

Analysis of LEED-NC Water Efficiency Credits for U.S. Army Facilities

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The 4th Infantry Brigade Combat Team (IBCT) complex at Fort Stewart, Georgia features several various facility types that can be found on Army installations. Some of these facilities include a Company Operations Facility (COF), Tactical Equipment Maintenance Facility (TEMF), Single Soldier Barracks, a Brigade/Battalion Headquarters, Physical Fitness Facility (PFF), Dining Facility (DFAC) and Soldier Family Care Clinic (SFCC). Completed in 2011, many of these facilities are either LEED® Silver certified or have the features so that the building can be certified in the future. In addition, several of these facilities were constructed from a template design used by the Army to standardize each facility type found at its many installations across the country. The inclusion of water efficient plumbing fixtures helped contribute to the Leadership in Environmental and Energy Design (LEED) Version 2.2 certification in New Construction for the facilities studied, particularly in the water efficiency category. In addition, Azhar, Carlton, Olsen, and Ahmad (2011) indicate that the initial up-front costs of LEED certification average 2%, which results in a life cycle savings of approximately 20% of the construction costs or a tenfold increase from the initial investment. The various Army facilities studied showed no significant initial cost increase by requiring LEED certification for the projects and were able to potentially reduce the water consumption and associated operating costs. However, the inclusion of water efficient urinals in some of the facilities actually generated regular maintenance costs that should be considered when specifying fixtures of this type.

Keywords: LEED, Water Efficiency, Army, Life Cycle Costs

Introduction

Today's construction world is ever evolving into one in which sustainable building practices and materials are at the forefront of the industry. Founded in 1993, the U.S. Green Building Council is a non-profit organization whose mission is to promote sustainability in the construction industry. One of their main contributions to the building industry was the introduction of the Leadership in Energy and Environmental Design, or LEED, rating system in March of 2000. This voluntary rating system is designed to encourage commercial, institutional and residential projects to incorporate environmentally friendly and health conscious practices and materials into the design and construction of new sites both in the United States and abroad (U.S. Green Building Council [USGBC], 2013e). The LEED for New Construction (LEED-NC) rating systems used for new construction today's industry focus on five required categories and an additional optional category: Sustainable Sites, Water Efficiency, Energy & Atmosphere, Materials & Resources, Indoor Environmental Quality, and Innovation in Design.

The impact that most of these categories found in the LEED-NC rating system have in the sustainability initiative varies from one region of the country to another. For example, a new construction project located in a densely populated area may benefit more from an emphasis on achieving the credits from the sustainable sites category than one in a rural area. However, water is a precious resource that is needed by every living creature, no matter the region of the country. Because of the increasing demand and shrinking supply of fresh water, it is predicted that many major cities will encounter serious water shortages within ten years (USGBC 2007). Given the universal requirement for water and the need to protect its availability for the generations to come, the water efficiency category of LEED-NC one of the most if not the most important category to consider when constructing new projects.

Background

The United States made the decision in 2007 to "Grow the Army" and expand the number of soldiers serving on active duty. As part of this process, several new Brigade Combat Teams would be formed, one of which was to be located at Fort Stewart, GA. This new Infantry Brigade Combat Team (IBCT) would be called the 5th IBCT and would require a complete set of new facilities since no available buildings existed among the four existing IBCTs at Fort Stewart. Although Congress decided not to activate a 5th IBCT at Fort Stewart in 2009, the officials at Fort Stewart expressed their need for facility upgrades and convinced the Army to continue the construction that had already begun at the time their decision was made. Construction continued, and the Army proceeded with the construction of twenty new 72-person barracks, six company operations facilities, six tactical equipment maintenance facilities, a combined brigade/battalion headquarters, a dining facility, a physical fitness facility, and a soldier family care clinic. These seven building types are core facilities that many soldiers either perform their daily duties in or visit on a daily basis and are very similar from one military installation to another. However, very little analysis has been performed on the performance of these facilities once constructed.

