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Water Management Plan for Fort Buchanan, Puerto Rico

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June 2004

Prepared for the
U.S. Department of Energy
Office of Energy Efficiency and Renewable Energy
Federal Energy Management Program
under Contract DE-AC06-76RL01830
and the
U.S. Army Southeast Region
under a Related Service Agreement
with the U.S. Department of Energy
under Contract DE-AC06-76RL01830

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William D. Chvala
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Pacific Northwest National Laboratory
Richland, Washington 99352

Water Management Plan
For
Fort Buchanan, Puerto Rico

Fort Buchanan has developed this management plan in cooperation with the Pacific Northwest National Laboratory (PNNL) and the U.S. Department of Energy (DOE), Office of Federal Energy Management Programs (FEMP). The subject plan has been evaluated by the Fort Buchanan Garrison Commander and the above mentioned agencies. The signatures below indicate approval of this water management plan.

PLAN APPROVAL

Edward C. Short
Colonel, U.S. Army
Commanding Officer
Fort Buchanan, Puerto Rico

____
Date

PLAN REVIEW

Alfredo J. Riera, P.E
Director of Public Works
Fort Buchanan, Puerto Rico

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Date

Felix M. Mariani
Chief, Environmental Division
Fort Buchanan, Puerto Rico

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Date

Jesus R. Gimenez
Energy Program Manager
Fort Buchanan, Puerto Rico

____
Date

Preface

The mission of the U.S. Department of Energy, Office of Federal Energy Management Programs (FEMP) is to reduce the cost of Government by advancing energy efficiency, water conservation, and the use of solar and other renewable technologies. This is accomplished by creating partnerships, leveraging resources, and transferring technology, and providing training and technical guidance and assistance to Federal agencies. Each of these activities is directly related to achieving the requirements set forth in the Energy Policy Act of 1992 and the goals that have been established in Executive Order 13123 (June 1999), as well as supporting activities that promote sound energy management of Federal financial and personnel resources. The Pacific Northwest National Laboratory (PNNL)[1] supports the FEMP mission in all activity areas.

This document reports findings and recommendations as a result of a design assistance project with Fort Buchanan with the goals of developing a water management plan (WMP). The WMP developed during this task is an amalgam of the templates and guidelines from the Federal Energy Management Program and Army regulations.

The objective of this report is to outline a strategy that can be used by Fort Buchanan to further establish an effective water management program. Once a strategy is accepted, the next step is to take action. Some of the strategies defined in this plan may be implemented directly. Other strategies may require development of a more sophisticated tactical or operational plan to detail a roadmap that will lead to successful realization of the goal. Similarly, some strategies are not single events. Rather, some strategies will require continuous efforts to maintain diligence or to change the culture of Fort occupants and their efforts to conserve energy resources.

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1 The Pacific Northwest National Laboratory (PNNL) is operated for the U.S. Department of Energy by Battelle Memorial Institute under contract DE-AC06-76RL01830.

Acknowledgements

The authors of this report would like to acknowledge the following people for their assistance in making this project possible. Thanks to Jesus R. Gimenez, Felix Mariani, and the Directorate of Public Works (DPW) staff at Fort Buchanan for providing invaluable input for this water management plan. Acknowledgments also go to Dave Hunt of Pacific Northwest National Laboratory (PNNL) for management of the project and Ab Ream of the Federal Energy Management Program (FEMP) for providing the funding for the project. Additional funding was provided by Ernesto Ortiz and Steve Jackson of the Army Southeast Region (SERO).

Executive Summary

Fort Buchanan, located in San Juan, Puerto Rico, is an Army facility with a primary mission to support troop mobilizations, the Army Reserve, the National Guard, and U.S. Army Garrison-Fort Buchanan. The post contains over 2.2 million square feet of building space consisting primarily of administration, housing, schools, storage, and other miscellaneous facilities. Fort Buchanan uses, on average, 8.9 million gallons of water per month or roughly over 100 million gallons per year.

In FY 2003, the Directorate of Public Works (DPW) decided to develop a water management plan (WMP), as required by Army regulations and Executive Order. The Federal Energy Management Program, U.S. Army Southeast Region, and the Pacific Northwest National Laboratory partnered with Fort Buchanan DPW to develop this plan.

The WMP identified several near-term measures for action:

- Update the water balance by improving water use estimates and adding additional metering to help quantify water consumption by building and/or process.
- Expand sub-metering on the Fort for billing and for utility management purposes.
- Implement near-term water conservation measures, including:
  - Form an equipment pool of water-efficient toilets, urinals, and showerheads to make replacements readily available. Work with maintenance, janitorial staff, and Army family housing to identify fixtures that need replacement. Go beyond minimum code-requirements in selecting water-efficient devices.
  - Require purchase of water-efficient appliances including horizontal-axis clothes washers and efficient residential dishwashers because these appliances are provided by the Fort.
- Commit to the implementation of four of the FEMP Best Management Practices (BMPs). The four that are recommended for Fort Buchanan are:
  - BMP #1: Public Information and Education Programs
  - BMP #2: Distribution Systems Audits, Leak Detection, and Repair
  - BMP #4: Toilets and Urinals
  - BMP #5: Faucets and Showerheads.

There are a number of long-term actions that the DPW should carefully consider. These include the following:

- Evaluate the recommendations for drought planning, contingency planning, and force protection and integrate these into the standard operating procedures for the DPW. These recommendations include the following:

- Develop drought management procedures and integrate these into the DPW standard operating procedures. Identify key individuals and assign responsibility.
- Evaluate current emergency planning and response procedures for responding to events on the site.
- Evaluate the water system (and other utility infrastructure) for terrorism or other threats. Identify capital improvement projects to protect the utility infrastructure.

- Evaluate the possibility of automated meter reading system for water and other utilities.

This document is meant to be a starting point for DPW to use to analyze water management practices and improve on the analysis as more data becomes available. The planning recommendations will need buy-in from the highest levels within DPW and command, and should be molded to fit the vision of command and planners on the post.

Table of Contents

PREFACE iii
ACKNOWLEDGEMENTS iv
EXECUTIVE SUMMARY v
INTRODUCTION 2

Section I: Facility Characterization

LEGISLATIVE BACKGROUND 3
Executive Order 13123 3
Army Regulations 3
Other Legislation 4
COMPREHENSIVE UTILITY INFORMATION 5
Water Provider 5
Historic Water Consumption 7
FACILITY INFORMATION 10
Site Description 10
WATER METERING 14
Secondary Metering 14
Future Metering Plans 18
Meter Maintenance Program 19
Water Planning Software 20
MAJOR WATER CONSUMERS 21
Constructing a Water Balance 21
Fort Buchanan Water Use 23
How to Use this Information 25

Section II: Operations and Maintenance

WATER CONSERVATION 26
Water Conservation Measures 27
Training 29
Tank Maintenance 29
BEST MANAGEMENT PRACTICES AND OPERATIONS AND MAINTENANCE RECOMMENDATIONS 33
BMP Recommendations for Fort Buchanan 33
BMP #1: Public Information and Education Programs 35
BMP #2: Distribution System Audits, Leak Detection, and Repair 37
BMP #3: Water-efficient Landscaping 38
BMP #4: Toilets and Urinals 42
BMP #5: Faucets and Showerheads 46
BMP #6: Boiler and Steam Systems 49
BMP #7: Single-Pass Cooling Equipment 49

BMP #8: Cooling Tower Management *49*
BMP #9: Miscellaneous High Water-Using Processes *51*
BMP #10: Water Re-use and Recycling *52*
FINANCIAL RESOURCES 54
FINANCIAL RESOURCES 54
Energy Savings Performance Contracts (ESPCs) *54*
Energy Conservation Investment Program (ECIP) *55*
Housing Funds *56*
Environmental Funds *56*
O&M Funds *56*
Utility Energy Services Contracts (UESCs) *56*

Section III: Water Planning

INTRODUCTION TO WATER PLANNING 56
DROUGHT MANAGEMENT PLANNING 57
Water Management Committee *57*
Defining the Threat *58*
Monitoring for the Threat *59*
Defining the Phases of Drought *63*
Responding to the Threats *64*
Other Important Issues *65*
Drought Resources *65*
EMERGENCY PLANNING 67
Fort Buchanan Drinking Water Contingency Plan *67*
Security Threat Phases *68*
Preparedness and Response to the Threats *70*
Protecting Water Supply from Terrorist Threats *71*
Other Important Issues *72*
Resources for Emergency Planning *73*
CONCLUSION 74
CONCLUSION 74
REFERENCES 76

Appendices

APPENDIX A: ADDITIONAL SITE INFORMATION 78
APPENDIX B – WATER DATA COLLECTION AND TEST EQUIPMENT 80
APPENDIX C: FEDERAL WATER USE INDICES 83
APPENDIX C: FEDERAL WATER USE INDICES 83
APPENDIX D. IRRIGATION SCHEDULING 85
Evapotranspiration *85*
Precipitation Rate (PR) *85*

List of Figures

Figure 1. 4-Year Average Water Consumption by Month 8

Figure 2. Building Total Floor Area by Use Type 10

Figure 3. Fort Buchanan Historical Population 11

Figure 4. Basic Water Balance Schematic 21

Figure 5. Fort Buchanan Water Balance for FY2002 23

Figure 6. Water Use Index "Glide Path" 26

Figure 7. U.S. Drought Monitor Map 60

Figure 8. U.S. Seasonal Drought Outlook 61

List of Tables

Table 1. Primary Water Meters at Fort Buchanan 14

Table 2. Secondary Metering for Reimbursable Customers 14

Table 3. Potential Secondary Metering 15

Table 4. Training Opportunities on Water Related Topics 31

Table 5. Estimated Savings by Low-Volume Toilets in Residential Applications 44

Table 6. Estimated Savings by Low-Volume Toilets in ICI Facilities 45

Table 7. Estimated Savings by Low-Volume Urinals in ICI Facilities 45

Table 8. Estimated Savings by No-Water Urinals in ICI Facilities 45

Table 9. Estimated Savings by Low-Volume Faucets in Residential Applications 48

Table 10. Estimated Savings by Low-Volume Faucets in ICI Facilities 48

Table 11. Estimated Savings by Low-Volume Showerheads in Residential Applications 48

Table 12. Potential Fort Buchanan Funding Options for Supporting BMP Implementation 55

Table 13. SPI Classification System 62

Table 14. Example Triggers for Mitigation Measures 64

Table 15. Mitigation Measures with Corresponding Phases 65

Table A1. Potable Water System Inventory (2001 Data) 78

Table A2. Wastewater System Inventory (2001 Data) 79

Table B1. Potential Data Collection, Equipment, and Tools for Water Analysis 80
Table C1. Federal Water Use Indices... 83
Table D1. Sample Irrigation Run Time Calculation 86

Introduction

This document is designed to satisfy the requirements for a water management plan (WMP) as defined in Army regulations and as required by Executive Order 13123. This document is divided into three sections: Facility characterization, operations and maintenance, and water planning.

Section I: Facility Characterization describes the site mission, buildings, and population. It also analyzes water consumption based on billing data, and sub-metered data, and estimates un-metered uses. It represents a snap-shot of the characteristics of the Post during FY 2002 and FY 2003.

Section II: Operations and Maintenance describes how to set water conservation goals, suggests potential water conservation measures, and discusses which of the FEMP Best Management Practices are appropriate for Fort Buchanan.

Section III: Water Planning describes how to plan for drought, how to do contingency planning, and how to protect the water system at the Fort.

This document is meant to be a starting point for DPW to use to analyze water management practices. The goal of DPW should be to take these results and improve upon the analysis over time. The planning recommendations will need buy-in from the highest levels within DPW and Command, and should be molded to fit the vision of Command and planners on the post.

Section I: Facility Characterization

Legislative Background

Fort Buchanan has three main regulations that require water management planning: 1) Executive Order 13123; 2) Army Regulation 420-46 for Water Supply and Wastewater; and 3) Army Regulation 420-49 for Utility Services. The Executive Order 13123 has established water conservation goals for the Federal government, which includes the development of a water management plan for individual sites. (FEMP 2000) The Army Regulation 420-46 and 420-49 specifies that Army sites must develop a comprehensive water resource plan. (Army 1992) This section describes each regulation.

Executive Order 13123

The Executive Order 13123 *Greening the Government through Efficient Energy Management* required the establishment of water conservation goals for Federal agencies in Section 503 (f) of the Executive Order. (FEMP 1999) The Federal Energy Management Program was responsible for developing these water conservation goals. In 1999, FEMP assembled the Water Working Group, which was comprised of members from Federal agencies and individuals from the private sector with distinct experience in water management to develop the water conservation goals.

By May 10, 2000, the Water Working Group developed guidance to establish water efficiency improvement goals for Federal agencies. The following bullets, which are taken directly from the guidance, list the threefold steps required by Federal agencies. (FEMP 2000)

1. Water management plans have been developed, revised, and incorporated into existing facility planning processes and operating plans.

2. Applicable operations and maintenance options have been put into practice. Retrofit/replacement options have been reviewed within the last 2 years and those appropriate for implementation have been identified.

3. Applicable cost-effective retrofit/replacement options have been implemented.

This report is addressing the first step of the requirements for water efficiency improvements – developing a WMP so that Fort Buchanan can incorporate it into the existing facility planning process and operating plans. At a minimum, a WMP should include sections on: comprehensive utility information, facility information, operations and maintenance recommendations, water shortage contingency plan, and comprehensive planning.

Army Regulations

The Army Regulation 420-46 for Water Supply and Wastewater section 2-5 and Army Regulation 420-49 for Utility Services section 4-3 requires that all Army sites develop a comprehensive water resource management plan that is updated annually. The requirements which pertain to this document are described in the following bullets:

- Water supply contingency plan for national or local emergencies: plan should follow American Water Works Association Manual 19
- Effective water conservation program
- Water metering that provides data on water consumption that helps to direct water conservation effort.

The Army Regulation 420-46 for Water Supply and Wastewater section 8-2 and Army Regulation 420-49 for Utility Services section 4-12 set specific requirements for water metering. These regulations include requirements to meter purchased water, sale of water, and operational control.

Another useful Army document is Army Pamphlet 200-1 *Environmental Quality: Environmental Protection and Enhancement.* The pamphlet deals with a number of environmental quality issues and Chapter 2 deals specifically with water management. (Army 200-1, 2002)

The format of this document follows the general outline set forth in the FEMP guidance, while also satisfying the Army-specific requirements. Finally, site-requested elements were added to make this a document that will be useful and have an impact.

Other Legislation

The FY 2001 National Defense Authorization Act; Section 1507 (Public Law 106-398) has a direct effect on the ability of Fort Buchanan to implement building projects and other upgrades. The Act states that no acquisition, construction, conversion, rehabilitation, extension, or improvement of any facility at Fort Buchanan may be initiated or continued on or after the date of enactment of this Act. This Act is a direct result of issues involving Navy activities on the island of Vieques, Puerto Rico. The exception to this construction moratorium is for actions necessary to maintain the existing facilities (including utilities) at Fort Buchanan and those affecting public safety and health.

Comprehensive Utility Information

To develop a useful water management plan, the site must have a clear understanding of how it is billed for water and how the utility is paid. This section will document the following:

- Contact information for all water and wastewater utilities
- Current rate schedules and alternative schedules for each metered account.
- Information on water/sewer bills for the past 2 years. Identify if there are any inaccuracies and determine that the site is using the appropriate rate structure.
- Information on financial or technical assistance available from the utility to help with facility water planning and implementing water efficiency programs.
- Contact information for the agency or office that pays the water/sewer bills.

Water Provider

Potable drinking water is supplied to Fort Buchanan by the Puerto Rico Aqueduct and Sewer Authority (PRASA). PRASA owns over 10,000 miles of water mains and aqueducts and 2,000 miles of sewage lines. Puerto Rico's water quality is subject to the same EPA standards that apply on the U.S. mainland.

PRASA owns and maintains a 66-inch high-capacity aqueduct within an easement that traverses the reservation in a west-to-east direction. Fort Buchanan receives a discount of 33% on its water rate because of the easement for PRASA's water main.

The main service point for the Fort is located near the Main Gate on the east side of the site. This is a 4-inch service. Two additional connections exist. The one near the old south gate is metered on a 4-inch line, but normally closed. An additional connection exists in the middle of the post near Howard Drive and Depot Road, which connects directly to the PRASA 66-inch main. This connection is 6-inches and normally closed.

Fort Buchanan owns its own potable water distribution system, although they are exploring the possibility of divestiture of the utility infrastructure. The potable water system consists of approximately 100,000 linear feet of piping, valued at over $2,173,000. Cast iron and ductile iron pipe are the majority, but the site also contains asbestos concrete, galvanized, copper pipe, and some PVC. (Gimenez, 2003a)

Wastewater is collected from throughout the reservation by Fort-owned sanitary sewer line and discharged to the PRASA-owned Bayamon 42-inch trunk sewer. Fort Buchanan does not treat any waste water on site. The Fort owns 51,530 feet of sanitary sewer consisting of concrete, iron, and vitrified clay pipe, valued at over $624,429. (Gimenez, 2003b)

Fort Buchanan has two water storage tanks that work in conjunction with the water booster pumps serving the Fort. The 500,000-gallon tank is located on the north side of the post. A 1,000,000-gallon tank is located to the south, near the Las Colinas housing area.

A complete inventory of the water and waste water system on the Fort is provided in Appendix B.

Utility Contact Information

The point of contact for PRASA is:

> Mrs. Imgard L. Pinero, Government Account Manager
>
> 604 Ave. Barbosa
>
> PO Box 7066
>
> San Juan, PR 00916-7066
>
> Telephone: 787-620-2277 Ext. 2017
>
> Fax: 787-764-7708

The nearest PRASA office is located at:

> Agencia Comercial de San Patricio
>
> PO Box 7398
>
> San Juan, PR 00916
>
> Telephone: 787-792-7255

Water Charges

Fort Buchanan receives a 33% discount on its water rate because of the easement required for PRASA's 66-inch water main. This includes both potable water purchases and sewage treatment costs.

Potable water costs $2.47 / Kgallons[2] ($0.65142 per cubic meter). There is a minimum annual meter charge of $279.73 for the two 4-inch meters that includes a minimum purchase of 2,642 gallons (10 cubic meters). The 6-inch meter has a minimum service charge of $704.81 that also includes a minimum purchase of 2,642 gallons (10 cubic meters).

Sewage treatment costs $1.36 / Kgallons ($0.35886 per cubic meter) based on potable water consumption. There is also a minimum sewage charge on the 4-inch meters of $177.23 and $568.50 on the 6-inch meter. This appears to be regardless of the number and location of connections to the sanitary sewer system.

The total combined cost for water is $3.83 / Kgallons.

---

[2] Kgallons = 1000 gallons

Marginal Cost of Water and Sewer

The marginal cost of water is the actual cost of the water purchases that are avoided, not including any flat fees, meter charges, operations and maintenance fees, or any costs that will still exist when consumption is reduced. In the case of block rates, the cost of water is the unit cost for water in the last purchase block. This cost will change if consumption is reduced enough to move charges into a reduced purchase block. Water savings should not only include potable water purchase costs, but also sewage costs if sewage fees are based on water usage. Marginal costs should be used in all economic analysis so that the true cost savings can be calculated.

Because Fort Buchanan has a simple flat rate, the marginal cost for water at Fort Buchanan is $3.83 / Kgallons.

Financial and Technical Assistance

At this time there are no financial programs or technical assistance programs available through the water utility. In 1995, the management of PRASA was contracted to Compañía de Aguas Corporation – also called Professional Services Group (PSG). PSG has struggled with management and operational problems in PRASA over its short time running the system. Unfortunately, the pressures of obtaining adequate quantities of water and maintaining high standards of quality have left very few resources for additional projects. That's not to say, however, that PRASA would not be interested in a substantial project at Fort Buchanan that would relieve some of the pressure on the system. Such a project would have to be initiated by the Fort and PRASA's management would have to be convinced of its value to them.

Historic Water Consumption

Fort Buchanan's water consumption averaged 8.9 million gallons per month from FY00 through FY2003. On a yearly basis, the Fort used roughly over 100 million gallons per year over the same period. Figure 1 shows the 4-year average water consumption by month, bounded by the maximum and minimum consumption for each month to give some idea of the variability over this time period.

August and September tend to be the months with the lowest water consumption, tied in part to the wet season of the year. The cause of the very low consumption in August 2000 (FY00) is not clear at this point in time. Most likely, the decrease in use was the result of a meter reading error. An estimate was made the following month to compensate for the misreading in August. Another reason for the variability of water use is changes in personnel assigned to the Fort. This will be discussed in detail later.

