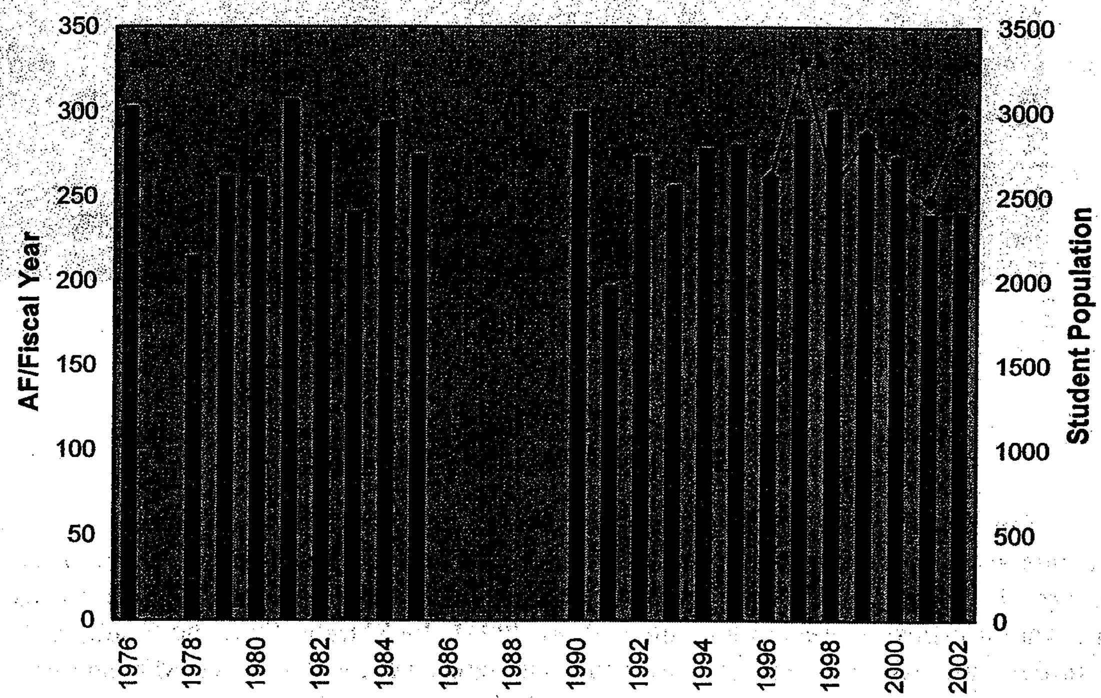


FIGURE ES-1
POM TOTAL WATER USE

Monthly water use data were available from October 1995 to October 2002 with a data gap from April 1994 to October 1995. Monthly water use at the POM is shown in Figure ES-2. The monthly data illustrates the seasonality of water use at the POM. Water use is at its low point of the year during the end-of-year winter break when students leave. Typical indoor use is best represented by water use in November or February when classes are in session yet there is no outdoor irrigation. The high point of the year (i.e., the peak use) typically occurs in July or August.

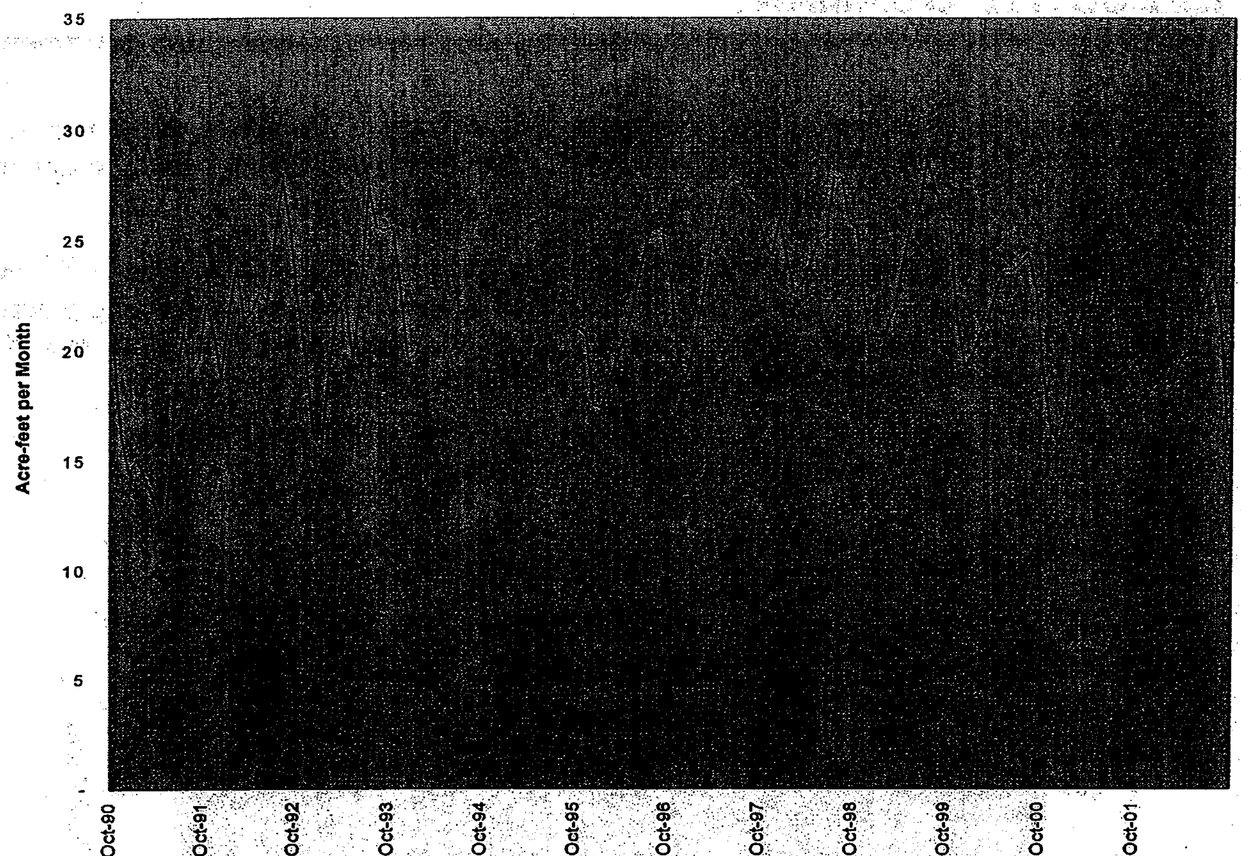


FIGURE ES-2
POM MONTHLY WATER USE

The Department of Public Works (DPW) has initiated a number of water efficiency measures at the POM beginning in 1998 with a showerhead replacement program and an active program to repair distribution system leaks within the POM. In 2000, a series of water conservation efforts were implemented at the POM. In March 2000, the Commandant's water use policy was issued that reinforced the Monterey Peninsula Water Management District's water conservation mandate regarding the scheduling of outdoor water use. In May 2000, the irrigation system at the Hill Top athletic field was replaced with a state-of-the-art system. In August 2000, water-efficient garbage disposal (SOMAT) systems were installed in two dining facilities. From December 2001 to March 2002, more than 170 waterless urinals were installed to replace less water-efficient urinals. In addition, landscape irrigation systems located around barracks that were prone to leaks and maintenance problems were removed.

Four different analytical approaches are used to characterize the conservation water savings:

a. Total water savings and indoor/outdoor water savings are estimated from an analysis of historical water use that compares average monthly water use before and after recent conservation initiatives

b. Total water savings are estimated from a regression analysis of historical water use that accounts for other factors that affect water use

c. Mechanical, or engineering, estimates are used to estimate water savings from two specific conservation measures: the waterless urinals and the SOMAT garbage disposal systems

d. A water use profile of the POM based on building square footage and indoor water use coefficients per square foot is developed for two time periods reflecting *before* and *after* conservation actions

The estimated conservation savings are summarized in Table ES-1, which shows an estimated percent reduction in water use, monthly water use savings in acre-feet per month, and an estimated annual water savings in acre-feet per year for each methodology.

TABLE ES-1
SUMMARY OF FINDINGS

	Percent Savings	Monthly Savings AF/month	Annual Savings AF/year
Comparison of Pre- and Post-Conservation Monthly Use	10.4%[1]	2.38	28.56
Comparison of Pre- and Post-Conservation Peak-Month Use	13.8%[2]	3.79	n/a
Comparison of Pre- and Post-Conservation Low-Month Use	10.2%[3]	1.93	23.16
Comparison of Pre- and Post-Conservation Winter Use (October - May)	7.6%[4]	1.65	19.8
Comparison of Pre- and Post-Conservation Summer Use (June - September)	14.7%[5]	3.82	n/a
FY1998 versus FY2002 Gross Square Footage X Water Use Coefficients	32.1%	5.53	66.37
Estimated Savings from Waterless Urinals and SOMATs	6.4%[1]	1.46	17.53
Regression Analysis Conservation Coefficient	8.95%	2.06	24.68[1]

[1]Assumes pre-conservation use of 22.98 AF per month, or 275.76 AF per year.
[2]Based on pre-conservation peak-month use of 27.4 AF/month.
[3]Based on pre-conservation low-month use of 18.9 AF/month.
[4]Based on pre-conservation winter use of 21.8 AF/month.
[5]Based on pre-conservation summer use of 26.1 AF/month.

The comparison of FY 1998 gross square footage (gsf) times gsf water use coefficients with similar calculations for FY2002 gsf at the POM is deemed to over-estimate savings due to the potential for data inaccuracies and not accounting for other factors that affect water use behavior that may have changed between these two time periods.

The comparison of mean monthly water use data for periods before and after the conservation actions began in March 2000 offers a number of perspectives, such as average monthly savings (2.38 acre-feet per month), winter savings (1.65 acre-feet per month), and summer savings (3.8 acre-feet per month).

Replacing flush urinals with waterless urinals and upgrading the food waste disposal systems in two of the dining halls are estimated to save 1.46 acre-feet per month.

The regression analysis indicates an 8.95 percent reduction in average monthly water use (or 2.06 acre-feet per month) when accounting for monthly seasonality, overall trends in water use, maximum temperature, and precipitation.

In summary, the water conservation activities at the POM since March 2000 have saved an estimated 1.65 acre-feet per month in indoor water use. During the summer months, water conservation efforts are estimated to save an additional 3.8 acre-feet per month. Average monthly water use, which includes both indoor and outdoor water usage, has been reduced by 2.06 acre-feet per month.

The reduction in average monthly water use is illustrated in Figure ES-3, which shows a comparison of monthly average water use before and after the implementation of the conservation efforts.