Additionally, a key focal point for all new facilities constructed by the Army in recent times is the standardization of designs and layouts for each of the varying facility types. For example, the Center of Standardization for Company Operations Facilities is located within the Savannah District of the U.S. Army Corps of Engineers. This "CoS" is responsible for ensuring the standard design for a COF is incorporated into the contract for construction of any new COFs that are appropriated. Similar centers exist for the various facility types and serve the same purpose for the construction of those facilities. While there is a lot of effort and coordination that goes into the standardization of Army facilities, it plays an important role in the life of a soldier. When an Army soldier relocates from one military post to another, it is critical that he or she can transition into their new role with a new unit smoothly. The standardization of facilities ensures that the soldier will be familiar with those of their new duty station because they were similar to those that they just left. Another less prominent benefit in the standardization efforts of the Army is the ability to use previous designs to improve the future construction of another facility of the same type. In terms of LEED and water efficiency, a study of the applicable LEED credits can help determine the best fixture types to specify in the design to help reduce the water consumption as best as possible as well as for the best value during programming and construction.

Purpose of the Study

The purpose of this study is to investigate the incorporation of the U.S. Green Building Council's LEED-NC rating system into the construction of various types of Army facilities and determine how the Army is helping conserve the usage of water. The Army's adaptation of the LEED certification program for construction of several of their various facility types can be explored to help justify and provide answers to the following areas of the sustainable water use initiative:

1. What features are being incorporated into new Army construction to reduce water consumption?
2. What investments are being made up front during design and construction to include features which aid in the achievement of the LEED-NC water efficiency credits?
3. What are the long-term benefits of incorporating these building components that help reduce the consumption of water? Are there any drawbacks to doing so?

Given the current financial crisis in the United States, new federally funded construction projects are thoroughly scrutinized. Any seemingly unnecessary costs associated with building a new facility are often scratched from the planning and programming of a new project simply because the public perception of the U.S. government's spending in today's economic state is very critical. Given the U.S. Green Building Council's successful drive for sustainability and environmental consciousness, it is important for the associated aspects of their Leadership in Energy and Environmental Design rating systems to be allowed for use in federal construction projects. By examining the life cycle tradeoffs of incorporating water efficient features into federal developments, the argument can be made that the long-term benefits, both environmentally and economical, far outweigh the upfront costs of using these technologies if any exist.

Research Design

In order to analyze the features of construction of the 5th IBCT Complex projects and their water efficient components, both a qualitative and quantitative approach was used in this study. In order to determine the types and quantities of water efficient fixtures that were used, thorough research was required to review the LEED-NC v2.2 submittal templates required by the USGBC for certification. From these documents, the types of fixtures installed on each of the projects could be determined along with the baseline and design water consumption estimates as calculated during design of each facility.

In addition to the research performed, a quantitative approach was used to determine the number of fixtures installed in each facility of the projects found in this study along with the average costs of each type. With this data being qualitative in nature, the findings concerning the actual costs incurred as a result of meeting the LEED-NC requirements of the WEc1, WEc2 and WEc3 credits can be very reliable. As a result, the conclusions drawn from the data collected is precise and can be used to accurately predict the cost implications of the water efficiency components of LEED certification.

Data Analysis

Summary of the LEED-NC Water Efficiency Credits Achieved or Pursued

Of the various facilities constructed as part of the 5th IBCT Complex, the DFAC and SFCC were formally submitted to the U.S. Green Building Council and certified as LEED v2.2 Silver. The COFs and TEMFs were also submitted as a multi-building project and certified as LEED Silver. The remaining buildings, the Barracks, HQ and PFF were not formally submitted to be certified, but rather were internally reviewed by the architectural firm providing the LEED review and documentation services for the Army and validated as LEED Silver "certifiable," concluding that the projects could be submitted along with the appropriate fees and become certified. The compliance with the credits for the water efficiency category of each of the facilities studied is illustrated in Table 1 below:

Water Efficiency LEED v2.2 Credits					
	WEc1.1: Water Efficient Landscaping- Reduce by 50%	**WEc1.2: Water Efficient Landscaping- No Potable Water Use or No Irrigation**	**WEc2: Innovative Wastewater Technologies**	**WEc3.1: Water Use Reduction- 20%**	**WEc3.2: Water Use Reduction- 30%**
Barracks	X	X		X	X
COFs/TEMFs	X	X	X	X	X
DFAC	X	X	X	X	X
HQ	X	X		X	X
PFF	X	X		X	X
SFCC	X	X		X	X

Table 1: Summary of Water Efficiency Credits by Project
Note: Each credit achieved contributes to one point towards the overall LEED score

Analysis of LEED-NC Credits WEc1.1 & WEc1.2

Credit 1 of the water efficiency category of the LEED-NC rating system allows for the award of two points towards a project's certification. The first point can be achieved if the project meets the requirements of WEc1.1 in which the amount of potable water used to irrigate landscaping is reduced by 50%. An additional point can be achieved by meeting the requirements of WEc1.2, which calls for the elimination of all potable water usage for landscaping purposes. The USGBC New Construction Version 2.2 reference guide outlines several strategies for doing so, including providing landscaping in the design that requires limited amounts of watering, installing water efficient irrigation that includes drip systems and collecting rainwater or graywater. According to the Green Building Information Gateway, or GBIG, 86% of LEED v2.2 certified buildings achieved the WEc1.1 credit (USGBC,

2013a). Statistics are not available from the GBIG for the LEED v2.2 WEc1.2 credit, but only 30% of projects certified under v.2.1 were able to eliminate all potable water use for irrigation and thus meet the WEc1.2 credit, indicating the additional potable water use reduction is more difficult to actually achieve (USGBC, 2013d).

As illustrated in Table 1, all projects studied achieved or are constructed to achieve the WEc1.1: Water Efficient Landscaping-Reduce by 50% and WEc1.2: Water Efficient Landscaping-No Potable Water Use or No Irrigation credits. In order to do so, all projects above eliminated the use of potable water for irrigation from their designs by installing landscaping that does not require permanent irrigation. According to the EPA WaterSense program, ways to eliminate the need for irrigation include selecting native species in the landscape design, grouping plants with similar watering needs together to allow better establishment, maintaining healthy soils for proper growing conditions and using mulch to reduce evaporation (U.S Environmental Protection Agency, 2013). By pursuing this strategy the projects required no calculations for documentation of the credits. Instead, each project submitted a narrative describing its landscaping plan and selection of plants that are native to the area, drought tolerant and are considered low maintenance after their acclimation period.

Analysis of LEED-NC Credit WEc2

Credit 2 of the water efficiency category of the LEED-NC rating system allows for the award of one point towards a project's certification by meeting one of two options. A project any either reduce potable water use for sewage conveyance by 50% or treat wastewater on site to tertiary standards. To meet the first option, a project may use water conserving fixtures or non-potable water for flushing to reduce the potable water use. For the later, the water may be treated in various natural or engineered ways but must be infiltrated or used on site once treated. The GBIG indicates that this credit is more difficult to achieve with only 13% of projects registered under v2.2 achieving the required reductions (USGBC, 2013b). This difficulty can be seen in the projects studied as part of this paper, with only two of the six pursuing the WEc2 credit.

The two projects that were able to achieve the WEc2 credit, the COFs/TEMFs and DFAC, were able to do so by incorporating water conserving water closets and waterless urinals into the design and construction of these facilities. Waterless urinals work by using gravity to send water down the drain and into a cartridge, where it "creates an airtight sealant liquid between the cartridge and the restroom, preventing bad odors from escaping the cartridge. The cartridge collects the uric sediment, preventing it from clogging the pipes" (Trbusic, 2012). The cartridges are replaced periodically depending on the usage of the urinal. By implementing waterless urinal technologies, the COFs/TEMFs and DFAC were able to reduce the potable water usage for sewage conveyance dramatically and ultimately surpass the 50% threshold required by the WEc2 credit. Figure 1 below illustrates the potable water usage savings for sewage conveyance achieved on each of the projects.

