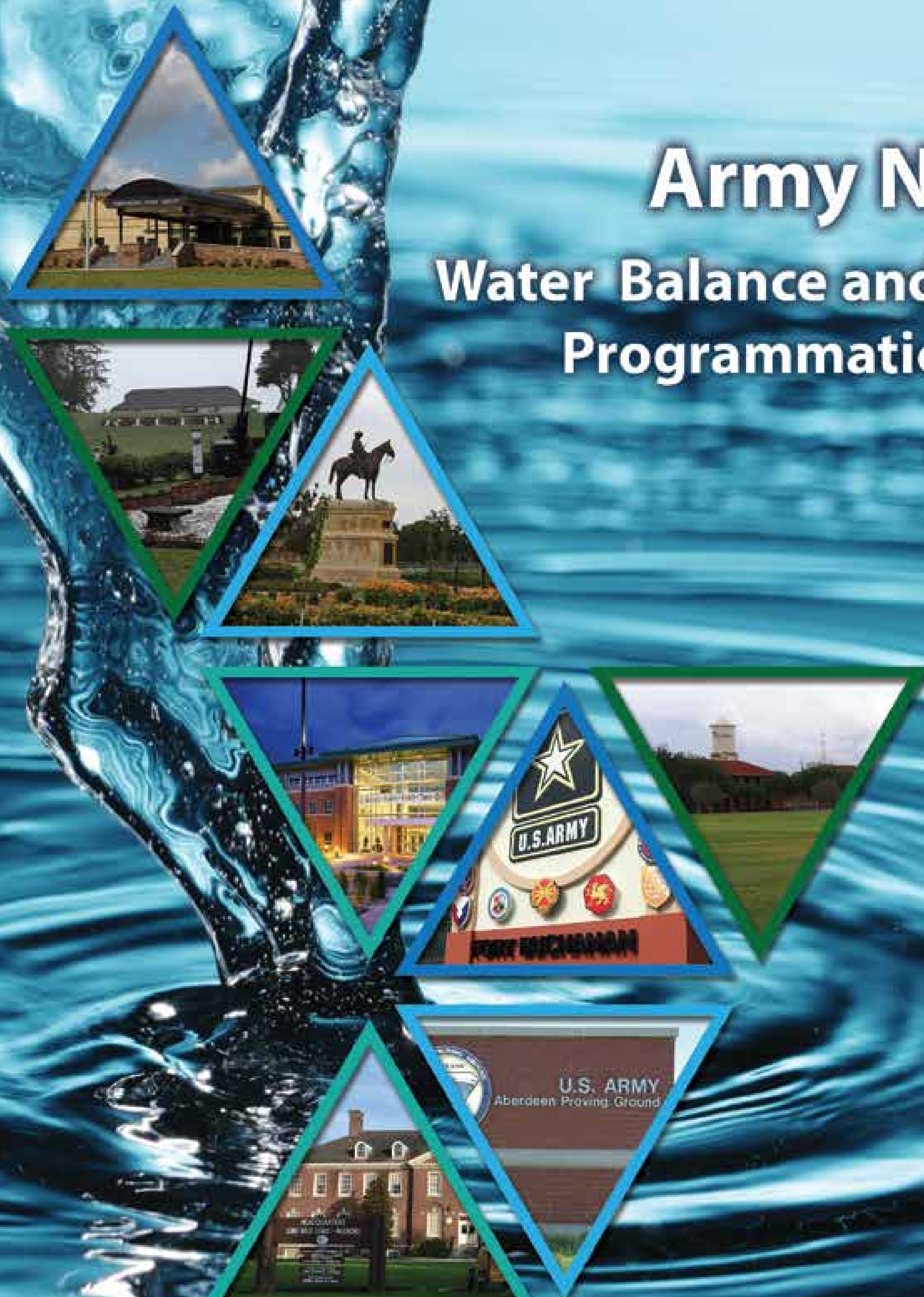
Army Net Zero

Water Balance and Roadmap Programmatic Summary



Charting the Course for the Eight Pilot Net Zero Water Installations

Army Net Zero
Water Balance and Roadmap Programmatic Summary

October 2013

Prepared by Pacific Northwest National Laboratory for the United States Army

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Message from Honorable Katherine Hammack

In October 2010, I announced the creation of the Army Net Zero Initiative. Net Zero is a holistic strategy founded upon long-standing sustainability practices and incorporating emerging best practices to manage energy, water, and waste at Army installations. The intent of the Net Zero Initiative originated from federal mandates, including Executive Order 13514, the Energy Policy Act of 2005, and the Energy Independence and Security Act of 2007. It is sustained through a recognition that better resource management contributes to mission effectiveness and more resilient installations.

The Net Zero Initiative was launched with installation-level pilot programs designed to serve as test beds to gather lessons learned, develop technical analysis and roadmaps, and construct a solid foundation to transition and institutionalize the Net Zero concept throughout the Army. I announced the 17 pilot installations on April 19, 2011. These installations were selected from a large pool of volunteers because they have a vision and passion with support from their Garrison Commanders and higher headquarters. These installations include six Net Zero energy, water, and waste installations each, two integrated Net Zero energy-water-waste pilot installations, and one statewide Army National Guard Net Zero energy pilot program. The pilot installations will continue to serve as model communities for sustainability and quality of life while the Army takes an even broader approach to sustainability by decentralizing and applying the Net Zero concept to all military installations.

A Net Zero water installation limits the consumption of freshwater resources and returns water to the same watershed so as not to deplete the quantity and quality of the ground and surface water resources of the region. The Net Zero water sites represent installations of different physical sizes, geographic locations, and Army commands. The Net Zero water strategy strives to balance water availability and use to ensure a sustainable water supply for years to come. This concept is of increasing importance because water scarcity is a serious and growing issue in many parts of the United States and around the world.

To support and assist in implementing the Net Zero Initiative, the Army contracted with the Department of Energy's Pacific Northwest National Laboratory to develop a water balance and a roadmap assessment for each Net Zero water pilot installation. Water balance assessments quantify water uses at the end-use level to help target efficiency improvements. Roadmap assessments provide a strategy for the installations to implement a time-phased approach for projects to reach the Net Zero water reduction goals and site-specific Net Zero water objectives by 2020.

This Army Net Zero Water Balance and Roadmap Programmatic Summary brings together two years of work and summarizes what we've found and where we're going.

Honorable Katherine Hammack
Assistant Secretary of the Army for Installations, Energy and Environment

Executive Summary

The Department of the Army created the Net Zero Initiative to increase the sustainability of the Army by better managing the use of natural resources. Net Zero espouses the belief that consuming natural resources responsibly based on knowledge of long-term resource availability creates a sustainable environment to support an installation's continuing mission. The Army is pursuing Net Zero programs in the areas of energy, water, and waste. The Net Zero Initiative was launched with installation-level pilot programs designed to establish an implementation framework and identify key lessons about alternative approaches that will lead to success.

Eight installations were selected to be pilot sites for water or solid waste, and nine were selected for energy. Two of these installations were designated as pilots in all three areas (Figure ES.1). Sites selected to pilot the concept of Net Zero water represent various installations of different physical sizes, geographic locations, and Army commands, including the Installation Management Command, the Army Materiel Command, the Reserves, and the National Guard.

As broadly defined by the Army, a Net Zero water installation limits the consumption of freshwater resources and returns water to the same watershed so

Figure ES.1. Net Zero Pilot Installations

Net Zero Water Pilot Installations:

- Aberdeen Proving Ground (APG)
- Camp Rilea
- Fort Bliss
- Fort Buchanan
- Fort Carson
- Fort Riley
- Joint Base Lewis-McChord (JBLM)
- Tobyhanna Army Depot (TYAD)

as not to deplete the groundwater and surface water resources of the region in both quantity and quality over the course of a year. The Net Zero water strategy balances water availability and use to preserve a sustainable water supply for years to come. This concept is of increasing importance because water scarcity is a serious issue in many parts of the U.S. and around the globe.

As part of the Net Zero water pilot demonstration, each pilot site must strive to meet the following aggressive water reduction goals:

- Reduce water use intensity (WUI), measured in gallons per square foot (gal/sqft) of gross building area, by 50% from fiscal year (FY) 2007 to FY 2020
- Reduce industrial, landscaping, and agricultural (ILA)[1] water use, measured in gallons, by 40% from FY 2010 to FY 2020

Along with the aggressive water reduction goals, each pilot installation developed a site-specific Net Zero water objective that is a tailored approach to meeting the location's unique requirements, for water supply and regional long-term sustainability.

To support the Net Zero water pilots, the Army contracted with the Department of Energy's Pacific Northwest National Laboratory to develop a water balance and a roadmap for each installation. The Army commissioned these assessments to provide a means for self-examination to determine areas where the Army is having success and areas that may need improvement. The overarching goal of the assessments was to identify common practices and lessons learned to improve water efficiency across the Army.

The water balances quantify water uses at the end-use level to help target efficiency improvements, whereas the roadmap provides a strategy for the installation to implement a time-phased approach for projects to reach the Net Zero water reduction goals and site-specific Net Zero water objective. This document is an overview of assessments performed at the eight Net Zero water installations and provides insight into common practices and lessons learned that were leveraged through the process.

Water Balance

The water balance assessments identified current water demand at the pilot installations and estimated water use for each major end-use including potable and ILA water applications.

Potable Water Use: In total, the eight pilot installations consume over 5.5 billion gallons (Bgal) of water annually. The four largest potable water users are Fort Bliss, JBLM, APG, and Fort Carson. These installations consume 86% of the water used at all the pilot installations. Fort Bliss is the largest potable water user, consuming nearly 2.0 Bgal of water in FY 2012.

[1] ILA water use is a category of water use specified in Executive Order 13514, defined by the Army as non-potable ground or surface water used in industrial, landscaping, and agricultural applications.

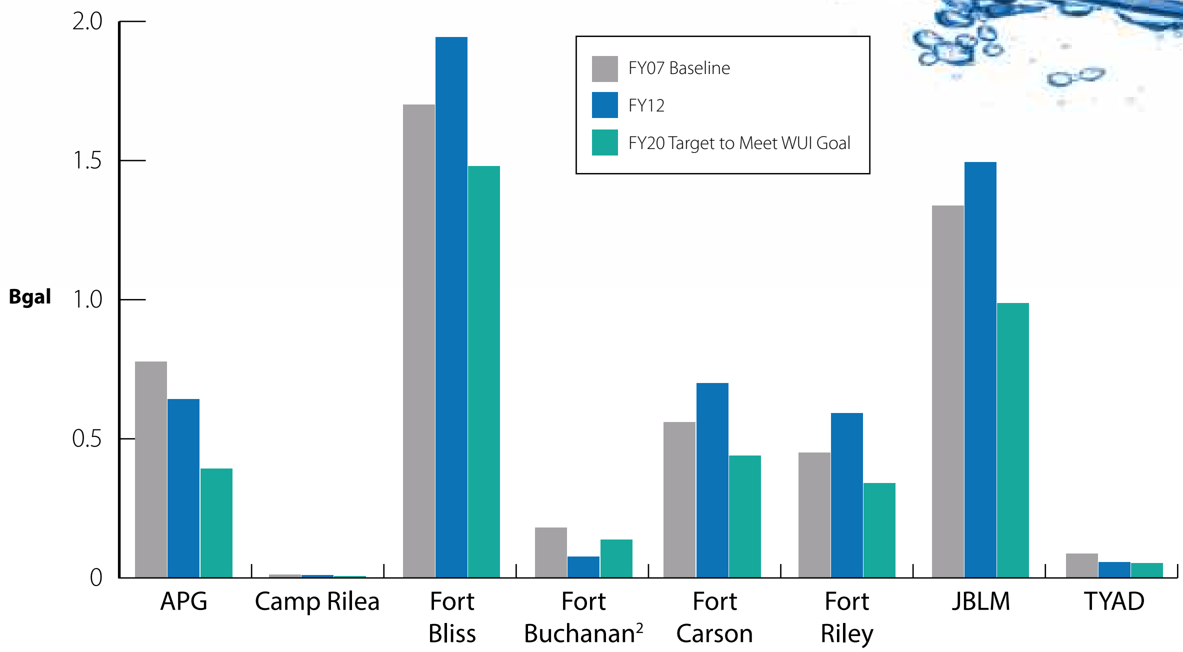


Figure ES.2. Pilot Installations Potable Water Use

From the FY 2007 baseline to FY 2012, the installations' water use increased from 5.1 Bgal to 5.5 Bgal. Population increases at Fort Bliss and Fort Riley are likely the primary cause of the increased potable water use. To meet the potable WUI reduction goal, pilot installations will be required to reduce their total potable water use by 1.7 Bgal in total by FY 2020 (Figure ES.2).

The water balance assessments identified the largest water-consuming end-uses to determine efficiency opportunities. The water balances evaluated water used in family housing separately from the rest of the post (referred to as "on-post"). Generally, for sites with a training mission (i.e., Fort Bliss, JBLM, Fort Carson, Fort Riley, Fort Buchanan, and Camp Rilea), plumbing fixtures[1] and irrigation for landscaping and golf courses were the predominant water uses. A principal water use at TYAD and APG was industrial processes. Distribution system leaks were found to be a major cause of water loss at some sites, with significant losses at Fort Buchanan and JBLM. For example, Fort Buchanan's water balance found that the installation's largest water "use" was likely distribution system leaks caused by the site's aging and deteriorated infrastructure.

Plumbing is the largest water end-use of the eight pilot sites, totaling 1.8 Bgal annually, including family housing. Irrigation is the second largest end-use at 1.3 Bgal per year. These two end-uses comprise half of the water used at installations. Annual total family housing water use at the eight pilots is 1.4 Bgal, which is nearly 25% of the total (Figure ES.3).

The water balance assessment revealed a significant "unknown" water use, which is the portion of the water balance that cannot be attributed to a specific end-use. The total unknown water use for the installations was 1.5 Bgal. This level of unknown water use likely can be attributed to the highly complex nature of large Army installations, transient Soldier and civilian populations, potentially higher-than-expected leak rates in distribution systems, and meter inaccuracy. The unknown water use highlights the

[1]Plumbing fixture water use represents water used in toilets, urinals, faucets, and showerheads.

[2]Target FY20 goal has already been exceeded because of drastic water reduction from FY07 through FY12.

Common WCMs and Typical Life-Cycle Cost-Effectiveness:

- $ High efficiency faucets and showerheads – very good
- $ High efficiency toilets and urinals – poor
- $ Efficient irrigation and native landscaping – marginal to poor
- $ Industrial process improvements – good
- $ Leak detection and repair – good to very good
- $ Efficient kitchen equipment – marginal to good
- $ Medical and laboratory equipment retrofits – good to very good

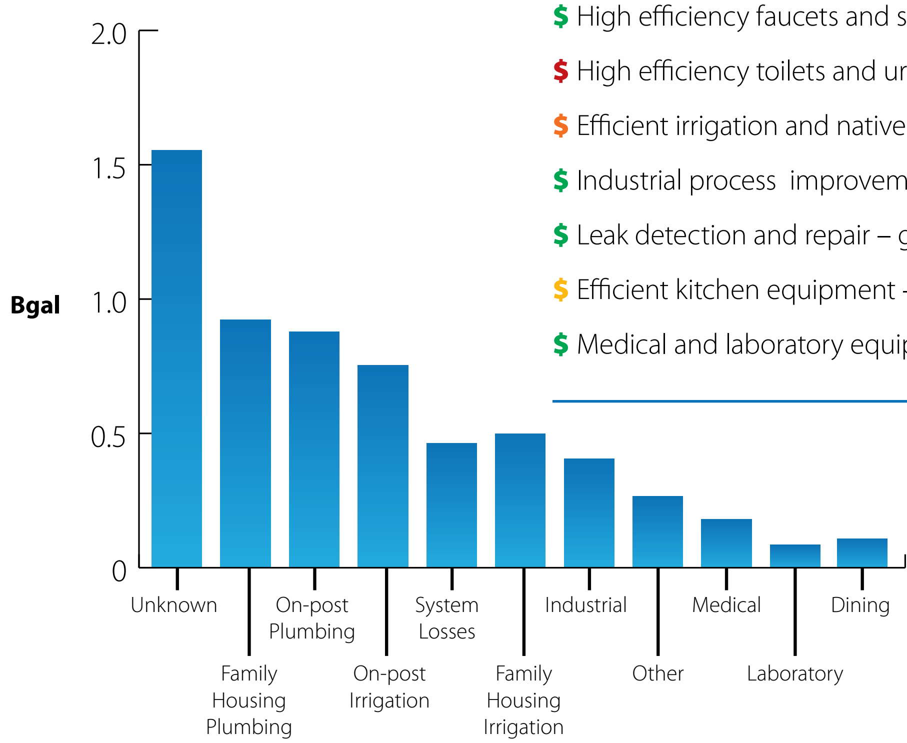


Figure ES.3. Potable Water End-Use Breakout

need for Army installations to perform ongoing leak detection monitoring and validate meter accuracy as comprehensive approaches to water management.