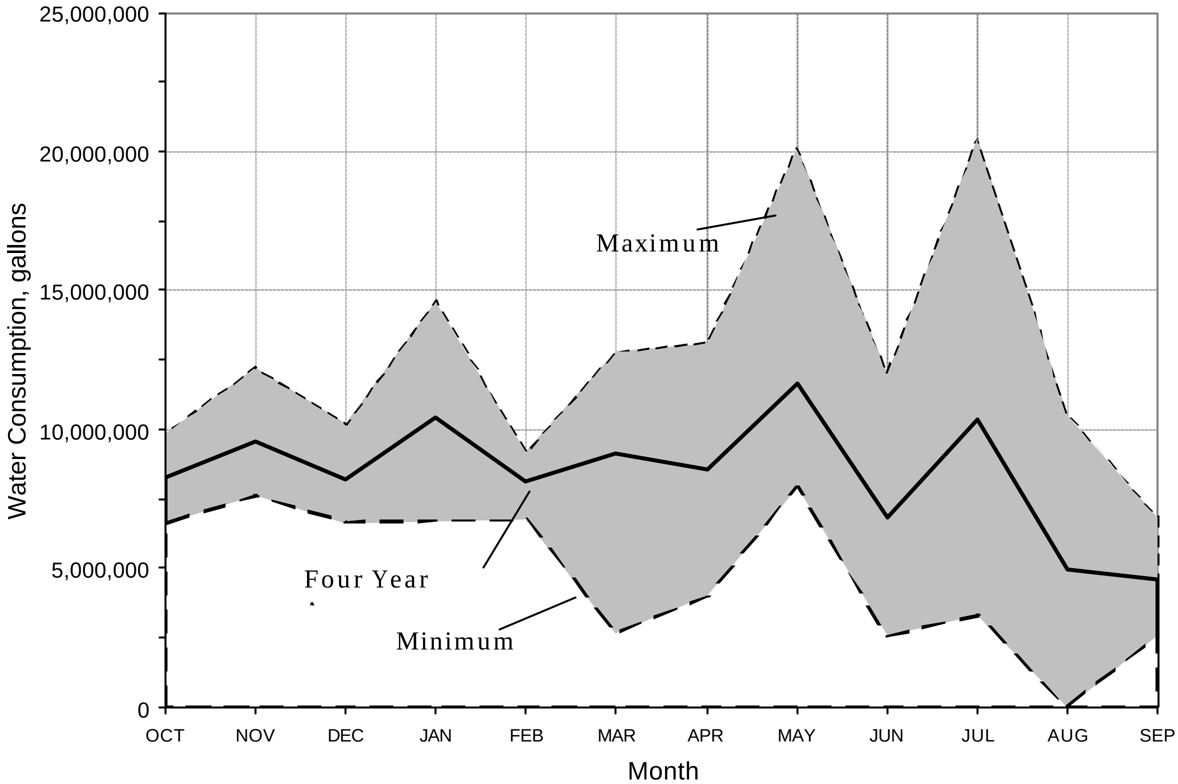

Figure 1. 4-Year Average Water Consumption by Month

More detailed information about water consumption in sub-metered facilities is provided later.

Fort Buchanan Contact Information

The main contact for the water system at the site is the Operations and Maintenance Chief:

Mr. Ferdinand Torres

Telephone: 787-707-3884

Email: ferdinand.torres@buchanan.army.mil

Water Billing Procedures: The Department of Publics Works Resource Division is responsible for consolidating all water utility bills. This consolidated billing data is sent to the Installation Budget Division, which is responsible for forwarding the bill with an accounting classification to the Defense Finance and Accounting Service (DFAS) in Orlando. This main budget department pays the water bill for Fort Buchanan.

At Fort Buchanan, the main contacts for billing information are:

Maria de los Angeles, Chief Engineering Resource Management Division
Telephone: 787-707-3887
Email: maria.lopez@buchanan.army.mil

Nydia Gonzales – Budget Analyst
Telephone: 787-707-4704
Email: nydia.gonzales@buchanan.army.mil

Josue Rodriguez, Management Assistant
Telephone: 787-707-3429
Email: josue.rodriguez@buchanan.army.mil

Facility Information

Site Description

Fort Buchanan is a U.S. Army installation located near San Juan, Puerto Rico in the municipalities of Guaynabo and Bayamon. The mission of Fort Buchanan is primarily to support troop mobilizations for Army Reserve and National Guard, and is headquarters to the U.S. Army Garrison-Fort Buchanan. From 1998 to 2002, Fort Buchanan was also home to the U.S. Army South (USARSO). USARSO was the Major Army Command (MACOM) with Central and South America and the Caribbean as its Area of Responsibility (AOR). USARSO has now relocated to Fort Sam Houston Texas.

The Fort consists of 746 acres with over 2.2 million square foot of building space. The two top building use categories at Fort Buchanan are administrative, with over 786,000 square feet of floor area (33% of total), and housing, with over 587,000 square feet (24% of total). Fort Buchanan also has schools, storage, maintenance, recreational, and health care facilities as one might expect of a typical Army installation. The distribution of each building type is shown in Figure 2. A more detailed description of various use areas is provided as follows.

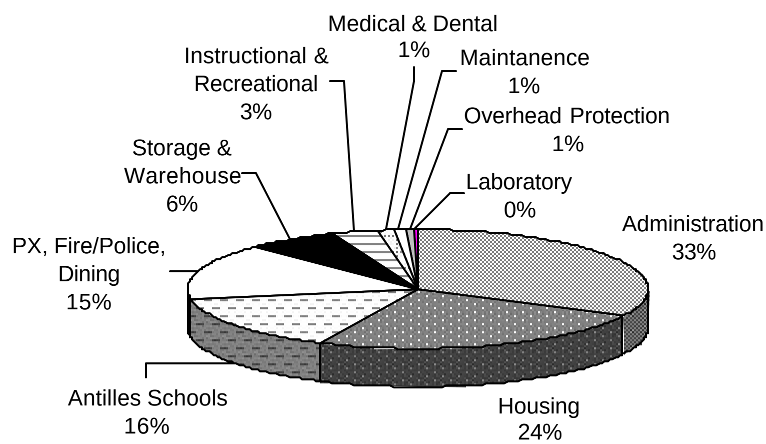

Figure 2. Building Total Floor Area by Use Type

The population at Fort Buchanan exploded in the late 1990s when USARSO was headquartered at the Fort. (see Figure 3) The Fort population – defined as staff assigned and working at the Fort, but not necessarily living in family housing – reached its peak in 2000 when 9,897 people were stationed at Fort Buchanan. This population boom is expected decline to 1997 levels of about 3,200 staff when the remaining USARSO staff are relocated from the Fort.

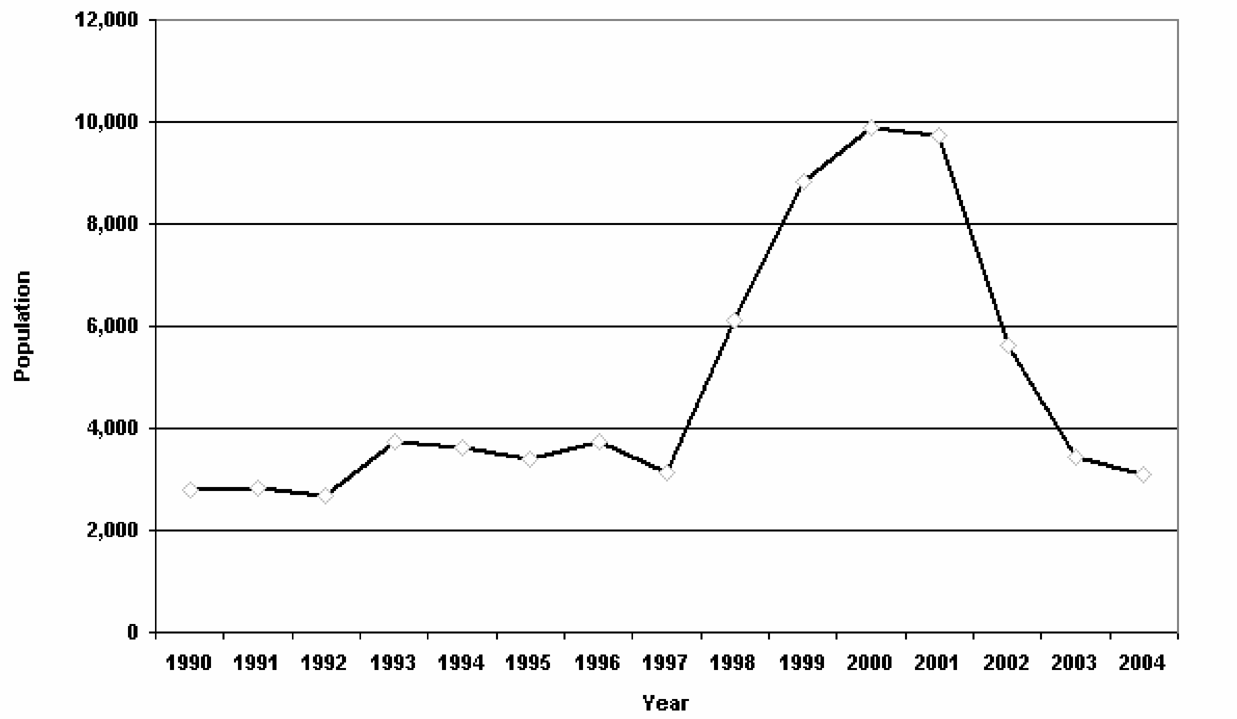

Figure 3. Fort Buchanan Historical Population

Administrative/Operational Facilities

The administrative facilities at Fort Buchanan account for over 786,000 square feet of floor area or approximately 33% of the total floor area at the site. These facilities range from the new 65th Army Reserve Center currently under construction to older World War II-style buildings.

Water use in the administrative buildings is dominated almost entirely by human consumptive uses. None of these buildings employ landscape irrigation. The new Reserve Center will also have a water pond feature.

Administrative buildings are not metered for water use. Water use can be estimated based on population (occupancy) data using the Federal Water Use Indices (for more information see Appendix C).

Army family housing

In Fiscal year 2002, the Fort Buchanan Army family housing (AFH) had a capacity for approximately 302 housing units and was home to approximately 906 personnel and family members.

The Las Colinas family housing area is located east of the Antilles Elementary School and was built in 1948 as housing for field grade officers. The Las Colinas Housing area consists of 31 housing units.

The Coqui Gardens family housing area is located in southeast corner of the post, on the east side of El Toro Creek and South Gate Road, built in 1955. Coqui Gardens consists of 91 duplex housing units originally constructed for non-commissioned officers. In 1993, the original iron pipe was replaced with PVC piping. Fifty-five housing units are in schedule for demolition.

The Coconut Grove family housing area was constructed in 1955 and consists of 141 houses. In 1991, the water distribution system was replaced with PVC pipe. Eighty housing units are in schedule for demolition.

The Buchanan Heights family housing area was built in two stages in 1941 and in 1964. This area consists of 98 housing units.

Fort Buchanan's unaccompanied personnel housing (UPH) is located in dormitory-style barracks in the 1300 area.

The majority of water in family housing is used for domestic purposes of bathing, cooking, and cleaning. Housing residents are responsible for lawn maintenance, so limited lawn watering occurs during dry months. AFH buildings are not metered for water use. Water use can be estimated based on population (occupancy) data using the Federal Water Use Indices.

Educational

The Fort Buchanan schools located on the post are associated with the Antilles Consolidated School System serving governmental and military families at Fort Buchanan, Roosevelt Roads Naval Station, and the U.S. Coast Guard at Ramey. The four schools at Fort Buchanan comprise over 378,000 square feet and represent 16% of the total floor area of the Fort.

The Antilles Elementary School is built for approximately 450 students in grades pre-kindergarten through grade 2. The elementary school was built in 1954 and consists of 25 mostly-interconnected buildings and portables. The Antilles Elementary School is not metered, but is billed based on estimated usage.

The Antilles Intermediate School houses students from grades 3 through 5. The intermediate school was built in 1962 and consists of 25 buildings and portables. The Antilles Intermediate School is not metered, but is billed based on estimated usage.

The Antilles Middle School is home to approximately 550 students from grades 6 through 8. The middle school was built in 1992 and consists of nine buildings. Each building is individually metered for both water and electricity.

The Antilles High School is home to students from grades 9 through 12. The high school was built in 1990 and consists of five buildings. There are two main water meters recording water use for the high school.

Community and Recreation

Fort Buchanan community and recreational facilities consist of a health center (gymnasium), youth center, bowling center, auto repair hobby shop, library, community NCO club, and other facilities. Fort Buchanan also has a newer water park with swimming pool and water slides. The Fort Buchanan commissary and exchange is also a newer building.

The Fort Buchanan Golf Club has a 14-hole par 36 course of over 3000 yards. It also includes a 250-yard driving range, chipping green, putting green and bunkers. The golf course does not water fairways, only greens and tee boxes as needed. They do not have automatic controllers, so all water is done manually with quick couplers and by pulling hoses. They have plans and funding to put in an irrigation system, but construction moratorium is a hurdle. They irrigate very little seven months out of the year. The drier months are February through June.

Water Metering

Fort Buchanan has three main water meters for determining the site total water consumption. The meter numbers and location are shown in Table 1.

Table 1. Primary Water Meters at Fort Buchanan

Location	Activity	Meter Number	Account Number
66"	PRASA Connection	9541631	#10206914-001-4
MAIN	PRASA Connection	95999999	#10206909-001-1
SOUTH	PRASA Connection	97110102	#10206910-001-8

Secondary Metering

Fort Buchanan also employs secondary meters for billing of reimbursable customers. The meters listed in Table 2 are for use in the billing of government and commercial reimbursable customers.

Table 2. Secondary Metering for Reimbursable Customers

Location	Activity	Meter Number
1087-B	ACSS Middle School	90307559
1085-C	ACSS Middle School	91044990
1081-D	ACSS Middle School	91894071
1073-E	ACSS Middle School	91894072
1071-F	ACSS Middle School	90307555
1075-G	ACSS Middle School	91694072
1077-H	ACSS Middle School	90307558
1083-J	ACSS Middle School	91044992
540	PRARNG	86001376
541	PRARNG	92134238
607	TSC & PRARNG	93200935
1062	ACSS High School	89003003
1068	ACSS High School	89003002
501	Banco Popular	12127086

Location	Activity	Meter Number
161	Aqua Park	96111893
172	Golf Course	92113561
678	Guest House	98849808
678	Guest House Hydrant	98849809
681	Guest House	98705192
680	Guest House	98705198
679	Guest House	98705196
611	Toyland	93200932
606	AAFES Furnishing Store	93223550
673	Credit Union	97072565
612	AAFES Storage	93200931
613	Shoppette	93200934
614	AAFES Storage	93200930
608	Not Working	91004564
689 (Deca)	Comm. Center (DECA)	10758979
690 (PX)	Comm. Center (PX)	10860827

Secondary metering can also be employed for purposes of utility management and better methods of space charges. The following table lists potential additional metering that should be considered. These include large facilities, major post tenants, and areas of the site. To meter some areas of the site that have multiple interconnections, it may be necessary to close all but one valve to meter the flow.

Table 3. Potential Secondary Metering

Location	Activity	Comments
138	Golf Course Irrigation	Will capture golf course irrigation system to track yearly usage patterns. Could also potentially allow billing reimbursement of actual water usage.
746	CID	For record purposes
390	Garrison HQTRS	For record purposes

Location	Activity	Comments
399	65^{th} RSC – 166 ASG	For record purposes
167	FITNESS CENTER	For record purposes
169	BOWLING CENTER	For record purposes
	MEDCOM Health Clinic	For record purposes
312	MEDCOM Dental Clinic	For record purposes
670	MEDCOM Vet Clinic	For record purposes
1079	ACSS Middle School	No Meter
1070	ACSS Field	No Access
540	PRARNG Hydrant	No Meter
294	Kennel, U.S Customs	Unclear if meter exists at this location.
73-86, T87-T99	ACSS Intermediate School	Currently using estimates for billing
1029-1042, T1043-T1054	ACSS Elementary School	Currently using estimates for billing
566	ACSS Admin/Engineering	Currently using estimates for billing
563	PRANG	For record purposes
522, 523, 525, 528, 539, 1305 - 1308, 1310, 1312, 1316 -1324	USAR Center (20 buildings)	For record purposes
800-831	Los Colinas Housing	Currently using estimates for billing
1243-1290	Coqui Gardens Housing	Currently using estimates for billing
1000-1025	Buchanan Heights Housing	Currently using estimates for billing
1101-1241	Coconut Grove Housing	Currently using estimates for billing.
1300-1327	1300 Area	For record purposes. It looks like 2 meters would be able to capture the 1300 area, but would need to subtract Building 399.
399	399 Building	For record purposes and possible billing. Fairly large admin building. Would need to subtract this usage to capture 1300 area.
556, 558, 570, 576, 578, 579	DPW	For record purposes. DPW can lead the way by making itself accountable for efficient use on a per square foot or per occupant basis.
Schools	Schools	Remaining schools AES/AIS, 200 Area Admin, 152 Welcome Center.
200 Area Admin	Administrative	Administrative buildings in 200 Area
152		152 Welcome Center

Justification for secondary metering

Justifying the installation of secondary metering for non-reimbursable customers can be difficult. The benefits to better utility management practices are generally not fully appreciated. These benefits can include:

- Customers whom are billed for actual usage receive the proper and accurate price signals (i.e., if you save water and you are charged less). For non-billable customers, sub-metering may allow DPW to use the information to recognize efficient users and create a competition for the most "green" organization.
- Site maintenance staff can use the metered data for diagnostic purposes (e.g., leak detection).
- Site operations staff can use the metered data to develop usage profiles, peak tracking demand, and forecasting, as occupancy changes
- These data become significant inputs to future infrastructure planning exercises (i.e., 5-year plans, installation modernization, etc.).

The benefits of sub-metering should be communicated to the highest levels within DPW. The goal would be to make it Fort policy that all new construction, renovations, and major alterations should require sub-metering to be installed. The incremental cost of a water meter would be small compared to the cost of any project. This should be the case whether the water service is for a reimbursable customer or not.

Metering Bundled with Other Projects

One strategy to positively affect secondary metering installation would be to install metering in conjunction with other potential projects. For example, a project to sub-meter a branch water line serving a group of buildings (e.g., a family housing area) might also include a back-flow prevention device or other isolation valve. The back-flow device would provide additional protection in the event of a loss of water pressure (e.g., during an outage or during fire fighting). The combination of personnel protection and utility management enhancements would make an attractive project that can be justified even under the construction moratorium.

Because the water system on most areas of the site has more than one interconnection with others areas, a detailed analysis of the feasibility of isolating parts of the system would need to conducted. For example, Buildings 1300 through 1313 are served by a loop that connects to the water system through two isolation valves – one at Davidson Road and Chrisman Road and the other at Depot Road and Mayaguer Barracks Road. Water use could be metered if it were possible to close one valve (and maintain adequate pressure) and install a meter at the other valve. Other examples like this probably exist at Fort Buchanan. Careful analysis of the system operation should determine other opportunities.

Future Metering Plans

While sub-metering can be an important utility management tool and desirable for DPW, the costs can be difficult to justify, not only the one-time installation cost of additional meters, but also the cost of reading additional meters, especially for non-reimbursable customers. After all, having meters is only half the battle; reading them and knowing what to do with these data is the most important factor. Many sites have found automated meter reading (AMR) systems as a way to get more data quickly without increased labor requirements for additional meter readings.

Automated Meter Reading

Almost all meter manufacturers now have models that are AMR-ready. When new meters are added, they should be specified to include AMR-ready features, even if they will be read manually in the short-term. Existing meters can be retrofitted with AMR-modules that count the standard rotations in a traditional meter and convert these into AMR pulses or signals. Simply make sure that the meter is capable of an output signal that is compatible with the communications infrastructure.

Data can be collected through a variety of means. The choice of communications infrastructure really depends on factors such as cost, meter density, expandability, and flexibility for example. Common methods of data collection include:

- Satellite-based meter reading
- Fixed radio network
- Short distance (packet) radio
- Drive-by and handheld radio
- Telephone reading
- Power-line carrier (PLC)
- Twisted-pair wired
- Local area network (LAN), Internet, Intranet-based communication
- Energy management control system (EMCS) as communications backbone
- Universal touchpad reading wands.