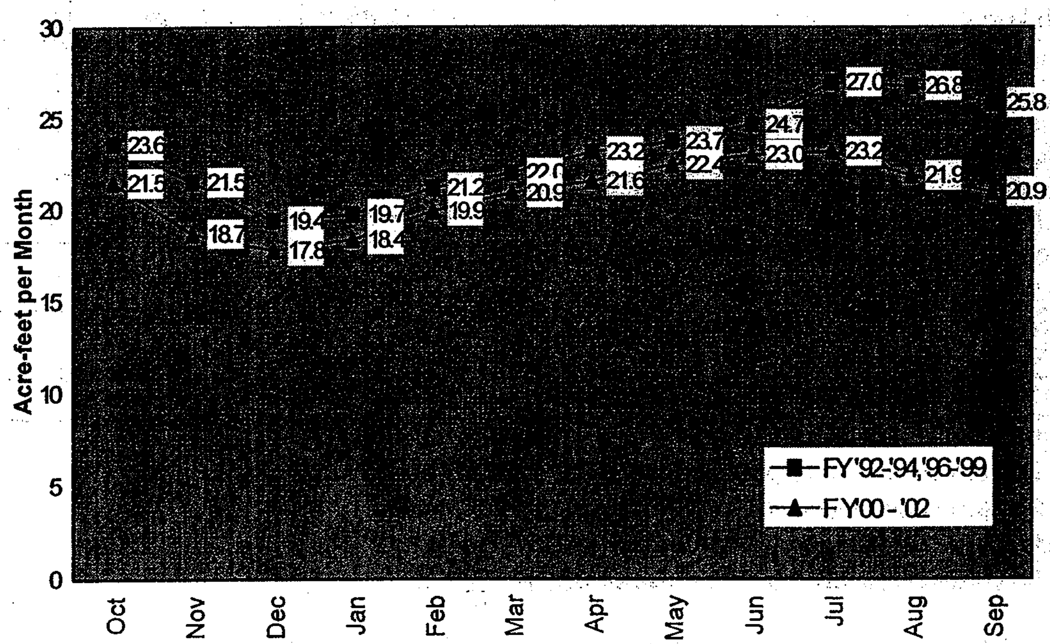


FIGURE ES-3
MONTHLY AVERAGE USE PRE- AND POST-CONSERVATION

I. INTRODUCTION

This technical memorandum documents the analysis of historical water use at the Presidio of Monterey (POM). This memorandum also documents recent water conservation efforts at the POM and provides estimated water savings from these efforts. Four different analytical approaches are used to characterize the conservation water savings.

- Total water savings and indoor/outdoor water savings are estimated from an analysis of historical water use that compares average monthly water use before and after recent conservation initiatives
- Total water savings are estimated from a regression analysis of historical water use that accounts for other factors that affect water use
- Mechanical, or engineering, estimates are used to estimate water savings from two specific conservation measures: the waterless urinals and the SOMAT garbage disposal systems
- A water use profile of the POM based on building square footage and indoor water use coefficients per square foot is developed for two time periods reflecting *before* and *after* conservation actions

The results of these different approaches are synthesized into a summary analysis of water use and water conservation savings at the POM.

BACKGROUND

The POM obtains it's water supply from California-American Water Company (Cal-Am). The source of the water is the Carmel River under the jurisdiction of the Monterey Peninsula Water Management District (the District). Cal-Am serves about 90 percent of the water customers in the District and provides about 80 percent of the water under the jurisdiction of the District.

In July 1995, the California State Water Resources Control Board ordered Cal-Am to reduce the amount of water being pumped from the Carmel River. Resulting conservation ordinances enacted by the District require obtaining sufficient water credits from the District as a result of building demolition or retrofit in order to obtain a water permit from the District for new construction or remodeling. Credits may be obtained from conservation activities within 18 months prior to the permit request, and credits may be held in reserve for a period of up to five years.

The POM is located on about 160 acres adjacent to the City of Monterey and the City of Pacific Grove. The POM functions as a community of its own under the direction of the Base Commandant. However, water delivered to the POM by Cal-Am is included in the District allocation to the City of Monterey. The POM is subject to District regulations and complies with the same water conservation goals as the neighboring communities.

The POM 1985 Master Plan details a schedule of building replacement and new construction to replace aging facilities. The Army is constructing replacement facilities as congressional funds are made available. The District Board of Directors has approved applications for water credits for newly constructed facilities based on preliminary water savings estimates. This memorandum documents the estimated water savings achieved at the POM.

ORGANIZATION OF REPORT

Following this introductory chapter, Chapter II provides an overview of water conservation efforts at the POM. Chapter III presents the available historical water use data and the comparison of average monthly water use from the pre-conservation period and the post-conservation period. Chapter IV describes an estimation of POM water use given the square footage of buildings at the POM in two different time periods. The water savings from the installation of waterless urinals and the SOMAT disposal systems are estimated in Chapter V. The development of a database and regression analysis of monthly water use is presented in Chapter VI. Chapter VII provides a summary of the findings and recommendations. Chapter VIII summarizes the District water production allocations to the jurisdictions served by the California-American Water Company.

II. Recent Water Conservation Efforts at the POM

In 1998, the POM contracted with the City of Monterey, which contracted with the California-American Water Company, to maintain the POM water system, actively repair distribution system leaks at the POM and begin a showerhead replacement program. From 1998 to the present, approximately 700 low-flow showerheads have been installed at the POM.

Also in 1998, the POM partnered with the City of Monterey for the dual use of historic Soldier's Field. A sports field was constructed and the water cannon previously used to irrigate the field was replaced with a state-of-the-art irrigation system.

In 2000, a series of water conservation efforts were implemented at the POM beginning in March 2000 with the issuance of the Commandant's water use policy. This policy mimics the District's water conservation mandate as follows:

- No outside watering on Monday, Tuesday or Friday
- Even addresses may water outside on Sunday and Thursday
- Odd addresses may water outside on Saturday and Wednesday
- Irrigation permitted only between 5 PM and 9 PM unless a drip system is used
- A shut-off nozzle must be used if hand watering or car washing
- Buildings, parking areas and driveways may not be washed with potable water

In May 2000, the irrigation system at the Hill Top athletic field was replaced with a state-of-the-art system. This system utilizes timers and moisture sensors to control the timing and amount of water applied.

In August 2000, water-efficient garbage disposal (SOMAT) systems were installed in two dining facilities.

From December 2001 to March 2002, more than 170 waterless urinals were installed to replace less water-efficient urinals.

In addition, landscape irrigation systems located around barracks were removed. These systems were prone to leaks and maintenance problems. Temporary irrigation systems were used to establish native vegetation and have subsequently been removed.

III. Analysis of Historical Water Use at POM

Water enters the POM through four water meters and flows to individual buildings through a distribution system that is interconnected. Thus, water use at the POM can only be measured as the sum of billed water consumption of the four meters. This water use total includes any system loss that occurs within the POM distribution system. Cal-AM is currently in the process of installing meters on individual buildings within the POM.

Records of water entering the POM system are available by fiscal year (FY). The fiscal year is from October 1 through September 30. Total metered water use by fiscal year at the POM is available since FY 1976, although data are not available for FY 1977, and FY 1986 through 1989. Gaps in the data are due to changes in personnel and inconsistent record-keeping practices.

The available POM annual water use data are shown in Table III-1 and illustrated in Figure III-1. Average annual water use from the available annual data is 269.3 acre-feet per year. Water use in FY 1991 was lower than normal due to drought-related water use restrictions. Lower water use in FY 2001 and FY 2002 is at least partly the result of the water conservation efforts described above.

Figure III-1 also includes available data on student population by fiscal year at the POM. The fluctuation in annual water use is not consistent with the fluctuations in student enrollment (correlation = 0.28). Thus, the variation in water use at the POM is most likely the result of other factors.

TABLE III-1
POM ANNUAL WATER USE

Fiscal Year	Acre-feet
1976	302.7
1977	
1978	214.3
1979	261.5
1980	260.3
1981	306.6
1982	285.5
1983	240.7
1984	294.0
1985	274.6
1986	
1987	
1988	
1989	
1990	299.8
1991	196.7
1992	273.3
1993	256.4
1994	278.0
1995	280.4
1996	261.7
1997	295.6
1998	301.2
1999	287.1
2000	273.4
2001	239.4
2002	240.9

Monthly data are available for FY 1991 through FY 1993 (i.e. October 1990 through March 1994), and FY 1995 through FY 2002 (i.e., October 1995 through October 2002). As with the annual data, the data gap is due to a change in personnel and record-keeping practices. Because of the lag between time of consumption and meter billing date, the monthly-billed consumption data is smoothed to reflect the month of actual consumption. This smoothing process assumes water consumption in a given month includes 50 percent of the current month's billed water use plus 50 percent of the following month's billed water use. For example:

July consumption = 0.5 (July billing) + 0.5 (August billing)

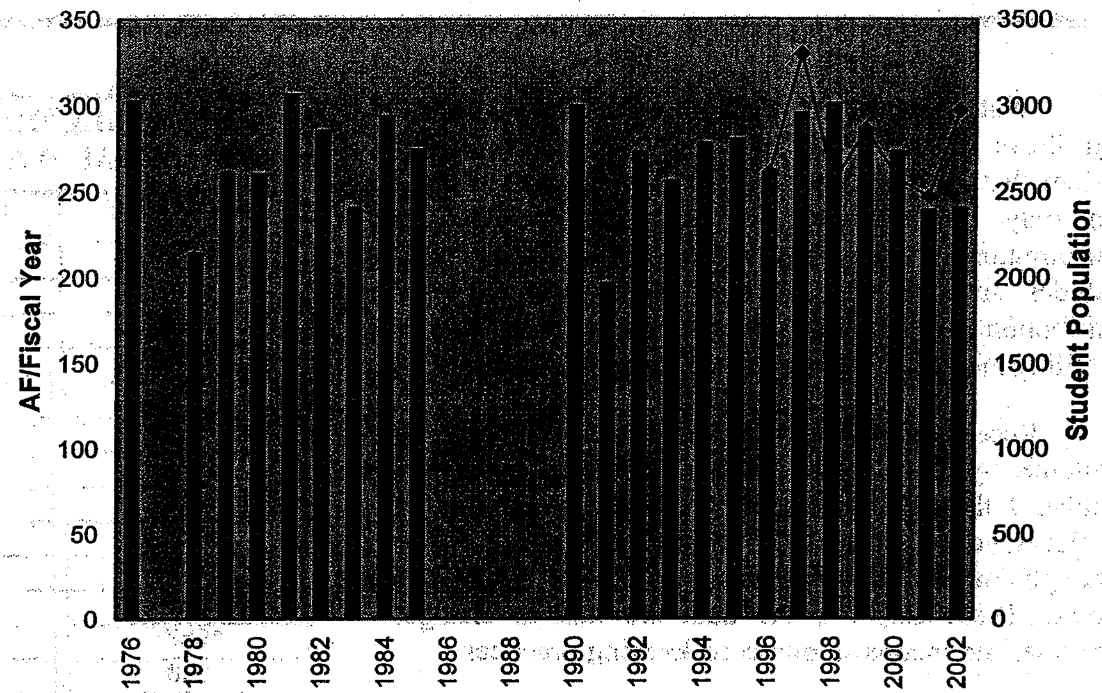


FIGURE III-1
POM TOTAL WATER USE

Monthly-billed consumption is reported in hundred cubic feet (CCF) units. After the smoothing process, the monthly consumption data is converted from CCF to acre-feet. (One acre-foot is equal to 43,560 cubic feet or 325,851 gallons.)