ILA Water Use: Only Fort Bliss, JBLM, and Fort Buchanan consume ILA water for golf course irrigation using on-site non-potable groundwater. The FY 2010 baselines for these sites are Fort Bliss with 320 million gallon (Mgal) per year, JBLM with 44 Mgal per year, and Fort Buchanan with 1 Mgal per year. To meet the ILA 40% reduction goal, these sites will have to reduce golf course irrigation by a total of 151 Mgal by FY 2020.

Roadmap Assessment

The roadmap assessments used the water balance results to formulate a strategy for the pilot installations to meet the reduction goals and site-specific Net Zero water objectives. Water conservation measures (WCMs) were identified for each roadmap and a life-cycle cost (LCC) analysis was performed on each WCM to determine the economic effectiveness of each measure,[1] both individually and as part of bundled projects. The potential water savings of the WCMs projected over the study period, based on the installation's implementation schedule, were used to determine if the pilot site could meet water reduction goals. The roadmaps identified a total of 688 Mgal per year of water reduction potential from LCC-effective WCMs.

[1]Projects with a savings-to-investment ratio greater than 1.0 were deemed LCC-effective.

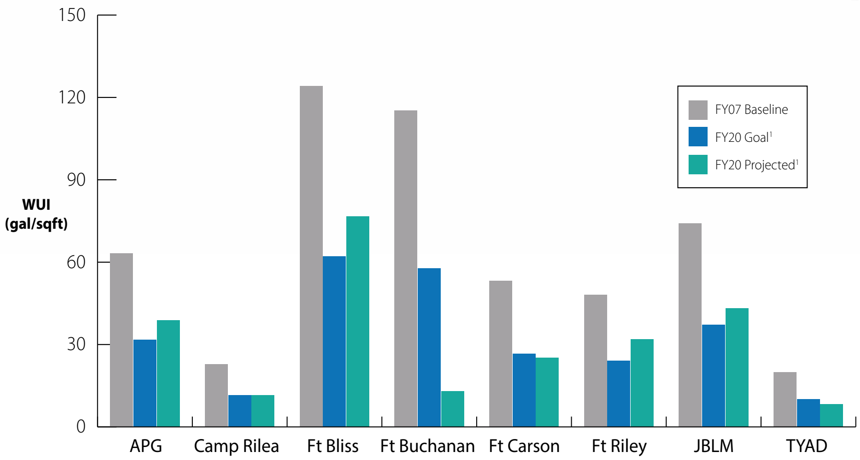


Figure ES.4. Individual WUI Projection for Pilot Installations

Alternative water projects, such as wastewater reclamation and rainwater harvesting, were also assessed as part of the roadmaps to help identify sources of water to displace the use of freshwater. The eight pilot sites have a potential of accessing 633 Mgal of alternative water. The majority of this alternative water is from reclaimed wastewater from on-site wastewater treatment plants (WWTP).

Based on the results of the roadmap assessments, it will be challenging for Fort Bliss, JBLM, Fort Riley, and APG to reduce potable water to the level that will meet the potable WUI reduction goal of 50% by FY 2020 (Figure ES.4). Water at these installations is inexpensive, significantly affecting the LCC-effectiveness of the projects.

The eight pilot sites have already made significant progress in reducing potable WUI. Collectively, it is projected that the eight pilot sites will fall short of meeting the collective WUI reduction with implementation of the recommended WCMs alone. However, when alternative water projects are implemented, the pilot sites can collectively almost

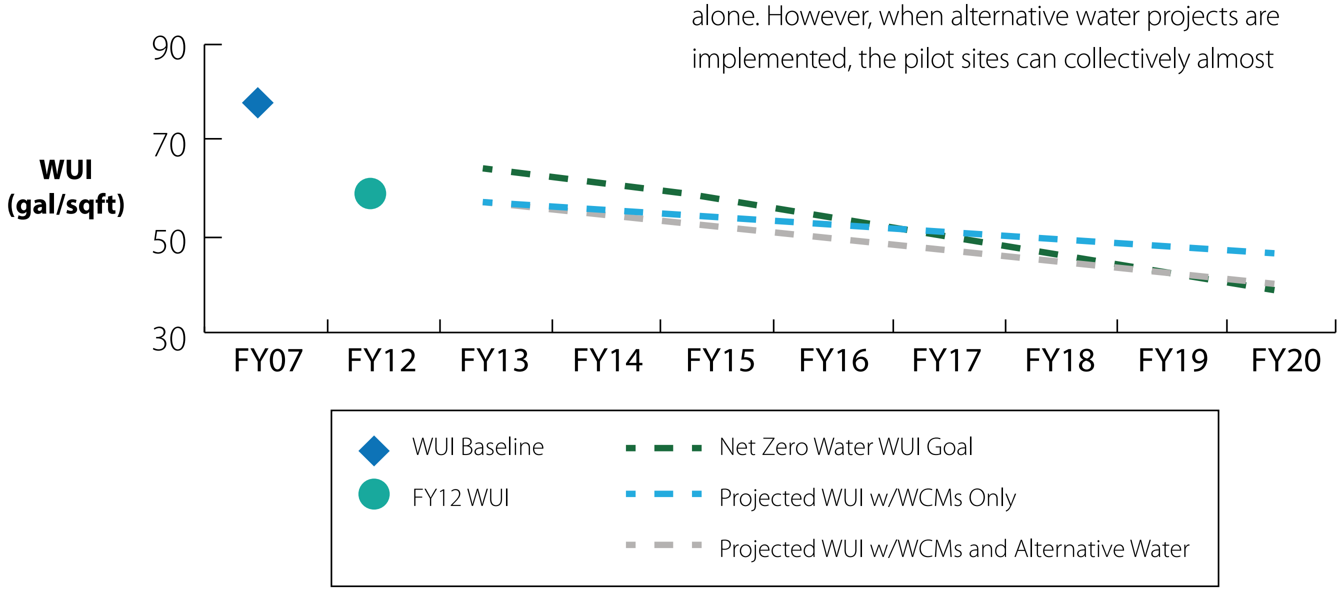


Figure ES.5 Collective WUI Projection for Pilot Installations

[1]"FY20 Goal" represents the annual water use required to meet the reduction goal, whereas "FY20 Projected" represents annual water use if WCMs are implemented.

meet the WUI reduction goal (Figure ES.5). A key conclusion resulting from the roadmap assessments is the importance of Army infrastructure investments at installations to access alternative water sources, which can significantly offset potable water demand.

To meet the 40% ILA water reduction goal, Fort Bliss, JBLM, and Fort Buchanan will have to improve irrigation-system efficiencies, reduce the amount of irrigated landscape areas, and find alternative water sources to displace currently used groundwater.

Common Practices and Lessons Learned

- **Alternative water sources are key to meeting Net Zero water goals and objectives.** On their own, WCMs typically do not provide enough water reduction. Alternative water projects are capital intensive, requiring investments in infrastructure upgrades and paradigm shifts in operational practices.
- **Economically attractive projects and low-cost operational changes can be leveraged** with WCMs that have poor economics to create LCC-effective project bundles. For example: bundle faucets and showerheads with toilets and urinals; low-cost landscape improvements with high-cost irrigation system technology and native landscape conversion.
- **Distribution system leaks can be a significant source of water loss.** A real-time leak monitoring program coupled to a strategic plan is crucial to target repair versus replacement of the distribution system.
- **Installations need to re-evaluate their landscape irrigation practices.** Adjust the concept of "high visibility" landscape to make water conservation a higher priority in vegetation selection.
- **Installation of sub-metering and validation of meter accuracy is essential.** Currently, installations tend to have inadequate sub-metering to monitor water use. The limited number of currently installed water meters are rarely calibrated or tested, which can lead to high "unknown" water use, overbilling by the water supplier, or revenue loss from reimbursable customers.
- **Changes in how people use water need to be implemented in conjunction with any technological solution.** Without these changes, further reductions in potable water use cannot be realized.

Plumbing | Irrigation | Losses | Industrial

Table ES.1. Net Zero Water Pilot Summary

Site	Potable Water Use Intensity (gal/sq ft):	FY07 (baseline)	FY12 (current)	FY20 (target)	FY20 (projected)
ABERDEEN PROVING GROUND	Plumbing	63	46	32[1]	39[1]
CAMP RILEA	Plumbing	23	18	11	10
FORT BLISS	Irrigation	124	92	62[1]	73[1]
FORT BUCHANAN	Losses	115	48	58	16

ABERDEEN PROVING GROUND

Where is Aberdeen Proving Ground now?

- *Predominant water uses: domestic plumbing is **25%** of total; industrial process is **22%** of total*

Where is Aberdeen Proving Ground headed?

- *Net Zero water objective: Pursue water efficiency projects and alternative water resources to achieve a 26% reduction of potable water use by FY 2015 and a 52% reduction by FY 2020*

How will Aberdeen Proving Ground get there?

- *Reclaim water from Canal Creek groundwater treatment plant and pursue other sources of alternative water*

CAMP RILEA

Where is Camp Rilea now?

- *Predominant water uses: domestic plumbing is **59%** of total; kitchen and laundry equipment is **22%** of total*

Where is Camp Rilea headed?

- *Net Zero water objective: Limit the consumption of potable water and return treated water to the local aquifer via infiltration basins in the same quantity that is pumped over the course of a year*

How will Camp Rilea get there?

- *Implement LCC-effective WCMs; note that Camp Rilea has already met the core Net Zero water objective by returning the same volume of water as is pumped from the local aquifer*

FORT BLISS

Where is Fort Bliss now?

- *Predominant water uses: irrigation is **46%** of total; domestic plumbing is **18%** of total*

Where is Fort Bliss headed?

- *Net Zero water objective: Offset freshwater withdrawals from the Hueco Bolson aquifer by using reclaimed wastewater for a percentage of irrigation needs and implement water conservation measures*

How will Fort Bliss get there?

- *Use reclaimed water for irrigation of the Sunrise and Sunset Golf Courses*

FORT BUCHANAN

Where is Fort Buchanan now?

- *Predominant water uses: unknown water uses are **43%** of total; domestic plumbing is **24%** of total; distribution system losses are **18%** of total*

Where is Fort Buchanan headed?

- *Net Zero water objective: Reduce potable water consumption volumetrically by 60% and become a self-sufficient system whereby water is produced and treated on-site and returned to the local aquifer*

How will Fort Buchanan get there?

- *Upgrade the distribution system infrastructure to limit losses; produce potable water and treat wastewater on-site*

[1]The results of the roadmap assessment forecasts that the site will not meet the WUI reduction goal.

Table ES.1. Net Zero Water Pilot Summary (continued)

Installation	Potable Water Use Intensity (gal/sq ft): FY07 (baseline)	FY12 (current)	FY20 (target)	FY20 (projected)
FORT CARSON	53	55	27	25
FORT RILEY	48	42	24[1]	32[1]
JOINT BASE LEWIS-MCCHORD	74	60	37[1]	48[1]
TOBYHANNA ARMY DEPOT	20	12	10	8

FORT CARSON

Where is Fort Carson now?
- *Predominant water uses: irrigation is **56%** of total; domestic plumbing is **27%** of total*

Where is Fort Carson headed?
- *Net Zero water objective: Reclaim water through the on-site WWTP equal to or greater than the amount of potable water supplied to the site over the course of a year*

How will Fort Carson get there?
- *Implement direct potable reuse to maximize use of reclaimed wastewater during non-irrigation months*

FORT RILEY

Where is Fort Riley now?
- *Predominant water uses: domestic plumbing is **36%** of total; irrigation is **10%** of total*

Where is Fort Riley headed?
- *Net Zero water objective: Limit the consumption of freshwater resources and return treated wastewater to the Kansas-Lower Republican basin in the same quantity that is withdrawn for potable water production over the course of the year*

How will Fort Riley get there?
- *Implement WCMs and use reclaimed wastewater for irrigation and other non-potable uses in the Custer Hill area*

JOINT BASE LEWIS-MCCHORD

Where is Joint Base Lewis-McChord now?
- *Predominant water uses: domestic plumbing is **33%** of total; unknown water uses are **27%** of total*

Where is Joint Base Lewis-McChord headed?
- *Net Zero water objective: Limit the consumption of freshwater resources and reclaim wastewater effluent so that there is no discharge from the WWTP to the Puget Sound*

How will Joint Base Lewis-McChord get there?
- *Implement indirect and direct potable reuse to maximize the use of reclaimed water from the WWTP*

TOBYHANNA ARMY DEPOT

Where is Tobyhanna Army Depot now?
- *Predominant water uses: industrial processes is **34%** of total; domestic plumbing is **19%** of total*

Where is Tobyhanna Army Depot headed?
- *Net Zero water objective: Limit the consumption of freshwater resources and return treated wastewater to the Hummler Run watershed in the same quantity that is pumped from groundwater wells for potable water production over the course of the year*

How will Tobyhanna Army Depot get there?
- *Utilize reclaimed water for WWTP applications; note that Tobyhanna Army Depot has already met the core Net Zero water objective by returning as much water to the local watershed as is pumped from the local groundwater source*

[1]The results of the roadmap assessment forecasts that the site will not meet the WUI reduction goal.

Table of Contents

Introduction

In 2011, the Department of the Army created the Net Zero Initiative to manage natural resources with a goal of Net Zero installations. Through this initiative, the Army is creating a culture that recognizes the value of sustainability. The Army is pursuing Net Zero programs in energy, water, and waste. To kick off the Net Zero Initiative, the Army selected installations to demonstrate the concept of Net Zero energy, water, and waste. This document is an overview of assessments performed at the eight Net Zero water pilot installations. Each assessment included a water balance and a roadmap to provide pilot installations with a strategic approach to achieve Net Zero goals.

Water Balance

A water balance provides information on water supplied to the installation, estimates water use by facility type and end-use, and then compares these uses to the total water supplied. The water balance (Figure 1) is an important benchmark for the Net Zero water initiative because it quantifies water use at the equipment level and identifies key areas to target for water reduction and efficiency improvements.

Each water balance assessment followed a series of steps:

1. Compile and analyze data from the site to understand use patterns and trends in water use, population, and building inventory.
2. Identify high priority buildings on which to perform walk-through audits during site visits.
3. Perform walk-through audits and interviews for representative buildings and large irrigated areas; these audits accounted for a combined 20 million square feet of facility space.
4. Quantify water use at the end-use level based on information gathered during the walk-through audits.
5. Compare end-use water consumption to the total water supplied to the installation to determine losses and unknown water use.

Roadmap

Following the water balance, a Net Zero water roadmap was developed for each pilot installation. Based on the major water uses, water conservation measures

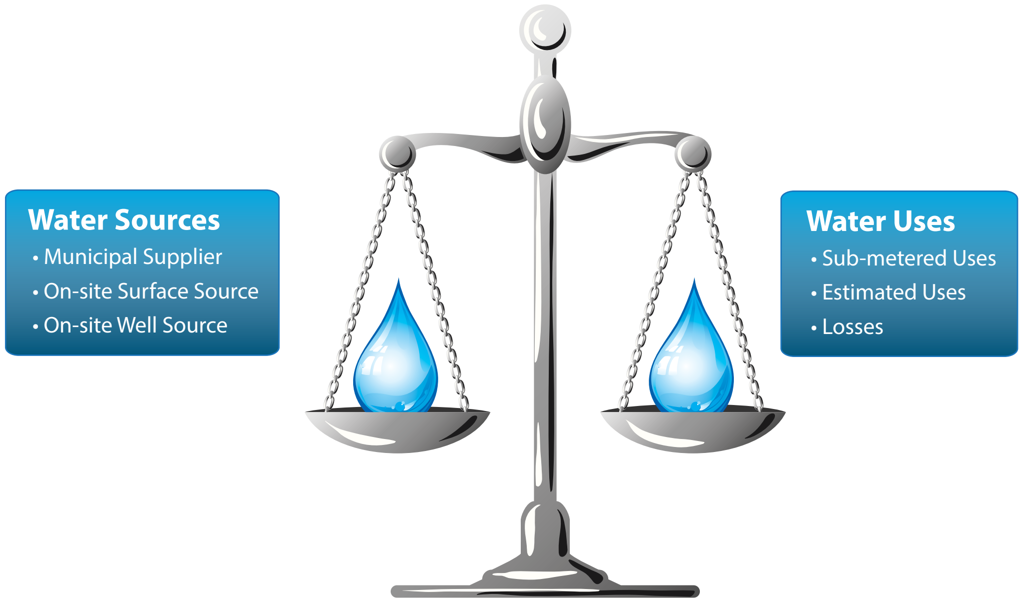


Figure 1. Water Balance

(WCMs) were identified and a life-cycle cost (LCC) analysis was performed for each. The LCC analysis identifies the cost effectiveness of each WCM, both individually and as part of a larger bundled project. WCMs are deemed LCC-effective when they have a savings-to-investment ratio (SIR) of greater than 1. SIR determines the "break-even" point of the project's cost. Therefore, a project is LCC-effective when the total savings stream is greater than the initial WCM cost. The LCC results were used to develop an implementation strategy for each site, including identification of possible funding sources and project phasing to help the installation meet the Army's Net Zero water goals in the identified timeframe. In addition to WCMs, the roadmaps assessed alternative water sources such as reclaimed wastewater that can be used to offset the use of surface and groundwater resources.