Intertwined with the selection of meter reading method is the selection of a protocol. Although there is no "universal" protocol for AMR meters, several of the major AMR/meter companies have their own protocols and offer multiple communications methods. In the current metering infrastructure, it is not important to exactly match the meter with the communications device. Clearly define the needs of the Fort and let the AMR companies work out the technical details. Focus on getting a company that will support the system long term, getting technology that is flexible, can be expanding incrementally, and with hardware that will be available long-term.

Economics of AMR

AMR systems generally have a high initial cost, although the cost per meter reading can be low. AMR has a number of additional benefits that add to the value of the system. AMR systems can meter all utilities including electricity, water, and gas, and are especially useful in hard to reach meter locations. AMR systems will have improved reliability and can collect time-series data (monthly, daily, hourly). The AMR infrastructure can sometimes be used to perform other functions such as leak detection on storage tanks or alarm for off-normal conditions. Some of the software offered by AMR systems may have electronic billing or other useful features.

DPW will have to be diligent and creative to fund the initial cost. Funding from a variety of sources would be an option, including taking advantage of year-end money. One of the few benefits of the construction moratorium is that there are very few major projects in the works and certain organizations may actually be trying to find projects that can be funded.

One possible strategy would be to secure one-time funding for automated data collection infrastructure that can be expanded as new sub-meters are added. If funding can be secured for the AMR infrastructure, the per-meter incremental cost should not be that great and can be borne by individual projects.

Meter Maintenance Program

Almost all water meters used for billable consumption have moving parts that degrade over time. In general, meters tend to under-record consumption as they age. Maintaining these meters by checking, recalibrating, or replacing is important for proper accurate billing and records of water use on post. As the number of meters on post increase, DPW will need to implement a procedure for annual checking of existing metering.

The American Water Works Association (AWWA) recommends a regular meter maintenance program that includes testing and, if necessary, recalibration and replacement. AWWA recommends that all meters 2 inches in diameter and above be checked yearly (AWWA M6, 1986). For meters smaller than 2 inches, a subset should be selected for testing or simple replacement, possibly based on meter age. A large Federal site may have a few meters 2 inches and larger but many, even hundreds of smaller water meters.

Fort Buchanan DPW should insist that the post main meters are calibration-checked on a yearly basis. Although meters often tend to under-report consumption as they age which would result in smaller water charges to the site, accuracy should be the goal.

For information on testing and maintaining meters, refer to AWWA Manual M6 and AWWA Manual M36.

Water Planning Software

Fort Buchanan should consider analyzing its water system with a computer model or water planning software tool. A software tool would allow DPW to play "what-if" scenarios and do long-term forecasting.

One possible tool is the Installation Water Resource Analysis and Planning System (IWRAPS) tool. IWRAPS offers utility planners and managers at military installations a water demand management tool which can assess the impact of mission changes as well as conservation/drought situations on future water demand. Specific versions have been developed for the Army, Air Force, and Navy and Marine Corps. Although the tool was originally developed with DOD funding and is supposedly available through the Army Center for Public Works, current development on the tool has been handed to a private contractor. It appears that the current marketing strategy is to sell analysis services rather than the tool itself. Fort Buchanan would need to obtain funding for these analysis services and ensure that the resulting model and related software is transferred to the Fort for ongoing use. For more information, visit http://www.eere.energy.gov/buildings/tools_directory/software/iwraps.htm .

Another possible avenue would be to utilize the recent work performed by the Army Corp of Engineers modeling the flow rates in Fort Buchanan's distribution system. (*"Water Distribution System Evaluation…"*2000) The project used the H2ONET software to analyze flows in the distribution system to determine if any problems exist. H2ONET (http://www.mwhsoft.com/page/p_product/net/net_overview.htm) implements the EPANET simulation methods within an AutoCAD environment to provide a powerful modeling tool. Although these tools are certainly available for purchase and use by DPW engineering staff, the learning curve would be substantial. A more efficient approach would be to contract directly with the COE Mobile Office who already have completed a computer model using H2ONET (a non-trivial task) to address specific questions regarding the distribution system.

Other than the IWRAPS and H2ONET tools, all the other tools looked at were either too simplistic or too complex to be of any real use to DPW.

Major Water Consumers

The first step in evaluating water use on site is to understand where water is being used. A common tool in this process is the "water balance." A water balance is a model that takes the total of all known sources and partitions them to all known uses, with the remainder accounting for losses, leaks, and thefts. As a closed system, the sum of all inputs must equal the sum of all the uses.

Constructing a Water Balance

Figure 4 shows a sample of what parts might be used to construct a water balance. Elements that are not relevant to Fort Buchanan are shown in gray. The process of constructing a water balance is described in detail in: *Water Audits and Leak Detection.* (AWWA M36, 1990)

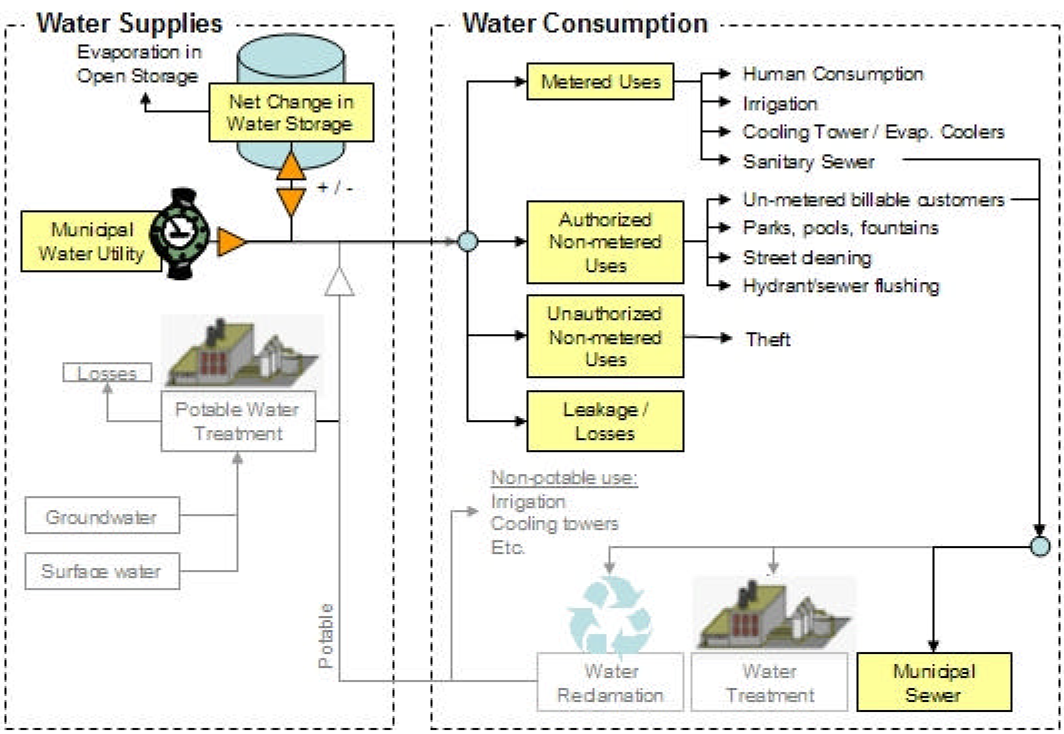

Figure 4. Basic Water Balance Schematic

Water Inputs

The water inputs (or sources) for Fort Buchanan are the three metering points from PRASA. If water is added to storage tanks for use later, the water quantity must be accounted for when deposits and withdraws are made. However, the operational strategy for the storage tanks at Fort Buchanan seeks to keep them at a relatively constant level with the fluctuations occurring with withdraws during peak usage times during the day and refill at night. This daily withdraw/recharge strategy will be lost in the data, which is monthly.

Metered Uses

The DPW maintains sub-meters for billing purposes on a number of facilities on post. (See "Secondary Metering" in the "Water Metering" section for more details.) These meters are installed, maintained, and read for the purpose of billing reimbursable customers.

Un-metered Uses

At Fort Buchanan un-metered uses can be broken down into to categories: un-metered reimbursable customers, un-metered unbilled customers, and miscellaneous system uses. To account for water use in these facilities, engineering estimates are used to disaggregate water usage to facilities. Some common techniques use the Federal Water Use Indices (for more information see Appendix C), square-footage-based estimates, or occupancy-based estimates. These estimating tools typically take the occupancy of the building and multiply it by an index. This index typifies the water use for a particular building type. Using methods based on occupancy levels usually reflect the most accurate water use estimates since water consumption is typically driven by how many people are occupying a building and not by the size of the building.

Estimating usage for these categories is important for constructing a water balance because it will provide an indicator of what the losses are in the system. For the purposes of this water balance, un-metered water uses were calculated based on building data (size and use type), installed equipment observed during the site visit, and occupancy data.

The un-metered reimbursable customers are customers that are billed for their water usage based on an engineering estimate (e.g., by square footage). These are customers that probably should be metered, but are often small consumers. Examples include the post office and health clinic at Fort Buchanan. Water consumption in the major housing areas are also estimated and billed accordingly. These major customers should be metered.

The un-metered, unbilled customers are those that are not billed because they are part of the Fort's general mission. These include the DPW, police, fire, and many administration buildings.

Losses

Water losses fall into two categories: leaks and theft. Theft can be a problem with large municipal systems, but on a military base except where family housing would be metered, there is very little incentive to steal water. Leaks on the other hand can be a major problem at Federal sites. Fort Buchanan's distribution system is fairly typical of an older distribution system that would be prone to leakage.

More information dealing with leaks is provided in the "BMP #2: Distribution System Audits, Leak Detection, and Repair" section.

Fort Buchanan Water Use

Consistent with Fort Buchanan's mission of troop mobilization and reservist activities, water consumption at the Fort consists almost entirely of domestic water uses. Figure 5 shows the water use distribution for Fort Buchanan for FY2002.

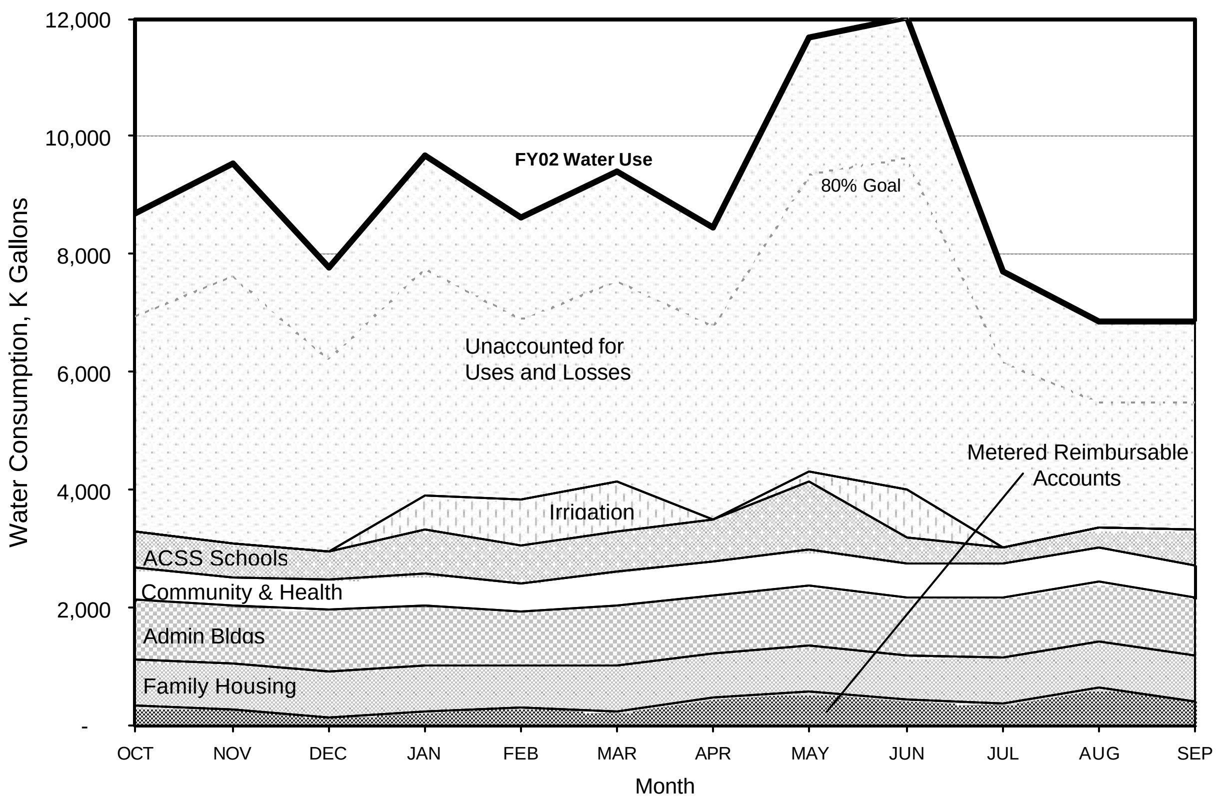

Figure 5. Fort Buchanan Water Balance for FY2002

The chart takes the known total water use (from the three PRASA meters) and partitions water consumption by users. Only one category "Metered Reimbursable Accounts" is a known quantity based on sub-metered data. The other categories are calculated based on building data (size and use type), installed equipment observed during the site visit, and occupancy data. A description of each category is provided in the following sections.

Metered Reimbursable Accounts

These are the sub-metered buildings that are billed for actual usage. This is the only category not based on engineering estimates of water usage. The complete list is provided earlier in Table 2.

Army family housing

A complete description of housing has been provided previously. Water usage was calculated using the building data (e.g., number of units, number of bedrooms in each unit), occupancy data, and Federal Water Use Indices. The water usage calculated from water use indices and occupancy data is substantially less (approximately 30%) than the estimates currently used for billing purposes. DPW should investigate whether AFH is being over-charged for their usage or if there is an error in the estimate developed during the site visit.

AFH would be the easiest category to be completely metered. DPW should explore the possibility of installing a sub-meter on each of the housing areas. This would resolve the discrepancies between the two estimating methods and provide a basis for billing each housing area.

Administrative Facilities

Administrative facilities are scattered throughout the post in a variety of building sizes and ages. In estimating water consumption, the ideal situation is to use building data, occupancy data, and fixture observations to estimate usage. Where occupancy data is unavailable, a water use per square foot estimate was developed from buildings that did have occupancy data and the estimate applied to the remaining buildings.

Although these estimates are fairly rough, it provides an “order of magnitude” estimate. The estimates can be improved by obtaining additional occupancy data or by adding sub-metering. Although it would not be practical to individually meter each facility, it may be feasible to meter clusters of buildings, areas, or the larger administration buildings.

Community and Health

The community and health category includes facilities such as the library, fitness center, bowling center, youth center, dental clinic, health clinic, P/X (commissary is metered), and Army Lodging facilities. Water usage was calculated using the building data, occupancy data, fixture observations, and Federal Water Use Indices.

ACSS Schools

A complete description of ACSS has been provided previously. This category is a mix of metered and estimated usage. The middle school and high school are metered, while the elementary and intermediate schools are not. The known usage was added to estimates based on building data, student enrollment, fixture observations, and Federal Water Use Indices.

Landscape Irrigation

Landscape irrigation at Fort Buchanan is minimal because of the tropical climate of Puerto Rico. Several new buildings on site have underground irrigation systems for median landscaping, but turf areas are not irrigated.

The golf course does not have an automatic underground irrigation system. Greens and tee boxes are watered during the dry season (February through June) with hoses and portable sprinklers on half the course and sprinklers and quick-couplers on the other half. At other times during the year, the course receives enough moisture naturally.

Tenants in family housing are responsible for maintaining their lawns, including watering. Because lawns are watered manually with hose and sprinklers, it is estimated that watering is not significant.

For the water balance, the size of irrigated acreage was estimated – basically tees and greens on the golf course, family housing, and a few additional buildings. Next, the precipitation rate for San Juan was used to determine which months no water occurred, which months partial watering may have occurred, and which months no watering occurred. Finally, the Federal Water Use Indices were applied. The "turf" estimate was used for the golf course and "non-turf" estimate for family housing.

Unaccounted for Uses and Losses

The "Unaccounted for Uses and Losses" category is, by far, the major category and may be quite surprising at first glance. This category consists of all losses and leaks from the system, as well as unaccounted for uses such as street cleaning, vehicle washing, water main flushing, fire flushing, etc. Losses are expected and it is impossible to meter everything, so this is very typical of other large installations, although the magnitude of this category (over 50%) is greater than expected.

As more sub-meters are added and more accurate estimates developed, it may be found that the other categories are underestimating water use. If this is the case (as is expected), this category will begin to shrink as more uses are identified and quantified. AWWA Manual M36 provides an excellent methodology for quantifying un-metered uses. Estimation methods that can be investigated include: batch method, discharge method, and comparison method. (AWWA M36)

Even as more uses are identified, this category will still be a large one – perhaps the largest. Among municipal water utilities (and an Army post is really a small town), a commonly accepted loss rate for a well-run distribution system is 20% (or end-uses account for 80% of the water produced/purchased). The dashed line on the chart in Figure 5 represents a 20% loss rate, which can serve as a goal for DPW to achieve.

How to Use this Information

The water balance can be a useful management tool to help DPW understand where water is used and where efforts are needed. This chart is a snap-shot of where the Fort is at this point in time. First, DPW can develop a similar balance for FY2003 and work to improve the data through improving the engineering estimates and by adding additional sub-metering. Second, the site needs to determine how much of the unaccounted for usage is authorized and how much is from losses. DPW may want to set a goal to reduce unaccounted for usage by a certain percent. The water balance should be viewed as a tool for management of water resources.

Section II: Operations and Maintenance

Water Conservation

Although the site is not required to meet a specific water reduction goal by E.O. 13123, tracking progress in water efficiency can be a useful management tool. It is important to choose a metric that accounts for swings in population because water consumption is so heavily influenced by domestic uses at Fort Buchanan. For example, selecting consumption per square foot would show increased progress when population is down (assuming no major loss of floor area), and would show progress as poor when population is up.

A water use index (WUI) that includes the current personnel count would provide a better indication of the "efficiency" of water use at the Fort. Figure 6 shows three different methods of generating a water use index. Index A is probably the most common, expressing water consumption per square foot of total floor area. This method does not account for swings in population, a key dependent variable for water use at the post. Index B expresses water use in terms of gallons per person. This method does not consider building floor area, but only post occupancy data. Finally, Index C expresses water usage as consumption per square foot per person. This is the most encompassing index because it accounts for both occupancy and floor area.

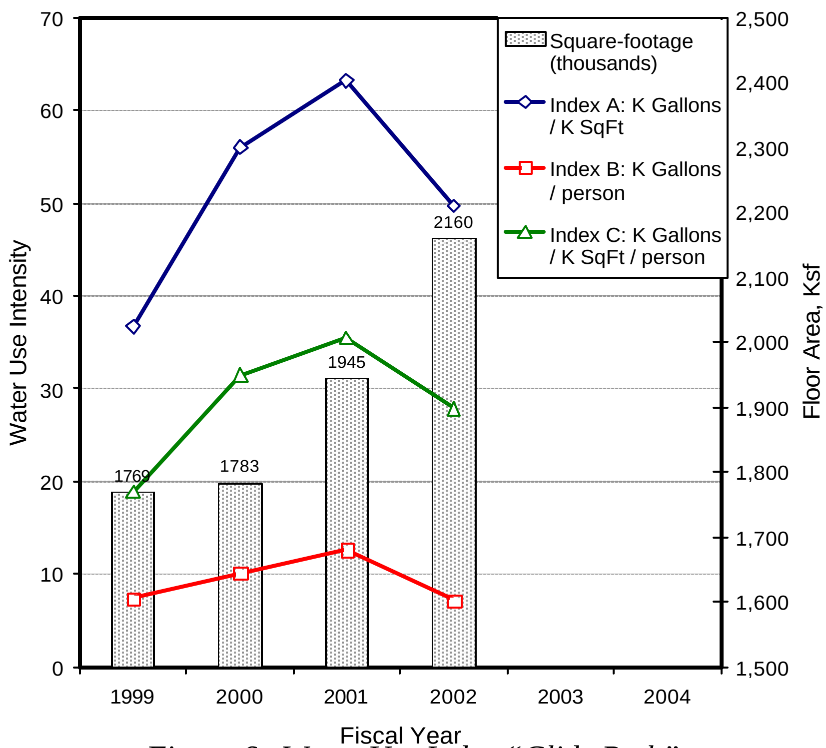

Figure 6. Water Use Index "Glide Path"

DPW should agree on a statistic that is most descriptive to conditions at the Fort. Clearly, Index A (gallons per square foot) is least useful because it does not consider occupancy. Although Index B (gallons per person) appears to show that the site is making the most progress in reducing water consumption, Index C (gallons per square foot per person) is probably the best metric.