Water use at the POM in acre-feet per month is shown in Figure III-2. Excluding data from FY 1991 when drought restrictions were enforced, the average monthly water use is about 22.3 acre-feet (9,725 hundred cubic feet) per month.

There is a distinct seasonal pattern to water use at the POM. Typically, lowest water use occurs in December and January as a result of the student exodus for the Christmas and New Year's break. Outdoor irrigation typically begins in March or April and ends in October. Typically, the largest quantities of water use occur in July or August. From October 1991 through December 1999, the low winter use was about 19 acre-feet per month and the summer peak use was about 28 acre-feet per month.

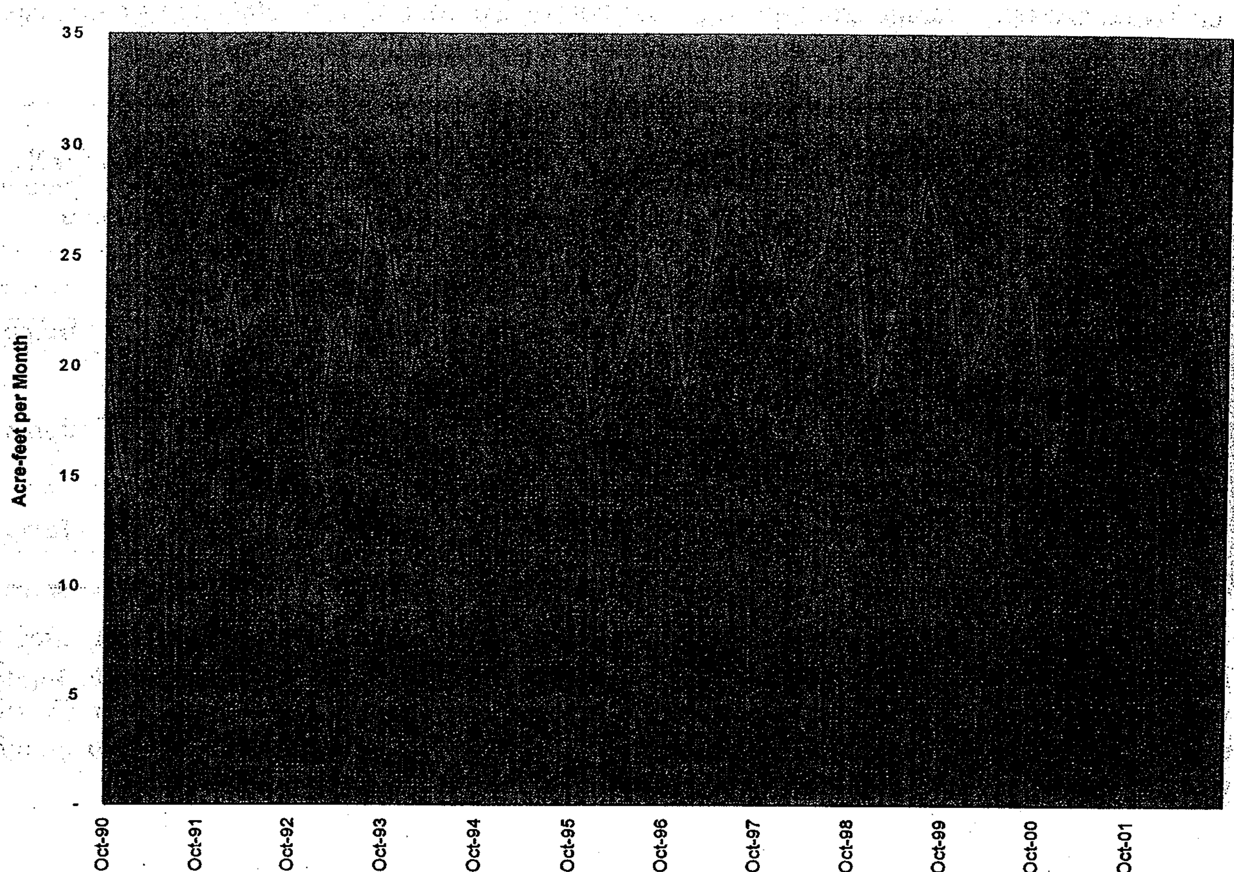


FIGURE III-2
POM MONTHLY WATER USE

Note that the low winter use occurs when students are gone and does not represent typical indoor use at the POM. Typical indoor use is better represented by water use in November or February (21 acre-feet per month) when classes are in session yet there is no outdoor irrigation.

IMPACT ON CONSERVATION ON AVERAGE MONTHLY WATER USE

The general impact of the conservation efforts can be seen in the decrease in monthly water use beginning in the summer months of 2000, as illustrated in Figure III-2. Some of the decrease in water use may be attributed to other factors, such as weather. Table III-2 shows a comparison of monthly water use before and after March 2000. Analysis of the peak-month water use of each year indicates that since March 2000, the summer peak-month water use has been about 3.8 acre-feet per month less than the peak-month water use in previous summers. This represents a 13.8 percent reduction in peak-month usage. This decrease is largely the result of both reduced outdoor water usage and reduced indoor water use. Analysis of the lowest month water use of each year indicates that winter minimum-month water use has decreased about 1.9 acre-feet per month, or 10.2 percent. The decrease in winter minimum-month water use is indicative of reduced indoor water use, however the minimum-month occurs when students are on break. Overall, average monthly water use before and after March 2000 shows a decrease of about 2.4 acre-feet per month. This represents a 10.4 percent reduction in water use.

TABLE III-2
AVERAGE MONTHLY WATER USE BEFORE AND AFTER CONSERVATION

	Oct 91 - Feb 94 Oct 95 - Feb 00		Mar 00 - Sept 02		Difference	
	82	# of months	31	# of months		
Average	22.98	AF/mo	20.60	AF/mo	2.38	AF/mo
					10.4%	
Average summer	6	# of months	3	# of months		
Peak month	27.44	AF/mo	23.66	AF/mo	3.79	AF/mo
					13.8%	
Average winter	8	# of months	2	# of months		
Minimum month	18.87	AF/mo	16.94	AF/mo	1.93	AF/mo
					10.2%	

Figure III-3 shows a comparison of monthly average water use before and after the implementation of the conservation efforts described in Chapter II. Pre-conservation monthly water use shown in Figure III-3 represents the average water use of each month from FY 1992 through FY 1994 and from FY 1996 through FY 1999 (n = 7). The post-conservation monthly water use is the average water use of each month in FY 2000 through FY 2002 (n = 3).

In both the pre- and post-conservation periods, the water use in December and January reflect the drop in water use as students leave the POM for the holiday break. Monthly water use in November and February is more representative of typical indoor water use with students occupying barracks and using classrooms and little or no outdoor water use. In the pre-conservation period, the average indoor water use is approximately 21 acre-feet per month. In the post-conservation months, the average indoor water use is approximately 19 acre-feet per month. Thus, conservation efforts (and any concurrent factors) appear to have reduced indoor water use by 1 to 2 acre-feet per month. The average reduction from November through April is 1.6 acre-feet per month.

As illustrated in Figure III-3, water use in the summer months increases above the average indoor monthly water use. This seasonal increase during the summer months is primarily the result of outdoor irrigation. However, in the post-conservation period, summer water use is significantly less than summer water use in the pre-conservation period. In July, August, and September, conservation efforts appear to have reduced total water use by 4 to 5 acre-feet per month. Given the reduction in indoor use of 1.6 acre-feet per month, the outdoor conservation efforts in the peak months of August and September are about 3.3 acre-feet per month. The average reduction from May through October is 3.1 acre-feet per month. Assuming the 1.6 acre-feet per month reduction from indoor use, the average outdoor reduction from May through October is about 1.5 acre-feet per month.

The comparison of means approach shows that average monthly water use has decreased after March 2000. This reduction is concurrent with the implementation of water conservation efforts. However, other evaluation techniques may be able to separate the impact of weather and other factors from the impact of conservation, particularly in the summer months when outdoor water use is affected by weather conditions.

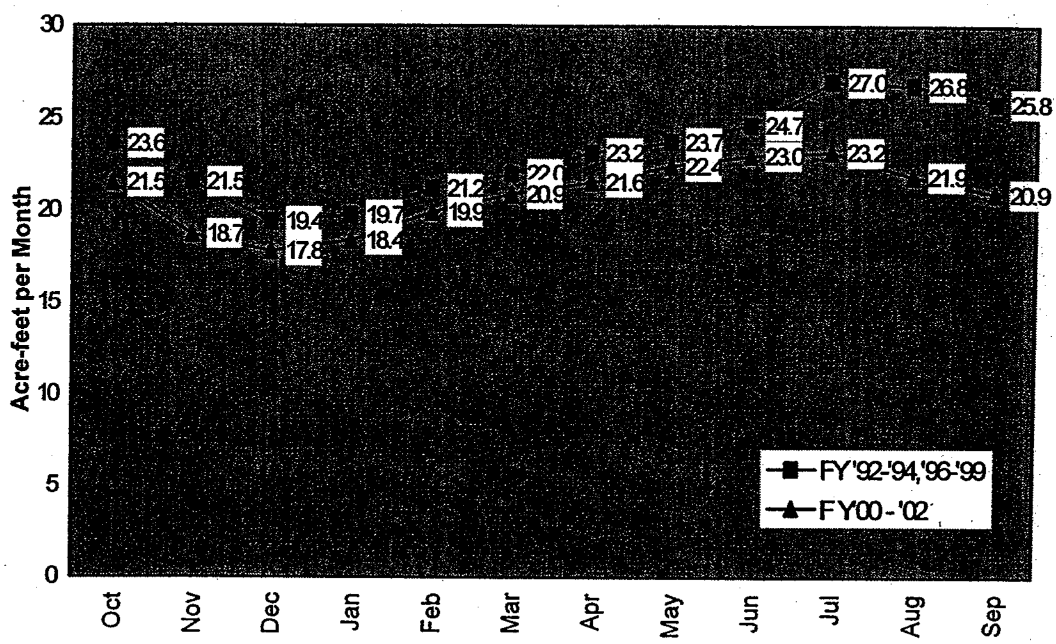
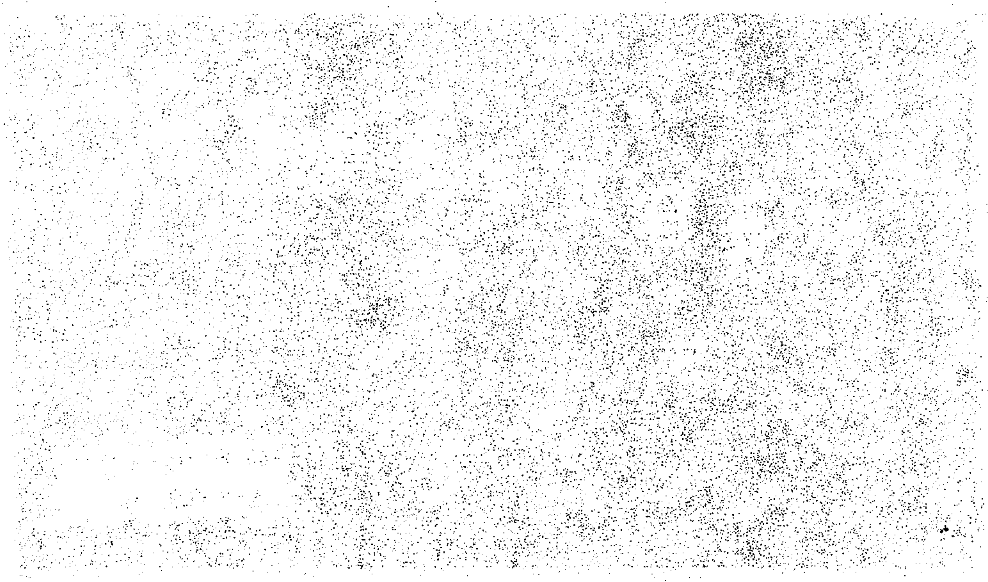


FIGURE III-3
MONTHLY AVERAGE USE PRE- AND POST-CONSERVATION



IV. Requirements-Based Estimation of Water Savings

This chapter presents an approach to estimating water use at the POM that uses water use coefficients, which quantify water use per square foot of building space in conjunction with building square footage at the POM. All U.S. military installations maintain records of building utilization that categorize buildings by function with standardized category codes. These records, known as Real Property Files (RPF), contain building utilization in gross square feet (gsf) for each building at a given installation.