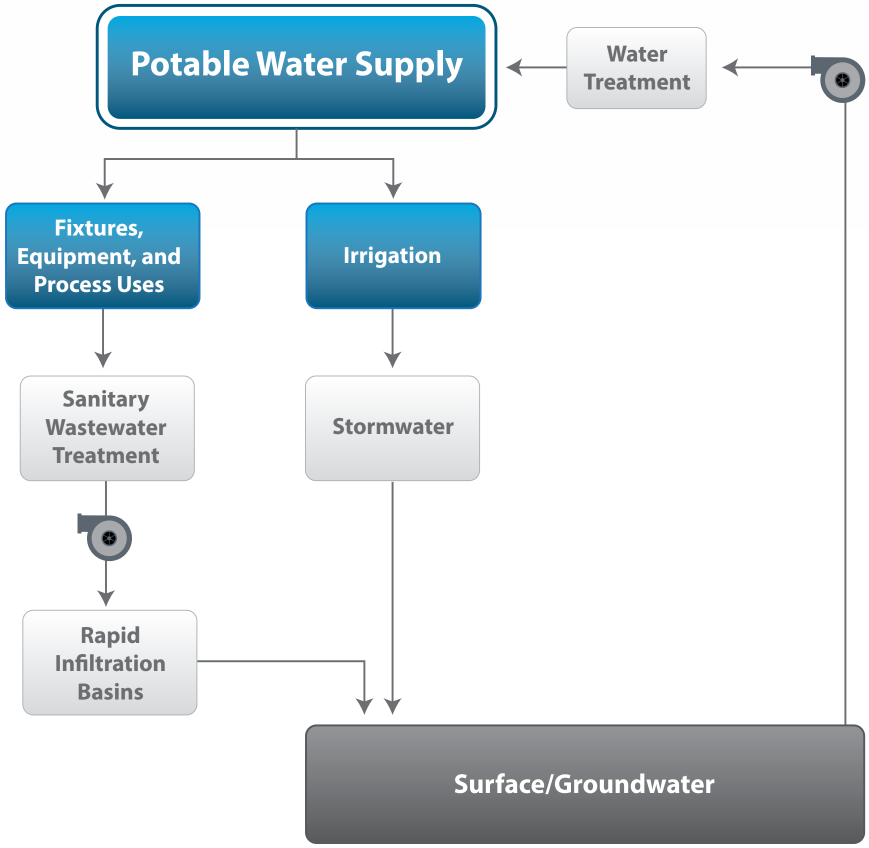


Figure 2. Net Zero Water Concept

Definition and Goals

The Army's definition of a Net Zero water installation is one that "limits the consumption of freshwater resources and returns water back to the same watershed so as not to deplete the groundwater and surface water resources of that region in quantity and quality over the course of a year." (Figure 2) The definition's intent is to foster sustainable water resource availability for the installation and surrounding community. Water supply and availability vary among installations and therefore can make meeting the Army's exact Net Zero water definition challenging. For example, some of the pilot sites purchase water from local suppliers that obtain water from multiple sources. In these cases, the installation developed a specific objective that is tailored to the location's unique characteristics including climate, water supply sources, and long-term regional water sustainability. In addition to meeting the site-specific objective, each pilot installation must strive to reduce water use intensity (WUI), measured in gallons per square foot (gal/sqft), by 50% from fiscal year (FY) 2007 to FY 2020 and reduce industrial, landscaping, and agricultural (ILA)[1] water use by 40% from FY 2010 to FY 2020.

[1] ILA water use is a category of water use specified in Executive Order 13514, defined by the Army as non-potable ground or surface water used in industrial, landscaping, and agricultural applications.

How to Use This Report

This report is organized to provide basic information on each Net Zero pilot installation, followed by more in-depth details. Each section opens with a "snapshot" of the results of the water balance and roadmap. This includes water use, facility space, and major water uses, termed "quick facts." The first page of each section provides a "roadmap shortcut" that highlights important roadmap results, including water savings potential, WUI metrics, and key recommended WCMs. The remainder of the section reflects the water balance and roadmap assessment results to show how water is consumed at the installation, the potential water reduction, Net Zero water goals, and the installation's efforts to date to achieve the goals.

The following information provides key terms and graphics that are used throughout the remainder of the report.

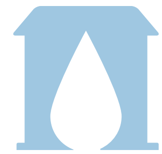
Common Acronyms

These acronyms are used throughout the report:

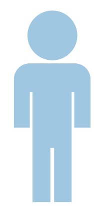
Btu	British thermal unit
FamHsg	family housing
FY	fiscal year
gal/person/day	gallons per person per day
ILA	irrigation, landscaping, and agricultural
LCC	life-cycle cost
Mgal	million gallons
SIR	savings-to-investment ratio
WCM	water conservation measure
WUI	water use intensity
WWTP	wastewater treatment plant

Key Terms

A common set of information is provided for each installation to help summarize the key findings of the roadmap:



Building water use intensity: Annual water use per square foot, which represents the total water reported by the installation divided by the gross facility area of the installation, in gallons per square foot (gal/sqft).



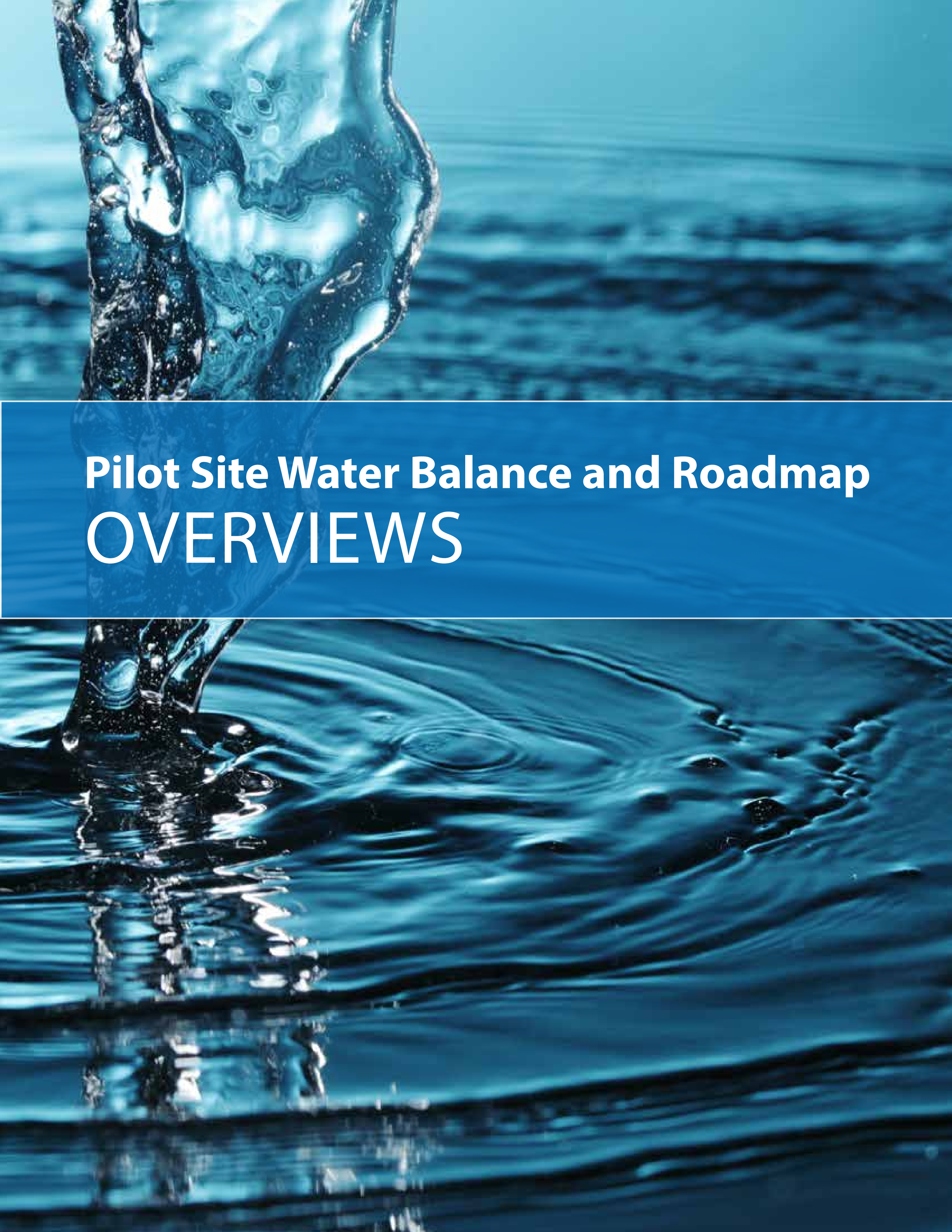
Population water use intensity: Daily water use per person, which represents the total water reported by the installation divided by the total population, in gallons per person per day (gal/person/day).

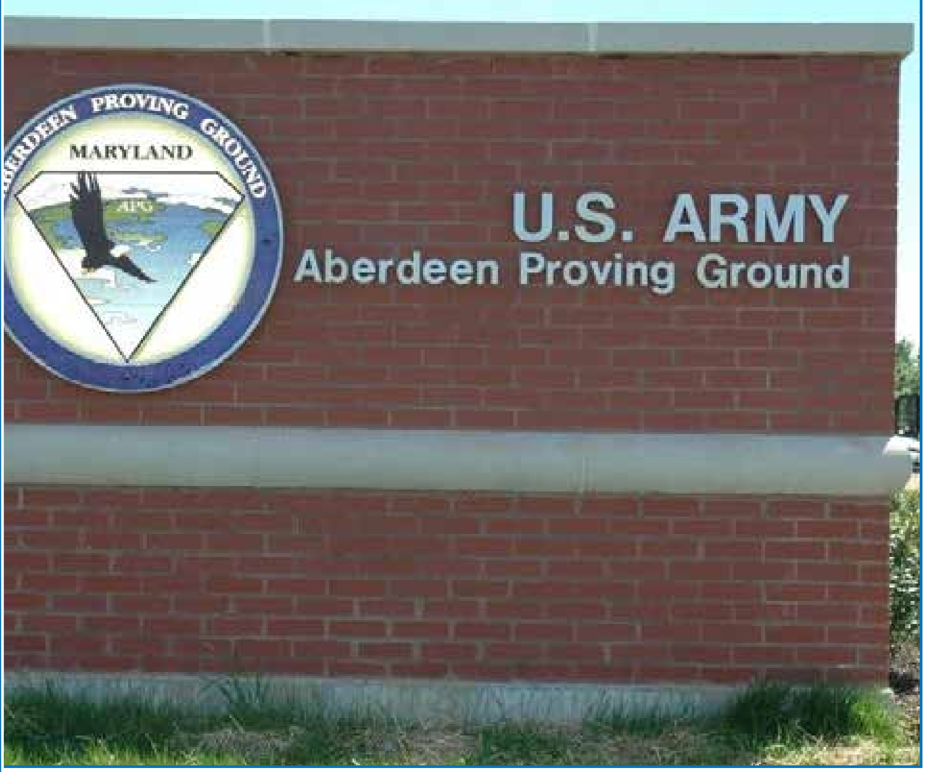
Regional water vulnerability: Represents the risk of limited water availability associated with the regional water supply.

Highly vulnerable regional water supply | Vulnerable regional water supply | Moderately vulnerable regional water supply | Minimally vulnerable regional water supply

Net Zero water game changer: The key project or group of projects that are pivotal to the installation's ability to meet the Net Zero water goals and objectives.

Pilot Site Water Balance and Roadmap
OVERVIEWS





Aberdeen Proving Ground's Net Zero water objective: *Pursue water efficiency projects and alternative water resources to achieve a 26% reduction of potable water use by FY 2015 and a 52% reduction by FY 2020.*

Aberdeen Proving Ground, Maryland QUICK FACTS

14 million sqft of facility space

643 Mgal FY12 potable water use

490 Mgal FY12 treated wastewater

25% of water is used in plumbing

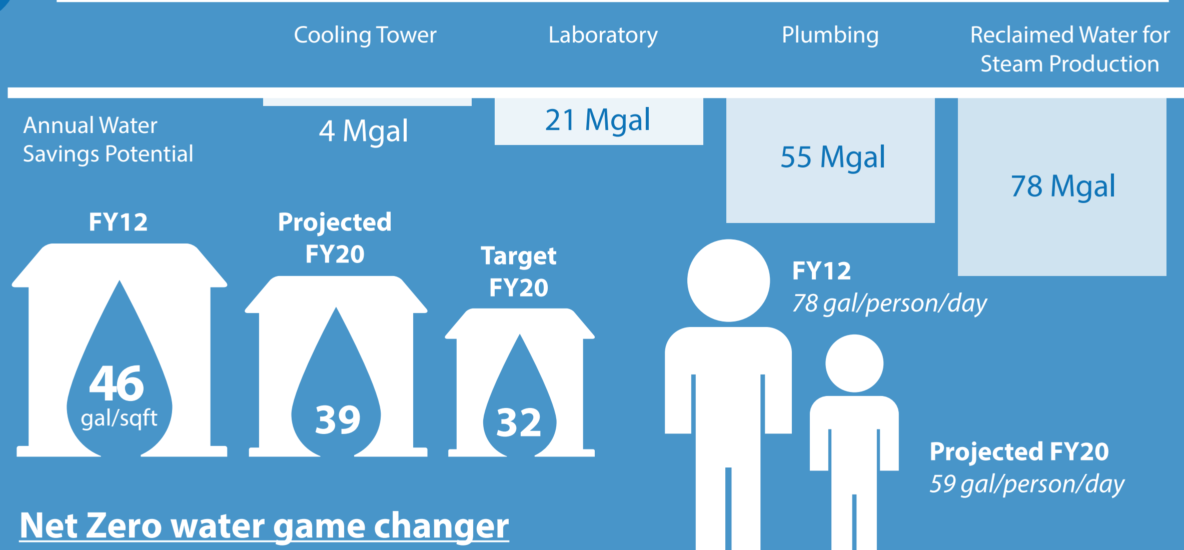
22% of water is used in industrial

Purchases potable water and produces on-site

Treats wastewater on-site, discharges to Bush River

Vulnerable regional water supply

ROADMAP SHORTCUT



Net Zero water game changer

Reclaim water from Canal Creek groundwater treatment plant and pursue other sources of alternative water.

Aberdeen Proving Ground

Background

Aberdeen Proving Ground (APG) covers more than 72,500 acres near the Chesapeake Bay in Harford County, Maryland, and is separated into two areas by the Bush River. The northern area is referred to as the Aberdeen Area and the southern area is known as the Edgewood Area. The Aberdeen Area of APG purchases potable water from the City of Aberdeen. The City of Aberdeen produces potable water from the Deer Creek pumping station and Chapel Hill Water Treatment Plant (WTP). The Aberdeen Area's wastewater is treated by the City of Aberdeen.

The Edgewood Area's water supply comes from the Van Bibber WTP via the Winters Run tributary of the Chesapeake Bay. The plant produces an average of 1.2 Mgal of potable water per day to meet water demands on-post, allowing for significant future growth. On occasion, Winters Run tributary is subject to drought conditions. When this happens, APG must supplement its supply by purchasing water from Harford County.

APG has two operating WWTPs at the Edgewood Area of APG: the Beach Point WWTP and the Canal Creek Groundwater Treatment Plant (GWTP). The Beach Point WWTP serves as the primary treatment plant for sanitary sewage from the Edgewood Area. Effluent water is discharged via a subsurface pipeline that drains into the Bush River.

Water Balance

APG's largest potable water end-use is plumbing fixtures (including toilets, urinals, faucets, and showerheads), totaling 160 Mgal annually, representing 25% of the total use. This portion of the water use also includes family housing. APG reports water used in family housing to the Army.