Water Conservation Measures

Identifying water conservation measures (WCMs) is important to reduce water consumption on the post. The following is a discussion of several potential WCMs that Fort Buchanan DPW may wish to consider. This will be an on-going activity of looking for water projects – this is a starting point.

Domestic Water Use

Because domestic water use (sinks, toilets, and showers) is so dominant at the Fort, most of the water savings will be from installation (and good on-going maintenance) of this equipment. The site visit identified that although the vast majority of showerheads were of the low flow variety, there were a number of areas that had older style showerheads that could be replaced. Buildings that would benefit from low-flow showerheads include:

- 1300 area barracks flowing very high at 6.0 gpm (3 barracks, 8 units per building, 2 showers per unit=48 showerheads)
- Girls locker room in the high school (eight, 2.5 gpm showerheads). Replacement cost may not be cost effective because the integrated wall-mounted shower head is difficult to replace.
- There will be a few older, damaged, or missing showerheads throughout the site, as evidenced in the site visit.

In addition to showerheads, the site visit identified approximately 40% of the toilets have been replaced with ultra-efficient (1.6 gallons per flush) toilets. However, many areas had flush-valve toilets where the flush volume was indeterminate or appeared to release more water than they should.

DPW would need to work with maintenance staff, the site O&M contractor, family housing, and janitorial services to facilitate identifying needed replacements/repairs.

- Consider recognizing staff that help identify water savings measures (See Education/Outreach in the Best Management Practices section.)
- DPW should also work with Army family housing to make sure the check-in and check-out procedures look at the need to replace water-consuming equipment. The checklist may also include measuring water pressure to help identify major pressure problems, as well as localized pressure problems that may be caused by a partially closed or broken valve.
- Fort Buchanan should consider purchasing an equipment "pool" of water-efficient equipment (toilets, showerheads, and faucets/aerators) to have on-hand for immediate use. With replacement equipment sitting in the warehouse, when opportunities are identified DPW will be able to respond quickly. Although low-water consumption fixtures are now required by code there are opportunities to go beyond minimum requirements.
- Consider purchasing one large and one small micro-weir pitchers (like the one used on the site visit) to measure shower and sink flow rates. Micro-weir pitcher is an accurate device for

determining the flow rate of faucets and showerheads. A small one will be useful for faucets, while a large one will work well for showerheads.

Despite slow user acceptance in some circles, no-water urinals have been shown to be effective in many Federal facilities. A pilot test is currently underway at the National Guard Headquarters building in San Juan. No-water urinals should be introduced to a population that is interested in conservation and willing to work at educating users of the benefits of no-water urinals. Ideally, once Fort Buchanan has an established education/outreach and recognition program for water conservation, DPW can suggest a pilot project with an organization that would be receptive to the technology. More information on no-water urinals is provided in the Best Management Practices section of this report.

Housing Appliances

Horizontal-axis clothes washers, although used for years in Europe, are just becoming popular in the U.S. markets. Fort Hood is the first major Federal site to install these washers and expects to use 38% less water and 32% less energy. In addition to saving water and energy, these washers have unexcelled performance and use less detergent. Now that family housing includes a post-provided clothes washer, DPW should push to provide the energy and water-efficient washers. For more information, see the FEMP fact sheets on energy-efficient clothes washers at:

- http://www.eere.energy.gov/femp/procurement/pdfs/clothes.pdf
- http://www.eere.energy.gov/femp/procurement/clothes_washers.html .

The other major water consumer in residential dwellings is the kitchen dishwasher. As these devices are added or replaced in homes, DPW should set standards that the highest efficiency (water and energy) washers will be purchased, not necessarily the lowest first cost models. See the FEMP fact sheet on efficient dishwashers:

- http://www.eere.energy.gov/femp/procurement/dishwashers.html

Irrigation

Although there is very little landscape irrigation on the installation, as new buildings are built, there will likely be more systems added. DPW should develop a policy on irrigation systems and controllers. Specifically, the issue with irrigation controllers is that the schedule is set in the controller (often by building tenants) and hardly ever changed. Water savings results from ensuring that water schedules aren't excessive (probably through education) and also from not watering when landscape receives precipitation.

The idea that water scheduling can be interrupted on rainy days for relatively little cost can be implemented through devices like soil moisture probes, which shut off watering when enough precipitation is received. These probes require periodic checks to ensure they are operating properly. Other controllers are designed to interrupt watering based on evapotranspiration (ET) rates received via radio communications. ET rates are calculated locally based on the amount of precipitation received, humidity conditions, and how fast water is evaporating from the soil and plants. For more information, refer to the section on BMP #3: Water-efficient Landscaping.

As more irrigation controllers are added, they could be configured to be interrupted from a central location likely someone within DPW. The interrupt signal could be sent via EMCS infrastructure or small radio frequency modules. This is a fairly advanced technology that may not be applicable for Fort Buchanan because of the small number of irrigation controllers, but is worth mentioning for long-term planning.

Cooling Towers

This is low priority because there are only two cooling towers on site (on the high school). That being said, the control of make-up water should be evaluated because there can be the potential for savings. Although the cooling towers are fairly small, DPW should work with the contractor in charge of chemical treatment of the tower to ensure that water conservation is one of their goals. An internet search reveals that there are a number of companies that offer training related to chillers and cooling towers.

Training

A significant part of the process of saving water can be having adequately trained staff. DPW should commit funding to provide on-going training for all DPW staff. Table 4 provides a partial list of training opportunities related to water.

Tank Maintenance

It is important to implement detailed procedures for operating and maintaining the large storage tanks at Fort Buchanan. The storage tanks should be evaluated for: withdraw/refill methodology, force protection/security, and scheduled maintenance.

- The withdraw/refill operation of the Fort Buchanan storage tanks should be evaluated in the context of the water system characterization model recently completed by the Army Corps of Engineers. A detailed computer model is required to ensure the storage tanks are utilized in an optimal manner.
- It is also important to protect the water storage (and water system) from accidental and intentional damage or sabotage. For more information, see "Protecting Water Supply from Terrorist Threats" in the Emergency Planning section.
- Finally, the DPW needs to address the maintenance procedures and periodic checks of the storage tanks in compliance with local, state, and Army regulations. CERL can also be a good resource on progressive maintenance techniques. For example, Army regulations require cathodic protection (CP) on metal water storage tanks. CERL has been evaluating remote

monitoring of CP in storage tanks.
(http://www.cecer.army.mil/td/tips/browse/publications.cfm?AREA=6)

Table 4. Training Opportunities on Water Related Topics

Training Course	Source: (F=DOE-FEMP; A=American Water Works Association ; S=ASHRAE; T-DOE-OIT)	Energy Program Manager	Environmental Division:	Engineering Design: Chief	Engineering Design:	Engineering Design:	Operations & Maintenance:	Supply Officer: Chief	Housing Officer: Chief	DPW Director	Master Planner	Contracting Officer	Legal Specialist
Water Resource Management	F	S		O	O		O				O		
Maintaining and Securing Your Water Distribution System	A	S	S				H			S	H		
Vulnerability Assessments for Small and Medium Water and Wastewater Utilities	A	S	S				S			S	S		
Buying Energy- and Water-Efficient Products	F	S		S	S	O	S	S	S	O			
Federal Life-Cycle Costing	F	H		H	O		O	O	O		S		
Implementing Renewable Energy Projects	F	L		L		O					O		
Federal Energy Management	F	H	O	S	S	S	S	O	O		S		
Introduction to FEDS [1]	F	S		O							O		
Advanced FEDS [1]	F	L											
Emergency Response Planning	A	S	S				H			S	H		
Irrigation Association Certification (www.irrigation.org/education)	Irrigation Association	L		L									

Terms:

H = Highest priority (within 1st year) – training considered required by staff after they take on responsibilities of position.

S = Short term (0 to 3 years) – training suggested for staff soon after they take on responsibilities of position.

L = Long term (3 to 5 years) – training suggested to staff once settled into position.

O = Optional – training considered relevant and useful but optional for staff in position.

Note:

This training list is not all-inclusive. Many similar training programs exist which may be adequate substitutes. The list of training subjects provided is directed toward the energy management program only and is not meant to identify all training requirements of the identified staff positions. Not all staff positions will require the training identified; a person who has demonstrated proficiency in the subject area may not require additional training.

[1] Planning is in the works for the FEDS software to incorporate water efficiency measures

Army Regulation 200-1, Environmental Protection and Enhancement, mandates compliance with the Safe Drinking Water Act (SDWA), which governs potable water systems. Many states and municipalities have their own guidelines and regulations on water storage. For example, Chapter VII – Water Storage in the "New Mexico Water Systems Operator Certification Study Guide" has good information on water storage. This can be found at http://www.nmenv.state.nm.us/swqb/FOS/Training/WSOC_Study_Guide/Chapter_VII-Water_Storage.pdf .

In 1997, the U.S. Army Center For Health Promotion And Preventive Medicine produced an excellent document called *Maintaining High Drinking Water Quality in Finished Water Storage Tanks and Reservoirs.* This document and the Water Supply Management Program within this organization may be a possible resource for Fort Buchanan DPW. This can be found at http://chppm-www.apgea.army.mil/dehe/pgm31/IPs/IP31-019.pdf .

Best Management Practices and Operations and Maintenance Recommendations

As part of the guidance issued with Executive Order 13123, and in addition to developing the installation-specific water management plan, Federal agencies must also implement at least four Best Management Practices (BMPs).

In this section, we present the FEMP BMPs, operations and maintenance (O&M) actions, and the retrofit/replacement options specific to Fort Buchanan. The O&M options focus on optimizing existing equipment and fixtures to minimize water use. The retrofit/replacement options require the investment of capital dollars to change the equipment, fixture, or process to reduce water use.

Not every O&M or retrofit/replacement option on the FEMP list is applicable to Fort Buchanan's applications. Rather than re-stating the FEMP guidance for each BMP, this section focuses on those options that are most applicable to the Fort. In addition to the FEMP's BMPs, this section makes use of data and recommendations as found in the *Air Force Water Conservation Guidebook* (CH2M Hill, 2002) as well as the *Handbook of Water Use and Conservation* by Amy Vickers. (Vickers, 2001)

To receive credit for implementing a BMP at Fort Buchanan, the following three steps must be taken:

- The WMP must be developed and incorporated into the existing operating plans for the site.
- Applicable O&M options must be put into practice. Retrofit and replacement options must have been reviewed within the last two years.
- Applicable cost-effective retrofit/replacement options have been implemented.

BMP Recommendations for Fort Buchanan

Table 7 provides a list of the BMPs for water (listed as provided by FEMP and not in priority order for Fort Buchanan). The BMPs recommended for Fort Buchanan and other comments are provided.

Table 7. Fort Buchanan Progress towards Meeting BMPs

Best management Practice	Applicability	credit for BMP?	comments
#1 Public Information and Education Programs	Recommended	No. Needs further initiatives on domestic and process water use	Active energy office and energy manager can build on current outreach activities to include water.
#2 Distribution System Audits, Leak Detection, and Repair	Recommended	No	Perform detailed distribution system audit and sample leak detection survey.
#3 Water Efficient Landscaping	No	No	Unlikely given relatively little landscape irrigation.
#4 Toilets and Urinals	Recommended	No. Although much of the equipment found on post is water-efficient, more is needed.	Survey existing equipment and replace older units.
#5 Faucets and Showerheads	Recommended	No. Although much of the equipment found on post is water-efficient, more is needed.	Survey existing equipment and replace older units.
#6 Boiler/Steam Systems	N/A	N/A	N/A
#7 Single-Pass Cooling Equipment	No	No	Very close to meeting BMP
#8 Cooling Tower Management	No	No	Only 2 small cooling towers found on post
#9 Misc. High Water-Using Processes	Possible	Must determine if complete replacement of clothes washers and dishwashers satisfy this BMP.	Army-owned and operated family housing units
#10 Water Reuse and Recycling	No	No	Seek other opportunities for recycle and reuse

The two BMPs that are clear selections for Fort Buchanan are: BMP #4: Toilets and Urinals and BMP #5: Faucets and Showerheads. Many of these fixtures have already been replaced with water efficient models, so an additional survey and subsequent replacements will satisfy this BMP. BMP #1: Public Information and Education Programs is also recommended. The current energy awareness program can be expanded to include water conservation. Finally, BMP #2: Distribution Systems Audits, Leak Detection, and Repair appears promising and a worthwhile activity for the post. It is not clear in which category Fort Buchanan's wholesale replacement of clothes washers and dishwashers in family housing might fit. Clarification may be needed to determine if BMP #9: Misc High-Water Using Processes may apply.

More information about each BMP is provided in the following sections.

BMP #1: Public Information and Education Programs

If water conservation technologies and methods are to be successful, educating users is very important. New operational procedures, retrofits, or replacements, are most effective when employees, contractors and the public know what the new technology or methods are and how to use them properly.

An additional benefit to water conservation is positive public opinion. If Fort Buchanan is doing its part to save the community resources - the community needs to know. Informing the public about your facility's commitment to reduce waste is good news. The news media is often interested in facilities that take a proactive stand on water conservation.

As is the case for most installations, this BMP will be one of the easiest and most cost-effective to implement. At minimal cost, a public information and education program providing a strong foundation for all water conservation efforts can be implemented. In addition, these programs enhance public opinion by emphasizing the priority given to environmental stewardship on post.

FEMP advises the following internal and external options be employed to implement this BMP.

Internal Options

- Enlist the cooperation of the public affairs staff at the Fort to develop/publicize all public information and education programs. Public affairs personnel can be a vital resource in helping develop the programs and communicating them to the public.
- Coordinate the efforts with other resource awareness programs (e.g., energy or waste-reduction programs) at the Fort.
- Establish feedback or reporting systems to report leaks or wastes of water. Respond to inquiries quickly to encourage continued participation.
- Place instructional signage near any new or retrofitted water-using equipment to explain the technology and how to use it.
- Conduct regular training and workshops for maintenance personnel to keep them updated on operational changes and maintenance procedures.

External Options

- Further develop your relationship with the Puerto Rico Aqueduct and Sewer Authority (PRASA) to develop comprehensive programs and share your success with others. Many water providers have public information and education programs you can take advantage of and use as templates to develop your own program. Fort Buchanan may need to lead the way in this relationship to convince PRASA of the importance of supporting conservation.

- Create displays in high traffic areas to communicate the goals and results of your water conservation program.
- Develop websites, brochures, and other materials for distribution to employees and the public to describe your program, its goals, and successes.

Fort Buchanan Implementation Measures

To receive credit for implementing this BMP at Fort Buchanan, the site should consider establishing a program that includes the following activities:

- Publish articles in any site newspaper/newsletters highlighting programs, activities and successful projects that promote water conservation.
- Identify high-traffic areas to communicate conservation efforts. If allowed, the main entry points (guard houses) for the site would make excellent locations. Lunch and break rooms also make good locations.
- Coordinate with site cable television providers to telecast water conservation information on site information channel.
- Develop water conservation module for site's website.
- Establish and publicize a telephone hotline number for site personnel to report leaks or other water waste.

Fort Buchanan Support Resources

State water management districts and local water utilities frequently have their own public education and information programs that you may be able to use at the Fort. Federal, state, and municipal governments, along with some private sector organizations, frequently develop promotional resources to support conservation programs. These local agencies should be your first source for an effective, low-cost public education program.

Other Information

Water Management: A Comprehensive Approach for Facility Managers, General Services Administration. http://www.gsa.gov/attachments/GSA_PUBLICATIONS/extpub/waterguide_new.pdf

Military Handbook 1165: Water Conservation, Naval Facilities Engineering Service Center; www.afcesa.af.mil/Directorate/ces/Civil/Water/Water.htm or http://energy.navy.mil/publications/water/mil_hdbk_1165.pdf .

A Water Conservation Guide for Commercial, Institutional and Industrial Users, New Mexico Office of the State Engineer 1-800-water-nm.

BMP #2: Distribution System Audits, Leak Detection, and Repair

Completing a distribution system audit/leak detection program can help reduce water loss while extending existing supplies to meet increasing demands. Reduced water loss results in water cost savings and the associated pumping, and treatment (i.e., chemicals). Additional benefits can include:

- Deferment of the construction of new water supply and/or treatment facilities or other costs associated with additional procurement.
- Reduced operating costs by repairing leaks that save water and the power associated with pumping.
- Reduced potential property damage. Repairing leaks can prevent damage to property and safeguard public health and safety.

Fort Buchanan's water distribution system encompasses about 18.9 miles of potable water lines. The distribution system consists of a combination of cast iron, asbestos cement, galvanized iron, ductile iron, and polyvinyl chloride (PVC) piping (USACE, 2000). Piping sizes range from 2 to 30 inches, with a significant portion of the distribution system being over 40 years old.

Considering the layout of Fort Buchanan, a leak detection program should target the larger (2 inches and larger) diameter distribution piping. Leak detection survey methods can locate underground leaks so that they can be repaired. An average leak detection survey and repair program can result in a 25 to 50 percent recovery of water being lost due to leaks. Small diameter piping and all connections should be the focus of periodic visual inspections.

By way of example, even small leaks can result in large water losses over time. If a number of smaller leaks combined total up to a loss-rate of 100 gpm (the equivalent of a 1-inch diameter hole), over the course of a year this would result in a loss of more than 50 million gallons. At Fort Buchanan's marginal cost of water/wastewater of $3.83/Kgallons, that would amount to more than $190,000 annually. Clearly, one would hope that a water leak of this magnitude would be found quickly, although it is not uncommon for small leaks to go undetected for many years.

The age of the water distribution system at Fort Buchanan indicates that it would likely be a good candidate for a leak detection survey. In light of the fact that most of the consumption at the site is domestic usage and that the Fort is doing fairly well at fixture replacement, leak detection may hold the most promise of finding water savings opportunities.

Background on Leak Detection

Typically, a leak detection survey is a thorough investigation of the entire distribution system to pinpoint leaks. Electronic listening devices would be used to listen for possible leaks at major contact points such as meters, valves, and hydrants. Sonic high frequency contact microphones are used for metallic piping and ultrasonic microphones are used for nonmetallic piping.

For metallic pipes, the sound of leaks can travel the distance of the pipe between connections. For nonmetallic piping, sound does not travel as well. Therefore, multiple listening points are required along a section of pipe. (AWWA 1990) Because the Fort has the majority cast iron and ductile iron piping, leaks should be relatively easy to locate. It is possible to purchase or rent the listening equipment, although the process is definitely an acquired skill.

Estimating Program Costs

Distribution system audits and leak detection programs require specialized expertise, trained personnel, and specialized equipment. In-house personnel seldom perform these programs; instead there are a number of local, regional, and national firms that specialize in providing the needed services.

A leak survey of the major water distribution lines at the Fort would cost approximately $5,000 to $7,000[3]. This would provide a detailed analysis of each leak including location of leak and estimated water losses from the leak. The cost for leak repair is extremely variable mainly because leaks can often be difficult to uncover. Leaks can be located under existing equipment or buildings, making excavation very expensive.

Fort Buchanan Operations and Maintenance Options

Perform (contract for) a full-scale audit and leak detection survey using a methodology consistent with that described in the American Water Works Association's *Water Audit and Leak Detection Guidebook Manual of Supply Practices,* AWWA Number M36. The audit can be all encompassing or focus on a particular area of the site.

Fort Buchanan Retrofit/Replacement Options

- Repair leaks or replace pipes when leaks are found.
- Document completion of leak detection survey to verify completion of BMP.

Additional Resources

The Naval Facilities Engineering Services Center (NFESC) conduct fee-based water leak detection surveys for military installations. For more information contact NFESC at (805) 982-6072 or http://www.nfesc.navy.mil .

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[3] Personal communications with Bruce Rubin. Utility Services Associates. Seattle, Washington. August 29, 2003.