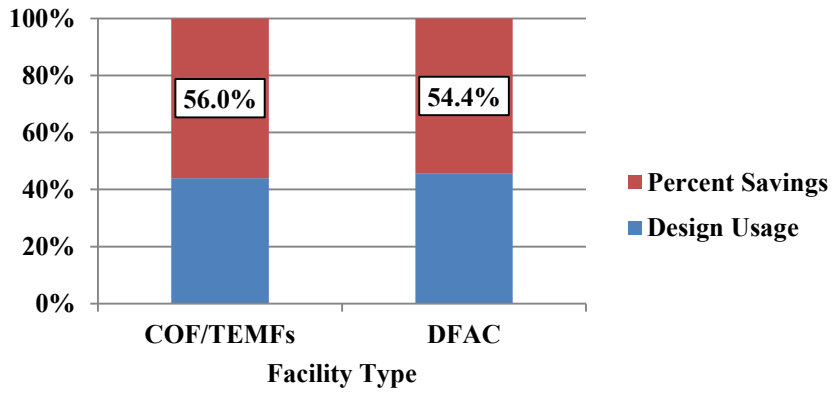

Figure 1: WEc2- Design sewage water savings compared to the baseline calculations

Analysis of LEED-NC Credits WEc3.1& WEc3.2

The final credit of the LEED-NC rating system in the water efficiency category also allows for two points to be awarded towards project certification. For the first point found in the WEc3.1 credit, a project must reduce water consumption by 20% over the baseline calculated for the building after also complying with the Energy Policy Act (EPAct) of 1992. An additional point may be awarded under the WEc3.2 credit if a project successfully reduces water consumption by 30% over the baseline. The calculations for the baseline usage and design case must not include irrigation and can only include the following fixtures, if found in the building: water closets, urinals, lavatory faucets, showers and kitchen sinks. The USGBC New Construction v2.2 reference guide provides several strategies for doing so, including the use of high-efficiency fixtures, dry fixtures, and the use of graywater for non-potable needs such as toilet and urinal flushing. Statistics from the GBIG indicate that WEc3.1 is one of the more popular credits, with 95% of LEED-NC v2.2 certified projects achieving a 20% reduction in water consumption (USGBC, 2013c). Statistics are not available from the GBIG concerning WEc3.2 for v2.2. However, the GBIG reports that only 23% of projects using v2.0 were able to use this credit towards achieving building certification, indicating it is not as easily achieved (USGBC 2013e).

A survey of the projects studied in this paper indicates that all facilities were able to reduce water consumption by more than 30%, thus achieving both the WEc3.1 and WEc3.2 credits. For some of the projects, an important interpretation proposed by the Army had to be approved by the USGBC to allow a deviation from the standard 50/50 male/female ratio of building users required for this credit. Normally, certain facilities such as a male dormitory can use a modified user ratio to show that the building occupants are 100% male, thus magnifying the water savings achieved by the use of waterless urinals. In the Army's case, the initial submission of the male-dominated occupancy for the COFs/TEMFs was rejected due to insufficient evidence that this population was accurate. A response was drafted by Atkins, the consultant hired by the Army to submit the LEED documentation, and an approval was granted to use an 85/15 ratio of males to females based on the demographics of soldiers stationed at Fort Stewart (personal communication, November 22, 2012). This ruling was used or assumed for the remaining facilities to ensure the WEc3.1 and WEc3.2 credits could be achieved for these projects studied.