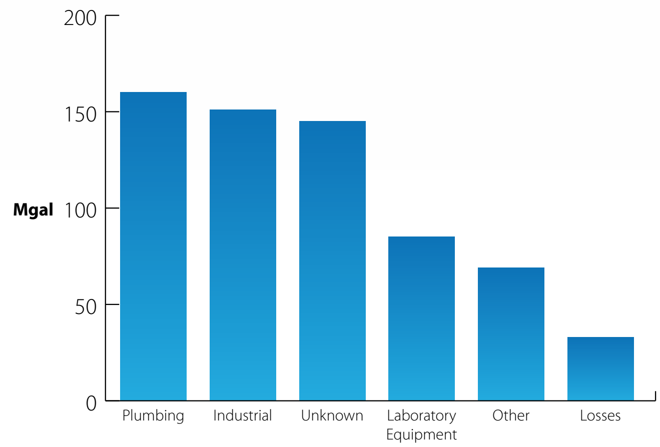


Figure 1.1 APG Annual Water Use Breakout

The water balance assessment revealed a significant unknown water use representing 23% of the total (Figure 1.1). This unknown water represents a variety of water uses that were not assessed due to APG's complex operations and because many buildings were not accessible for the water balance assessment. The large amount of unknown water use could also be attributable to a higher-than-expected loss rate in APG's distribution system. Industrial water use is a significant water consumer at APG, totaling 140 Mgal annually, accounting for 22% of the total use. Industrial uses at APG include water used in steam production and cooling towers.

Roadmap

The roadmap assessment evaluated WCMs to determine LCC-effective projects that APG should pursue to assist in meeting the Net Zero water reduction goal (Table 1.1). LCC-effective plumbing fixture retrofits offer a large potential savings for APG, totaling a reduction of 55 Mgal annually. Replacement of commercial laundry equipment and pre-rinse spray valves in the dining facilities were also found to be LCC-effective, with modest savings potential of approximately 1 Mgal per year. Specific recommendations provided in the roadmap assessment include the following:

- **Edgewood Area plumbing fixture replacement post-wide:**
  - 1.28 gallon-per-flush (gpf) flush-valve and 1.0 gpf tank-type high efficiency toilet replacement
  - Pint-flush urinal replacement
  - 0.5 gallon-per-minute (gpm) tamper-proof laminar flow lavatory faucet
  - 1.0 gpm tamper-proof laminar flow kitchen faucet
  - 1.5 gpm low-flow pressure-compensating showerheads
- **Aberdeen Area plumbing fixture replacement in barracks and lodging:**
  - 1.28 gpf flush-valve and 1.0 gpf tank-type high efficiency toilet replacement
  - 0.5 gpm tamper-proof laminar flow lavatory faucet
  - 1.5 gpm low-flow pressure-compensating showerheads
- **Commercial kitchen upgrades:** Replace existing pre-rinse sprayers with 1.24 gpm high efficiency units in Aberdeen dining facilities
- **Laundry projects:** Replace existing washing machines in the Aberdeen and Edgewood areas with high efficiency front load units

Table 1.1 Water Conservation Measure LCC Analysis Results

Net Zero Water Project	Water Savings (Mgal/yr)	Energy Savings (million Btu/yr)	Cost Savings ($/yr)	Installed Cost ($)	Simple Payback (yr)	Savings-to-Investment Ratio	Net Present Value ($)
Edgewood Reclaimed Water System	80	0	217,000	1,423,300	7	2.3	116,600
Edgewood Plumbing	34	6,000	250,700	806,200	3	4.1	1,023,100
Aberdeen Barracks/ Lodging Plumbing	22	6,400	33,100	59,600	2	6.6	80,300
Commercial Laundry	0.4	900	6,300	40,200	6	4.0	19,500
Commercial Kitchen	0.3	1,100	12,500	17,900	1	8.5	22,500

Along with WCMs, alternative water sources must be considered as part of APG's Net Zero water strategy. Alternative water offsets the use of freshwater from surface and groundwater sources. A key source of potential alternative water for APG is reclaiming water from the Canal Creek GWTP, which treats contaminated water in the Edgewood Area. This reclaimed water can be used for non-potable industrial applications and has the potential to offset potable water consumption by nearly 78 Mgal annually. To meet the Net Zero water objective, APG should also consider pursuing other sources of alternative water such as reclaimed water from the Edgewood WWTP, condensate capture, and rainwater harvesting.

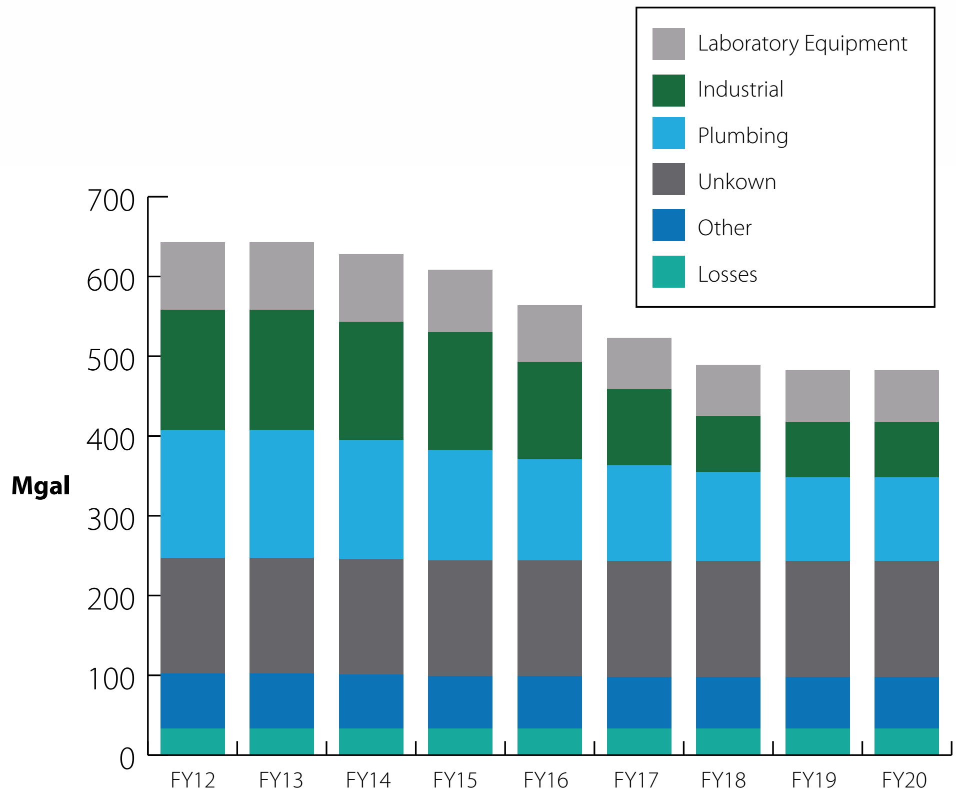


Figure 1.2 APG Projected Water Use

Through the roadmap process, a plan was developed that resulted in a recommended schedule for implementing the LCC-effective projects between FY 2013 and FY 2020. If all recommended LCC-effective WCMs are implemented, APG will reduce water use by 161 Mgal annually, taking into account population and building inventory changes (Figure 1.2). With these savings, APG's WUI will be 39 gal/sqft, which falls short of the reduction goal of 32 gal/sqft. This gap represents 89 Mgal of potable water that APG will have to offset to meet the WUI reduction goal.

Roadmap Progress

APG is currently in the process of developing an energy savings performance contract (ESPC) and awarding the initial phase. High efficiency plumbing fixtures will be replaced in the Edgewood Area as part of Phase 1 of the ESPC. The ESPC will also include reclaiming water from the Canal Creek GWTP to be used in steam production in Building 5126.

Camp Rilea's Net Zero water objective: *Limit the consumption of potable water and return treated water to the local aquifer via infiltration basins in the same quantity that is pumped over the course of a year.*

Camp Rilea, Oregon QUICK FACTS

400 thousand sqft of facility space

8.5 Mgal FY12 potable water use

8.5 Mgal FY12 treated wastewater infiltrated to groundwater

59% of water is used in plumbing

19% of water is used in kitchen equipment

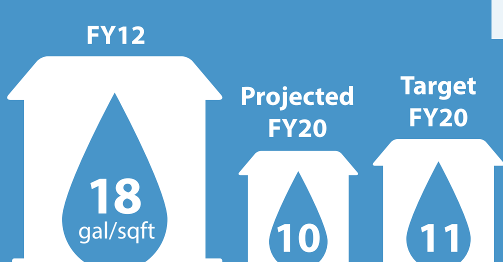
Produces all water on-site

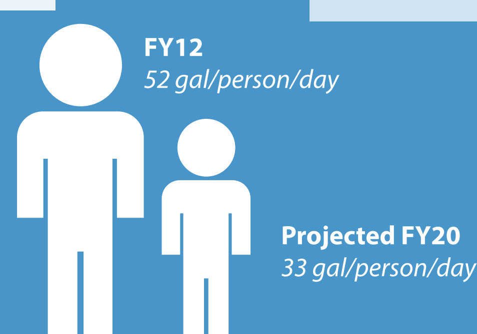
Reclaims wastewater for irrigation

Minimally vulnerable regional water supply

ROADMAP SHORTCUT

	Potable		Class A	
	Kitchen and Laundry	Plumbing	Rainwater Harvesting	Irrigation
Annual Water Savings Potential	0.7 Mgal	2.3 Mgal	0.7 Mgal	2.5 Mgal





Net Zero water game changer

Implement comprehensive plumbing and irrigation LCC-effective WCMs.

Camp Rilea

Background

Camp Rilea Armed Forces Training Facility is situated on approximately 1,800 acres between Astoria and Seaside, on the northern Oregon Coast. Camp Rilea's primary mission is to serve as a training facility for organizations such as units of the Oregon Army National Guard, Oregon Air National Guard, United States and foreign reserve and active duty military forces, and law enforcement. Camp Rilea's water supply system is supplied on-site via two ground source wells. The water supply system is designed to provide between 7 and 8 Mgal of potable water per month at peak water demand. Camp Rilea produced on average 8 Mgal of potable water annually between FY 2007 and FY 2012.

Camp Rilea treats wastewater on-site. The treatment facility is composed of primary and secondary settling basins with a maximum volume capacity of 5 Mgal between the two basins. Wastewater is drawn from the secondary settling basin and receives minimal chlorine treatment before being pumped to one of four rapid infiltration basins to recharge the local groundwater (Figure 2.1). The rapid infiltration basins came online in September 2011. In addition, starting in 2013, Camp Rilea is reclaiming wastewater that is treated to Class A standards[1] and reused for landscape irrigation to further conserve its groundwater supply.

Camp Rilea lies in a region with low water scarcity because of abundant precipitation, relatively low regional growth, and stable groundwater resources.

Figure 2.1 Camp Rilea Rapid Infiltration Basin

Water Balance

Camp Rilea's predominant potable water use is plumbing fixtures, totaling more than 4 Mgal per year, representing nearly 60% of the total water use on-site. Kitchen equipment and laundry is also a significant water use, totaling nearly 2 Mgal annually (Figure 2.2).

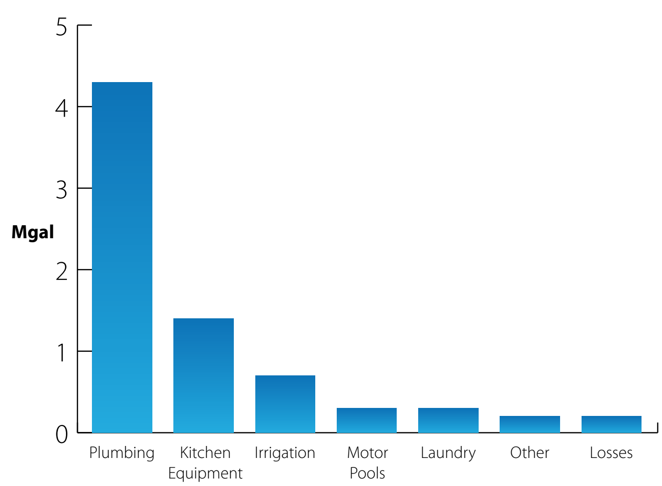


Figure 2.2 Camp Rilea Annual Water Use Breakout

[1] Regulated through the Oregon Department of Health Services, Class A water is treated to the level that is suitable for beneficial non-potable uses such as irrigation.

Roadmap

Camp Rilea is well on its way to meeting the site-specific Net Zero water objective. Camp Rilea infiltrates as much water through the rapid infiltration basins as is pumped from groundwater for potable use. Therefore, by definition, Camp Rilea is currently Net Zero water. However, Camp Rilea has not yet met the FY 2020 potable WUI reduction goal. WCMs were analyzed as part of the roadmap analysis to determine LCC-effective projects (Table 2.1). Plumbing fixture replacements were not LCC-effective on its own; however when bundled with a suite of other WCMs, the resulting SIR was 1.4. The comprehensive bundled projects include:

- Comprehensive plumbing retrofits with high efficiency fixtures
- Laundry WCMs: ENERGY STAR clothes washing machine replacement and commercial ozone system
- Commercial kitchen equipment retrofits:
  - ENERGY STAR food steamers
  - High efficiency pre-rinse spray valves
  - Garbage disposal controls
- Implementation of low- and no-cost irrigation operation and maintenance improvements for areas that use potable water
- Irrigation system enhancements, advanced controls, and conversion to native landscaping of Class A irrigation areas

Table 2.1 Water Conservation Measure LCC Analysis Results

Net Zero Water Project	Water Savings (Mgal/yr)	Energy Savings (million Btu/yr)	Cost Savings ($/yr)	Installed Cost ($)	Simple Payback (yr)	Savings-to-Investment Ratio	Net Present Value ($)
Plumbing	2.0	500	21,500	224,500	10	0.9	-8,300
Class A Irrigation Areas	2.4	-	39,500	231,700	6	2.0	233,700
Kitchen Equipment	0.2	100	2,500	28,700	10	1.3	4,400
Laundry	0.4	300	6,100	41,600	6	2.4	12,300
Rainwater Harvesting	0.7	-	10,700	42,000	4	3.7	65,000

- Rainwater harvesting to supplement Class A irrigation

Through the roadmap process, a plan was developed that resulted in a recommended schedule for implementing the LCC-effective projects between FY 2013 and FY 2020. Taking into account expected population growth and changes in building inventory through FY 2020, the demand for potable water can be reduced by 3 Mgal by FY 2020, representing a 35% decrease (Figure 2.3). This water reduction will enable Camp Rilea to achieve a potable WUI of 10 gal/sqft, which will exceed the goal.

In addition to WCM implementation, Camp Rilea should consider adding storage for the Class A water plant so that the demand for irrigation of the landscaped areas can be met using alternative water sources. Currently, the Class A treatment plant cannot produce enough water weekly to meet the demand for irrigation during the irrigation season. A storage reservoir of approximately 1 Mgal would be required to meet the irrigation demand of the landscape that uses Class A water during the irrigation season if recommended WCMs are implemented. Without such storage, potable water makeup will be required. However, it costs significantly more to produce Class A water than to inject treated wastewater into the local aquifer through the rapid infiltration basins. Therefore, Camp Rilea should carefully consider any plans to increase production of Class A water rather than return water to groundwater for future use.

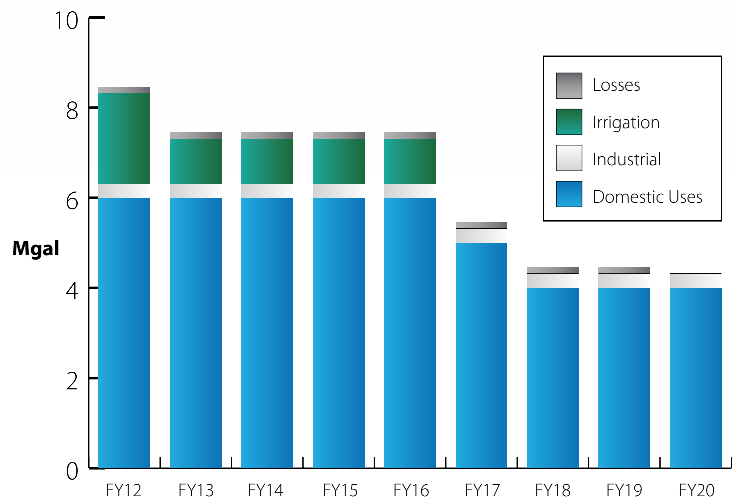


Figure 2.3 Camp Rilea Projected Potable Water Use

Roadmap Progress

Camp Rilea's Class A reclaimed water plant came fully online in the spring of 2013, with a daily maximum production rate of 23,000 gallons. From May through mid-August, Camp Rilea has reclaimed more than 1 Mgal, which has been used in landscape irrigation. In addition, Camp Rilea is developing a comprehensive stormwater management plan that includes replacing irrigated turf with native and adaptive landscaping.