BMP #3: Water-efficient Landscaping

Water use for landscape irrigation can be difficult to quantify. At Fort Buchanan there are a number of relatively small areas receiving irrigation – most are small turf and landscaped areas near the entrances to particular site buildings. Residents within family housing are responsible for irrigation of turf areas surrounding their residence, per the Fort Buchanan Housing Handbook:

- Family housing residents are responsible for the area extending 50 feet from quarters, halfway to adjacent building, all the way to center of street, playground, or drainage, whichever is greater.
- When rainfall is insufficient for proper lawn maintenance, lawns may be watered. Lawn watering will not start prior to 1800, and will stop at 2300. Longer times can be allowed for larger yards, if approved by DPW.
- Run-off on streets resulting from over-watering will not be allowed. Sprinklers will not be placed where they force people from sidewalks.

The golf course at Fort Buchanan sees irrigation only on the greens and tee boxes. There are no automatic controllers. The irrigation at the greens and tee boxes is provided by a combination of dedicated underground lines with quick couplers and by hose and sprinklers. The golf course is irrigated most intensely during the months February though June.

Fort Buchanan Operations and Maintenance Options

Because there are currently no automatic timers on the grounds irrigation equipment, the main operation improvement will entail proper training of staff and residents about efficient watering practices (described below under *Efficient Management Practices*). For future improvements, the Fort should consider implementing the recommendations that are outlined in this section and use this section as a basis for a landscape management plan. This should include:

- Installing efficient irrigation equipment sub-surface irrigation for turf
- Implementing a standard procedure to planting native landscaping that requires little additional water and is tolerant to local climate changes
- Providing training to maintenance staff and residents on efficient watering techniques and scheduling
- Installing automatic controls with multiple stations so that flexible watering schedules can be achieved.

There are basic O&M practices that can be employed that have the potential of reducing the water consumption of irrigated areas at the Fort. These practices include irrigation scheduling, performance standards, and ground maintenance described below.

Irrigation Scheduling

Proper scheduling of irrigated grounds is at the root of water-efficient irrigation and landscaping practices. The most important aspect of efficient irrigation scheduling is understanding the adequate water requirements for the specific plant type and accurately irrigating this required water volume at optimal conditions. More information is provided on specifics of irrigation scheduling in Appendix E.

Irrigation Management

Site maintenance staff should be trained and updated on irrigation management performance guidelines. These guidelines should include water efficiency as one of the top priorities. Many times the maintenance staff is instructed only to keep the grounds green, but this often times means that water is being wasted. There should be accountability for water use by the maintenance staff. If possible, irrigation should be metered or estimated so that it can be monitored. The maintenance department performance metrics can include the following:

- Report and repair all equipment problems such as broken sprinkler heads.
- Perform periodic inspection of all irrigation systems – this should be a minimum at the beginning and end of the irrigation season.
- Specify the irrigation scheduling technique that should be performed (as stated above for example).
- Require specific maintenance practices that promote efficiency – specific measures are defined below in the following section.

Efficient Maintenance Practices

There are easy low- and no-cost solutions to maintaining irrigated grounds that can help minimize water needs. Here is a list of some recommendations. These should be considered for family housing, site buildings, and the golf course:

- *Aerate Soil*: In turf areas, aerate soil once or twice per year. Aeration promotes nutrient and water intake, reduces thatch that can smother grass. Aeration also promotes a deep root system that is vital to a health turf. Avoid aerating during hot season.
- *Mulch*: In beds and around trees, layer at least 3 inches of mulch. Mulch can be a variety of materials including wood chips, bark, composted leaves, or rocks. Mulch helps to slow down evaporation of water off the soil, keeps the soil cooler, reduces weed growth, and adds variety to the landscape.
- *Water at Ideal Times*: Irrigate early in the morning to reduce evaporation and wind drift. Avoid watering during the hot times of the day and during windy periods.
- *Water Deeply*: It is better to irrigate deeply less often than lightly every day. This will promote a deeper and stronger root system that is more tolerant to drought.
- *Moisture Sensor*: Install a moisture sensor to monitor soil moisture levels to help ensure that watering schedule is irrigating to a deep enough level.
- *Water Pressure*: Check water pressure to ensure that it is set at manufacturers recommended range so that the precipitation rate is accurate.

- *Mowing Height*: Keep grass height to at least 3 inches in length. This helps to shade root system and reduces water requirements. Alternate mowing height to encourage roots to grow deeply.
- *Routine Inspection of Equipment*: Inspect equipment for leaks and broken heads, and make sure that sprinkler heads are adjusted appropriately for the area to limit overspray.

Select climate appropriate turf, trees, shrubs and ground cover and eliminate "strip grass" to the greatest extent possible. Small strips of grass, common in parking islands and between sidewalks and the roadway are hard to maintain and difficult to efficiently water, use bushes, mulch, colored tiles, instead.

Golf Course Irrigation Options

During discussions with the golf-course manager, options for moving the golf course from potable city water to local surface water were identified. These options, while subject to the same construction moratorium as the rest of the site, should be investigated further for their potential economic and water-security impacts. These options include:

- Further development of existing proposal to construct a small pond behind the course clubhouse and parallel to fairways, on holes 10 and 11. This proposal holds merit for its proximity to the course and its additional benefit of providing flood control for the near-by intersections and the Main Gate.

Fort Buchanan Replacement Options

For future implementation of irrigation equipment, the Fort should consider implementing efficient irrigation technologies. For turf area, the most efficient technology available on the market is sub-surface irrigation. Sub-surface irrigation is underground piping that delivers water directly to the root system of the turf. The distinct advantages for sub-surface irrigation include:

- Improved distribution uniformity
- No overlap
- No wind drift
- No evaporation losses
- Flexible water schedule

Studies performed by New Mexico State University have reported a savings of up to 60% for sub-surface irrigation when comparing to traditional rotor irrigation sprinkler system. Typically, there will be about a 20% increase in initial costs with a sub-surface irrigation system, as documented in the New Mexico State University case study. [As reported in a PowerPoint presentation by Dr. Bernard Leinauer of NMSU Extension Plant Sciences on August 29, 2002]

For more information on sub-surface irrigation go to Center for Irrigation Technology at:

http://www.cati.csufresno.edu/cit

Resources

Irrigation Association Water Management Resources: This website offers best management practices for irrigation at: http://www.irrigation.org/conservation.htm .

Resources for Irrigation Management for Turf Landscape through the Northern Colorado Water Conservancy District at: http://www.ncwcd.org/ims/ims_turfandurban.asp .

Scheduling Methods Using ET as a Management Tool; downloaded at: http://www.ncwcd.org/ims/ims_info/scheduli.pdf, Brent Mecham, Northern Colorado Water Conservancy District, Loveland, Colorado, 1997.

Irrigation Scheduling: This site provides resources on understanding proper irrigation scheduling for turf at: http://www.hort.usu.edu/pli/schedule.html .

American Society of Landscape Architects website at http://www.asla.org.

Xeriscape website http://www.xeriscape.org, for information on water-wise landscaping.

BMP #4: Toilets and Urinals

Studies show that water used to flush waste accounts for nearly one-third of a typical office-style building's total water consumption. While the office-style buildings at Fort Buchanan may not be considered typical, an overview survey of the Fort indicates that many of the toilets and urinals are old and represent a significant opportunity for reducing water consumption.

Prior to 1994, typical toilets consumed 5- to 7-gallons-per-flush (gpf). Federal laws enacted on January 1, 1994 required that residential toilets use no more than 1.6 gpf, and in 1997 a similar limit was established for commercial toilets. Urinals were limited to 1.0 gpf by the 1997 requirements.

The 1.6 gpf toilets come in three basic categories: (1) flush valve; (2) pressure assisted; and, (3) gravity toilets. Generally, the flush valve and pressure-assisted toilets perform more effectively than gravity toilets because they use the water system pressure to assist in their operation. Design also plays a key role in operational effectiveness. Inexpensive models that lack proper bowl and water flow design may require occasional double-flushing.

Today's low flow toilets are far more effective than those available when the new laws first went into effect. The early models were sometimes only 3.5-gpf toilets equipped with 1.6-gpf tanks or flush valves that required frequent double flushing and often became clogged.

Fort Buchanan Operations and Maintenance Options

There are simple low- and no-cost operations and maintenance practices that can avoid wasting water in the lavatories on site and in family housing. These are centered on making sure the fixtures are operating properly and are not leaking. Below is a list of O&M recommendations for restroom facilities:

- Assign a staff person who is responsible for performing routine maintenance in restrooms the following activities:
    - replacement of worn parts - valves, flapper valves and faucet aerators
    - leak detection
    - periodic sampling of flush rates
- Establish a user-friendly reporting mechanism for staff to alert problems with fixtures. Name and number of the person responsible for repairing restroom fixtures should be posted in restrooms.
- Educate staff and institute a public outreach program to teach the importance of water conservation so that fixtures are not disabled and maintenance issues are reported
- Test system pressure to ensure that it is between 40 and 80 pounds per square inch. Pressure over this level will waste water and wear out fixtures faster.

Fort Buchanan Replacement Options

Domestic water use (water used for toilets, urinals, sinks, and showers) at Fort Buchanan represents the majority of the site's total water use. Preliminary estimates put this water use at more than 70% of the total. A good opportunity for saving water at the site in the category is the replacement of standard-efficiency toilets and urinals with water-efficient types.

Toilet replacements: replace 3.5- to 7-gpf toilets, to maximize water savings, with valves and porcelain specifically designed to use 1.6 gpf. Site specific evaluation of existing waste lines, water pressure, distance, usage, settling, and types of users (employees, residents, occasional members of the public, high visitor populations, etc) is necessary to determine the appropriate models for a specific site. Where appropriate, recycle used parts (crushed vitreous china can be used for roadbed materials), to minimize landfill impacts.

No-water urinals: No-water urinals are urinals that do not use water for flushing. These urinals use a trap in the drain of the urinal that contains a liquid that is less dense than urine, allowing the urine to pass through the trap and into the drain line. This liquid prevents sewer vapors from escaping back into the restroom. No-water urinals have been installed in hundreds of Federal facilities all across the country at great success. Some benefits of no-water urinals include:

- Trap liquid is biodegradable and safe for handling
- Significant maintenance reduction will be experienced because there are no valves to repair or replace
- Pipes do not corrode from high concentration of urine.

Studies have been preformed that have documented the effectiveness of the no-water urinals. The University of California performed a study that compared a traditional urinal to a no-water urinal. The study found less bacteria growth in the no-water urinal compared to the traditional urinal, and in addition there was no detectable ammonia odor found in the no-water urinal. Pacific Northwest National Laboratory recently conducted a study that tested no-water urinals for ammonia odor and found that all sampled urinals had no detectible odor resulting from maintenance issues with the no-water urinals.

When replacing standard flush urinals with no-water urinals, there are some important considerations that must be taken. The maintenance staff should be included in the decision-making process and must be educated on how to properly clean and maintain the no-water urinals. In addition, male staff must be educated about the urinals prior to installation. If both the male staff and maintenance crew are not fully on board with no-water urinals, the chance of success is low. When considering replacement of existing urinals with no-water urinals, installing demonstration urinals that are placed in high traffic restrooms is a good way to test the user acceptability.

There are two models of the no-water urinals on the market and available to the Federal government through the Federal Supply Service. These brands are the Falcon Waterfree Technologies™ and the Waterless No-Flush Urinal™. Both of these urinals function similarly (as described above) but differ in cost, material composition, and trap design.

Fort Buchanan Savings Potential

Tables 6, 7, 8, and 9 below summarize the estimated water use/savings resulting from the installation of water-efficient fixtures. These data were adapted from

Average water use and savings by low-volume and high-volume toilets are shown in Table 5 for residential (i.e., family housing) applications. Table 6 shows this data for industrial, commercial, and institutional (ICI) facilities. Average water use and savings by low-volume and high-volume urinals are shown in Table 7, and no-water urinals in Table 8.

Table 5. Estimated Savings by Low-Volume Toilets in Residential Applications

Fixture Year of Installation	**Average fixture water use (gal / use)**	**Daily Water Use (5.1 uses / person / day)**	**Annual Water Consumption (gal / year)**	**Annual Water Savings (gal / year)**
1994 – Present	1.6	8.2	2,993	-
1980 – 1994	4.0	20.4	7,446	4,453
1950-1980	5.0	25.5	9,308	6,315
Pre 1950	7.0	35.7	13,031	10,038

(Source: CH2M Hill, 2002)

Table 6. Estimated Savings by Low-Volume Toilets in ICI Facilities

Fixture Year of Installation	Average fixture water use (gal / use)	Daily Water Use Male / Female (uses / day)	Daily Water Consumption Male/Female (gal / day)	Annual Water Consumption Male/Female (gal / year)	Annual Water Savings Male/Female (gal / year)[1]
1994 – Present	1.4	1.0/3.0	1.6/4.8	416/1,248	-
1980 - 1994	4.0	1.0/3.0	4.0/12.0	1,040/3,120	624/1,872
1950-1980	5.0	1.0/3.0	5.0/15.0	1,300/3,900	884/2,652
Pre 1950	7.0	1.0/3.0	7.0/21/0	1,820/5.460	1,404/4,212
[1] Savings are presented per person, per year, by gender					

(Source: CH2M Hill, 2002)

Table 7. Estimated Savings by Low-Volume Urinals in ICI Facilities

Fixture Year of Installation	Average fixture water use (gal/use)	Daily Water Use (uses/day)	Daily Water Consumption (gal/day)	Annual Water Consumption (gal/year)	Annual Water Savings (gal/year)
1994 – Present	1.0	2.0	2.0	520	-
1980 - 1994	2.0	2.0	4.0	1,040	520
Pre 1980	5.0	2.0	10.0	2,600	2,080

(Source: CH2M Hill, 2002)

Table 8. Estimated Savings by No-Water Urinals in ICI Facilities

Fixture Year of Installation	Average fixture water use (gal / use)	Daily Use (uses/day)	Daily Water Consumption (gal / day)	Annual Water Consumption (gal / year)	Annual Water Savings (gal / year)
1994 – Present	1.0	2.0	2.0	520	520
1980 – 1994	2.0	2.0	4.0	1,040	1,040
Pre 1980	5.0	2.0	10.0	2,600	2,600

(Source: CH2M Hill, 2002)

To use this information you will need to estimate the number of personnel who work in the Fort facilities (by gender) and calculate the installed cost of fixtures specific to your site, plumbing configuration, and security related issues. R.S. Means (http://www.rsmeans.com) is a good source for fixture costs and labor rates/times. Water and sewer cost savings associated with the installation of low-volume toilets can be calculated by multiplying the volume of water/wastewater reductions expected in facilities by the incremental water and sewer rates.

During our walk-through audits of representative site buildings and family housing, we estimate that between 40-50% of the existing fixtures are inefficient and good candidates for replacement. The next step in this process is to conduct detailed water audits targeting buildings and homes with older fixtures. Once accurate fixture counts are assembled, the water savings analysis and economics can be completed and specific projects developed.

Other Information:

Toilet Performance Studies:

- California Urban Water Conservation Council - website has links to toilet performance studies and information at: http://www.cuwcc.org/products_tech.lasso .
- Saving Water Partnership – website has toilet performance study done by the National Association of Homebuilders (October 2002) titled: Water Closet Performance Testing, which can be downloaded for free at: http://www.savingwater.org/toilettest.htm .

References

Federal Energy Management Program Water Efficiency Best Management Practice, Toilets and Urinals, May 2000.

University of California, Los Angeles, Department of Civil and Environmental Engineering. 2000. *Waterfree Urinal Study*

Pacific Northwest National Laboratory, Testing for Ammonia Odor from Urinals, L.L. Larson, November 2002.

BMP #5: Faucets and Showerheads

Tremendous amounts of water and energy can be wasted through use of non-water-efficient faucets and showerheads. Federal guidelines mandate that all lavatory and kitchen faucets and replacement aerators manufactured after January 1, 1994 use no more than 2.5 gpm measured at normal water pressure (typically 80 pounds per square inch, psi). Metered valve faucets manufactured after the same date are limited to 0.25 gallons per cycle. Relevant to Fort Buchanan are family housing and most site building lavatory and kitchen/break-room faucets, as well as shower facilities.

Fort Buchanan Operations and Maintenance Options

It is recommended that Fort Buchanan implement the following O&M options (where applicable) to help conserve water used in lavatories and showers:

- Fixing leaks is the most cost-effective manner to reduce water consumption for faucets and showerheads. Prior to spending money on retrofit or replacement, ensure that that leaks are repaired.
- Establish a user-friendly method to report leaks and a process of fixing them quickly. Encourage cleaning and custodial crews to report problems.
- Test system pressure to make sure it is between 20 and 80 psi. If the pressure is too low, then low consuming devices will not function properly. If the pressure is above 80 psi, the faucets will deliver more water than their rated amount and the fixture will wear out faster.
- Install expansion tanks and pressure reducing valves as appropriate. Reduce water heater settings to prevent temperature and pressure relief valves from discharging water.
- Lower the setting of the hot water temperature to achieve ancillary savings in electricity or natural gas used to heat water.
- Correctly adjust and maintain automatic faucet sensors to ensure proper operation.
- With infrared or ultrasonic sensor faucets make sure that the flow controller connected to the sensor does not become clogged with impurities carried by the water.
- Post energy/water awareness information at point-of-use to encourage conservation.

Fort Buchanan Replacement Options:

The following retrofit/replacement options should be investigated to determine their applicability for conserving water at your installation:

- Equip faucets with aerators. Placed on top of the faucet head, aerators add air to the flow stream and increase the effectiveness of the flow to require less water.
- Replace old showerheads that use 3 to 7 gpm with new models that achieve the 2.5-gpm rate. The newer model showerheads feature a narrower spray area and a greater mix of air than conventional showerheads. These features allow for a decrease in the overall water consumption while maintaining the feel of a full-volume shower.

Fort Buchanan Water Savings Potential

Tables 9, 10, and 11 summarize the estimated water use/savings resulting from the installation of water-efficient fixtures. Average water use and savings by low-volume and high-volume faucets are shown in Table 9 for residential (i.e., family housing), Table 10 for industrial, commercial, and institutional (ICI) facilities. Average residential water use and savings by low-volume and high-volume showerheads are shown in Table 11.

Table 9. Estimated Savings by Low-Volume Faucets in Residential Applications

Fixture Year of Installation	Average Fixture Flow Rate (gal / min)	Daily Water Use per Person (min / day)	Annual Water Consumption (gal / year)	Annual Water Savings (gal / year)
1994 – Present	2.5	8.1	7,391	-
1980 - 1994	2.7	8.1	8,130	739
Pre 1980	4.0	8.1	11,286	4,435

(Source: CH2M Hill, 2002)

Table 10. Estimated Savings by Low-Volume Faucets in ICI Facilities

Fixture Year of Installation	Average Fixture Flow Rate (gal / min)	Daily Water Use per Person (min / day)	Annual Water Consumption (gal / year)	Annual Water Savings (gal / year)
1994 – Present	2.5	1.0	650	-
1980 - 1994	2.7	1.0	702	52
Pre 1980	4.0	1.0	1,040	390

(Source: CH2M Hill, 2002)

Table 11. Estimated Savings by Low-Volume Showerheads in Residential Applications

Fixture Year of Installation	Average Fixture Flow Rate (gal / min)	Daily Water Use per Person (min / day)	Annual Water Consumption (gal / year)	Annual Water Savings (gal / year)
1994 – Present	2.5	5.3	4,863	-
1980 - 1994	3.0	5.3	5,803	940
Pre 1980	7.0	5.3	13,541	8,678

(Source: CH2M Hill, 2002)

Water and sewer cost savings associated with the installation of low-volume faucets and showerheads can be calculated by multiplying the volume of water/wastewater reductions expected in facilities by the incremental water and sewer rates.

To use this information you will need to estimate the number of personnel who work in the Fort facilities and residents in family housing, and calculate the installed cost of fixtures specific to your site, plumbing configuration, and any related security issues. R.S. Means (http://www.rsmeans.com) is a good source for fixture costs and labor rates/times. Saving water used in lavatory/kitchen faucets and/or showerheads also results in energy savings involved in heating water. Statistics indicate that 60 percent of water used from a showerhead is heated, while 50 percent of water used from a lavatory/kitchen faucet is heated. It requires 0.2 kWh of electricity to heat 1 gallon of water, and 0.5 cubic feet of natural gas to perform the same task. Reviewing utility bills from the energy utility can determine kilowatt-hour charges for electricity and cubic-foot rates for natural gas. Add the projected energy cost savings to the water/wastewater cost savings to enhance the simple pay-back period of a faucet/showerhead retrofit or replacement project.

BMP #6: Boiler and Steam Systems

Fort Buchanan does not currently have boiler and steam systems; therefore this BMP is not applicable.