To achieve the WEc3.1 and WEc3.2 credits, the projects incorporated various types of high-efficiency toilets (HETs), high-efficiency urinals (HEUs) and water saving lavatories, kitchen sinks and other flow fixtures. A HET is a water closet that flushes 20% below the EPAct of 1992 maximum allowable flush volume of 1.6 gallons per flush (gpf), which equates to a flush of 1.28 gpf or less. HEUs are urinals that have an average flush volume less than the maximum 1.0 gpf flush volume allowed by the EPAct of 1992. This category includes 0.5 gpf urinals and other "fractional flush models," as well as waterless urinals (Allen, 2007). These fixtures can be identified by a labeling system introduced as part of the Environmental Protection Agency's WaterSense program, which is similar to the ENERGY STAR program used for appliances. (Jahrling, 2007). Flow fixtures can also be identified by labeling adhering to the WaterSense standards that surpass the requirements of the EPAct of 1992. For instance, a showerhead needs to have a maximum flow rate less than 2 gallons per minute when tested at pressures of 20, 45 and 80 pounds per square inch to be compliant with the WaterSense standards, which is less than the 2.5 gpm at 80 psi required by the Energy Policy Act of 1992 (Kennedy, 2011) The projects studied used various combinations of these WaterSense fixtures to achieve greater than 30% water consumption savings. Figure 2 below illustrates the potable water usage savings achieved on each of the projects.

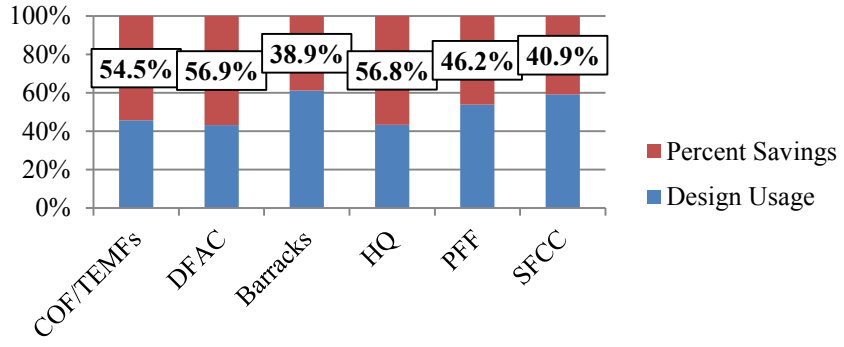

Figure 2: WEc3- Design potable water savings compared to the baseline calculations

Based on the design and baseline water usage calculations performed as part of the LEED-NC documentation, the annual cost savings can be determined for the 5th IBCT project facilities at Fort Stewart. Fred Cavedo, director of the Operations and Maintenance Branch of the Directorate of Public Works, states that the average cost of water production, which includes electrical power consumption and maintenance of the water distribution system, is approximately $0.66 per thousand gallons of water (personal communication, November 7, 2013). Based on this information, the incorporation of water efficient fixtures meeting the LEED-NC requirements is predicted to save approximately $11,055 per year in water consumption. These savings based on the annual cost of water consumption for the buildings considered in this study can be seen in Figure 3 below.

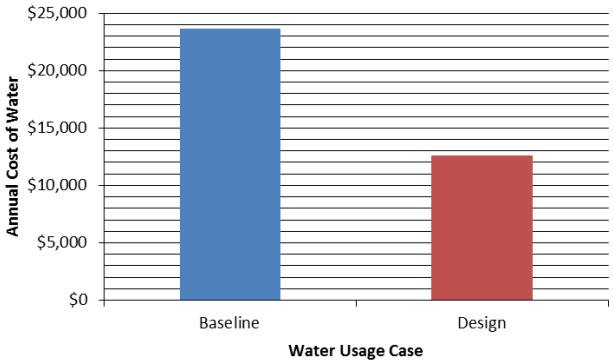

Figure 3: Annual cost of water based on the baseline and design usage calculations.