The *Installation Water Resources Analysis and Planning System*© (IWRAPS©) software is a water resource planning tool used to estimate water requirements at Army, Navy and Air Force bases in the continental United States (CONUS). The IWRAPS© algorithms for estimating winter water requirements are based on the building square footage and activity level for each building sector. The IWRAPS© algorithms for estimating summer water requirements are models that include variables for weather, climatic region, and primary mission of the installation. The IWRAPS© software incorporates future construction and demolition of buildings, as well as water conservation and force mobilization, to predict varying future water requirements of a given installation. A detailed description of the original IWRAPS© System is provided in *Volume II: Installation Water Resources and Planning System* (Feather et al., Planning and Management Consultants, Ltd. 1993a)[1].

The IWRAPS© software has been used to estimate water needs at the former Fort Ord as a component of the Environmental Impact Statement required for analysis of the downsizing of Fort Ord associated with base realignment and closure actions (see *Water Requirements at Fort Ord Under Base Realignment and Closure*, Feather et al., Planning and Management Consultants, Ltd. 1993b). Furthermore, IWRAPS© was utilized to develop a water requirements profile for the Presidio of Monterey Annex (POMA) in planning the resource needs associated with the reuse of the former Fort Ord (see *Presidio of Monterey Annex, California, Water Use Profile*, Beezhold et al., Planning and Management Consultants, Ltd. 1999).

The analysis reported in this chapter uses a simplified IWRAPS© approach to estimating the total water requirements of the POM. Water use coefficients (in gallons per square foot per day) for appropriate water use sectors are applied to the Real Property File data from the POM for FY 1998 and FY 2002. The resulting water use estimate for FY 1998 is assumed to represent a pre-conservation level of water use at the POM. The resulting estimate of water use for FY 2002 is assumed to represent a without-conservation estimate of water use, which is then compared to the observed FY 2002 water use. The difference between the estimated and observed FY 2002 water use provides an estimate of water conservation savings, assuming that all other factors remain the same between FY 1998 and FY 2002.

It is important to note that this approach does not constitute a complete IWRAPS© analysis of water requirements at the POM. Such an analysis is beyond the scope of this project. The evaluation reported here does not utilize the IWRAPS© summer water requirements

[1] A Windows-based version of the IWRAPS© software was released by PMCL in 2000.

algorithm and thus does not properly characterize summer irrigation water use, nor does this analysis account for differences in weather conditions between FY 1998 and FY 2002.

Table IV-1 shows the water use coefficients used in this analysis. The coefficients are obtained from studies cited above. The source of each coefficient is identified in Table IV-1. Most of the coefficients are the average rates of water use determined for similar building types from military installations throughout the continental United States (CONUS) and represent the default IWRAPS© coefficients for the respective building type. The water use coefficients for the Post Exchange and family housing are derived from data at Vandenberg Air Force Base, which is located on the California coast south of Monterey. The coefficient for restaurant water use was derived from data specific to the POMA (Beezhold et al., 1999).

TABLE IV-1
IWRAPS© SECTOR WATER USE COEFFICIENTS AND ORIGINS

Water Use Category	Water Use Coefficient[1]	Source
Administration	0.20915	CONUS Average
Barracks	0.15611	CONUS Average
Community	0.06078	CONUS Average
Dining	0.23112	CONUS Average
Exchange	0.32084	Vandenberg AFB
Family Housing	0.2443	Vandenberg AFB
Gym	0.14719	CONUS Average
Health Dental Clinics	0.12282	CONUS Average
Maintenance	0.26235	CONUS Average
Restaurant	0.44105	POMA
Service Station	0.07842	CONUS Average
Warehouse	0.02383	CONUS Average

[1] in gallons per square foot per day.

Table IV-2 summarizes the estimation of FY 1998 and FY 2002 water requirements using the IWRAPS© coefficients. Most of the real property data is summarized into 3-digit category codes, except for some of the community facilities (code 740), which are listed individually. Each building type is associated with a corresponding water use coefficient. The gross square footage of each building type is multiplied by the corresponding water use coefficient to provide an estimate of water use in gallons per day. The gallons per day estimate is multiplied by the number of days per year of operation for the building type to provide an estimate of the annual water use.

Table IV-3 provides a summary and comparison of the estimated water use for 1998 and 2002 with the observed water use for those years. The estimated water use values for both years are within one percent of each other, 346 AF in FY 1998 and 348 AF in FY 2002. The slight increase in estimated water use in FY 2002 is due to the change in square footage among the different building types. Estimated water use for FY 1998 overestimates observed water consumption for FY 1998 by 15 percent. Thus, with all other factors held constant, one would expect the estimation of FY 2002 water use to also be overestimated by 15 percent. However, the FY 2002 water use is overestimated by 47 percent, or an additional 32 percent.

TABLE IV-2
ESTIMATED WATER USE FOR FY 1998 AND FY 2002

Category Code	Code Description	1998 Total Area Gross Square Feet	2002 Total Area Gross Square Feet	Water Use Category	Water Use Coefficient	Estimated 1998 Gallons per Day	Estimated 2002 Gallons per Day	Operation Days per Year	Estimated 1998 Gallons per Year	Estimated 2002 Gallons per Year
131	Communications	59,816	46,892	Administration	0.20915	12,511	9,807	244	3,052,566	2,393,021
141	Operations	57,877	67,642	Administration	0.20915	12,105	14,147	244	2,953,614	3,451,947
171	Training	553,836	560,082	Administration	0.20915	115,835	117,141	244	28,263,691	28,582,441
219	Maintenance	12,061	5,858	Maintenance	0.26235	3,164	1,537	244	772,066	374,990
442	Storage	69,023	70,745	Warehouse	0.02383	1,645	1,686	244	401,336	411,348
540/550	Health Clinics	19,457	19,457	Health Dental Clinics	0.12282	2,390	2,390	244	583,089	583,089
610	Admin General Purpose	98,122	93,132	Administration	0.20915	20,522	19,479	244	5,007,421	4,752,768
711	Family Housing	182,086	182,086	Family Housing	0.2443	44,484	44,484	365	16,236,518	16,236,518
714	Family Housing	10,743	10,743	Family Housing	0.2443	2,625	2,625	365	957,948	957,948
720	Transient Quarters	48,188	48,188	Barracks	0.15611	7,523	7,523	365	2,745,759	2,745,759
721	Enlisted Barracks	659,907	671,422	Barracks	0.15611	103,018	104,816	365	37,601,600	38,257,726
722	Dining	22,059	22,059	Dining	0.23112	5,098	5,098	365	1,860,871	1,860,871
730	Community Facilities	15,751	15,202	Community	0.06078	957	924	244	233,592	225,451
740	Community Facilities	35,078	72,105	Community	0.06078	2,132	4,383	244	520,218	1,069,340
74028	Physical Fitness Ctr	72,759	72,759	Gym	0.14719	10,709	10,709	362	3,876,802	3,876,802
74047	Service Club	8,754	8,754	Dining	0.23112	2,023	2,023	200	404,645	404,645
74052	Gas Svc Station	1,184	1,184	Service Station	0.07842	93	93	244	22,655	22,655
74053	Post Exchange	55,000	55,000	Exchange	0.32084	17,646	17,646	362	6,387,924	6,387,924
74062	Snack Bar	4,050	4,050	Restaurant	0.44105	1,786	1,786	244	435,846	435,846
74068	Recreation Ctr	8,431	8,431	Community	0.06078	512	512	365	187,039	187,039
760	Museum	1,813	1,813	Administration	0.20915	379	379	244	92,522	92,522
Total		1,995,995	1,844,775			367,157	369,188		112,597,721	113,310,650
						1.13 AF/day	1.33 AF/day		345.55 AF/year	347.74 AF/year
									28.80 AF/month	28.98 AF/month

TABLE IV-3 ESTIMATION OF 1998 AND 2002 WATER USE			
	FY 1998	**FY 2002**	**Difference (2002 – 1998)**
IWRAPS© Estimation (AF)	345.55	347.74	2.19
			0.6%
Observed Water Use (AF)	300.97	236.79	-64.18
			-21.3%
Difference (AF)	44.58	110.95	66.4
% of Observed	14.8%	46.9%	32.1%
Average Maximum Temperature (°F)	65.0	62.9	2.1
Total Precipitation (inches)	47.4	15.6	31.8

This additional difference between the estimated and observed 2002 water use may be attributed to water conservation efforts, differences in weather conditions and other factors that affect water use. As noted in Table IV-3, the average daily maximum temperature in FY 2002 was both cooler than in FY 1998 and cooler than the normal annual average of 65.4 degrees (F). Precipitation in FY 2002 was less than the normal average annual precipitation of 19.7 inches of rainfall, suggesting more water use for irrigation than in an average year. Total precipitation in FY 1998 was much greater than normal due to the combined 24.5 inches of rainfall in January and February 1998, although the timing of this surplus rainfall would not be expected to affect water use.

It should be noted that this methodology for estimating conservation savings produces rough estimates due to the potential for inaccuracies in the square-footage data for the two comparison years as well as a lack of direct incorporation of the impact of weather conditions. The methodology as applied here merely compares water use in two points of time without accounting for factors that affect water use. A thorough review of the square-footage data for the two periods, as well as a complete IWRAPS© application, would be recommended. At best, the difference in FY2002 estimated and observed water use suggests a maximum range of conservation effects, which should be narrowed when considering other concurrent factors that impact water use at the POM.