BMP #7: Single-Pass Cooling Equipment

Fort Buchanan does not have major single-pass or once-through cooling systems; therefore this BMP may not be applicable. Commercial ice machines were found at various places on post and may represent some potential for savings.

BMP #8: Cooling Tower Management

Cooling towers help regulate temperature by rejecting heat from air-conditioning systems or by cooling hot equipment. In doing so, they use significant amounts of water. The thermal efficiency, proper operation and longevity of the water cooling system all depend on the quality of water and its re-use potential.

In a cooling tower, water is lost through evaporation, bleed-off, and drift. To replace the lost water and maintain its cooling function, more make-up water must be added to the tower system. Sometimes water used for other equipment within a facility can be recycled and re-used for cooling tower make-up with little or no pre-treatment, including the following:

- Water used in a once-through cooling system
- Pretreated effluent from other processes, provided that any chemicals used are compatible with the cooling tower system.
- High-quality municipal wastewater effluent or recycled water (where available).

Fort Buchanan Operations and Maintenance Options

If the Fort is not currently credited for this, consider measuring the amount of water lost to evaporation. Water utilities should be willing provide a credit to the sewer charges for evaporative losses.

Find out if conductivity is actually representative of your controlling parameter. Depending on your water supply, the equipment being cooled and the temperature differential across the tower, your parameter may be hardness, silica, total dissolved solids, algae or others. Once you determine the relationship between conductivity and your controlling parameter, set you blow-down valve to keep that parameter constant.

Install conductivity and flow meters on make-up and bleed-off lines. Meters that display total water being used as well as current rate of flow are most useful. Check the ratio of conductivity of make-up water and the bleed-off conductivity. Then check the ratio of bleed-off flow to make up flow. If both ratios are not about the same, check the tower for leaks or other unauthorized draw-off. Read conductivity and flow meters regularly to quickly identify problems. Keep a log of make-up, bleed-off consumption, dissolved solid concentration, evaporation, cooling load, and concentration ratio.

Consider using acid treatment such as sulfuric or ascorbic acid, where appropriate. When added to recirculated water, acid can improve the efficiency of the water by controlling scale buildup created from mineral deposits. Acid treatment lowers the pH of the water, and is effective in converting a portion of the calcium bicarbonate, the primary cause of scale, into the more readily soluble forms. Make sure that staff is fully trained in the proper handling of acids. Also note that acid overdoses can severely damage a cooling system, so use a timer and add acid at points where the flow of water is well mixed and reasonably rapid. Also beware that lowering pH may mean you may have to add a corrosion inhibitor.

Select your chemical treatment vendor with care. Tell vendors that water conservation is a high priority and ask them to estimate the quantities and costs of treatment chemicals, volumes of bleed-off water and the expected concentration ratio. Keep in mind that some vendors may be reluctant to improve water efficiency because it means the facility will purchase fewer chemicals. In some cases, saving on chemicals can outweigh the savings on water costs. Vendors should be selected based on "cost to treat 1000 gallons make-up water" and highest "recommended system water cycle of concentration."

Fort Buchanan Retrofit Options

Consider installing a side-stream filtration system that is composed of a rapid sand filter or high-efficiency cartridge filter to cleanse the water. These systems draw water from the sump, filter out sediment and return the filtered water to the tower, enabling the system to operate more efficiently with less water and chemicals. Side-stream filtration is particularly helpful if your system is subject to dusty atmospheric conditions. Side-stream filtration can turn a troublesome system into a more trouble-free system.

Install covers to block sunlight penetration. Reducing the amount of sunlight on tower surfaces can significantly reduce biological growth such as algae.

Consider alternative water treatment options such as ozonation or ionization, to reduce water and chemical usage. Be careful to consider life cycle cost impact, both of equipment and operations, of such systems.

If not currently installed, install automated chemical feed systems on large cooling tower systems (over 100 ton). The automated feed system should control blow-down/bleed-off by conductivity and then add chemicals based on make-up water flow. These systems minimize water and chemical use while optimizing control against scale, corrosion and biological growth.

Fort Buchanan Replacement Options

Fort Buchanan has relatively new and apparently well-functioning cooling towers. System replacement does not seem like a reasonable opportunity at this time.

Other Information

Water Management: A Comprehensive Approach for Facility Managers, General Services Administration, http://hydra.gsa.gov/pbs/centers/energy/water.htm .

Military Handbook 1165: Water Conservation, Naval Facilities Engineering Service Center; http://www.afcesa.af.mil/Directorate/ces/Civil/Water/Water.htm or http://energy.navy.mil/publications/water/mil_hdbk_1165.pdf.

A Water Conservation Guide for Commercial, Institutional and Industrial Users, New Mexico Office of the State Engineer 1-800-water-nm

BMP #9: Miscellaneous High Water-Using Processes

Many other high water-using processes are found at Federal facilities, including kitchens and food processing, cleaning/laundry services, laboratories, and other process uses. High water-using processes should be identified and analyzed for potential water and energy efficiency improvements. Analyze system design to determine if improvements can be made.

Although this BMP typically implies to large industrial-type processes (such as commerical-size laundry facility), Fort Buchanan may make the case that complete replacement of clothes washers and dishwashers in family housing (which are not currently privitized) could satisfy this BMP. Clarification on the definition of this BMP will need to come from FEMP.

Other Information

Water Management: A Comprehensive Approach for Facility Managers, General Services Administration, http://hydra.gsa.gov/pbs/centers/energy/water.htm .

Military Handbook 1165: Water Conservation, Naval Facilities Engineering Service Center; http://www.afcesa.af.mil/Directorate/ces/Civil/Water/Water.htm or http://energy.navy.mil/publications/water/mil_hdbk_1165.pdf .

A Water Conservation Guide for Commercial, Institutional and Industrial Users, New Mexico Office of the State Engineer 1-800-water-nm .

BMP #10: Water Re-use and Recycling

Some facilities or processes at Fort Buchanan may have water uses that can be met by use of non-potable water. These applications should be identified during the review of water use practices at the Fort. Use of non-potable water is generally most cost effective when considered and accommodated during the planning phase of a facility or system. Therefore, a process should be in place to evaluate non-potable water alternatives at the earliest phases of design.

There are three categories of water re-use and the definitions and terminology may vary for each category. For the purpose of this plan the categories and definitions shown below should be used.

On-Site Water Recycling

On-site water recycling relies on reusing water for the same purpose at the same location. The recycled water is usually filtered or treated in some manner to make it acceptable for its intended re-use. For instance, car washes that use recycled water are equipped to collect water, filter it, and then re-use it in the wash process for additional vehicles. In this application, potable water is used only in the rinse process and/or to provide make-up water to replace losses.

Potential Fort Buchanan Applications

On-site water recycling applications include single-pass cooling, commercial wash systems and other non-critical water uses. Before considering use of on-site recycled water in a process you must first verify that the process is in compliance with any site, local, or state codes governing the use of recycled water.

Typical treatment processes remove suspended solids, but leave dissolved solids (such as salts) in the recycled water. Salts can increase in concentration and present corrosion problems. While not particularly problematical for vehicles, the increased concentration of salts could cause corrosion problems for wash racks or other systems and parts.

Water Re-use

Sometimes referred to as reclaimed water, water re-use refers to the re-use of effluent from wastewater treatment plants following treatment to very high standards and approval for non-potable use. In some instances the treated water may even meet many drinking water standards, but because of public perception and regulations, it is restricted to non-potable uses.

Re-use water is distributed in separate systems (e.g., purple pipe systems) to identify it as non-potable water. Before considering water re-use in a process, you must first verify that the process is in compliance with any site, local, or state codes governing the re-use of water.

Potential Fort Buchanan Applications

These applications include:

- common area landscape irrigation
- firefighter training pits
- power plants
- cooling towers.

Before considering re-use for these or other applications, several questions need to be answered.

- Is a re-use source available?
- How much is available? If re-use water is not available in sufficient quantity, then re-use is not practical, but there may be opportunity to use reclaimed water as a supplemental source.
- Is it on-site or from a municipal source? On-site re-use has more economic potential because it will not require purchase of re-use water from a municipal source. In addition, re-use water from an on-site source will (at a minimum) reduce the size of the transmission/distribution system necessary to deliver the water to where it is needed.
- Does it meet water quality requirements for its intended re-use? Assuming re-use water is available in sufficient quantities from a viable source, it must also meet regulatory requirements for re-use. Supervisory personnel from the re-use water supplier should have this information. If not, the regulatory authority responsible for permitting the re-use source will be able to answer the question.

Other Information

Water re-use, recycling and use of non-potable sources can save water and help limit or avoid disposal costs. Refer to the following sources for further information to assist your evaluation of this BMP.

Southwest Florida Water Management District, *Reclaimed Water Guide*
http://www.swfwmd.state.fl.us/ .

U.S. Environmental Protection Agency Manual, *Guidelines for Water Re-use*
http:/ /www.usepa.gov/ .

American Water Works Association, *Backflow Prevention and Cross-Connection Manual*
http://www.awwa.org.

Water Environment Federation, *Water Re-use Guide*, http://www.wef.org. You may also refer to the AFCEE website at http:/ /www.afcee.af.brooks.mil.

Financial Resources

In most cases the implementation of relevant water-efficiency BMPs will require a capital investment. While at this writing, there are no specific funding mechanisms targeting cost-effective water-efficiency BMP projects, there are six potential funding options that should be considered (Air Force Civil Engineers Support Agency, May 2002). These potential funding options are:

- Energy savings performance contracts (ESPCs)
- Energy Conservation Investment Program (ECIP)
- Housing funds
- Environmental funds
- Operations and maintenance (O&M) funds
- Utility energy services contracts (UESC).

Table 12 reflects the potential for these options to support BMP retrofit/replacement initiatives as they relate to Fort Buchanan.

Energy Savings Performance Contracts (ESPCs)

ESPCs provide a vehicle for an energy services company (ESCO) to design, finance, acquire, install, and in some cases operate energy and water saving equipment and processes. All acquisition costs are paid by the ESCO for which they then are paid a steam of payments based on future savings. Any of the BMP retrofit/replacement options identified at Fort Buchanan could be considered candidates for implementation by ESPC. An initial economic analysis showing a simple pay-back period of 10 years or less is a starting point for considering use of an ESPC.

While ESPCs have traditionally focused on energy-only projects, currently projects that combine energy and water savings (e.g., hot water savings or pump energy savings) are considered for selection. Legislation has been proposed that will open ESPCs to water cost reducing projects as well.

Table 12. Potential Fort Buchanan Funding Options for Supporting BMP Implementation

	ESPC	ECIP	Housing Funds	DPW Energy/ Environmental Funds	O&M Funds	UESC
#1-Public Information and Education Programs			X		X	
#2-Distribution System Audits, Leak Detection and Repair	X	X	X	X	X	X
#3-Water-efficient Landscaping	X		X		X	X
#4-Toilets and Urinals	X	X	X		X	X
#5-Faucets and Showerheads	X	X	X		X	X
#8-Cooling Tower	X	X	X		X	X
#9-Miscellaneous High Water-Using Processes	X	X	X	X	X	X
#10-Water Re-use/Recycling	X	X		X	X	X

Energy Conservation Investment Program (ECIP)

ECIP is an annually funded military construction program targeting energy conservation retrofits of existing buildings. Depending on the year, typical eligibility requirements include:

- The projects have a simple payback of 10 years or less.
- At least 20 percent of projected annual dollar savings come from reduced energy (Btu) savings (water projects are exempt from this provision).

The projects have a savings-to-investment ratio (SIR) of at least 1.25. SIR is the savings generated over the entire performance period, or the life-cycle of the equipment or contract term, brought back to present value (PV) and divided by the capital investment of the project (SIR = Savings(PV) / Capital Investment). It should be noted that ECIP projects compete Army-wide for the limited dollars.

Housing Funds

Water conservation initiatives related to Fort housing may be eligible for implementation using housing funds. Recent DoD efforts to improve the quality-of-life for active duty personnel and dependents have resulted in more robust housing budgets. Consequently, implementing retrofit/replacement options through use of housing funds could be a viable strategy.

Environmental Funds

Environmental funds are not normally used for capital projects related to water efficiency or conservation. Exceptions to this include situations where the project or retrofit is driven by an environmental compliance issue. In these cases, the primary focus of the project will be achieving compliance with environmental regulations. Any water savings that occur will be a supplemental benefit.

Examples of successful water-efficiency projects funded through environmental sources usually pertain to reductions in wastewater discharge. These projects take credit for reductions in effluent discharge or re-use of effluent thus displacing potable water uses. While Fort Buchanan does not treat it wastewater, environmental opportunities should not be discounted for funding options.

O&M Funds

While very competitive, O&M funding offers one of the most flexible and widely used funding vehicles for a variety of retrofit projects. Because it is so widely used, competition among projects can be very great. Making a clear case for cost-justification is critical to a proposal's success. Procedures and proposals to apply for O&M funding typically vary site-to-site, thus Fort Buchanan staff need to understand their system, timeline and procedures when applying for these funds.

Utility Energy Services Contracts (UESCs)

Similar to the ESPC, a UESC can and have been be used to fund water savings projects. The key to this type of funding mechanism lies in the interest of the serving utility. In Fort Buchanan's case, the PRASA has not been particularly active in offering programs targeting water conservation or efficiency. However, when PRASA faces capacity issues, this type of program serves as an opportunity to increase system capacity in a cost-effective manner.

Section III: Water Planning

Introduction to Water Planning

Contingency planning for water shortage is an integral part of water resource management. It ensures that the site will be able to meet the mission critical needs during time of a water shortage such as a drought or emergency interruption.

The purpose of this contingency plan is to outline the strategies to prepare and respond to a water shortage. All too often water shortages are not prepared for and can leave the site very vulnerable with a panicked response by staff and tenants. This plan can help the Fort plan proactively to prepare for water shortages or outages. This section discusses the formation of a Water Management Committee that will assign responsibility for responding to drought or emergency conditions.

This section of the report will provide two distinct areas: 1) drought management planning; 2) emergency planning. The drought management plan will provide a general overview of how the Fort can help prepare for water supply restrictions caused by drought. The section on emergency planning will briefly outline key aspects to emergency planning relating to hazardous and destructive acts on the system, tying into the previously prepared document, *Drinking Water Contingency Plan, Fort Buchanan, Puerto Rico,* which was produced in January 2000 by the Fort. This document will not replace or duplicate any information contained in the *Drinking Water Contingency Plan, Fort Buchanan, Puerto Rico.*

Drought Management Planning

Drought management planning enables the site to proactively plan for drought and be prepared to respond so that mission critical needs are met by staff and residents. There are five major aspects to drought management planning that are described in this section with the goal to help the Fort develop a strategy for planning, monitoring, and responding to drought. The plan entails:

- Establishing a team of core staff at the Fort that are responsible for coordinating and developing the drought management plan
- Monitoring for potential drought in the area so the site is aware of the risks and can have sufficient time to prepare for impending water shortage
- Defining drought phases that tie the severity of the drought to the actions taken by the Fort
- Responding to the drought and enacting mitigation measures tied to the severity of the drought to ensure the site meets mission critical water needs
- Developing public education and outreach program to help educate staff and residents on drought and water conservation.

An important aspect of effective contingency planning is a well coordinated group of staff with assigned responsibilities. This Water Management Committee will coordinate and lead the drought plan, monitor drought conditions, and initiate response to drought conditions. To successfully plan for water shortages caused by drought, it will be crucial for these teams to meet on a regular basis to build a strategy on monitoring and responding to drought.

The following section describes the responsibilities of the Water Management Committee in relation to drought conditions. It is recommended the Fort use this as a guideline to form this comprehensive team to develop a proactive drought management plan for the site.

Water Management Committee

The Water Management Committee will be made up of key people that will be responsible for coordinating and overseeing this plan. This team will be responsible for enacting the mitigation plan in case of drought, will act as the liaison with the outside community, and will also be responsible for setting the direction and policies of the plan and coordinating between all the stake holders. Specific duties of the committee related to developing a drought management plan are as follows:

- Approve implementation of water mitigation measures in response to a drought
- Enact each phase of mitigation depending on the situation
- Be the point of contact between site, Cities of Bayamon / Guaynabo or applicable municipality, and other community officials
- Coordinate the activities of the drought committees

- Be the key point of contact in times of drought
- Oversee the plan and evolving polices of the contingency plan.

The Water Management Committee should be responsible for accessing the site's vulnerability to a drought that may cause water shortage to the Fort. The committee may wish to assign responsibility for each position on the Water Management Committee:

- Monitoring Manager: This staff member will develop a monitoring system that will identify the potentiality of a drought. This would include tracking weather information for potential drought and keeping close attention to drought alerts posted by the outside community. More is described later in this section.
- Drought Data Management Coordinator: This staff member will collect, manage, and analyze the data to monitor key elements of probable drought
- Liaison: This staff member will work closely with the other committees if modifications are necessary in monitoring efforts
- Water Data Management Coordinator: This person will maintain water consumption data on supply and distribution to have a clear understanding of the water demand on site and know the mission critical water needs of the site.

The Water Management Committee is the team that enacts the mitigation measures caused by a drought. These are key people at the site that have responsibility for the operations of the Fort and grounds, including the tenants. The following are key people that should be involved in the committee:

- Energy/Resource Manager: This person is in charge of managing the water program for the site and interfacing with all levels of DPW.
- Grounds Maintenance Manager: This person maintains and operates the irrigation systems and will be responsible for enacting all mitigation measures to reduce water use by irrigation system on the grounds, including the tenant properties.
- Facility Managers: These key facility managers are responsible for buildings and areas that have a large impact on water consumption. These facility managers will be responsible for enacting all mitigation measures to ensure that mission critical water needs are met during the drought.

Defining the Threat

First, it is important to define the threats to the water supply system at the site. The following list summarizes the general definitions, but these should be reviewed and accepted by the Water Management Committee.

Drought: Drought is a common climatic occurrence that originates from a long term lack of precipitation resulting in a water shortage for the local community. Drought is a natural event that usually creates a longer-term water shortage as compared to a natural disaster or intentional act (described in the following paragraphs.) Precipitation during a drought is usually compared to historical average, which is often based on a 30-year period of record. (National Drought Mitigation Center Website 2003)

An operational definition of a drought should be defined in phases that point to the severity of the water shortage. This can be done by tracking climate conditions of the area and determining the appropriate phase of drought and the appropriate mitigation measures that should be enacted. This document defines drought phases and response measures in the next sections.

Monitoring for the Threat

As part of the contingency plan, potential drought must be monitored closely to help the site prepare for an impending water shortage. The Water Management Committee will be responsible for evaluating the possibility of drought in the area and making recommendations for the appropriate phase of drought mitigation that should be enacted for the site.

There are several approaches that can be taken to monitor for potential drought. For the purposes of this plan, it is recommended that drought is monitored for predicting the possibility of a drought and also the severity of the drought once it has hit the area. Three drought monitoring methods are summarized below which can help monitor for both prediction and severity: 1) Drought Monitor Map, 2) US Seasonal Drought Outlook Map, and 3) the Standardized Precipitation Index. All three methods are commonly used to help predict when drought may hit an area. Often time, utilities and large installations use more than one method to predict drought because each method have distinct advantages and disadvantages. It is recommended that at least two of these methods are tracked so that the Fort can monitor effectively for drought and help identify the appropriate phase of mitigation is appropriate.

Drought Monitor Map

The Drought Monitor Map is a combination of multiple drought indicators that are compiled into one system and mapped over the entire US, including Puerto Rico. This mapping system is developed and coordinated through the US Department of Agriculture, National Drought Mitigation Center, and the National Oceanic and Atmosphere Administration (NOAA).

The Drought Monitor Map provides current drought information on a scale from abnormally dry to exceptional drought conditions. It rates each area based on how the drought is affecting agriculture (crops, pastures, and grasslands) and hydrology (water levels) in any given area. An example of the Drought Monitor Map is provided in the figure below, which includes Puerto Rico, in the right hand corner. At this point in time, Puerto Rico shows no drought activity.

Because this map is easily available and updated on a regular basis, it can help the Fort identify the severity of drought conditions. However, a disadvantage of the Drought Monitor Map is that it only gives current climate information. For updated maps please go to the following website:

- http://www.drought.unl.edu/dm/monitor.html .