Cost Impacts of Pursuing or Achieving WEc3.2

The underlying contribution towards achieving the WEc2 and WEc3 credits of LEED-NC v2.2 is the installation of water saving fixtures in the facilities. However, it is predicted that these fixtures come at an additional expense to the projects in which they are used. According to Nyikos, Thal, Hicks and Leach (2012), building construction costs increase by about 2% on average to achieve the LEED certified level being pursued, and the LEED Silver level of certification is approximately 2.77% more expensive than standard construction. Because of these increased costs, legal authorization must come from the appropriate authorities since federally funded construction projects must follow the Federal Acquisition Guidelines (FAR). As explained by Millian (2011), several Executive Orders signed by the President require the reduction in energy consumption of federal facilities in the upcoming years and promote sustainable building practices. Millian presents the following conclusion for the strategies implemented to comply with these directives:

> *All federal agencies have been given the same targets and deadlines, but each agency has been left to determine its own approach to actually complying with these mandates. As a result, many agencies have turned to frameworks developed by third parties to aid in the design and construction of high-performance buildings. Among larger agencies, the most popular model is the US Green Building Council's Leadership in Energy and Environmental Design (LEED).*

In order to determine the cost implications of meeting the water efficiency credits, a quantity takeoff was needed to determine the types and number of fixtures used in the projects of this study. The results of the quantity takeoffs performed for each of the facilities can be found in Figure 4 below.

	Flush Fixtures				**Flow Fixtures**				
	Water Efficient Toilet	Dual-Flush Water Efficient Toilet	Water Efficient Urinal	Waterless Urinal	Low Flow Lavoratory	Low Flow Shower	Kitchen Sink	Janitor's Sink	Utility Sink
Barracks	720	0	0	0	720	720	720	60	0
COF/TEMFs	84	0	0	48	66	84	6	12	30
DFAC	10	0	0	3	13	1	11	3	0
HQ	0	30	0	12	38	25	8	3	0
PFF	21	0	6	0	9	25	3	1	0
SFCC	0	25	5	0	23	1	1	0	0
TOTALS:	835	55	11	63	869	856	749	79	30

Figure 4: Quantity takeoff for the 5th IBCT projects for various fixture types.

Next, a market survey of the fixtures installed on each of the projects was conducted to determine average fixture prices for the types found in the quantity takeoff. Due to the varying installed models, brands and features, it is not reasonable to compare the exact models installed on the projects. For instance, some specifications required battery-powered flush valves while others called for DC hard-wired flushing systems. A comparison of the prices for these differing systems would not depict an accurate average cost per fixture type. On the contrary, market research of three of the top manufacturers will yield a more accurate difference in cost between standard flowing fixtures and those with reduced flow rates.

The market survey included fixtures from American Standard, Sloan and Kohler and included complete battery-powered flush valve and fixture combinations. An attempt was made to ensure similar product lines were chosen to best compare products with similar features. The janitor's and utility sinks were omitted from the market survey since these fixture types are not commonly offered in water efficient options. The inclusion of these two specialty fixture types in the LEED calculations for the water efficiency credits was only necessary to factor their use in the overall water consumption calculations. Results of the market survey can be seen in Figure 5 below.

	Flush Fixtures					**Flow Fixtures**		
	Standard Water Closets	Dual Flush Water Closets	Urinals	Waterless Urinals	Waterless Urinal Yearly Maintenance	Lavoratories	Commercial Showers	Kitchen Sinks
Range of Costs: Baseline	$694.25-$846.00	$694.25-$846.00	$430.10-$975.00	$430.10-$975.00	N/A	$483.00-$759.00	$55.38-$144.00	$153.70-$219.00
Range of Costs: Design	$694.25-$846.00	$755.85-867.00	$437.05-$975.00	$556.00-$599.05	$44.72-$61.90	$483.00-$759.00	$55.38-$144.00	$153.70-$219.00
Average Cost Difference	**$0.00**	**$41.30**	**$2.32**	**($158.93)**	**$53.71**	**$0.00**	**$0.00**	**$0.00**

Figure 5: Market survey results for various fixture types.