V. Mechanical Estimates of Water Savings from Waterless Urinals and SOMAT Systems

This chapter focuses on the water savings from two specific conservation actions taken at the POM. The first action is the replacement of nearly 170 existing urinals with waterless urinals. The second action is the replacement of dining facility waste-disposal systems with SOMAT state-of-the-art disposals systems. These actions are described in detail. A mechanical approach to estimating water savings is applied to each of these actions. The mechanical approach utilizes engineering design estimates of water use for the various water fixtures to derive estimates of savings once the fixtures are installed.

Waterless Urinals

Beginning in December 2001, the Directorate of Public Works began to replace flush urinals at the POM with waterless urinals. A total of 173 urinals were replaced in non-housing facilities. Urinals in dormitories and barracks were not replaced due to concerns about maintaining proper maintenance of the urinals by transient residents.

Table V-1 lists the buildings in which flush urinals were replaced. For each building the number of urinals retrofitted with waterless urinals is shown. Where known, the average gallon per flush (gpf) flush rate of the replaced fixtures in each building is shown. The flush rate of the replaced urinals ranges from 3.0 gpf to 1.0 gpf. The overall average is about 1.7 gpf. The average flush rate of 1.7 gpf is used in calculations below for buildings for which the replacement flush rate is unknown.

It is necessary to estimate the number of times per day that a urinal is flushed in order to estimate the water savings from replacing a flush urinal with a waterless urinal. The Department of Energy uses assumed values of 30 flushes per day and 260 days per year to calculate the cost-effectiveness of waterless urinals (DOE, Federal Energy Management Program, *How to Buy a Water-Saving Replacement Urinal*, November 2000.) A previous analysis of water conservation potential at the POM (Black & Veatch, 1998) calculated average urinal use in non-housing facilities as follows:

- 4,300 student/teacher/employee population
- 4 restroom visits per day per person (in 8 hour work day)
- 50 percent male
- 50 percent male restroom visits use urinal
- Therefore 4300 total urinal uses per day for non-housing facilities
- 347 urinals at POM (138 in housing, 209 in non-housing facilities)
- Therefore (4300/209) 20.6 flushes per day per urinal in non-housing facilities

TABLE V-1 LOCATION AND FLUSH RATE OF REPLACED URINALS			
Building Type	**Building**	**# Replaced Urinals**	**Flush Rate of Replaced Urinals (GPF)**
Classroom	205	1	
Classroom	206	1	
Classroom	207	1	
Theater	208	2	1
Class/Office	210	3	1
Class/Office	212	3	1
Class/Office	214	3	1
Class/Office	216	3	1
Support facilities	220	1	1
Club	221	3	
Outdoor Rec	228	1	
Logistics warehouse/admin	235	2	
Class/Office	274	3	1
Class/Office	276	3	1
Info center/admin	277	1	
Printing Center	324	2	1
Function Hall/Museum	326	4	3
Center for Cont. Educ.	339	1	
Center for Cont. Educ.	340	1	
Medical/dental clinic	422	2	3
Class/Office	451	3	1
Class/Office	453	3	1
Health/wellness	454	2	
Transportation	517	1	
Classroom	610	24	1.8
Office	614	4	3
Library	617	1	
Classroom	620	6	2.5
Classroom	620	6	2.5
Classroom	620	6	2.5
Classroom	624	5	1
Classroom	624	1	1
Classroom	624	5	1
Classroom	624	5	1
Classroom	630	1	1
Classroom	631	5	3
Classroom	632	2	3
Classroom	634	2	3
Classroom	636	5	3
Classroom	637	5	3
Post Exchange	660	2	1
Gym	842	12	1.6
Student Center	843	1	
Classroom	848	5	1.8
Classroom	848	5	1.8
Classroom	848	5	1.8
Classroom	848	5	1.8
Classroom	848	5	1.8
Total		173	
Average			1.74

The Black & Veatch analysis also assumed 250 days per year of operation at POM non-housing facilities.

For the current analysis of urinal savings, average urinal flushes are calculated on an hourly rate since the POM non-housing facilities have different hours of operation per day. The hourly rate of use is calculated as follows:

- 4,300 student/teacher/employee population
- 66 percent male
- 0.5 restroom visits per hour (i.e., once per two hours)
- 50 percent male restroom visits use urinal
- Therefore 709.5 total urinal uses per hour for non-housing facilities
- 209 urinals in non-housing facilities
- Therefore 3.39 flushes per hour per urinal in non-housing facilities

This hourly rate of urinal use is multiplied times the hours of operation for each building with retrofitted urinals to determine the average number of urinal flushes per day per building. This rate is multiplied times the average replaced urinal flush rate for each building to estimate the gallons saved per day. The gallons saved per day are multiplied times the annual days of operation for each building to calculate the estimated gallons saved per year for each building. These calculations are shown in Table V-2.

Estimated water savings from urinal replacement in the gym (building 842) were calculated differently. The average daily traffic flow at the gym is 1,093 persons per day, of which approximately 80 percent are male. For this analysis, it is assumed that each male visitor to the facility flushes a urinal one time. The calculation for building 842 is shown separately at the bottom of Table V-2.

The retrofit of flush urinals with waterless urinals is estimated to save about 11,490 gallons per day (0.035 acre-feet per day). Given the different days of operation per year of each building, as shown in Table V-2, the waterless urinals save a total of approximately 2,980,271 gallons per year, or 9.063 acre-feet per year.

TABLE V-2
WATER SAVINGS FROM WATERLESS URINAL RETROFIT

Building Type	Building	# Retrofit Urinals	Replaced gpf	Hours per day	Urinal use per hour per urinal	Flushes per day per urinal	Gallons per day saved	Days per year	Gallons per year saved
Classroom	205	1	1.7	10	3.39	33.95	57.7	244	14,081.4
Classroom	206	1	1.7	10	3.39	33.95	57.7	244	14,081.4
Classroom	207	1	1.7	10	3.39	33.95	57.7	244	14,081.4
Theater	208	2	1	4	3.39	13.58	27.2	244	6,626.5
Class/Office	210	3	1	10	3.39	33.95	101.8	244	24,849.5
Class/Office	212	3	1	10	3.39	33.95	101.8	244	24,849.5
Class/Office	214	3	1	10	3.39	33.95	101.8	244	24,849.5
Class/Office	216	3	1	10	3.39	33.95	101.8	244	24,849.5
Support facilities	220	1	1	10	3.39	33.95	33.9	244	8,283.2
Club	221	3	1.7	10	3.39	33.95	173.1	200	34,626.3
Outdoor Rec	228	1	1.7	12	3.39	40.74	69.3	244	16,897.6
Logistics warehouse/ admin	235	2	1.7	10	3.39	33.95	115.4	244	28,162.7
Class/Office	274	3	1	10	3.39	33.95	101.8	244	24,849.5
Class/Office	276	3	1	10	3.39	33.95	101.8	244	24,849.5
Info center/admin	277	1	1.7	10	3.39	33.95	57.7	244	14,081.4
Printing Center	324	2	1	10	3.39	33.95	67.9	244	16,566.3
Function Hall/Museum	326	4	3	10	3.39	33.95	407.4	244	99,397.9
Center for Cont. Educ.	339	1	1.7	10	3.39	33.95	57.7	244	14,081.4
Center for Cont. Educ.	340	1	1.7	10	3.39	33.95	57.7	244	14,081.4
Medical/dental clinic	422	2	3	10	3.39	33.95	203.7	244	49,698.9
Class/Office	451	3	1	10	3.39	33.95	101.8	244	24,849.5
Class/Office	453	3	1	10	3.39	33.95	101.8	244	24,849.5
Health/wellness	454	2	1.7	10	3.39	33.95	115.4	244	28,162.7
Transportation	517	1	1.7	10	3.39	33.95	57.7	244	14,081.4
Classroom	610	24	1.8	10	3.39	33.95	1466.5	244	357,832.4
Office	614	4	3	10	3.39	33.95	407.4	244	99,397.9
Library	617	1	1.7	10	3.39	33.95	57.7	244	14,081.4
Classroom	620	6	2.5	10	3.39	33.95	509.2	244	24,247.4
Classroom	620	6	2.5	10	3.39	33.95	509.2	244	124,247.4
Classroom	620	6	2.5	10	3.39	33.95	509.2	244	124,247.4
Classroom	624	5	1	10	3.39	33.95	169.7	244	41,415.8
Classroom	624	1	1	10	3.39	33.95	33.9	244	8,283.2
Classroom	624	5	1	10	3.39	33.95	169.7	244	41,415.8

TABLE V-2 (CONT.)
WATER SAVINGS FROM WATERLESS URINAL RETROFIT

Building Type	Building	# Retrofit Urinals	Replaced gpf	Hours per day	Urinal use per hour per urinal	Flushes per day per urinal	Gallons per day saved	Days per year	Gallons per year saved
Classroom	624	5	1	10	3.39	33.95	169.7	244	41,415.8
Classroom	630	1	1	10	3.39	33.95	33.9	244	8,283.2
Classroom	631	5	3	10	3.39	33.95	509.2	244	124,247.4
Classroom	632	2	3	10	3.39	33.95	203.7	244	49,698.9
Classroom	634	2	3	10	3.39	33.95	203.7	244	49,698.9
Classroom	636	5	3	10	3.39	33.95	509.2	244	124,247.4
Classroom	637	5	3	10	3.39	33.95	509.2	244	124,247.4
Post Exchange	660	2	1	10	3.39	33.95	67.9	362	24,577.9
Student Center	843	1	1.7	16	3.39	54.32	92.3	365	33,702.9
Classroom	848	5	1.8	10	3.39	33.95	305.5	244	74,548.4
Classroom	848	5	1.8	10	3.39	33.95	305.5	244	74,548.4
Classroom	848	5	1.8	10	3.39	33.95	305.5	244	74,548.4
Classroom	848	5	1.8	10	3.39	33.95	305.5	244	74,548.4
Classroom	848	5	1.8	10	3.39	33.95	305.5	244	74,548.4
Subtotal		**161**					**10,091.2**		**2,473,818.1**

Building Type	Building	# Retrofit Urinals	Replaced gpf	Average daily population	% Male	Urinal use per male	Urinal flushes per day	Gallons per day saved	Days per year	Gallons per year saved
Gym	842	12	1.6	1093	0.8	1	874.4	1,399.0	362	506,452.5
Total		**173**						**11,490.2**		**2,980,270.5**
								0.035 AF/day		9.063 AF/yr

WATER SAVINGS FROM SOMAT SYSTEMS

The SOMAT system is a food waste pulping and dewatering system that replaces the scraping trough (scullary) and garbage disposal system in kitchens. The SOMAT system uses water to move material scraped off plates at the feed tray to a pulper, which cuts the solid waste into a slurry. The slurry flows from the pulper to the water extractor (Hydra-Extractor©) which removes the water and produces an odor-free, semi-dry pulp. The extracted water is returned to the feed tray to complete the closed-loop cycle. The water level in the pulper is automatically controlled. To prevent water from becoming too thick from constant reuse, a small amount of water (1-3 gallons per minute) is bled off from the extractor and replaced with fresh water by the automatic water level control system[2].