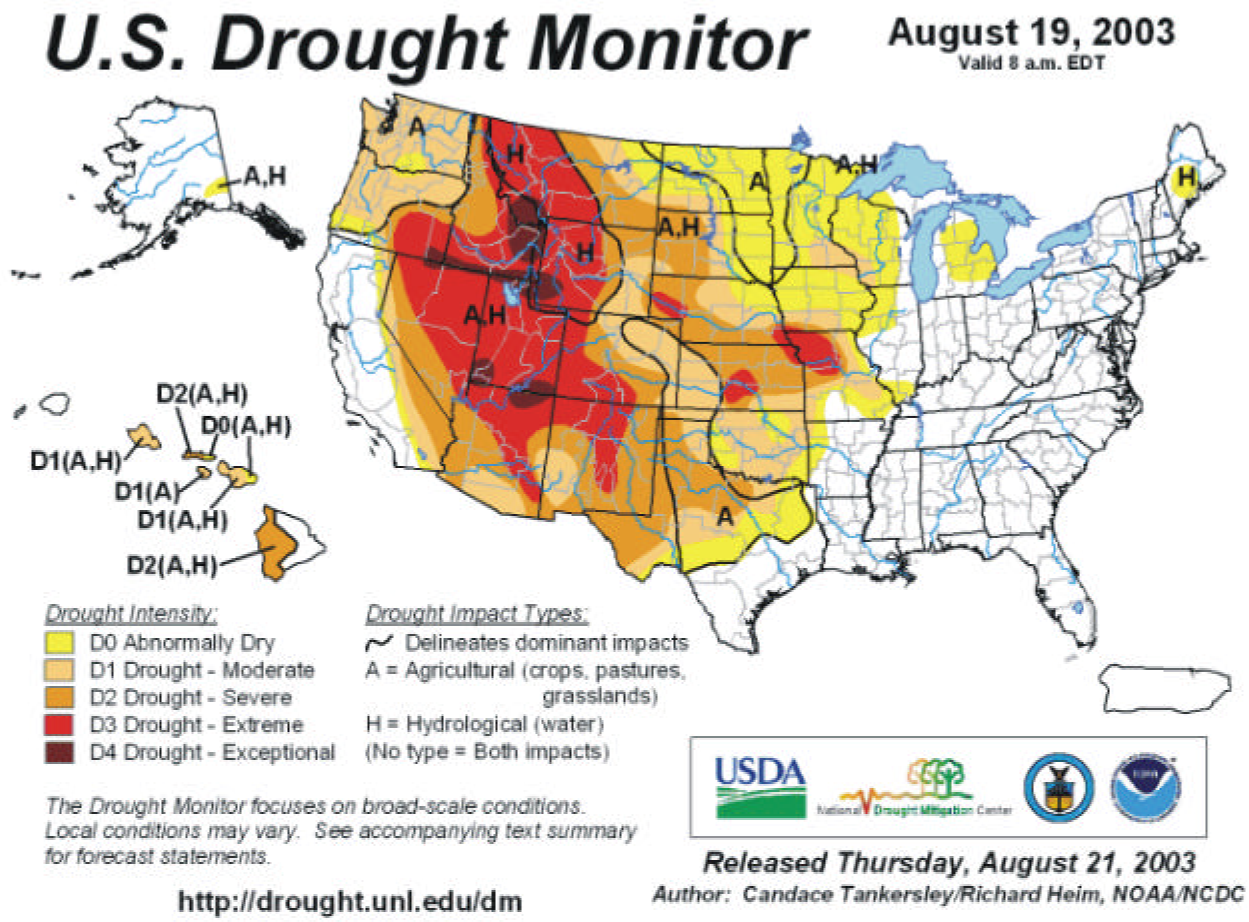

Figure 7. U.S. Drought Monitor Map

US Seasonal Drought Outlook Map

The National Oceanic and Atmosphere Administration (NOAA) Climate Prediction Center helps to assess and forecast impacts of short-term weather-related risks. The center puts out a US Seasonal Drought Outlook Map to help forecast how drought will likely be changing in an area. It also predicts if a drought is expected to develop. An example of this map is given in Figure 8, showing drought prediction through November 2003. Puerto Rico is included in the lower right hand corner showing no drought activity expected through November. The advantage of this map is that it helps to understand future likelihood of drought, but it does not rate drought in terms of severity. For updated versions of this map for drought monitoring, go to the NOAA website at:

- http://www.cpc.ncep.noaa.gov/products/expert_assessment/seasonal_drought.html .

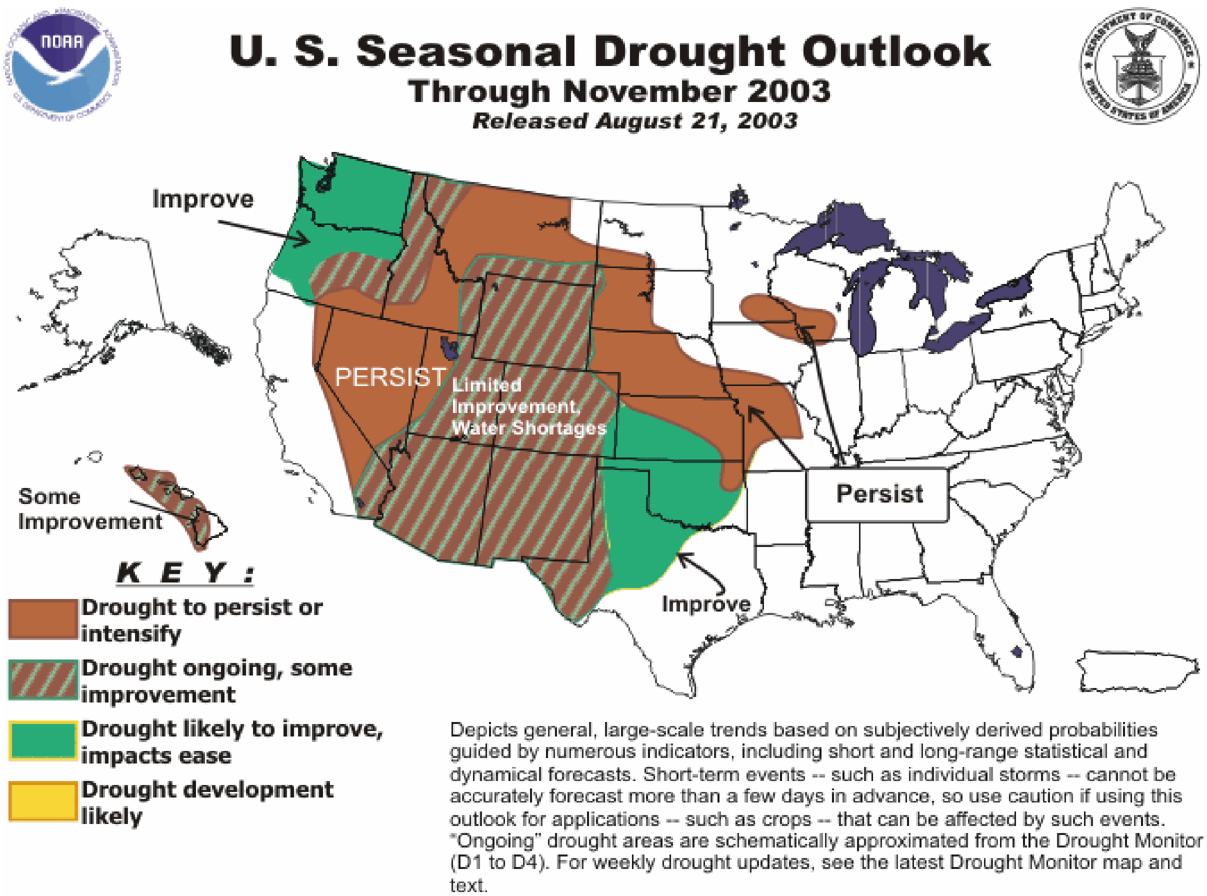

Figure 8. U.S. Seasonal Drought Outlook

Standardized Precipitation Index

The Standardized Precipitation Index (SPI) is relatively new for drought monitoring. It was developed by the National Drought Mitigation Center (NDMC). The NDMC is based out of the University of Nebraska at Lincoln which is one of the leading organizations specializing in preparation and risk management for drought.

SPI is based on precipitation exclusively and is used to monitor drought in variety of time intervals. Therefore the SPI can be used for monitoring the probability of both long-term and short-term drought. For more background on SPI go to:

- http://www.drought.unl.edu/monitor/spi.htm.

Table 13 shows the SPI classification system which rates the relative moisture levels of the given area.

Table 13. SPI Classification System

SPI	Conditions
2.0+	Extremely Wet
1.5 to 1.99	Very Wet
1.0 to 1.49	Moderately Wet
-0.99 to 0.99	Near Normal
-1.0 to -1.49	Moderately Dry
-1.5 to -1.99	Severely Dry
-2.0 and less	Extremely Dry

(Source: http://www.drought.unl.edu/monitor/spi.htm)

A distinct advantage to the SPI is that it can provide early drought warning; however, a disadvantage is that it may be cumbersome to obtain up to date SPI values for Puerto Rico. To obtain the SPI for San Juan, Puerto Rico, the National Drought Mitigation Center has a free software program that can be downloaded from the website. This will provide SPI values for a variety of time intervals. Please go to the following website to gain access to this software program and detailed information:

- http://www.drought.unl.edu/monitor/spi/program/spi_program.htm

Further information on specific weather and climate information on Puerto Rico may be available through:

Dr. Amos Winter
Dept of Marine Sciences
College of Arts and Sciences
University of Puerto Rico
Mayaguez, PR 00681-9013
Tel: 787-265-5416
Fax: 787-265-2195
Internet Email: a_winter@rumac.uprm.edu
WWW: http://atmos.uprm.edu

Defining the Phases of Drought

Once a system for monitoring drought conditions and the likelihood of a potential drought has been developed, the site will be in a position to respond proactively to drought instead of reactive. A key to proactive drought response is defining phases of drought that ties the severity of the drought to the mitigation actions taken. Also, the plan should define triggering mechanisms that indicates which mitigation measures are appropriate. This section provides recommendations for defining drought phases and triggers for response.

Drought Contingency Phases

The bulleted list below provides recommended phases that correspond to specific drought levels and the general level of response for each phase. Each phase will alert the site of the required mitigation measures that will allow the site to meet the mission critical needs of the site during a drought.

- Phase 1: Advisory No action required
- Phase 2: Drought Alert Voluntary conservation
- Phase 3: Conservation Mandatory conservation
- Phase 4: Drought Emergency Mandatory water rationing

Specific definitions and mitigation measures will be described in following section *Responding to the Threat,* which corresponds to each phase.

Triggering Mechanisms

The Water Management Committee will need to develop how the severity of drought will trigger the phase of response, which will in turn help the Fort meet their minimum water requirements during a drought.

These triggering mechanisms described below are based on the drought monitoring methods described in the above section, *Monitoring for the Threat*. The Drought Monitor Map, NOAA's U.S. Seasonal Outlook, and/or the Standardized Precipitation Index (SPI) can be used in conjunction to help indicate triggers for each phase of drought. Table 14 provides recommendations for the drought levels that should trigger each phase of the response to the drought.

Table 14. Example Triggers for Mitigation Measures

Phase	Drought Monitor Map Trigger	US Seasonal Outlook Trigger	SPI Trigger
No Action Required	Normal or wet conditions	No likely development of drought	0 +
Phase 1: Advisory	D0: Abnormally dry	Drought development likely	-0.1 to -0.99
Phase 2: Drought Alert	D1: Moderate Drought	Drought ongoing, some improvement or drought likely to improve, impacts ease	-1.0 to -1.49
Phase 3: Conservation	D2: Severe Drought	Drought ongoing, some improvement or drought to persist or intensify	-1.5 to -1.99
Phase 4: Drought Emergency	D3 & D4: Extreme and Exceptional Drought	Drought ongoing, some improvement or drought to persist or intensify	Exceed -2.0

Responding to the Threats

Once the drought phase is identified, mitigation measures need to be employed to help the Fort meet the mission critical water needs of the site. The Water Management Committee will be responsible for coordinating the mitigation measures for the appropriate phase of drought identified. An important aspect of developing mitigation responses is having an open forum for communication between the key stakeholders at the site, such as facility managers, operations staff, and onsite residents. This will ensure that the mitigation measures are appropriate and reasonable.

Because the prime use of water at the Fort is for domestic uses, the focus for mitigation during a drought should be public outreach and education. By educating tenants and staff on drought and water conservation, large impacts on water use are possible. For example, Fort Carson in Colorado Springs, Colorado instituted a public outreach program during the drought of 2002. By educating staff and residents on water saving tips and restrictions on turf irrigation, vehicle washing, and street washing, the Fort was able to reduce water use by 30%. (Fort Carson 2002)

Recommended Mitigation Response

The following table provides suggested mitigation measures tied to the severity of the emergency to help the Fort meet mission critical needs during a drought, shown in Table 15.

Table 15. Mitigation Measures with Corresponding Phases

Drought Phase	Mitigation Measures
Phase 1: Advisory	*No Action Required*: educational materials should be distributed to on-site residents providing information on drought and useful tips to reduce household water use, both indoor and out.
Phase 2: Drought Alert	*Voluntary Conservation*: shut down once-through cooling while not in operation. Irrigation should be limited and appropriate watering schedules should be followed. (See O&M recommendations for information on efficient landscape irrigation.) Car washing should be restricted. Leak detection of larger water users should be initiated.
Phase 3: Conservation	*Mandatory Conservation:* all voluntary conservation is mandatory as described above. Restrictions of ground irrigation to once per week. Ornamental fountains should be shut off. Street washing should be restricted to highest priority.
Phase 4: Drought Emergency	*Mandatory Rationing:* No irrigation of grounds, no car washing, and no street washing. Public education and outreach should be a high priority to ensure all tenants and staff are reducing water consumption to the minimum.

Other Important Issues

Communication for Response to Drought

There should be a concise and clear communication method for informing staff at the site of the drought and appropriate mitigation measures corresponding to the phase. This can be in the form of postings that describe each phase and appropriate mitigation measures. This posting should contain a point of contact from the Water Management Committee for general information and also points of contact for specific mitigation measures that are required in distinct areas of the site.

Public Education and Outreach

As stated in the Responding to the Threats section above, public education and outreach will be a crucial part of drought management and planning at the Fort. Public education and outreach is also a FEMP Best Management Practice, which is described previously in this report. WaterWiser, a water conservation organization through the American Water Works Association, has information on water education programs and links to other resources. Find more information at:

- http://www.awwa.org/waterwiser/corepage.cfm?CI=9

Drought Resources

The following are additional resources for drought management planning:

- USGS Water Resources for the Caribbean: http://pr.water.usgs.gov/
- National Drought Mitigation Center: http://www.drought.unl.edu/index.htm
- National Oceanic and Atmosphere Administration Climate Center: http://www.noaa.gov/climate.html
- National Oceanic and Atmosphere Administration Drought Information Center: http://www.drought.noaa.gov/
- Environmental Protection Agency Water Efficiency Program Drought Planning: http://www.epa.gov/OW-OWM.html/water-efficiency/drouhome.htm
- National Drought Policy Commission: http://www.fsa.usda.gov/drought/
- US Army Corps of Engineers Institute for Water Resources: http://www.iwr.usace.army.mil/

Emergency Planning

The key vulnerability of the Fort's water supply is an emergency interruption caused by damage to the water system as a result of hurricane or tropical storm. However, the site is also vulnerable to terrorist attack and sabotage of the system. This WMP presents a general summary of emergency planning and provides resources for further information to help the site to develop a more detailed strategy for emergency planning.

Fort Buchanan Drinking Water Contingency Plan

The Fort issued a contingency plan for the drinking water supply in January 2000, titled: *Drinking Water Contingency Plan, Fort Buchanan, Puerto Rico*. This document establishes the basic procedures which are to be employed at the Fort in time of emergency interruption or threat to the drinking water supply. This plan establishes procedures for hazardous acts to the water system specifically related to hurricanes. However, this document does not address security threats to the system and also does not outline the specific responsibilities that will help to carry out the requirements which are laid out in the *Drinking Water Contingency Plan, Fort Buchanan, Puerto Rico*. Therefore, this document will use the existing contingency plan as a foundation and help guide the site to proactively plan for emergency interruption.

Structure and Responsibilities

An important aspect of effective emergency planning is a well coordinated group of staff that is responsible for the different aspects of the plan. The Water Management Committee will also coordinate and lead emergency planning for the Fort and are responsible for carrying out the actions needed to execute the plan. To successfully plan for water shortages or interruptions, it will be crucial for these teams to meet on a regular basis to build a strategy on monitoring and responding to threats to the water supply.

In addition to the roles and responsibilities of the Water Management Committee outlined previously, the following functions are specific to emergency response. The Water Management Committee is responsible for assessing the sites vulnerability to threat of the water system that may cause shortage or interruption to the site's supply water. The following bullets list important functions that should be assigned to a specific individual:

- Threat Monitoring Manager: This staff will develop a monitoring system that will identify the potentiality of threats to the water supply. This will entail keeping close watch on emergency alerts posted by the outside community, and also maintaining high level of awareness of potential terrorist threats. More is described later in this section.
- Data Management Coordinator: This staff will collect, manage, and analyze the data to monitor key elements of the threat.

- Water Consumption Data Manager: This person will maintain water consumption data on supply and distribution to have a clear understanding of the water demand on site and know the mission critical water needs of the site.

The Water Management Committee is responsible for enacting mitigation measures in response to an emergency. Key people at the site that have operational responsibility should be included on the team:

- Distribution System Manager: This person maintains the distribution system and will be responsible for disconnecting portions of the Fort's water distribution system to protect areas from contamination.
- Water Storage Tank Response Team: Team of staff that have specific training to respond to sabotage of the water tanks
- Facility Managers: These key facility managers are responsible for equipment and processes at the site that have large impact on water consumption. These facility managers will be responsible for enacting all mitigation measures to ensure that mission critical water needs are met during time of an emergency.

Security Threat Phases

It is important to have well defined phases that allow the site to enact measures in response to threats on the water system, corresponding to a degree of severity. The Fort should have distinct phases for both hurricanes and intentional acts. Presently the Fort has defined mitigation measures for levels of hurricane threat, or is defined in the *Drinking Water Contingency Plan, Fort Buchanan, Puerto Rico*.

Hurricane Phases

In Appendix A of the *Drinking Water Contingency Plan, Fort Buchanan, Puerto Rico*, the Fort has a time line of mitigation measures corresponding to the phases of a hurricane threat. These phases are tied to the local alerts that will be provided to the site, warning of an impending hurricane. The Fort has established well defined mitigation measures to respond to each level of alert.

- Condition III – 48 hour advance warning of an impending hurricane
- Condition II – 24 hour advance warning of an impending hurricane
- Condition I – 12 hour advance warning of an impending hurricane.

Security Threat Status

Varying degrees of a security threat should also be defined so that response can be coordinated with the severity of security threats. Developing a specific system for the Fort is beyond the scope of this report. However, some general guidelines and additional resources are provided below.

Department of Homeland Security: One source of information that can help identify the potential threat and the degree of severity are the Terror Alerts published by the U.S. Department of Homeland

Security. These Terror Alerts help prepare the country for impending terror attacks. These alerts include intentional contamination or destruction of water systems. These threat conditions are defined as follows: (More information can be found at: http://www.dhs.gov)

- *Low – Green*: low risk of terror attacks.
- *Guarded – Blue*: general risk of terror attacks
- *Elevated – Yellow*: significant risk
- *High – Orange*: high risk
- *Severe – Red*: critical risk.

American Water Works Association (AWWA): Another source of information for defining phases of security threats on the water system is through the American Water Works Association, *Security Analysis and Response for Water Utilities* (AWWA 2001). This document defines emergency status in four stages:

1. *Normal Operations/Minor Emergencies*: Response lies within the public works department and does not require "emergency response"
2. *Alert Condition*: Security threats may be forthcoming. This condition triggers the water Management Committee to assemble a team of personnel to assess the situation.
3. *Emergency Condition*: Security threat is imminent or has occurred, and full response is necessary by external personnel to guard public safety.
4. *State of Emergency*: This stage involves the greater community and is usually declared by the governing body of the community. This would most likely be a large attack on the city system and would require response by the broadest resources available.

Threat Categories

It will be helpful to describe key types of threats that are potential risk to the water system at the Fort. AWWA has defined types of threats and categorized them into two distinct areas: 1) physical and 2) contaminant.