Fort Bliss's Net Zero water objective: *By FY 2020, Fort Bliss will offset freshwater withdrawals from the Hueco Bolson aquifer to the greatest practical extent by using reclaimed wastewater for up to 46% of post irrigation demand, and by implementing conservation measures that meet the Army Net Zero water goals.*

Fort Bliss, Texas QUICK FACTS

24.5 million sqft of facility space

1,944 Mgal FY12 potable water use

78% of water produced on-site

46% of water is used in irrigation

18% of water is used in plumbing

22% potable water purchased from El Paso Water Utility

Highly vulnerable regional water supply

ROADMAP SHORTCUT

	Plumbing/ Dining	Irrigation	Reclaimed Water
Annual Potable Water Savings Potential	30 Mgal	238 Mgal	479 Mgal

FY12 92 gal/sqft

Projected FY20 62

Target FY20 62

FY12 *123 gal/person/day*

Projected FY20 *94 gal/person/day*

Net Zero water game changer

Investigate the use of reclaimed water for irrigation of the Sunrise and Sunset Golf Courses, which could reduce freshwater demand from the Hueco Bolson aquifer by up to 320 Mgal per year.

Fort Bliss

Background

Fort Bliss covers nearly 1.1 million acres in Texas and New Mexico, with the main cantonment area located adjacent to El Paso, Texas. The mission of Fort Bliss is to train, deploy, and sustain combat ready units. Potable water is supplied to Fort Bliss by a collection of on-site wells drawing from the Hueco Bolson aquifer. Fort Bliss supplements its on-site water supply with purchased water from the El Paso Water Utility (EPWU). During the analysis period, Fort Bliss water consumption increased from a low of 1,260 Mgal in 2008 to a high of 2,200 Mgal in 2011, consistent with population growth during the same period. Fort Bliss discharges all of its wastewater to the EPWU wastewater system. Wastewater is treated at the EPWU Haskell R. Street WWTP and then discharged either to the Rio Grande River or to the American Canal, where it is used for agricultural purposes.

Fort Bliss experiences large summer peak water loads, primarily due to turf and landscape irrigation. Water use during the irrigation season (April through September) varied from 300 to 650 Mgal during the period of FY 2008 to FY 2011. Fort Bliss uses non-potable freshwater at its two golf courses, which meets the Army's ILA definition for landscaping water use.

Fort Bliss lies in a highly vulnerable region for water scarcity considering the stretched resources of the regional water supply, potential climate change effects, growing regional population, and frequency of natural drought conditions.

Water Balance

The primary water users at Fort Bliss are irrigation and plumbing (Figure 3.1). These uses comprise 55% of the total water consumption at Fort Bliss. The water balance assessment revealed a large unknown water use, representing 26% of the total production. This unknown water represents a variety of water uses that were not assessed due to the installation's size and complexity. The high unknown water may also be caused by potentially higher-than-expected leak rates in the distribution system, and meter inaccuracy.

Fort Bliss's family housing is privatized; however, family housing water use historically has been included in the water use reported by Fort Bliss to the Army.

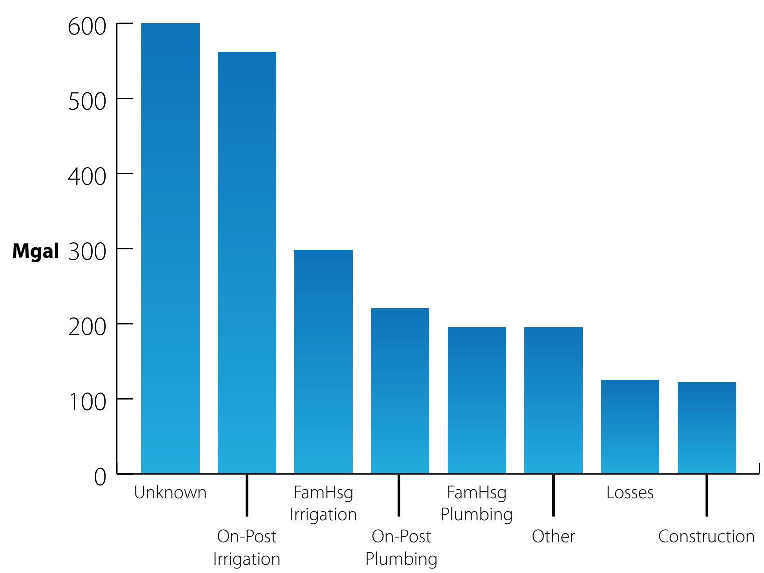


Figure 3.1 Fort Bliss Annual Water Use Breakout

Roadmap

To meet the goals of the Net Zero water program, Fort Bliss must aggressively implement efficiency improvements across the major water end-uses and implement alternative water sources. Based on the results of the water balance, Fort Bliss should target irrigation systems, plumbing fixtures, and potable water distribution and loss prevention. Other opportunities include retrofits of commercial kitchen and hospital equipment. LCC analysis of the WCMs revealed that very few are cost-effective because freshwater is very inexpensive at Fort Bliss.

Through the roadmap process, a plan was developed that resulted in a recommended project implementation schedule between FY 2013 and FY 2018 for projects with the greatest potential for reducing freshwater withdrawals from the Hueco Bolson aquifer (Table 3.1). Under this implementation schedule, and taking into account expected population growth and changes in building inventory through FY 2020, the withdrawals from the aquifer can be reduced by 30% by FY 2020. This reduction in potable water will enable Fort Bliss to reach a potable WUI of 62 gal/sqft, which will meet the Net Zero water WUI 50% reduction goal (Figure 3.2).

To meet its tailored Net Zero water objective, Fort Bliss must significantly reduce the amount of potable freshwater used for irrigation. The Net Zero roadmap investigated improvements to existing irrigation systems and implementation of a new advanced system to increase overall water efficiency. The recently constructed Brigade Combat Team and Infantry Brigade Combat Team areas of Fort Bliss include advanced irrigation systems, but these were found to be either not connected or not functioning as designed. These systems need to be audited and commissioned to operate as designed. The balance of irrigation systems on-post are conventional timer-based systems that operate on a technician-set schedule. The roadmap recommended that the installation convert to an advanced weather-based system that can improve

Table 3.1 Water Conservation Measure LCC Analysis Results

Net Zero Water Project	Water Savings (Mgal/yr)	Energy Savings (million Btu/yr)	Cost Savings ($/yr)	Installed Cost ($)	Simple Payback (yr)	Savings-to-Investment Ratio	Net Present Value ($)
Plumbing	21	4,900	79,000	350,500	5	3.5	282,000
Kitchen Equipment	-	1,400	9,600	88,400	9	1.3	2,200
Irrigation	237	0	84,500	5,900,000	70	0.2	-1,800,000

efficiency by up to 15%. Fort Bliss should also consider converting small areas of low visibility turf to xeriscape. In addition, the entire irrigation system should be audited to verify that sprinkler heads are sized and aligned correctly and are working in concert with the weather-based control system. In total, Fort Bliss can reduce irrigation by 238 Mgal annually if these measures are implemented.

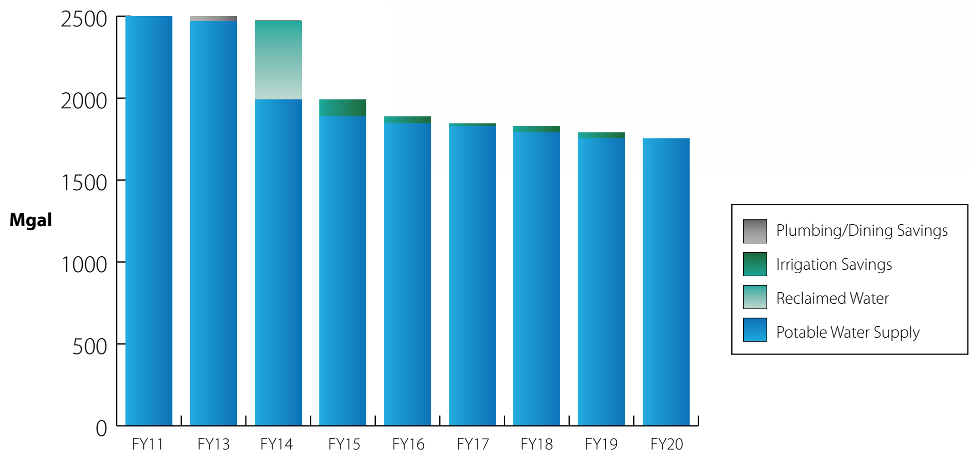


Figure 3.2 Fort Bliss Potable Water Withdrawals

The second largest water use category at Fort Bliss is plumbing. It is estimated that 30 Mgal annually can be saved by implementing plumbing and dining WCMs, including high efficiency faucet aerators, toilets, urinals, showerheads, and commercial kitchen equipment. Of the 30 Mgal savings potential, 21 Mgal is accounted for in projects with an SIR greater than 1, indicating that a minimum test of cost-effectiveness could be met.

Finally, the roadmap recommended that Fort Bliss consider purchasing reclaimed water as part of the EPWU's North Central Reclaimed Water Project. This water can be used at Fort Bliss for irrigation as well as evaporative cooling and fire protection. Based on the results of the roadmap, this water source could offset 479 Mgal per year of freshwater withdrawals. EPWU reclaimed water is significantly more expensive than the cost for Fort Bliss to produce water. At the time the roadmap was developed, the reclaimed water rate was $1.28 per thousand gallons (kgal), whereas the rate of self-produced water was $0.30 per kgal. As a result, transitioning to reclaimed water will not be cost-effective for Fort Bliss, but is a crucial project for Fort Bliss to implement to meet the Net Zero water goals.

Although the Fort Bliss Directorate of Public Works does not have responsibility over project implementation for family housing, the estimated 493 Mgal of potable water consumed annually between irrigation and plumbing indicates that there are significant savings opportunities. The WCMs detailed in the roadmap are applicable to family housing as well. The roadmap identified several potential options for multiple funding sources such as incorporating WCMs into the ESPC and use of military construction funds.

Roadmap Progress

Fort Bliss has an ongoing ESPC project that incorporates water efficiency measures. Currently toilets, showerheads, and faucet aerators are being upgraded to high efficiency plumbing fixtures. In addition, Fort Bliss has initiated a project that includes xeriscaping and use of reclaimed water for irrigating portions of the parade field and other historic portions of the post as well as installating weather-based irrigation controls.

For Buchanan's Net Zero water objective: *Reduce potable water consumption volumetrically by 60% and become a self-sufficient system whereby water is produced and treated on-site and returned to the local aquifer.*

Fort Buchanan, Puerto Rico QUICK FACTS

16 million sqft of facility space

76 Mgal FY12 potable water use

1 Mgal of ILA water used in non-potable golf course irrigation

24% of water is used in plumbing

18% of water is attributed to system losses

Purchases potable water from Puerto Rico Aqueduct and Sewer Authority

Developing on-site potable wells

Vulnerable regional water supply

ROADMAP SHORTCUT

	Golf Course Irrigation	Plumbing	Distribution System Loss Reduction
Annual Potable Water Savings Potential	1 Mgal	11 Mgal	22 Mgal

FY12 48 gal/sqft

Projected FY20 16

Target FY20 [1] 58

FY12 *79 gal/person/day*

Projected FY20 *45 gal/person/day*

Net Zero water game changer

Upgrade the distribution system infrastructure to limit losses; produce potable water and treat wastewater on-site.

[1]Target FY20 goal has already been exceeded because of drastic water reduction from FY07 through FY12.

Fort Buchanan

Background

U. S. Army Garrison, Fort Buchanan covers 746 acres in metropolitan San Juan, Puerto Rico. Established in 1923, Fort Buchanan is an Army Reserve site known as the Sentinel of the Caribbean. Currently, Fort Buchanan's potable water is supplied by Puerto Rico Aqueduct and Sewer Authority (PRASA). Fort Buchanan discharges all of its wastewater to PRASA.

Fort Buchanan lies in a vulnerable region for water scarcity considering sedimentation of reservoirs, growing regional population, increasing demand due to climate change, and infrastructure leaks.

Water Balance

Fort Buchanan consumes potable water in end-uses such as plumbing fixtures and commercial kitchen equipment in barracks, family housing, schools, and administration buildings across the installation. However, the water balance revealed that the predominant water use at Fort Buchanan is distribution system losses and "unknown" water use (Figure 4.1). Unknown water use is unaccounted for water that cannot be attributed to specific end-uses investigated during the water balance assessment. The high level of unknown water use is likely due to a higher-than-expected loss rate in Fort Buchanan's distribution system and meter inaccuracy. ILA water is consumed at Fort Buchanan in irrigation at the golf course through a recently installed non-potable well. Approximately 1 Mgal is used annually.

Roadmap

Through the roadmap process, Fort Buchanan developed a conceptual framework for achieving Net Zero water. This concept transitions Fort Buchanan to a self-sufficient system whereby the majority of potable and non-potable water will be produced on-site from local groundwater resources and wastewater will be treated on-site and infiltrated back to the groundwater through infiltration basins (Figure 4.2).

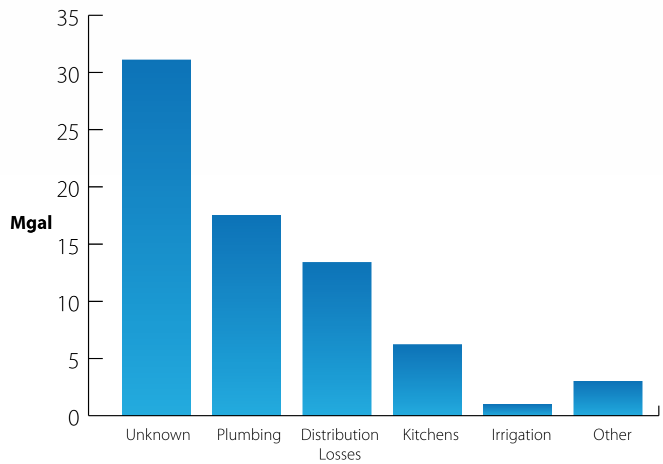


Figure 4.1 Fort Buchanan Annual Water Use Breakout

To reduce its demand for potable water, Fort Buchanan is implementing several water efficiency projects through its ESPC, including high efficiency plumbing fixtures and rainwater harvesting for flushing toilets and urinals, with a total savings of 10 Mgal annually. Therefore, the roadmap assessment focuses on reducing distribution system losses, which were identified in the water balance.

Three options for distribution system improvements were analyzed as part of the roadmap including 1) replacement of the entire distribution system; 2) annual leak detection surveys and repair; and 3) implementing a continuous leak monitoring program. The first option is a wholesale replacement of the potable water distribution system. Fort Buchanan has documented frequent repairs of the distribution system, indicating that the infrastructure is in disrepair and may need a

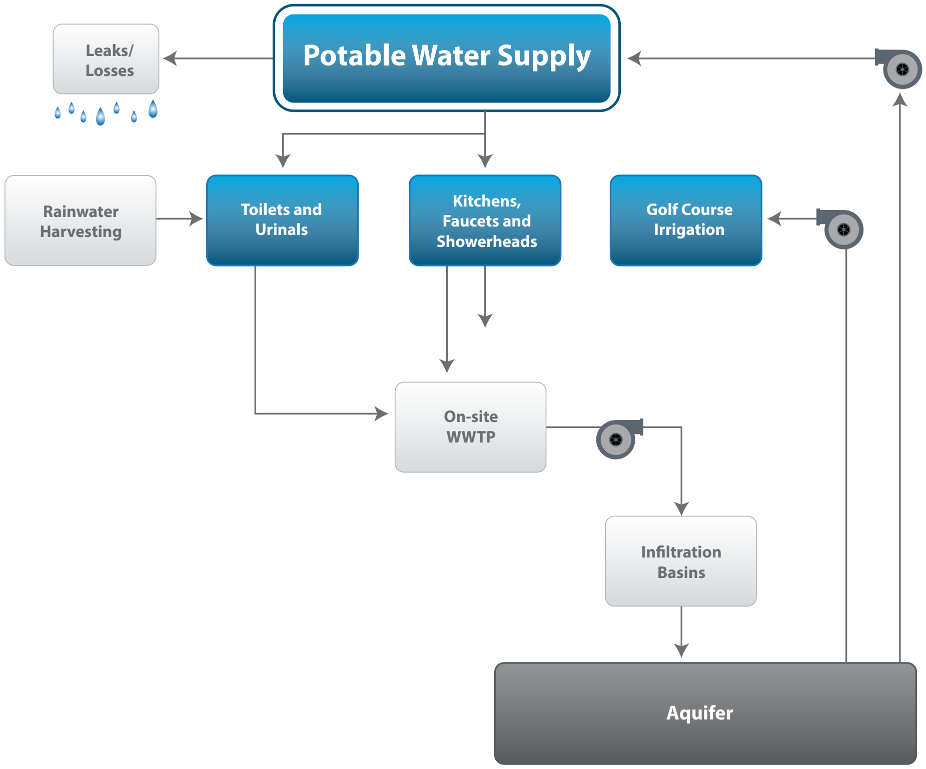


Figure 4.2 Fort Buchanan's Proposed Net Zero Water Concept

comprehensive replacement. In addition to distribution replacement, the roadmap also assessed the less aggressive option of ongoing leak monitoring. Two distinct strategies were investigated: leak detection using conventional leak surveys and leak monitoring using a network of leak noise loggers (LNLs). The conventional leak detection survey uses acoustic equipment to manually listen for leaks at exposed parts of the distribution system. The survey is typically a one-time event providing a snapshot of system leaks. An alternative to conventional leak detection surveys is leak monitoring, which uses a network of LNLs deployed in a grid around a section of the distribution system. The loggers listen for leak sounds at programmed intervals (e.g., at night) and record the sound data. Software analyzes the data to determine whether the LNLs are detecting leaks.