A SOMAT system was installed in building #627 and #838. In each building a system of two feed trays and two pulverizers are linked to a single extractor. The new system eliminates the need to separate food scraps, paper and plastic waste; and has reduced by half the time spent by staff in preparing dishes to be washed. The previous system of scullary and garbage disposal operated for a total of about seven (7) hours per day (2 hours at breakfast, 3 hours at lunch and 2 hours at dinner) with a continuous flow of water. Black & Veatch estimated that the garbage disposals used about 5 gallons per minute (gpm) and the scullary used about 6 gpm. The current system is in operation a total of about 3.5 hours per day (1 hour at breakfast, 1.5 hours at lunch, and 1 hour at dinner) and uses about 2 gpm[3].

Previous water use is estimated as follows:

Garbage disposal flow:	5	gpm
Scullary flow:	6	gpm
Total flow:	11	gpm
Hours of operation: 7 hours	420	minutes
Daily water use per building:	4,620	gallons
Number of buildings:	2	
Total daily water use:	9,240	gallons
Days per year operation:	365	days
Annual water use:	3,372,600	gallons
	10.350	acre-feet

---

[2] Information obtained from SOMAT Corporation (www.somatcorp.com).

[3] Hours of operation with both systems obtained from personal communication with Mr. Bent Ramskoff.

Current water use is estimated as follows:

Water use per pulper:	2	gpm
Pulpers per building:	2	
Hours of operation: 3.5 hours	210	minutes
Daily water use per building:	840	gallons
Number of buildings:	2	
Total daily water use:	1,680	gallons
Days per year operation:	365	days
Annual water use:	613,200	gallons
	1.882	acre-feet

Estimated water savings from the SOMAT systems are 7,560 gallons per day or 2,759,400 gallons per year (8.468 acre-feet per year).

VI. Regression Analysis of Monthly Water Use

The historical monthly water use from October 1991 through August 2002 is evaluated with regression analysis. Multivariate regression analysis evaluates the simultaneous effects of independent variables on water use (the dependent variable). Thus, the impacts of water conservation, weather, and other factors that affect water use can be statistically separated. This chapter describes the data used in the regression analysis, the water use model, and the resulting estimate of conservation effects on water use when evaluated concurrently with the impacts of other factors.

Regression Database

A database of monthly water use and associated variables was created for this analysis. The following sections describe variables included in the database.

Monthly Water Use

Traditionally, water demand models are specified as log models given the skewness of water use distributions (i.e., many small water users and a few large water users). When water use is transformed to its log form (natural logarithm), the distribution of use is more like the typical bell-shaped normal distribution. In this analysis, the dependent variable is the natural logarithm of the smoothed monthly water use. For example, the smoothed water use value of 9,686.5 CCF in October 1991 is converted to the natural log (ln) of 9,686.5, which is 9.178. The smoothing of monthly water use data is described above in Chapter III. As noted in Chapter III, there are gaps in the available data due to changes in personnel and inconsistent record-keeping practices. The monthly water use data included in the database extend from October 1991 through February 1994 and from October 1995 through August 2002 (the last month for which concurrent weather data were available). This represents a total of 112 monthly observations.

Seasonality and Trend

To account for the seasonality of water use (i.e., the month-to-month variation in water use described above), binary variables were added to the model as explanatory variables representing the months of the year. Binary variables have a value of either zero or one. For example, the binary variable for January was assigned a value of one for all observations in the data set occurring in January, while the binary variables representing the other months of the year were assigned values of zero; and so on for all months. To avoid perfect multicollinearity among the data, one of the twelve months must be dropped from the model. Thus, the binary variable for December was dropped for the month since December has the lowest average monthly use. The model intercept implies water use in December, the lowest use month, and the parameter estimate for each monthly binary variable indicates the addition to the lowest monthly use due to the seasonality of water use for that month (everything else held constant in the model). Inclusion of binary variables makes the model a partial-log model. Binary variable interpretation is discussed below.

Alternatively, a set of sine and cosine variables (a Fourier series) can be created within the database to reflect cyclical patterns. Each of these variables models a sine or cosine wave of different wave lengths. For example, one sine variable can be defined as having a twelve-month cycle, while a second sine variable can be defined as having a six-month cycle. A Fourier series is often useful in modeling the cyclical patterns in seasonal water use while reducing the required number of variables in the model to represent seasonal patterns. Figure VI-1 illustrates the cyclical patterns defined by sine (1), cosine (1), sine (2) and cosine (2) functions.

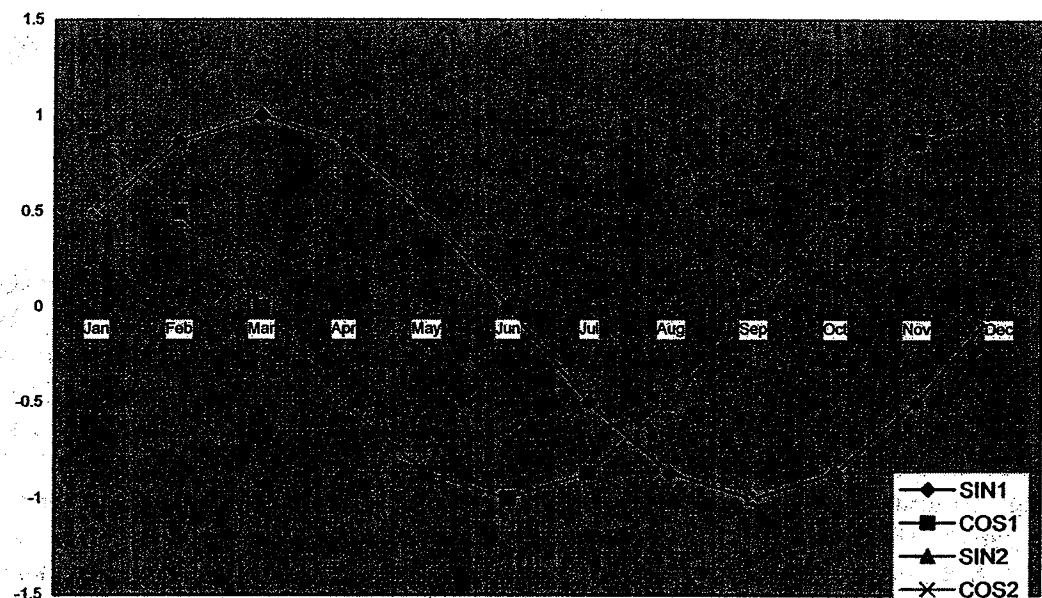


FIGURE VI-1
SINE AND COSINE SEASONALITY

Separate from the seasonal pattern of water use is the issue of trend. Trend is indicated by an increase, or decrease, in water use associated with the passage of time. Thus, a trend variable is merely a function of time, such as numbering the monthly observations 1 through (n). Trend variables may be included in the modeling data set, and if statistically significant in the model are indicative of a systematic change in water use over time. A significant trend variable is usually a proxy for other factors that affect water use that are more difficult to define and isolate and for which data are lacking or incomplete. Linear, square and cubic trend terms are added to the models to account for systematic factors that are not readily measured.

Weather

Two weather variables were included in the data set to determine the relationship between weather and water use: (1) average daily maximum temperature per month, and (2) total monthly precipitation. Historical monthly weather data from January 1949 to August 2002 were obtained for the Monterey weather station from the Western Region Climate Center[4]. These two variables are defined as follows:

- Average daily maximum temperature for the month is calculated as the average of the daily maximum temperatures in degrees Fahrenheit (F)
- Total precipitation is defined as the total amount of rain (in hundredths of inches) for the month

Figures VI-2 and VI-3 illustrate the observed monthly average maximum temperature and total precipitation, respectively, from October 1995 to August 2002. Also shown in Figures VI-2 and VI-3 are the monthly long-term average (i.e., *normal*) values for maximum temperature and precipitation, respectively. Note that since March 2000 (i.e., the conservation period) maximum temperatures have been slightly cooler than normal and monthly precipitation has been less than normal. In theory, the cooler temperatures would result in lower water use while the lower precipitation would be associated with more water use.

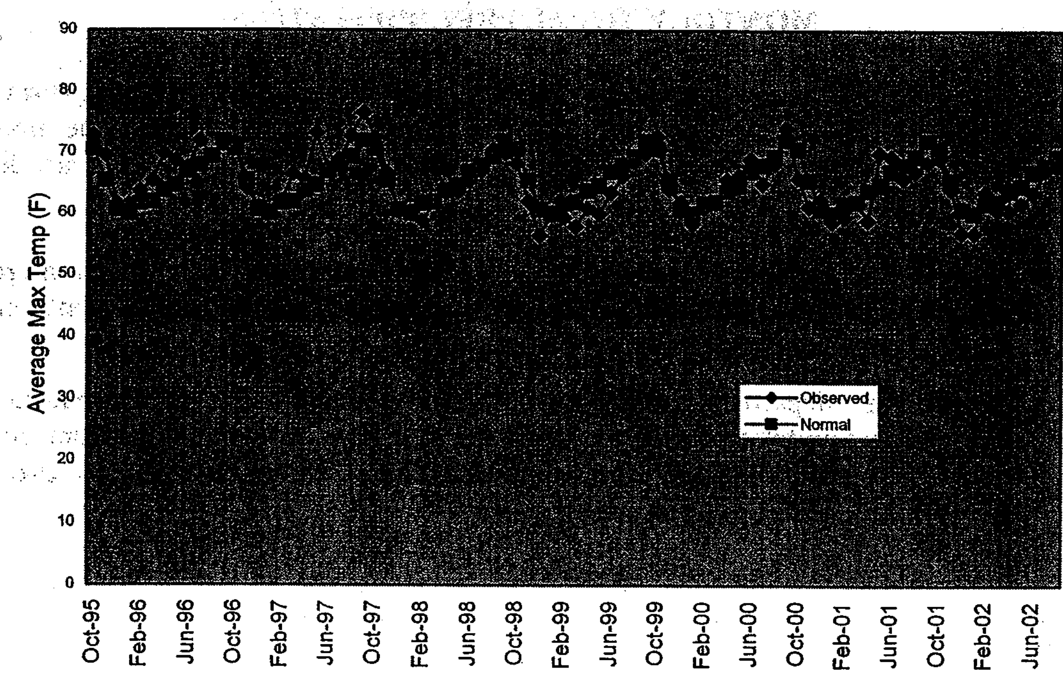


FIGURE VI-2
MONTHLY AVERAGE MIXIMUM TEMPERATURE

[4] (http://www.wrcc.dri.edu).