Physical threats tend to be most probable because devices such as explosives are more readily available (AWWA 2001). Types of physical attacks are:

- Aerial attacks: attacks on treatment facility from airplane assault
- Cyber terrorism: attacks on data acquisition systems
- Explosives: attacks on distribution system to compromise pumping stations, storage, or transmission
- Fire: attacks from fire could effect computer controls, pumps, or motors for example
- Personnel: attacks on public works staff.

Intentional contamination of the water supply by a terrorist attack or sabotage is another threat. General categories of contaminants that could possibly be introduced into the water supply system are biochemical toxins, microbial agents, industrial chemicals, nerve agents, and radioactive materials. All of these contaminants have specific chemical properties and have different effects on the water supply. A good description of each type of contaminant, sources, and availability are described in AWWA's *Security Analysis and Response for Water Utilities* (AWWA 2001).

Preparedness and Response to the Threats

The goal of emergency planning is to prepare the site to respond appropriately to threats on the water system to ensure the site meets mission critical needs. In the Fort's Drinking Water Contingency Plan it is not clear whether a detailed plan has been established to prepare and mitigate a terrorist attack or sabotage to the water system. Therefore, the general guidelines will be outlined.

American Water Works Association Guidance

The American Water Works Association has published a guidebook titled *Water System Security: A Field Guide* (AWWA 2002). This guidebook was published after the September 11 terrorist attack, focusing on assisting water utilities in preparedness for intentional acts of destruction. AWWA's *Emergency Planning for Water Utilities: M19 Manual* is used as a foundation for this guidebook. Both of these AWWA guidebooks should be considered key resources for the Fort in preparing for hazardous and destructive acts to the water system.

A primary focus that is detailed in these AWWA resources is vulnerability assessment of the system. In the Fort's Drinking Water Contingency Plan, it appears that the risk assessment has identified the key vulnerabilities of the system for a hurricane emergency, but not for security threats. The vulnerability assessment will help to identify priorities for the mitigation and response activities. The vulnerability assessment should identify the following: (AWWA 2002)

1. Identification and description of water supply system components
2. Identification of threats and estimation of probable effects on each system component
3. Establishment of performance goals and acceptable level of provided service
4. If system would fail under certain circumstances, the following would be identified:
    - Vulnerability of key system components and system vulnerabilities responsible for the condition
    - Corrective measures and procedures.

Environmental Protection Agency Guidance

The Environmental Protection Agency (EPA) has published guidelines for water and wastewater utilities to guard against and prepare for security threats against drinking water supplies. These guidelines provide a plan for assisting water utilities to prepare for intentional acts on the water system. The guidelines have established strategies for the following areas for each level of Terror Alert posted by the Department of Homeland Security.

- Detection
- Preparedness
- Prevention
- Protection.

This document is considered to have sensitive information for protecting water systems, and it is crucial that is does not fall into the hands of terrorist because it can provide them with detailed information.[4]

Protecting Water Supply from Terrorist Threats

It is important to identify key mitigation measures that can used to both protect the system and respond to terrorist threats. The key vulnerability of the Fort for sabotage of the water supply is the area between the boundary of the site and water storage tanks. These tanks are vulnerable to intentional contamination and destruction. Presently there are only two chain link fences that separate the boundary of the city with storage tanks. As characterized in the AWWA *Water System Security: A Field Guide* (AWWA 2002), it is recommended that the Fort identifies and implements a protective barrier to safeguard the water supply from contamination.

The goals behind protection to the water supply are three fold: 1) detect, 2) delay, and 3) respond.

Detection Systems

The goal of detection devices is to provide the site with enough information to analyze the threat. Some examples of detection sensors that are available are microwave, ultrasonic, infrared, vibration, and video motion detectors (AWWA 2002).

Closed circuit television is another option for detection technology, although it is not recommended. It is unrealistic to consider monitoring the system 24 hours per day.

Delay Systems

Delay systems provide an obstacle to the intruder which provide some time to respond to the threat. Some examples of delay systems are fencing, gates, locks, concrete barriers, earth-berms, guard stations (AWWA 2002). The least effective delay system is fencing. Fences only give a limited delay to an intruder. The best approach is to employ several forms of defense to force an intruder to overcome more than just a single barrier.

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[4] Email Communications: Denna Cash. Environmental Engineer, Missouri Department of Natural Resources Public Drinking Water Program. June 26, 2003.

Response Phase

Once the intruder is detected, it is crucial to have a staff that is capable to respond to the emergency. This will include a three step approach.

- First, the response team must be aware that there is an emergency situation. After the detection device has detected an intruder, there must be a mechanism that communicates this information to the appropriate members of the response team.
- Secondly, the response team must be deployed.
- Thirdly, the response team must be trained appropriately to neutralize the adversary.

Other Important Issues

Communication for Response to Threats

There should be a concise and clear communication method for informing staff at the site of the emergency phase and appropriate mitigation measures corresponding to the phase of emergency. This can be in the form of postings that describe each phase and appropriate mitigation measures. This posting should contain a point of contact from the committee for general information and also points of contacts for specific emergencies such as main line breaks or the need to shut down a specific section of the site to avoid contamination.

Training

Training may be necessary to ensure that key facility managers have an understanding of what mitigation measures are required, especially emergencies that will require the shut down of key areas of operation. Drills may be necessary to run through the procedures of shutting down the system.

Other key areas that should be well understood for responding to emergencies are:

- Water distribution system
- Valve locations
- Hydrant locations
- Diagram of plumbing station layouts, piping, and equipment
- Location of water mains from the city
- Chemical storage – contents and amounts.

Alternative Water Supply

The site should be able to provide an adequate amount of drinking water to site staff in the case of an emergency interruption. In the Fort's *Drinking Water Contingency Plan*, additional supply sources are described:

- 1,000,000-gallon tank of drinking water located southeast of the field grade officer housing development
- 500,000-gallon drinking water tank located west of the single senior non-commissioned officer quarters
- Alternate water mains: 6-inch water main line is located at the south gate entrance and a 10-inch water main line is located near the main gate on the east border of the installation.

It also should be noted that this plan describes that purchased water sources are tested by the industrial hygienists in the Environmental Office. The purchase water or bottle water is tested by the Veterinary Clinic. Records are located in Building 21, records section.

Resources for Emergency Planning

American Water Works Association. 2002. *Water System Security: A Field Guide*. Denver, Colorado.

American Water Works Association. 2001. *Emergency Planning for Water Utilities: Manual for Water Supply Practices M19*. Denver, Colorado.

American Water Works Association. 2001. *Security Analysis and Response For Water Utilities*. Denver, Colorado.

Environmental Protection Agency. *Guarding Against Terrorist and Security Threats: Suggested Measures for Drinking Water and Wastewater Utilities*. Electronic PDF file obtained through Missouri Department of Natural Resources Public Drinking Water Program. June 26, 2003. Contact Kate McMordie at water@pnl.gov for a copy.

Conclusion

This document analyzes the current water use patterns at Fort Buchanan and provides the framework for a comprehensive water resource management plan. There are several immediate actions that the DPW can implement, as well as a framework for long-term plans. It is important that the DPW take ownership of this plan by updating the content as needs change and by implementing the concepts into the DPW operating procedures.

In the near-term, DPW should consider acting on the following:

- Update the Fort Buchanan water balance through improved estimating processes and by adding additional sub-metering
- Expand sub-metering on the Fort for billing purposes (e.g., remaining ACSS schools) and for utility management purposes.
- Implement near-term water conservation measures including:
    - Form an equipment pool of water-efficient toilets, urinals, and showerheads. Work with maintenance, janitorial staff, and Army family housing to identify fixtures that need replacement.
    - Require purchase of water-efficient appliances including horizontal-axis clothes washers and efficient residential dishwashers.
- Commit to the implementation of four BMPs. The four that are recommended for Fort Buchanan are:
    - BMP #1: Public Information and Education Programs
    - BMP #2: Distribution Systems Audits, Leak Detection, and Repair
    - BMP #4: Toilets and Urinals
    - BMP #5: Faucets and Showerheads

There are a number of long-term actions that the DPW should carefully consider. These include the following:

- Evaluate the recommendations for drought planning, contingency planning, and force protection and integrate these into the standard operating procedures for the DPW. These recommendations include the following:
    - Develop drought management procedures and integrate these into the DPW standard operating procedures. Identify key individuals and assign responsibility.
    - Evaluate current emergency planning and response procedures for responding to events on the site.

    - Evaluate the water system (and other utility infrastructure) for terrorist threats or other emergency conditions. Identify capital improvement projects to protect the utility infrastructure.
- Evaluate the possibility of automated meter reading system for water and other utilities.

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AWWA 1991. *Manual of Water Supply Practices: Water Audits and Leak Detection.* American Water Works Association (AWWA) AWWA M36.

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Appendices

Appendix A: Additional Site Information

Table A1. Potable Water System Inventory (2001 Data)

Description	Units	Quantity	Approx. Unit Value	Total Value
16 in. Ductile Iron	linear feet	7,057	$53.00	$374,021.00
10 in. Ductile Iron	linear feet	6,213	$33.50	$208,135.50
8 in. Asbestos Concrete	linear feet	10,967	$19.50	$213,856.50
6 in. Asbestos Concrete	linear feet	7,917	$14.60	$115,588.20
6 in. Cast Iron	linear feet	26,351	$12.50	$329,387.50
8 in. Cast Iron	linear feet	26,351	$20.00	$527,020.00
6 in. Galvanized Iron	linear feet	846	$22.00	$18,612.00
8 in. Galvanized Iron	linear feet	2,015	$29.00	$58,435.00
4 in. Cast Iron	linear feet	7,786	$8.25	$64,234.50
2 1/2 in. Galvanized Iron	linear feet	407	$5.35	$2,177.45
2 in. Galvanized Iron	linear feet	1,139	$3.36	$3,827.04
2 in. Copper Pipe	linear feet	1,660	$5.95	$9,877.00
1 1/2 in. Copper Pipe	linear feet	1,206	$3.94	$4,751.64
Subtotal LF		**99,915**		$1,929,923.33
Valves	each	195	$700.00	$136,500.00
Back Flow Preventers	each		$5,565.00	$0.00
Fire Hydrants	each	131	$725.00	$94,975.00
500 GPM Pumps, main booster Station	each	2	$3,300.00	$6,600.00
Altitude check and gate valves at tanks	each	2	$1,400.00	$2,800.00
Chlorine Injector	each	1	$2,500.00	$2,500.00
Subtotal		**331**		$243,375.00
Total Cost Value				**$2,173,298.33**

Table A2. Wastewater System Inventory (2001 Data)

Description	Units	Quantity	Approx. Unit Value	Total Value
24 in. Concrete	linear feet	2,460	$11.30	$27,798.00
12 in.	linear feet	420	$5.20	$2,184.00
12 in. Concrete	linear feet	380	$5.20	$1,976.00
10 in.	linear feet	350	$4.23	$1,480.50
8 in.	linear feet	1,980	$3.82	$7,563.60
8 in. Concrete	linear feet	33,560	$3.82	$128,199.20
6 in. Concrete	linear feet	7,590	$3.47	$26,337.30
8 in. Cast Iron	linear feet	120	$20.50	$2,460.00
6 in. Cast Iron	linear feet	3,090	$12.90	$39,861.00
4 in. Cast Iron	linear feet	790	$6.25	$4,937.50
8 in. Vitrified Clay	linear feet	350	$4.14	$1,449.00
6 in. Vitrified Clay	linear feet	440	$2.93	$1,289.20
Subtotal		**51,530**		**$245,535.30**

Source: (Gimenez 2003a)

Appendix B – Water Data Collection and Test Equipment

The following is a list of equipment that is considered useful in performing water audits of buildings in a campus setting, collecting data on water consumption, and assessing the performance and quality of a water distribution system. Equipment listed is suitable for temporary and/or permanent installation. This list does not purport to be a comprehensive list, but will cover the majority types of equipment. The Pacific Northwest National Laboratory and the Department of Energy do not specifically endorse any of the equipment and/or manufacturers listed herein.

Table B1. Potential Data Collection, Equipment, and Tools for Water Analysis

Tool	Description	Price Range
Portable Equipment		
MicroWeir Pitcher	Plastic pitcher calibrated to measure water flow rates (e.g., showers) when the amount of water flowing in reaches equilibrium with the water flowing out the holes in the side.	$100
T5 Flushmeter	Turbine-meter that measures volume of water during one toilet flush. Very limited application with flush valve or pressure assisted toilets. http://www.t5flushmeter.com/need.html	$950
Ultrasonic Flow Meters	Portable, clamp-on meters to measure flow rates. Can be fairly expensive and takes some practice to get good readings. A few examples: o http://www.americansigma.com/products/flow.cfm#8500 o http://www.globalw.com/inflow.html. This is an insertion flow meter, so you really need an insertion point. It is pretty cheap, however, $695. o http://www.flows.com/category.asp?catID=9 several interesting meters here.	$700 to $3000
Leak Detection Equipment	Sensitive electronic equipment used to detect sounds of leaking water Vendors include: o www.fisherlab.com o http://www.flowmetrix.com	$1,000 to $10,000
Dedicated Equipment		

Water Metering	Typically turbine-type or rotating disk flow meters. Installation requires system shut down, but meters are durable, dependable, and typically revenue grade Vendors include: • Badger Meter www.badgermeter.com • ABB/Kent Water Meter http://www.abb.com	$200 to $3000 depending on size
Optional Equipment for Consideration		
Infrared Camera	Camera system used to measure temperatures in the infrared spectrum. System can come with still image recorder, video image recorder, and computer interface, depending on level of sophistication. Use to measure heat loss. Applicable to thermal equipment, electrical transmission and distribution equipment, general building structures, and general operations and maintenance.	$5000 to $15,000
Software		
Motor Master	Use to evaluate energy-efficiency measures for motor and motor drives systems. May also be use to support motor inventory.	Free or low cost from DOE-OIT
Pump-Flo®	Pump-Flo® and Pipe-Flo® are part of a suite of tools from Engineered Software that help design, specify, and troubleshoot pumps and pipe systems. http://www.eng-software.com/default.htm	See website.
IWRAPS	Installation Water Resource Analysis and Planning System (IWRAPS) offers utility planners and managers at military installations a water demand management tool. The tool was originally developed with DOD funding and is supposedly available through the Army Center for Public Works, current development on the tool has been handed to a private contractor. It appears that the current marketing strategy is to sell analysis services rather than the tool itself. http://www.eere.energy.gov/buildings/tools_directory/software/iwraps.htm .	See website.
H20NET	H2ONET implements the EPANET simulation methods within an AutoCAD environment to provide a powerful modeling tool for water distribution systems. Although these tools are certainly available for purchase and use by DPW engineering staff, the learning curve would be substantial. The Army Corps of Engineers recently modeled Fort Buchanan using this tool and may be an additional source of information. http://www.mwhsoft.com/page/p_product/net/net_overview.htm	See website or contact COE Hunstville Group.
FEDS	Facility Energy Decision Screening: Use to assess building energy-efficiency measures in a campus setting	Free from DOE-FEMP

Energy Simulation	There are a number of energy simulation software systems available. The level of sophistication of the software differentiates the level of analysis. The simpler end of the spectrum may include a “temperature bin-type” analysis, whereas the high end of the spectrum may include an “hour-by-hour” level of analysis. Many of these systems are proprietary.	Large range

Appendix C: Federal Water Use Indices

The Federal Water Use Indices are rules-of-thumb to estimate water use in facilities. These are adapted for Federal facilities based on data from the American Water Works Association. Based primarily on occupants, they are useful for typical facilities found on Federal sites. They are not very useful for estimating water usage in industrial facilities, processes, or other high water consumers.

Table C1. Federal Water Use Indices

	Unit	**Gallons/unit/per day**	
		Range	**Typical**
Commercial			
Airport	Passenger	4-5	3
Apartment house	Person	100-200	100
Boarding house	Person	25-50	40
Hotel	Guest	40-60	50
	Employee	8-13	10
Lodging house and tourist home	Guest	30-50	40
Motel	Guest	25-40	35
Motel with kitchen	Guest	25-60	40
Laundry (self-service)	Machine	400-650	550
Office	Employee	8-20	15
Public Lavatory	User	3-6	5
Restaurant, Conventional	Customer	8-10	9
Restaurant, Short-order	Customer	3-8	8
Shopping center	Parking Space	1-3	2
	Employee	8-13	10
Open Space			
Non-turf	Acre		785
Turf	Acre		1,571
Recreational			
Apartment, resort	Person	50-70	60
Bowling alley	Alley	150-250	200
Camp			
Pioneer type	Person	15-30	25

with toilet and bath	Person	35-50	45
Day, with meals	Person	10-20	15
Day, without meals	Person	8-18	13
Trailer	Trailer	75-150	125
Campground	Person	20-40	30
Country club	Members	80-125	100
	Employee	10-15	50
Dormitory (bunk house)	Person	20-45	35
Fairground	Visitor	1-2	3
Picnic park with flush toilets	Visitor	5-10	6
Swimming pool and beach	Customer	5-15	10
	Employee	8-15	10
Visitor center	Visitor	4-8	5
Institutional			
Assembly hall	Seat	2-4	3
Hospital, medical	Bed	130-250	150
	Employee	5-15	10
Hospital, mental	Bed	80-150	120
	Employee	5-15	10
Prison	Inmate	80-150	120
	Employee	5-15	90
Rest home	Resident	5-120	90
	Employee	5-15	10
School day			
with cafeteria, gym and showers	Student	15-30	25
with cafeteria only	Student	10-20	15
without café & gym	Student	5-15	10
School, boarding	Student	50-100	75

Source: http://www.eere.energy.gov/femp/aboutfemp/indices.html

Appendix D. Irrigation Scheduling

Proper scheduling of irrigated grounds is at the root of water-efficient irrigation and landscaping practices. The most important aspect of efficient irrigation scheduling is understanding the adequate water requirements for the specific plant type and accurately irrigating this required water volume at optimal conditions.

Evapotranspiration

A scientific and accurate way of determining required water needs for a plant is evapotranspiration (ET). ET is a calculated measurement of a plant's true need for water under specific weather conditions. ET rate corresponds to the water lost by the soil due to evaporation and the Fort's use of water through transpiration, under specific weather conditions including the levels of sunshine, wind, temperature, and humidity. ET is given in terms of water millimeters or inches per time period such as hourly or daily. (For more information, see http://www.coloradoet.org/whatiset.html.)

ET can be used to properly schedule turf irrigation, which on any given day, the irrigated turf can be given the appropriate amount of water depending on the water requirements for that day. Usually ET rates are given for alfalfa and can be modified for specific turf types with a crop coefficient based on mowing height – denoted as Kc_o. So by knowing the ET rate on a particular day and multiplying it by the crop coefficient for the specific turf type, the amount of water measured in inches can be determined.

ET rates must be obtained for the local area. While no specific resource was identified for San Juan Puerto Rico, rainfall and temperature statistics can be found at the following website: http://www.srh.noaa.gov/sju/climate.html.

Precipitation Rate (PR)

To use ET rate for irrigation scheduling, a keen understanding of the rate of water applied to the grounds by the irrigation system is necessary. This is known as precipitation rate (PR), given usually in inches per hour. The PR is calculated by understanding the sprinkler head application rate – given in gallons per minute (under a specific pressure) and the performance of the sprinkler system – or in other words, how evenly the sprinkler system is able to irrigate to the entire area. Ultimately, the performance of the sprinkler system depends on how well the system has been designed and installed and also how well the equipment is maintained.

The PR can be determined through the equipment manufacturer, which should be provided in the specifications for the equipment. For example, a PR for a typical impact sprinkler heads range from 0.4 to 0.6 inches per hour. A more accurate precipitation rate can be determined by a site-specific audit of the system. Developing a site-specific precipitation rate of the system at Fort Buchanan is out of the scope of this document.

Scheduling Using Evaportranspiration and Precipitation Rate: By understanding the daily water requirement for the turf type and the amount of water that will be applied to the irrigated grounds, a specific water schedule can be determined to meet the actual water requirements of the irrigated areas. A simple formula can be used to estimate the run time for an irrigation system:

$ET \times Kc_o \times PR = \text{Run Time}$

An example is given below:

Table D1. Sample Irrigation Run Time Calculation

ET Rate (in/week)	Crop Coefficient - Kentucky Blue Grass (mowing height 3")	Precipitation Rate - (in/hour)	Hours of Run Time*
0.94	0.95	0.5	1.8

* This run time indicates the amount of water needed to meet Kentucky Blue grass water requirement for a week. Note: Other grass types will have different water requirements.