An LCC analysis was performed to provide Fort Buchanan with an economic indicator for the three options (Table 4.1). The analysis found that leak detection is very cost-effective, whereas distribution system replacement is not. A feasibility study of the distribution system will be needed to determine the extent to which line replacement is needed. The study should determine the current condition and identify targeted areas for replacement versus rehabilitation. Note that large infrastructure replacement projects can be funded through military construction funds that do not require the project to be LCC-effective.

As part of the roadmap, a plan was developed to formulate options for Fort Buchanan to achieve the Net Zero water objective, which includes distribution system improvements, efficient plumbing fixtures,

Table 4.1 Distribution System Improvements LCC Analysis Results

Net Zero Water Project	Water Savings (Mgal/yr)	Cost Savings ($/yr)	Installed Cost ($)	Simple Payback (yr)	Savings-to-Investment Ratio	Net Present Value ($)
New Distribution System	21	264,400	11,520,000	62	0.5	-6,081,900
Annual Leak Detection Survey	10	105,200	238,800	N/A	5.3	1,036,600
Leak Monitoring	10	105,200	100,000	2	12.8	1,175,400

rainwater harvesting, and offsetting potable use with non-potable well water for golf course irrigation. These projects achieve an impressive water reduction of approximately 34 Mgal annually through FY 2020 (Figure 4.3).

Fort Buchanan's FY 2007 WUI baseline was 115 gal/sqft. For Buchanan's current WUI is 48 gal/sqft, which is already well ahead of the WUI reduction goal of 58 gal/sqft. If the planned activities and recommended WCMs are implemented, Fort Buchanan will further reduce its WUI to approximately 16 gal/sqft. In addition to meeting the potable WUI reduction goal, Fort Buchanan should also strive to meet the ILA water reduction goal of 40% by FY 2020, reducing the golf course irrigation from an FY 2013 baseline of 1,060 kgal to less than 636 kgal by FY 2020.

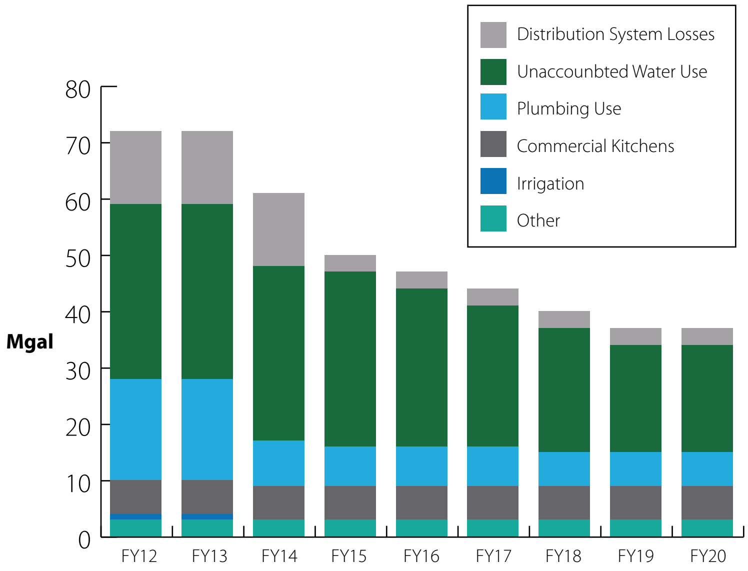


Figure 4.3 Fort Buchanan Projected Water Use

Roadmap Progress

Fort Buchanan has implemented high efficiency plumbing retrofits installation-wide through its ESPC. In addition, Fort Buchanan has already transitioned from purchased potable water to on-site non-potable groundwater to irrigate the golf course. Pursuing rainwater harvesting for flushing toilets and urinals along with potable wells through its ESPC will offset the amount of potable water purchased from PRASA. Fort Buchanan is working with the Army Corps of Engineers to develop a comprehensive hydraulic model of its distribution system to help formulate a strategic plan for reducing losses in the system. Feasibility studies are being conducted to investigate whether a WWTP can be built on-site. The treated water from the WWTP could be sent to rapid infiltration basins to recharge the aquifer.

Fort Carson's Net Zero water objective: *By FY 2020 Fort Carson will reclaim water through the on-site wastewater treatment plant equal to or greater than the amount of potable water that is supplied to the site over the course of the year.*

Fort Carson, Colorado QUICK FACTS

11.8 million sqft of facility space

700 Mgal FY12 potable water use

100 Mgal FY12 wastewater reclaimed

56% of water is used in irrigation

27% of water is used in plumbing

Purchases potable water from Colorado Springs Utility

Highly vulnerable regional water supply

ROADMAP SHORTCUT

	Plumbing	Irrigation	Distribution System	Reclaim Expansion
Annual Potable Water Savings Potential	27 Mgal	37 Mgal	60 Mgal	140 Mgal

FY12 45 gal/sqft

Projected FY20 25

Target FY20 26

FY12 *66 gal/person/day*

Projected FY20 *35 gal/person/day*

Net Zero water game changer

Implement direct potable reuse to dramatically increase reclaimed water from the WWTP during non-irrigation months.

Fort Carson

Background

Fort Carson is located near Colorado Springs, Colorado and covers 137,000 acres with the mission to train, deploy, and sustain combat ready units. Fort Carson's potable water is supplied by Colorado Springs Utility (CSU). Between FY 2008 and FY 2011, Fort Carson consumed an annual average of 853 Mgal of potable water across the entire installation, including family housing. Consumption during this same time period averaged 500 Mgal annually when family housing was excluded. Wastewater is treated at the on-site WWTP. Wastewater is discharged from the WWTP to Fountain Creek and further treated to be reclaimed for irrigation. Fort Carson reclaimed an average of 80 Mgal per year between FY 2008 and FY 2011.

Fort Carson experiences peak demand during May through September, primarily due to landscape irrigation. Summer water use varies between 91 and 134 Mgal per month. Winter water purchase and wastewater discharge volumes are closely correlated, suggesting that leaks in the distribution system are relatively small and that supply and wastewater discharge meters are fairly well calibrated. Fort Carson does not consume ILA water.

Fort Carson lies in a highly vulnerable region for water scarcity considering the stretched resources of the CSU water supply, potential effects of climate change, growing regional population, and frequency of natural drought conditions.

Water Balance

Fort Carson's top four water users are on-post irrigation, not including family housing irrigation, plumbing fixtures in family housing, on-post plumbing fixtures (including laundry and kitchen), and family housing irrigation. These four uses comprise 87% of the total water consumption at Fort Carson (Figure 5.1).

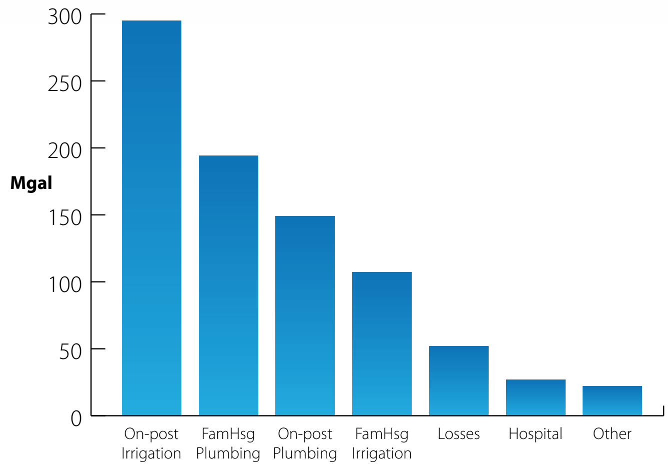


Figure 5.1 Fort Carson Annual Water Use Breakout

Fort Carson's family housing is privatized. Water use associated with family housing is thus excluded from the water use reported by Fort Carson to the Army. Irrigation accounts for 56% of the total water use when family housing is excluded. Plumbing fixtures represent a significant portion of the overall water use, accounting for 27% of the total (Figure 5.2).

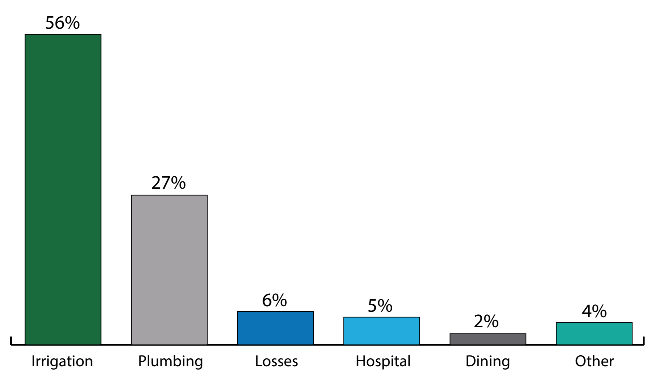


Figure 5.2 Fort Carson Water Use Breakout Excluding Family Housing

Roadmap

To meet the goals of the Net Zero water program, Fort Carson must aggressively implement efficiency improvements across the major water end-uses and investigate ways to access alternative water sources. Based on the results of the water balance, Fort Carson should target irrigation and plumbing water efficiency. Other opportunities include distribution line replacement and retrofits of commercial kitchen and hospital equipment. An LCC analysis was performed on each WCM to identify the projects that are cost-effective and should be implemented (Table 5.1).

To meet its tailored Net Zero water objective, Fort Carson must significantly increase the use of alternative water sources by reclaiming wastewater effluent from the on-site WWTP for reuse on the installation. The installation is currently expanding its capacity to reclaim wastewater for landscape irrigation. The expansion project will enable Fort Carson to serve five major irrigation areas with reclaimed water: the golf course, Iron Horse Park, the Sports Complex, Pershing Field, and the parade field. By 2016, when the expansion project is completed, it is estimated that approximately 170 Mgal of water can be reclaimed for irrigation.

Through the roadmap process, a plan was developed that resulted in a recommended project implementation schedule between FY 2013 and FY 2018 for the LCC-effective projects. Under this implementation schedule, the demand for potable

Table 5.1 Water Conservation Measure LCC Analysis Results

Net Zero Water Project	Water Savings (Mgal/yr)	Energy Savings (million Btu/yr)	Cost Savings ($/yr)	Installed Cost ($)	Simple Payback (yr)	Savings-to-Investment Ratio	Net Present Value ($)
Plumbing	27	8,600	214,800	1,801,00	8	1.3	181,300
Irrigation	37	100	189,800	722,700	4	3.7	748,300
Distribution Line Replacement	60	200	464,500	12,036,700	26	0.9	-397,300
Commercial Kitchen Equipment	1	700	17,300	209,200	12	1.3	748,300
Hospital Equipment	2	-	12,000	48,000	4	3.4	115,000

water can be reduced by 32% by FY 2020. This reduction in potable water will enable Fort Carson to reach a potable WUI of 25 gal/sqft, which will meet the Net Zero water WUI 50% reduction goal. The roadmap identified several potential options for multiple funding sources.

However, for Fort Carson to meet its tailored Net Zero water objective, it must find a way to use more reclaimed water. During non-irrigation months, November through March, Fort Carson will have approximately 106 Mgal of wastewater effluent available for direct potable reuse, which would further reduce purchased potable water (Figure 5.3). A direct potable reuse system treats wastewater until it meets requirements for potability and can be introduced directly into a potable water distribution system. The process includes microfiltration or ultrafiltration, reverse osmosis, and advanced oxidation to ensure microorganisms and pharmaceuticals are neutralized.

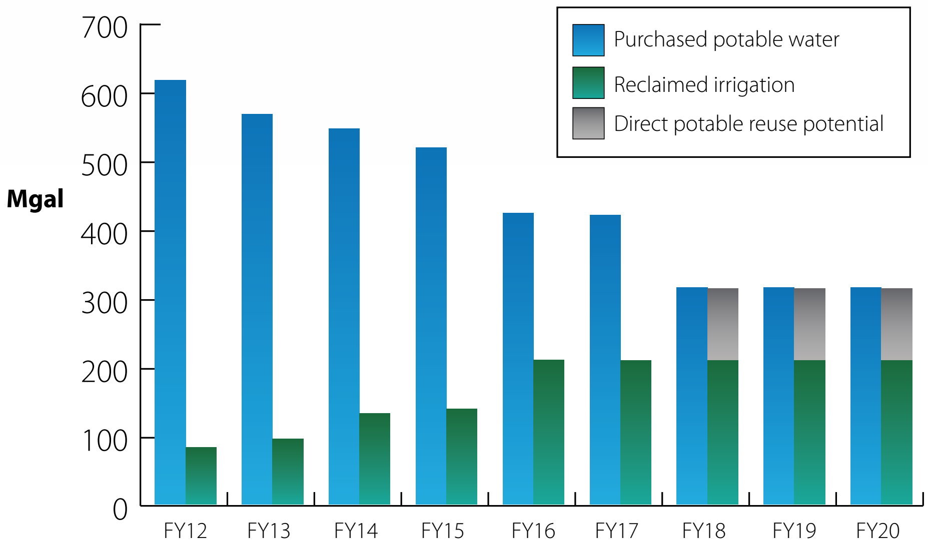


Figure 5.3 Net Zero Water Concept for Fort Carson

Direct potable reuse is technologically feasible, but significant barriers must be overcome for the project to succeed. Personnel and residents at Fort Carson may resist the concept of direct potable reuse. Public perception barriers need to be examined very early in the planning process and an active outreach and communication program should be enacted to help educate the installation's population. Regulatory issues should be examined to ensure that there are no major hurdles that may delay the project. Also, direct potable reuse is energy intensive. With Fort Carson chosen as a Net Zero energy pilot installation, the effect of a new energy intensive process on the installation's ability to reach "Net Zero energy" needs to be well understood.

Roadmap Progress

The Phase 1 construction of the reclaimed water expansion project was initiated in 2013 and will be completed in 2014. Phase 1 will extend the reclaimed distribution system to Iron Horse Park. Phase 2, which is currently in the design phase, will expand the retention pond and extend the distribution system to the Sports Complex. In addition, high efficiency plumbing fixtures have been implemented across the installation through Fort Carson's ESPC.

Fort Carson's water use decreased 34% from April through August 2013 compared with the same period in 2012. This impressive savings is a result of irrigation watering restrictions that Fort Carson has enacted because of a severe regional drought.

Fort Riley's Net Zero water objective: *Limit the consumption of freshwater resources and return treated wastewater to the Kansas-Lower Republican basin in the same quantity that is withdrawn for potable water production over the course of the year.*

Fort Riley, Kansas QUICK FACTS

19.5 million sqft of facility space

592 Mgal FY12 potable water use

549 Mgal FY12 treated wastewater discharged to local surface water

36% of water is used in plumbing

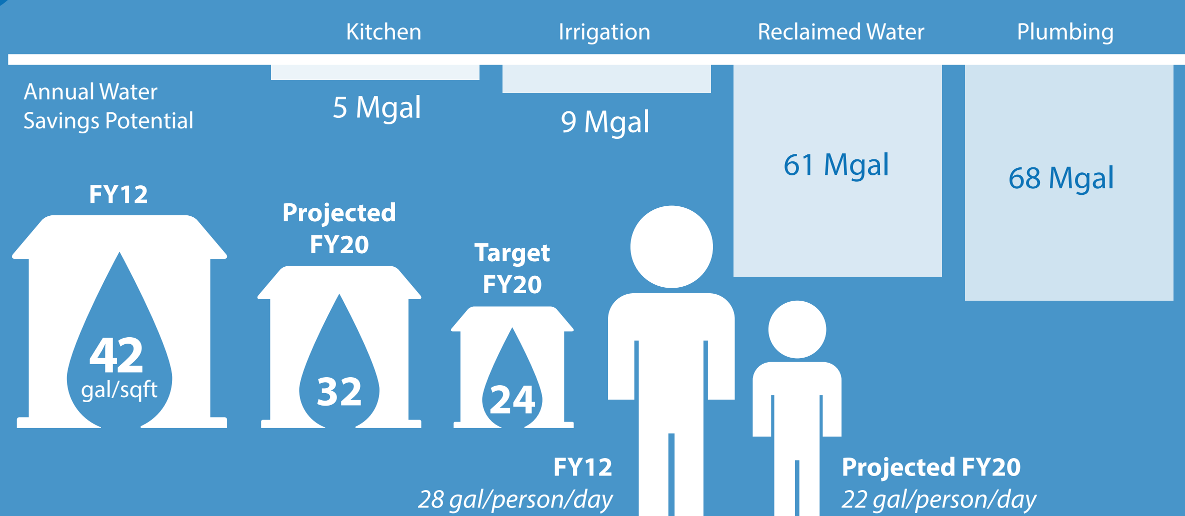
10% of water is used in irrigation

Produces all water on-site

Wastewater treated on site, discharged to local surface water sources

Vulnerable regional water supply

ROADMAP SHORTCUT



Net Zero water game changer

Fully utilize wastewater from both WWTPs (requires continued operation of Custer Hill WWTP).