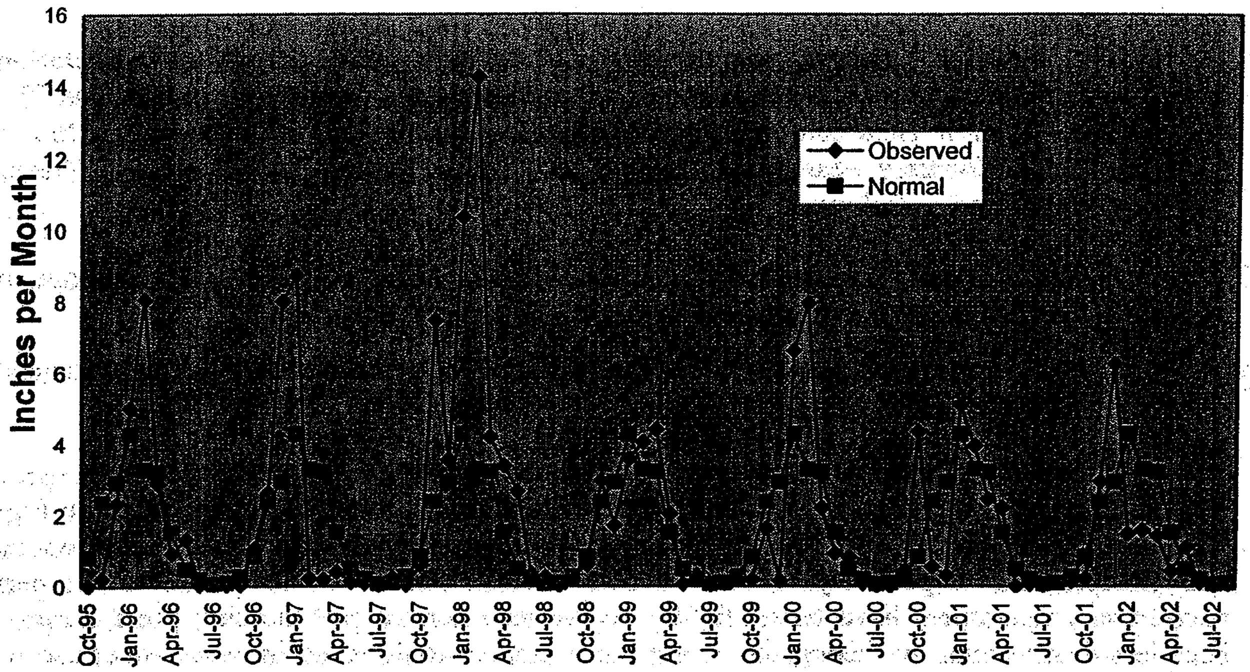


FIGURE VI-3
MONTHLY TOTAL PRECIPIPITATION

The effects of temperature, and rainfall are modeled as deviations from their long-term normals in order to estimate their effects independently from the seasonal component of the models (i.e., the monthly binary variables). Departures are measured in logarithmic form and are defined as follows:

- Logarithmic departure from normal average maximum daily temperature is the natural log of observed average maximum daily temperature for the month minus the average of natural log values for that month.
- Logarithmic departure from normal monthly precipitation is the natural log of observed precipitation for the month (plus 1) minus the average of natural log values (plus 1) for that month. (A value of one is added to all monthly values to avoid taking a log of zero, which is undefined.)

Student Population

The mission of the Presidio of Monterey is to provide language training to U. S. military personnel. The personnel on assignment at the POM for language training (i.e., the students) reside in dormitory-style barracks or apartment-style family quarters. Typically, students have meals, participate in daily physical training, do laundry, etc. within the POM facilities seven days a week. The student population constitutes 67 percent of the POM population (in FY 1997). The remaining 33 percent of the population at the POM are made up of military and civilian language instructors, administrators, and base personnel. The student population since FY 1996 is shown in Table VI-1.

TABLE VI-1
POM STUDENT POPULATION

Fiscal Year	Students
FY96	2607
FY97	3302
FY98	2555
FY99	2859
FY00	2575
FY01	2473
FY02	2974
FY03	3080

Conservation Indicator

The conservation efforts described above in Chapter II are represented in the database by a binary (0/1) variable. This conservation variable is assigned a value of zero in all months up through March 2000. For months after March 2000, the variable is assigned a value of one to represent the presence of conservation actions.

REGRESSION MODELS

A total of 112 observations of monthly water use and other explanatory variables were used to estimate the POM water use model. Numerous combinations of variables were tested statistically in the process of deriving the model with the best unbiased explanatory power. Table VI-2 presents the estimated coefficients of the final model. The variables in the model include seasonal, trend, weather, and conservation components of water use[5].

Models were tested that included the student population variable with a shorter time period representing FY 1996 through FY 2002. The population data varied annually while the water use observations and other explanatory variables changed monthly, thus creating some "noise" in the model. A better explanation of variance was obtained by excluding the student population data and using the longer time period. Some of the effect of student population on variation in water use may be detected by the significance of the trend variables.

The calendar month indicators show that average water use follows a distinct seasonal pattern. The month of July was found, on average, to be the month of peak water use. The month of December was found to have the least average water use and thus was excluded from the model to avoid multicollinearity. (That is, not all 12 months can be represented in the model

[5] The model was fitted using an estimated generalized least squares approach in which the Yule Walker estimation method was used to correct for autocorrelation. The analysis indicated a significant second-order positive autocorrelation process and the models were corrected accordingly.

simultaneously. By eliminating the binary variable for December, the model intercept represents water use in December, the minimum month.)

The trend variables represent continuous patterns throughout the data associated with variance in the monthly water use observations. As stated above, the trend variables may represent other factors that affect water use but which are not represented in the database. Inclusion of the trend variables improves the overall explanatory power of the model and helps to separate the impact of other extraneous factors from the discrete change in water use as a result of conservation actions, as indicated by the binary conservation indicator.

The model indicates that higher than normal average daily maximum temperatures increase average water use. The lag of the maximum temperature variable measures a significant lingering effect of weather occurring in proceeding month. This is due both to the "memory" of past weather events that leads to contemporaneous adjustments in water use and to the remaining effects of billing cycle that could not be eliminated via data smoothing. Furthermore, water use is shown to decrease with greater than normal monthly rainfall.

The conservation indicator is statistically significant in the water use model. Thus, the conservation actions after March 2000 have a significant impact on water use when concurrently accounting for the effects of seasonality, trend, and weather. The binary variable for conservation has a coefficient of –0.0926. The negative sign of the coefficient indicates that, on average, conservation results in reduced water consumption (i.e., results in water savings). However, due to the natural logarithmic transformation of the model, the value of the conservation variable does not translate directly into expected (mean) percent change (decrease) in water use. Rather, the coefficient gives a relative (median) percent interpretation. In order to translate the coefficient estimate into expected (mean) percent change, a small-scale correction must be made. An unbiased estimate of the mean percent water savings can be calculated using the following formula:

$$1 - e^{\beta - 0.5(\sigma^2)} \times 100$$

Where β is the coefficient on the binary variable, and σ_β is the standard error of the coefficient (each shown in Table VI-2). Using this formula, the adjusted estimate of percentage water savings for the conservation effort is calculated as:

$$1 - e^{-0.0926 - .5(0.049^2)} \times 100 = 8.95 \text{ percent}$$

Thus, on average, months after the implementation of conservation show about 9 percent less water use than months prior to implementation, given the other variables in the model.

TABLE VI-2 POM WATER USE MODEL					
Variable	**DF**	**Estimate**	**Standard Error**	**t Value**	**Approx Pr > |t|**
Intercept	1	12.2369	0.0522	234.32	<.0001
Indicator for January (0/1)	1	0.0285	0.0205	1.39	0.1693
Indicator for February (0/1)	1	0.1107	0.0309	3.58	0.0006
Indicator for March (0/1)	1	0.1352	0.0363	3.72	0.0003
Indicator for April (0/1)	1	0.1846	0.0386	4.78	<.0001
Indicator for May (0/1)	1	0.2133	0.0393	5.43	<.0001
Indicator for June (0/1)	1	0.2491	0.0390	6.38	<.0001
Indicator for July (0/1)	1	0.3224	0.0386	8.34	<.0001
Indicator for August (0/1)	1	0.2941	0.0385	7.65	<.0001
Indicator for September (0/1)	1	0.2471	0.0367	6.73	<.0001
Indicator for October (0/1)	1	0.1922	0.0311	6.18	<.0001
Indicator for November (0/1)	1	0.0809	0.0206	3.93	0.0002
Trend 1 (#1, 2, 3,...112)	1	-0.005874	0.003526	-1.67	0.0992
Trend 2 (# squared)	1	0.000144	0.0000619	2.33	0.0223
Trend 3 (# cubed)	1	-8.009E-7	3.0551E-7	-2.62	0.0103
Departure of ln (maxt) from long-term normal	1	0.2654	0.1551	1.71	0.0905
1-month lag of Departure of ln (maxt) from long-term normal	1	0.3477	0.1587	2.19	0.0310
Departure of ln (precip + 1) from long-term normal	1	0.0248	0.0107	-2.32	0.0225
Indicator for conservation (0/1)	1	-0.0926	0.0490	-1.89	0.0618

Dependent Variable: natural log of adjusted daily water use
N = 112
Root MSE = 0.05517
R-Square = 0.875
Durbin-Watson = 1.804
Number of autoregressive terms assumed given = 2

VII. Findings and Recommendations

This report has provided an assessment of water use at the Presidio of Monterey (POM), developed a profile of water use at the POM, and documented water conservation savings resulting from conservation actions at the POM. There has been a significant decrease in water use at the POM since water conservation efforts were begun in the year 2000. This report provides different approaches to quantifying these conservation savings. The estimated conservation savings are summarized in Table VII-1, which shows an estimated percent reduction in water use, monthly water use savings in acre-feet per month, and an estimated annual water savings in acre-feet per year for each analytical methodology.

TABLE VII-1
SUMMARY OF FINDINGS

	Percent Savings	Monthly Savings AF/month	Annual Savings AF/year
Comparison of Pre- and Post-Conservation Monthly Use	10.4%[1]	2.38	28.56
Comparison of Pre- and Post-Conservation Peak-Month Use	13.8%[2]	3.79	n/a
Comparison of Pre- and Post-Conservation Low-Month Use	10.2%[3]	1.93	23.16
Comparison of Pre- and Post-Conservation Winter Use (October - May)	7.6%[4]	1.65	19.8
Comparison of Pre- and Post-Conservation Summer Use (June - September)	14.7%[5]	3.82	n/a
FY1998 versus FY2002 Gross Square Footage X Water Use Coefficients	32.1%	5.53	66.37
Estimated Savings from Waterless Urinals and SOMATs	6.4%[1]	1.46	17.53
Regression Analysis Conservation Coefficient	8.95%	2.06	24.68[1]

[1]Assumes pre-conservation use of 22.98 AF per month, or 275.76 AF per year.
[2]Based on pre-conservation peak-month use of 27.4 AF/month.
[3]Based on pre-conservation low-month use of 18.9 AF/month.
[4]Based on pre-conservation winter use of 21.8 AF/month.
[5]Based on pre-conservation summer use of 26.1 AF/month.

The comparison of FY 1998 gross square footage (gsf) times gsf water use coefficients with similar calculations for FY2002 gsf at the POM, and with observed FY 2002 water use, results in an estimated reduction in water use of about 66 acre-feet, or a 32 percent reduction in annual water use. This estimate is deemed to over-estimate savings due to the potential for data inaccuracies and not accounting for other factors that affect water use behavior that may have changed between these two time periods.