Based on the quantity takeoff performed and the market survey, the next step in determining the cost implications of installing water efficient fixtures is to calculate the total added costs (or savings) to the projects. This calculation is performed for each fixture type by multiplying the number of fixtures by the average cost difference between fixtures with flow rates complying with the minimum EPAct of 1992 standards and those used in the design that incorporate further reduced flow rates. The results of these calculations are summarized in Figure 6 below.

	Flush Fixtures					**Flow Fixtures**		
	Standard Water Closets	Dual Flush Water Closets	Urinals	Waterless Urinals	Waterless Urinal Yearly Maintenance	Lavoratories	Commercial Showers	Kitchen Sinks
Total Number of Fixtures Installed	835	55	11	63	63	869	856	749
Average Cost Difference	$0.00	$41.30	$2.32	($158.93)	$53.71	$0.00	$0.00	$0.00
Total Added Cost (or Savings) to Projects	$0.00	$2,271.50	$25.48	($10,012.80)	$3,383.48	$0.00	$0.00	$0.00

Figure 6: Added project costs (or savings) as a result of using water efficient fixtures.

A secondary cost implication that resulted from the selection of waterless urinals for the COF/TEMFs, DFAC and HQ projects is the necessity of routine maintenance that must be performed on the fixtures. Of the three major manufacturers considered in the market survey, waterless urinals sold by American Standard and Sloan require the specialized cartridges that must be changed after a certain number of uses, and Kohler versions require special liquid that must be refilled every so often. One example of the cartridge style urinal includes the Sloan WES-150 Waterfree Urinal Water Cartridge Kit which must be changed after every 7,000 uses (Sloan, 2009).

Conclusions & Future Research

From the results of this study, it appears that the projects that are part of the 5th IBCT Complex at Fort Stewart, GA were successful at reducing the amount of water consumed by achieving the various water efficiency credits of the

LEED-NC v2.2 rating system. All projects were able to earn four of the five possible credits of the category by eliminating all potable water use for irrigation and reducing potable water consumption by 30% over their baseline statistics. In addition, two of the projects were able to earn a fifth point by reducing potable water use for sewage conveyance by 50%.

As a result of pursuing and achieving the LEED-NC v2.2 water efficiency credits, the total annual cost of water consumption for the 5th IBCT Complex was reduced by approximately 49%. In order to achieve these savings, this study suggests that the initial investment made during construction to incorporate the water efficient fixtures necessary to do so is negligible. The market research performed actually demonstrated an overall cost savings due to the lower cost of waterless urinals than low flow versions. If it is considered that solely low flow fixtures were installed instead of the water-free fixtures, the overall investment needed for a project of this size would only total about $2,442. This research indicates that the cost of providing high-efficiency versions of the fixtures in the various types of Army facilities is negligible to the overall multi-million dollar price tag of buildings of this nature.

While the costs to incorporate the water efficient fixtures is proven to be negligible based on average fixture costs on the market, additional research could be performed to study the various features offered with flush and flow fixtures. As noted by Turner (2006), assumptions are made during the baseline calculations about the frequency and duration of restroom flow fixture use, and the industry could benefit from further studies of water use to improve benchmark data. Likewise, further analysis of the purchase and installation costs of waterless urinals using actual project costs could be performed to compare these against the long-term maintenance costs required once in use. As explained by Anand and Apul (2011), it is important to consider water and wastewater service rates and the possibility of these costs increasing when performing an analysis of the cost savings of water efficient fixtures, which is a factor not considered as part of this study. However, the common deduction from this study points towards success in generating both water consumption and cost savings when the achievement of the water efficiency credits of LEED-NC are required for a project, regardless of the type of Army facility being constructed.

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