Fort Riley

Background

Fort Riley covers 100,671 acres near Manhattan, Kansas and is home to the 1st Infantry Division. Fort Riley serves as an Active Component/Reserve Component installation. The water supply system that serves Fort Riley consists of a system of subterranean wells that supply water to the central WTP in the Custer Hill cantonment area. The WTP is designed to provide 10 Mgal per day at maximum capacity. Currently, the plant produces an average of 2 to 3 Mgal per day to meet water demands on-post.

Fort Riley has two on-site WWTPs, which discharge into local creek watersheds that eventually feed the Kansas River and replenish the regional aquifer. Storm and sanitary sewer systems are separate, but minor infiltration and intrusion is expected. One of the WWTPs is located in the Custer Hill cantonment area and can treat 2 Mgal per day under normal conditions, with a maximum treatment capacity of 8 Mgal per day during storm events. The other WWTP is new, located in the Camp Funston cantonment area, and can treat 3 Mgal per day under normal conditions, with a maximum treatment capacity of 7 Mgal per day during storm events. Combined, the two WWTPs discharge an average of 2 Mgal daily.

Fort Riley lies in a region vulnerable to water scarcity based on historical water availability, natural drought conditions, forecasted climate change effects, growing regional population, and regional water shortages.

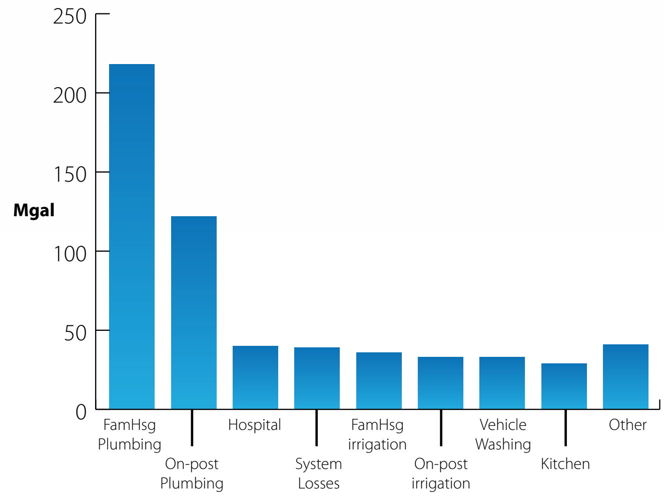


Figure 6.1 Fort Riley Annual Water Use Breakout

Water Balance

Fort Riley's predominant potable water use is plumbing fixtures, accounting for 59% of the site's annual water use. Water used in plumbing fixtures and laundry equipment in family housing accounts for 218 Mgal, 38% of the site's total use. On-post plumbing uses an additional 122 Mgal, or 21% of the total. Other significant uses include the hospital, distribution system losses, irrigation, vehicle washing, and kitchen equipment, accounting for a combined 34% (Figure 6.1).

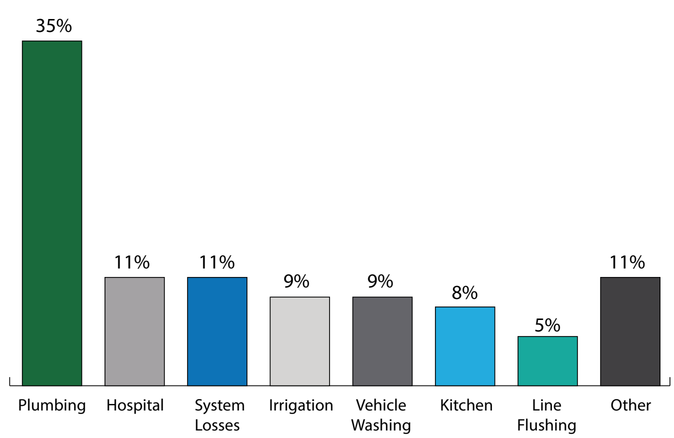


Figure 6.2 Fort Riley Water Use Breakout Excluding Family Housing

Family housing at Fort Riley is privatized and the installation does not include water used by family housing in its reporting to the Army. When water use attributed to family housing is excluded from consideration, on-post plumbing accounts for 35% of the total. The "Other" category includes schools, Morale, Welfare, and Recreation facilities, and boiler plants (Figure 6.2).

Roadmap

Even with aggressive pursuit of water conservation strategies, Fort Riley will have difficulty achieving the potable WUI reduction goal of 50%. Meeting the WUI goal is even more problematic due to an ever expanding unmetered irrigation demand on-post and development of irrigated turf and landscaping in common areas. Although meeting the Net Zero water goal is difficult, if the LCC cost-effective WCMs are implemented, Fort Riley can make significant progress on WUI reduction (Table 6.1). In this scenario, Fort Riley can reduce the potable WUI to 35 gal/sqft, resulting in a 27% WUI reduction from the 2007 baseline. Fort Riley could also pursue a more aggressive approach that integrates the use of alternative water supplies, further reducing the WUI to 32 gal/sqft. The WCMs evaluated in the roadmap for Fort Riley are as follows:

- Comprehensive plumbing retrofits with high efficiency fixtures
- Commercial kitchen equipment retrofits:
  - ENERGY STAR food steamers
  - High efficiency pre-rinse spray valves

Table 6.1 Water Conservation Measure LCC Analysis Results

Net Zero Water Project	Water Savings (Mgal/yr)	Energy Savings (million Btu/yr)	Cost Savings ($/yr)	Installed Cost ($)	Simple Payback (yr)	Savings-to-Investment Ratio	Net Present Value ($)
All Plumbing	68	17,900	360,800	4,027,800	11	1.2	20,900
Irrigation	9	-	12,700	177,300	14	1.1	4,400
Commercial Kitchen Equipment	5	1,100	69,600	510,500	7	1.9	127,600
Pool	1	2,500	3,300	22,300	7	2.6	1,300
Reclaimed Systems	61	-	54,300	2,141,400	39	0.4	86,700

- Garbage pulper retrofits
- Ice machine retrofits
- Dish washer replacements with ENERGY STAR equipment

• Irrigation system upgrades, including installation of weather-based controllers and high efficiency distribution nozzles

• Implementation of a reclaimed water system that will reuse treated wastewater in grounds irrigation and industrial processes

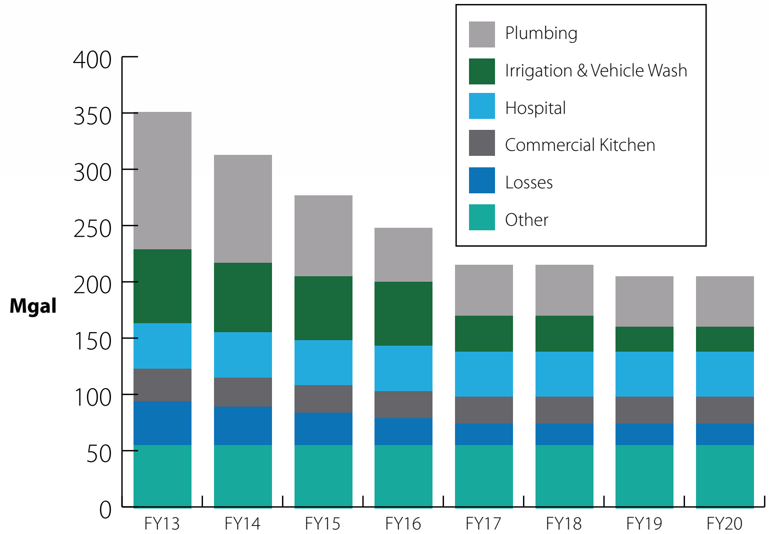


Figure 6.3 Fort Riley Projected Water Use

Through the roadmap process, a plan was developed that resulted in a recommended project implementation schedule between FY 2013 and FY 2020. Taking into account expected changes in population and building inventory through FY 2020, the demand for potable water can be reduced to approximately 150 Mgal by FY 2020, representing a 33% decrease (Figure 6.3). This water reduction will achieve a potable WUI of 32 gal/sqft, approximately 8 gal/sqft short of the Net Zero water goal.

Roadmap Progress

Currently, Fort Riley is conducting infrastructure replacement on the aging potable water distribution and storage systems. Along with replacing sections of the potable water system, Fort Riley is installing water meters to enable a strategic monitoring and verification program.

In addition, the Fort Riley Directorate of Public Works is collaborating with Environmental Protection Agency (EPA) on two water conservation pilot projects. The first is the development of a targeted social and educational water conservation campaign intended to foster and encourage behavioral changes needed to reduce water consumption and promote long-term water conservation. As part of the EPA collaboration with the Army, the installation will demonstrate innovative water monitoring technologies, explore social and behavioral aspects of technology demonstration and implementation, and monitor and record the results. Fort Riley is also the demonstration site for membrane bioreactor technology. This technology is intended to reclaim and process wastewater through decentralized sewage treatment and distribute the flow for non-potable uses. The project will install commercial-off-the-shelf equipment by the end of FY 2013 with follow-on projects in FY 2014 and FY 2015.

Joint Base Lewis-McChord's Net Zero water objective: *Limit the consumption of freshwater resources and reclaim wastewater effluent so that there is no discharge from the WWTP to the Puget Sound.*

Joint Base Lewis-McChord, Washington QUICK FACTS

24 million sqft of facility space

1,495 Mgal FY12 potable water use

50 Mgal used in non-potable golf course irrigation

33% of water is used in plumbing

16% of water is used in irrigation

Produces all water on-site from groundwater resources

On-site WWTP treats all wastewater and discharges to Puget Sound

Moderately vulnerable regional water supply

ROADMAP SHORTCUT

	Golf Course Irrigation	Plumbing	Potable Irrigation	Distribution System
Annual Potable Water Savings Potential	15 Mgal	62 Mgal	70 Mgal	75 Mgal

FY12 60 gal/sqft

Projected FY20 48

Target FY20 37

FY12 *46 gal/person/day*

Projected FY20 *39 gal/person/day*

Net Zero water game changer

Implement indirect and direct potable reuse to maximize the use of reclaimed water from the WWTP.

Joint Base Lewis-McChord

Background

In 2010, Fort Lewis and McChord Air Force Base were combined to create Joint Base Lewis-McChord (JBLM). The combination was a result of requirements in the 2005 Base Realignment and Closure Act. JBLM is the largest military installation on the West Coast, covering 90,815 acres in the Puget Sound region of Washington State, south of Tacoma. JBLM's mission is to support mission commanders and the joint base community, and train and mobilize Warfighters for combat.

JBLM produces all water on-site. The drinking water supply systems that serve JBLM are owned by the Department of Army, operated by the JBLM Directorate of Public Works, and permitted by the Washington State Department of Health. The potable WTP produces 3.3 Mgal per day. The Lewis and McChord areas have separate potable water systems. All wastewater is treated at JBLM's Solo Point WWTP. Treated wastewater is currently discharged to the Puget Sound.

JBLM lies in a moderately vulnerable region for water scarcity considering the potential climate change effects, growing regional population, and reduced groundwater recharge.

Water Balance

JBLM's top potable water end-use is plumbing fixtures, representing 33% of the total use. The water balance assessment revealed a large unknown water use representing 27% of the total production. This unknown water represents a variety of water uses that were not assessed due to JBLM's size and complexity (Figure 7.1).[1] JBLM reports water used in privatized family housing to the Army. JBLM's two golf courses use on average 50 Mgal annually from dedicated on-site non-potable wells, which is considered an ILA water source.

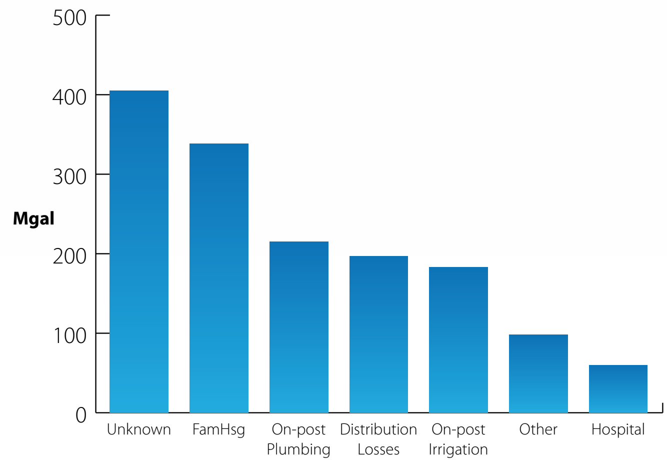


Figure 7.1 JBLM Annual Water Use Breakout

Roadmap

To meet the water reduction goals of the Net Zero water pilot, JBLM must implement WCMs that were assessed in the roadmap, which include high efficiency plumbing fixtures, irrigation upgrades in grounds landscaping and golf courses, distribution system upgrades, and commercial kitchen equipment (Table 7.1).

Through the roadmap process, a plan was developed that resulted in a recommended schedule for implementing the LCC-effective projects between FY 2013 and FY 2020. If all recommended LCC-effective WCMs are implemented from FY 2013 through FY 2020, JBLM will reduce water use by 203 Mgal annually, taking into account population and building inventory changes[2] (Figure 7.2). With these savings, JBLM's WUI will be 48 gal/sqft, which falls short of the reduction goal by 30%. This gap represents 304 Mgal of potable water that JBLM will have to offset with alternative sources to meet the WUI reduction goal.

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[1] The large amount of unknown water could be attributable to a higher-than-expected loss rate in JBLM's system and meter inaccuracy.

[2] It is assumed that privatized family housing water use will not decrease over time because JBLM does not administer or own family housing.

Table 7.1 Water Conservation Measure LCC Analysis Results

Net Zero Water Project	Water Savings (Mgal/yr)	Energy Savings (million Btu/yr)	Cost Savings ($/yr)	Installed Cost ($)	Simple Payback (yr)	Savings-to-Investment Ratio	Net Present Value ($)
Lewis Distribution System Leak Repair	75	-	101,000	150,000	2	7.9	1,039,000
Plumbing	62	11,500	296,900	3,668,100	12	1.1	495,400
Lewis Irrigation Projects	41	-	587,200	5,716,500	10	1.2	1,284,600
McChord Irrigation Projects	29	-	107,300	5,439,000	51	0.2	-4,165,100
Golf Course Irrigation Projects	15	-	56,100	118,000	2	5.6	547,400
Commercial Kitchen Projects	3	1,200	139,800	1,559,900	11	1.4	558,600
Central Plant Pump Repair	2	4,400	41,800	18,200	<1	41.5	737,300

JBLM also is expected to meet the ILA water reduction goal of 40% by FY 2020 from an FY 2010 baseline. When golf course irrigation projects are implemented, ILA water use will be 34 Mgal per year by FY 2020, which will not meet the 40% reduction goal. Therefore, JBLM must supplement groundwater used for golf course irrigation with 8 Mgal per year of water from an alternative source, such as wastewater reclaim.

JBLM is in the initial phase of replacing the Solo Point WWTP with a new WWTP that will have the capability to generate reclaimed water that can ultimately be used beneficially in applications such as irrigation and industrial processes. JBLM's future plan is to implement a distribution system for the Class A reclaimed water. Indirect potable reuse[3] is also being proposed, whereby JBLM's groundwater can be recharged with treated wastewater via infiltration galleries. In addition, JBLM plans to infiltrate all irrigation and stormwater runoff into the groundwater. JBLM's Net Zero water objective

[3] By definition, indirect potable reuse is the augmentation of a freshwater source, such as surface or groundwater, with treated wastewater.