The comparison of mean monthly water use data for periods before and after the conservation actions began in March 2000 offers a number of perspectives. Average monthly use decreased 10.4 percent for annual savings of about 29 acre-feet. However, this comparison does not adjust for weather differences between the pre- and post-conservation time periods that may affect water use, particularly in the summer months in which outdoor irrigation occurs.

Comparison of the peak month of each year in the before and after water conservation implementation (i.e., pre- and post periods) shows a 13.8 percent reduction in peak month water use for average savings of 3.8 acre-feet in the peak month. Similarly, water use in the high use summer months of June through September show an average of 3.8 acre-feet per month reduction, or about 14.7 percent reduction in average summer monthly water use. Approximately half of these water savings are attributed to outdoor water use reductions.

Comparison of the lowest monthly use in each year in the pre- and post periods shows an average reduction of 1.9 acre-foot, or 10.2 percent, in the low-month water use. However, the lowest-month water use typically occurs during the winter break when students have left the POM. Average water use in the winter (or non-irrigation season) months of October through May shows a reduction of 1.65 acre-feet in average monthly use from the pre-conservation period to the post-conservation period. This represents a 7.6 percent reduction from the pre-conservation period average winter monthly use. This reduction in water use is indicative of the indoor water conservation savings.

Two of the conservation actions that impact indoor water use were evaluated from an engineering approach. This approach calculates the daily impact of water using fixture replacement and then estimates the resulting annual savings. Department of Public Works at the POM invested in replacing flush urinals with waterless urinals and also replaced the food waste disposal systems in two of the dining halls. These two conservation efforts are estimated to save 1.46 acre-feet per month, or 17.5 acre-feet annually. This represents a 6.4 percent reduction in average monthly water use given the pre-conservation average monthly use of 23 acre-feet per month. The water savings from these two conservation actions represent about 88 percent of the 1.65 acre-foot reduction in indoor water use. The remaining reduction in indoor water use can be attributed to replacement of showerheads and behavioral changes in response to the Commandant's order to improve water efficiency at the POM.

Finally, statistical regression analysis was used to evaluate variations in monthly water use with respect to seasonal patterns, trends, monthly weather, and the implementation of conservation actions at the POM. Unlike the comparison of pre-and post conservation period water use averages, this approach controls for the impact of weather and other systematic factors with respect to water use. The regression analysis indicates an 8.95 percent reduction in average monthly water use when accounting for monthly seasonality, overall trends in water use, maximum temperature, and precipitation. Given the pre-conservation period average monthly use of 23 acre-feet, the 8.95 percent reduction translates into average water savings of 2.06 acre-feet per month, or 24.7 acre-feet annually.

In summary, the water conservation activities at the POM since March 2000 have saved an estimated 1.65 acre-feet per month in indoor water use. During the summer months, water conservation efforts have saved an estimated 3.8 acre-feet per month. Average monthly water use, which includes both indoor and outdoor water usage, has been reduced by 2.06 acre-feet per month.

RECOMMENDATIONS

First, and foremost, it is important to continue to collect and archive data. Monthly water consumption is currently the aggregate data of four meters. As buildings at the POM become individually metered, the volume of consumption data will increase, as will the ability to conduct more detailed water use analyses. A system should be in place to archive monthly consumption data by facility. This will not only facilitate the aggregation of monthly consumption data, but also enable future analyses of water use at the facility level.

Data on the POM student enrollment and base population should also be archived, as it becomes available. A log, or chronology, of all conservation activities should be maintained as well.

Given sufficient facility-level data, comparisons of water use can be made between buildings that have been retrofitted with water efficient fixtures and similar buildings that have not been retrofitted.

It is recommended that the database used in this analysis be updated. Analysis of water use patterns at the POM may be further refined with facility-level data and data from a longer period of record.

VIII. A Note on the Monterey Peninsula Water Management District Water Allocation

The Presidio of Monterey (POM) receives its water from the California-American Water Company (Cal-AM). The water is under the management of the Monterey Peninsula Water Management District (the District). The District provides water via Cal-Am and other water purveyors to the following jurisdictions:

- City of Monterey
- Carmel-by-the-Sea
- Pacific Grove
- Seaside
- Sand City
- Del-Rey Oaks
- Monterey Peninsula Airport District
- Unincorporated areas of Monterey County, including Pebble Beach and Carmel Valley

Water used by the POM is through the jurisdiction of the City of Monterey.

In 1980, the Cal-Am total system water production limit was set at 20,000 acre-feet per year. This limit was estimated as an average water demand under normal hydrologic conditions. This system production limit was allocated among seven jurisdictions based on housing counts and water demand projections provided by the jurisdictions. (Note that the Monterey Peninsula Airport District was not a jurisdiction at that time.) The allocation of Cal-Am total production up to November 1990 is shown in Table 1.

In 1990, the Cal-Am production limit was lowered to 16,744 acre-feet per year and the allocation formula was modified. The production limit was lowered to account for water supply problems that occur during dry (rather than normal) hydrologic conditions and to account for environmental impacts of water withdrawals from the Carmel River. This allocation is shown in Table 2.

TABLE VIII-1
APRIL 1981 - NOVEMBER 1990
WATER ALLOCATION PROGRAM: CAL-AM ANNUAL PRODUCTION LIMIT = 20,000 AF

Jurisdiction	%	AF
Carmel	5.542%	1,108
Del Rey Oaks	1.318%	264
Monterey	**30.890%**	**6,178**
Pacific Grove	12.641%	2,528
Sand City	1.799%	360
Seaside	12.858%	2,572
Monterey County	34.952%	6,990
Total	100.000%	20,000

Source: MDWMD

The production limit was subsequently raised as a result of development of the Peralta well in Seaside, retirement of non-Cal-Am water use on golf courses, and other minor adjustments. Table 3 shows the supplemental allocation of the Paralta well supply. A later reallocation of the Peralta Allocation was made in February 1995. This allocation came from an uncommitted portion of the District allocation in Table 3. As shown in Table 4, the additional 37.33 acre-feet per year was equally distributed among the jurisdictions.

TABLE VIII-2
NOVEMBER 1990 - JULY 1993 WATER ALLOCATION PROGRAM: CAL-AM ANNUAL PRODUCTION LIMIT = 16,744 AF

Jurisdiction	%	AF
Carmel	5.543%	928
Del Rey Oaks	1.326%	222
Monterey	**32.930%**	**5,514**
Pacific Grove	12.685%	2,124
Sand City	1.800%	301
Seaside	12.858%	2,153
Monterey County	32.757%	5,485
MP Airport District	0.101%	17
Total	100.000%	16,744

Source: MDWMD

The current Cal-AM system total production limit has been 17,641 acre-feet per year since 1997. However, in 1995 the California State Water Resources Control Board ruled that 70 percent of water Cal-Am withdrawals from the Carmel River was illegal usage. Nonetheless, Cal-Am was allowed to continue to use 80 percent of its District allocation. Thus, the current allocation of 17,641 acre-feet per year to Cal-Am is limited to 15,285 acre-feet per year.

It is assumed that 7 percent of the Cal-Am production limit goes to unaccounted-for water losses. Therefore, consumption limits are 93 percent of the production allocation. This loss adjustment applies to the Cal-Am total as well as the allocation to each jurisdiction.

TABLE VIII-3
JULY 1993 SUPPLEMENTAL WATER ALLOCATION: AVAILABLE ANNUAL PARALTA WELL PRODUCTION = 385 AF

Jurisdiction	%	AF
Carmel	4.209%	16
Del Rey Oaks	1.050%	4
Monterey	**20.106%**	**77**
Pacific Grove	5.986%	23
Sand City	13.274%	51
Seaside	17.070%	66
Monterey County	23.288%	90
MP Airport District	1.050%	4
MPWMD	13.966%	54
Total	100.000%	385

Source: MDWMD

TABLE VIII-4
FEBRUARY 1995 WATER ALLOCATION ADJUSTMENT: REMAINDER OF MPWMD PARALTA PRODUCTION = 37.33 AF

Jurisdiction	%	AF
Carmel	12.500%	4.67
Del Rey Oaks	12.500%	4.67
Monterey	**12.500%**	**4.67**
Pacific Grove	12.500%	4.67
Sand City	12.500%	4.67
Seaside	12.500%	4.67
Monterey County	12.500%	4.67
MP Airport District	12.500%	4.67
Total	100.000%	37.33

Source: MDWMD

City of Monterey Allocations and Accounts

The City of Monterey has a historical allocation that is a portion of the Cal-Am production allocation. This historical allocation is based on "grand-fathered" historical use by the City in 1980 and amounted to 6,178 acre-feet per year. This allocation was lowered to 5,514 acre-feet per year in November 1990 when the Cal-Am limit was reduced. This decrease in allocation resulted in a moratorium on new water permits.

As of 1993, all water use by the jurisdictions was assumed to be legal and permitted. Between 1980 and 1993, changes in the allocation methodology resulted in an additional 52 acre-feet allocated to the City in what is referred to as the "Pre-Peralta account."

In 1993, water production at the Peralta well in Seaside was increased by 385 acre-feet per year. This additional supply is referred to as the "Peralta account," of which the City of Monterey is permitted to use 76.32 acre-feet per year.

The City of Monterey has a third account of permitted water known as the "Public Credit account." This account accumulates, or "earns" water use credits as a result of permanent and provable water conservation actions. For example, conversion of park irrigation meters from potable water to reclaimed water "earned" the City a credit of 29 acre-feet per year. The City may then use up to 85 percent of the earned credit, while the District retains the remaining 15 percent.

Expansion of Jurisdictions

Water credits "earned" as a result of demolition or permanent water efficiency actions at the POM are technically recorded as credits under the water allocation of the City. There is a "gentleman's agreement" that POM water credits may be used at the POM for new construction and renovations, rather than be claimed by the City.

The question is posed whether or not the POM could be established as a separate water jurisdiction within the District, rather than be served through the jurisdiction of the City of Monterey. Separation of the POM from the City allocation would:

- Facilitate the tracking of water credits at the POM
- Avoid processing POM water use permits through the City credits
- Allow the POM to plan and manage water resources independently
- Facilitate the process of obtaining water permits for new construction and renovations at the POM
- Assure the POM's mission to provide language training for national defense and security

Water use at the POM, and possibly the Naval Post Graduate School, would thus be managed separately from the City of Monterey allocation. Such a jurisdiction would require an allocation of approximately 300 acre-feet or less than 2 percent of the Cal-Am annual production limit. Such an allocation would be about the magnitude of the Sand City allocation.

The Monterey Peninsula Airport District was recognized as a registered jurisdiction in 1990. Thus, establishment of new jurisdictions within the District boundaries is possible. The water allocation of the Airport District is many times smaller than the allocation would be for the POM.

It is unlikely that the issue of recognizing a new jurisdiction with the District would be considered given the current political climate of the Monterey Peninsula Water Management District. Nonetheless, a request that the POM water service be separated from the City of Monterey allocation should be presented to the Board for consideration in the future.