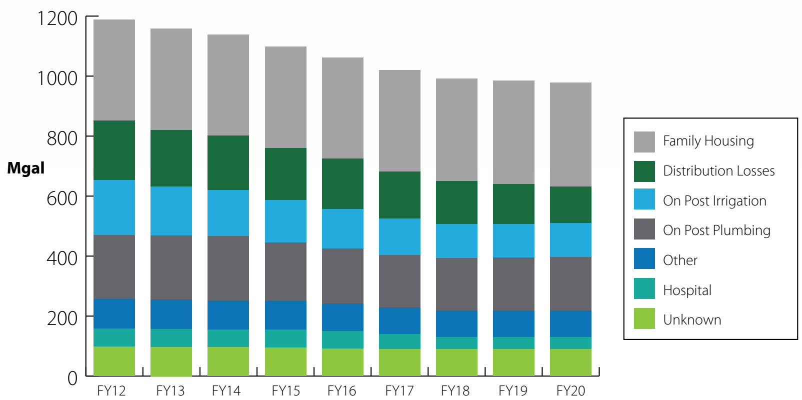


Figure 7.2 JBLM Projected Water Use

is to create a zero discharge WWTP by 2025, wherein all of the treated wastewater is reclaimed for beneficial use or reuse and no wastewater effluent is discharged to the Puget Sound (Figure 7.3).

The roadmap assessed the total potential availability and demand for reclaimed water. Based on wastewater discharge, efficiency improvements, and population growth, JBLM's total wastewater effluent available for reclaimed water in FY 2020 will be approximately 718 Mgal. Of this total, 172 Mgal can potentially serve non-potable uses, such as irrigation and industrial applications, and 546 Mgal remains available for reuse. As an alternative to indirect potable reuse, JBLM could also consider direct potable reuse, which is the introduction of treated recycled water directly into a potable water distribution system. Major hurdles must be addressed when considering direct potable reuse, including the high capital cost of the potential technologies, public concern about the quality of water supplied by such a system, and regulatory permitting. If JBLM pursues direct potable reuse, an aggressive education and outreach campaign will be needed to ensure the recipients are aware of the quality of the water.

Roadmap Progress

JBLM received $91 million in military construction funds in FY 2013 for the design and Phase 1 construction of the new WWTP. Currently, JBLM is in the design phase of the plant, which is expected to be completed in October 2013. Once funded, the next phase of the project is the implementation of a reclaimed water distribution system that will distribute reclaimed water to key areas on-post for non-potable uses and recharge groundwater sources through infiltration galleries. In addition to replacing the WWTP, JBLM is actively pursuing potable distribution line replacement of aging infrastructure to help reduce distribution system losses and developing irrigation efficiency projects at both golf courses.

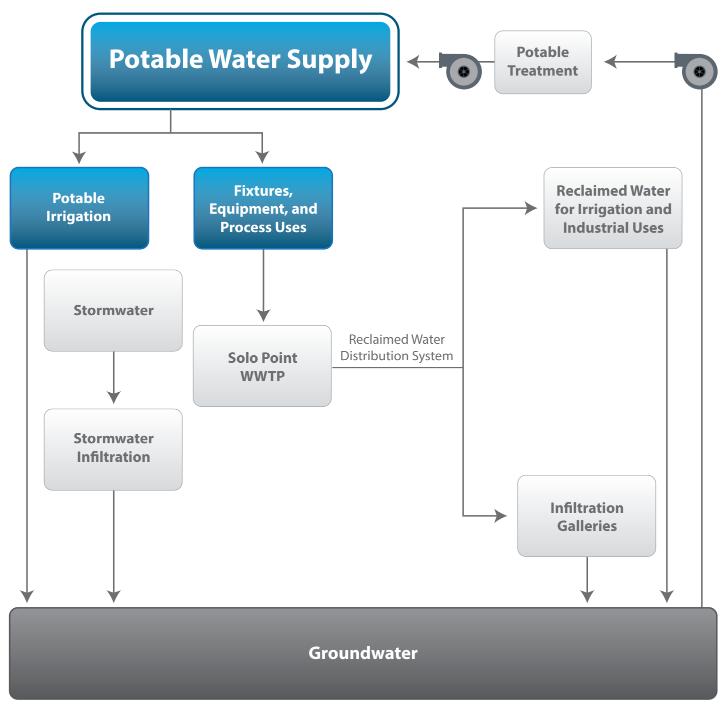


Figure 7.3 JBLM Net Zero Water Objective

Tobyhanna Army Depot's Net Zero water objective: *Limit the consumption of freshwater resources and return treated wastewater to the Hummler Run watershed in the same quantity that is pumped from groundwater wells for potable water production over the course of the year.*

Tobyhanna, Pennsylvania QUICK FACTS

4.6 million sqft of facility space

55 Mgal FY12 potable water use

62 Mgal FY12 treated wastewater and stormwater discharged to local watershed

34% of water is used in industrial processes

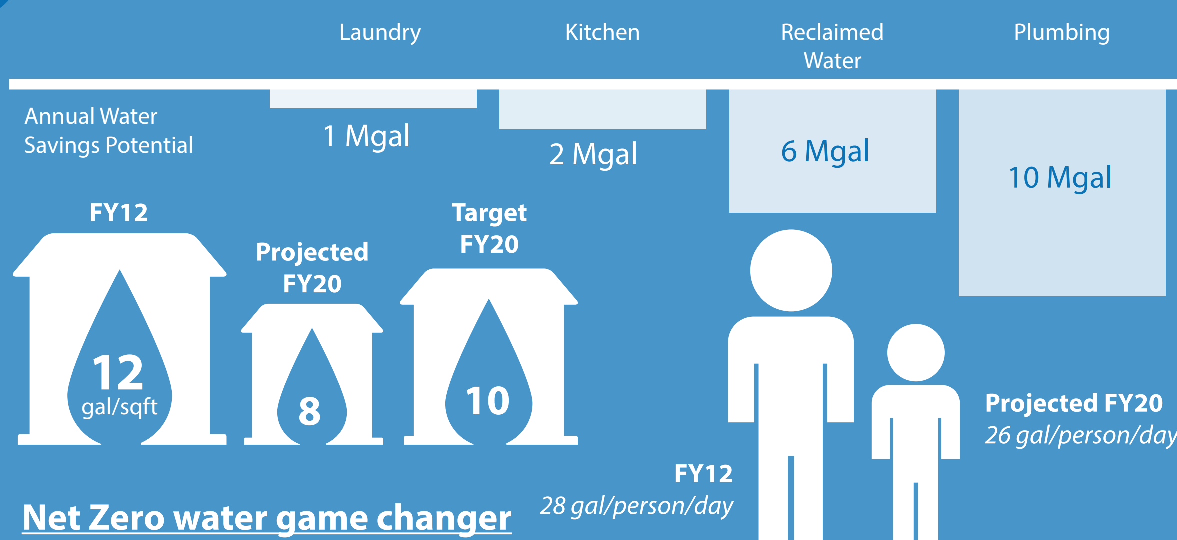
19% of water is used in plumbing fixtures

Produces all water on-site

Wastewater is treated on-site and discharged to the Hummler Run watershed

Minimally vulnerable regional water supply

ROADMAP SHORTCUT



Net Zero water game changer

Utilize reclaimed water for WWTP applications such as screen washing, yard hydrants, and polymer makeup.

Tobyhanna Army Depot

Background

Tobyhanna Army Depot (TYAD) covers 1,296 acres in northeast Pennsylvania, south of Scranton, including 398 acres of dedicated industrial process area. Having served the nation for more than 59 years, TYAD is the largest full-service electronics maintenance facility within the Department of Defense.

The potable water supply system that serves TYAD consists of six subterranean wells collectively producing an average of 260 kgal per day to meet water demands on-post.

TYAD has one on-site WWTP that discharges into the Hummler Run watershed under a National Pollutant Discharge Elimination System permit. The TYAD WWTP is sized to accommodate flows of up to 4 Mgal per day using conventional screening and trickling filter type treatment coupled with denitrification towers, sand filtration, and ultraviolet sterilization. Sludge from the digesters and settling tanks is thickened, pressed, and dried. Solids are disposed of in a landfill.

Due to difficulties maintaining current standards, the age of the equipment, and the inherent complications associated with cold weather operation of trickling filters, TYAD has recently solicited information for the construction of a new sequential batch reactor WWTP. If constructed, the new plant is intended to enable reuse of effluent for non-contact industrial purposes such as process cooling, fire water, and washing, provided the water is of sufficient quality for use in these areas.

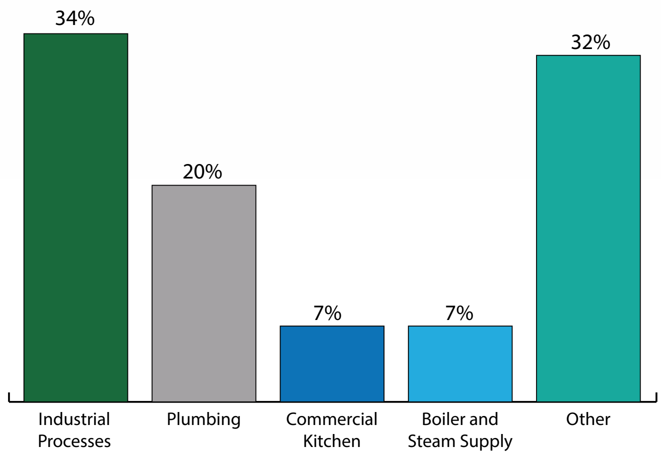


Figure 8.1 Tobyhanna Army Depot Annual Water Use Breakout

Water Balance

Currently the predominant potable water use at TYAD is industrial processes, accounting for 34% of the site's annual water use and totaling more than 19 Mgal per year. Water used in plumbing fixtures across the site accounts for 11 Mgal per year or 20% of the annual use. Commercial kitchens and boiler and steam supply each use an additional 4 Mgal per year accounting for 14% of annual use. Other significant uses include the WTP, Army Materiel Command headquarters, system losses, and miscellaneous uses, accounting for a combined 32% of annual water use (Figure 8.1).

Roadmap

TYAD has made impressive progress in meeting the Net Zero water objective and reduction goal due to the diligence of personnel and the strategic deployment of water conservation projects and loss prevention activities. TYAD has reduced potable WUI by 8 gal/sqft since FY 2007, and is on track to exceed the 50% reduction goal by FY 2020. TYAD has already achieved its Net Zero water objective. Since FY 2011, more water was discharged into the Hummler Run watershed than was pumped from groundwater wells for potable water production.

The most significant reduction in potable water use is due to the implementation of a comprehensive leak detection program and a continuous monitoring and verification system. After several major leaks were found and repaired, TYAD subsequently installed leak detectors in 2011 and began to monitor, verify, and address additional system leaks. This project alone reduced potable water use on-site by an average of 17 Mgal per year.

Even though Tobyhanna Army Depot has already met the Net Zero water objective, WCMs were identified that could help the site exceed the 50% WUI reduction goal (Table 8.1). The WCMs evaluated in the roadmap for TYAD are:

- Comprehensive plumbing retrofits with high efficiency fixtures
- Commercial kitchen equipment retrofits:
  - ENERGY STAR food steamers
  - High efficiency pre-rinse spray valves
  - Ice machine retrofits
  - Dish machine replacements with ENERGY STAR equipment

Table 8.1 Water Conservation Measure LCC Analysis Results

Net Zero Water Project	Water Savings (Mgal/yr)	Energy Savings (million Btu/yr)	Cost Savings ($/yr)	Installed Cost ($)	Simple Payback (yr)	Savings-to-Investment Ratio	Net Present Value ($)
All Plumbing	10	900	93,700	361,100	3	2.7	299,500
Commercial Kitchen	2	900	44,700	339,800	8	1.4	-29,700
Laundry	1	300	8,600	41,600	5	1.4	11,900
Reclaimed Water System	6	-	46,200	1,648,900	36	0.4	-502,500

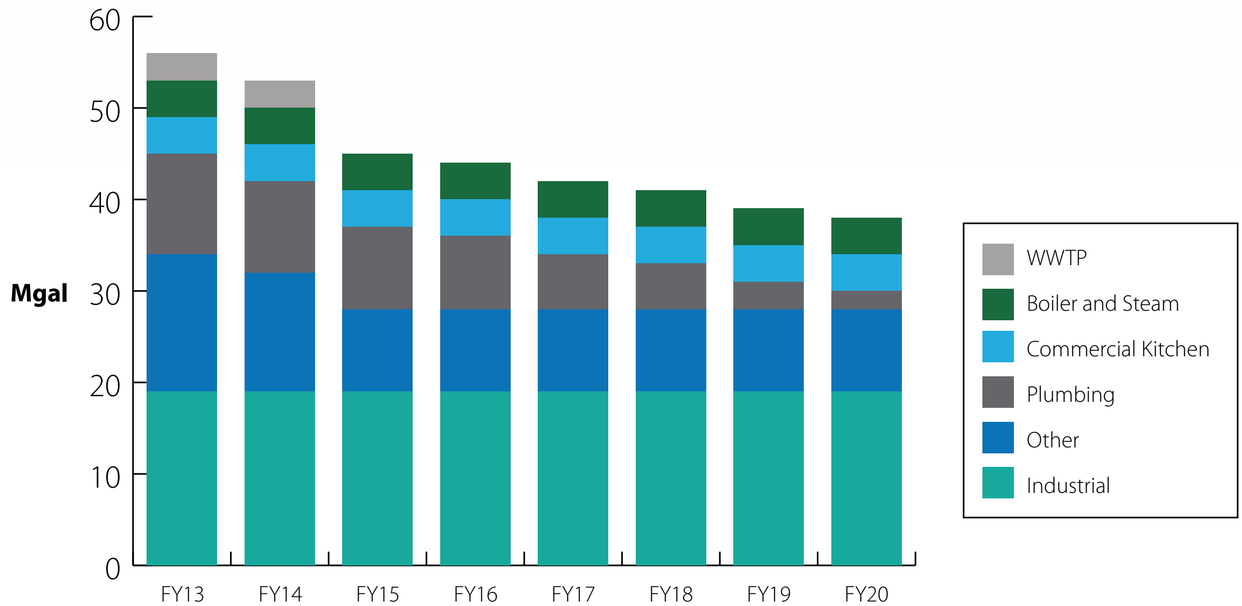


Figure 8.2 Tobyhanna Army Depot Water Use

- Laundry retrofits, including ENERGY STAR equipment for smaller applications and an ozone support system for commercial equipment
- Use of excess capacity from high purity water production for boiler make-up
- Implementation of a reclaimed water system as part of a new WWTP, with water being used to recharge aquifers and augment wetlands and in applications such as vehicle wash, fire protection, and process uses.

Through the roadmap process, a plan was developed that resulted in a recommended project implementation schedule between FY 2013 and FY 2020. Taking into account expected changes in population and building inventory through FY 2020, the demand for potable water can be reduced to approximately 37 Mgal by FY 2020, representing a reduction of nearly 60% (Figure 8.2). This water reduction will achieve a potable WUI of 8 gal/sqft, which will exceed the WUI reduction goal.

Roadmap Progress

TYAD continues to implement and capitalize on water conservation projects that will contribute meaningfully to the reduction of potable water on site. Examples include replacement of the WWTP, which can reduce potable water consumption by as much as 6 Mgal per year, remodeling and upgrading the café in Building 11 with new kitchen equipment, and eliminating once-through cooling water flow in selected applications.

Acronyms

APG	Aberdeen Proving Grounds
Bgal	billion gallons
Btu	British thermal units
CSU	Colorado Springs Utility
EPA	Environmental Protection Agency
EPWU	El Paso Water Utility
ESPC	energy savings performance contract
FamHsg	family housing
FY	fiscal year
gal/person/day	gallons per person per day
gal/sqft	gallons per square foot
gpf	gallons per flush
gpm	gallons per minute
GWTP	groundwater treatment plant
ILA	industrial, landscaping, and agricultural
JBLM	Joint Base Lewis-McChord
kgal	thousand gallons
LCC	life-cycle cost
LNL	leak noise logger
Mgal	million gallons
PRASA	Puerto Rico Aqueduct and Sewer Authority
SIR	savings-to-investment ratio
TYAD	Tobyhanna Army Depot
WCM	water conservation measure
WTP	water treatment plant
WUI	water use intensity
WWTP	wastewater treatment plant

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14. ABSTRACT In 2011, the Department of the Army created the net zero initiative to advance the sustainability of the Army by managing natural resources with the goal of establishing net zero installations. The net zero concept is founded upon the idea of consuming natural resources responsibly based upon knowledge of long-term resource availability, creating a sustainable environment to support the installation's long-term mission. The Army is pursuing net zero programs in energy, water, and solid waste. To kick off the net zero initiative, the Army selected installations to demonstrate the concept of net zero energy, water, and waste. This document is an overview of assessments performed at the eight net zero water installations. Each assessment included a water balance and a roadmap intended to provide pilot installations with a strategic approach to achieve net zero goals.			
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